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Kontribusi : Penulis Pertama dan Koresponding

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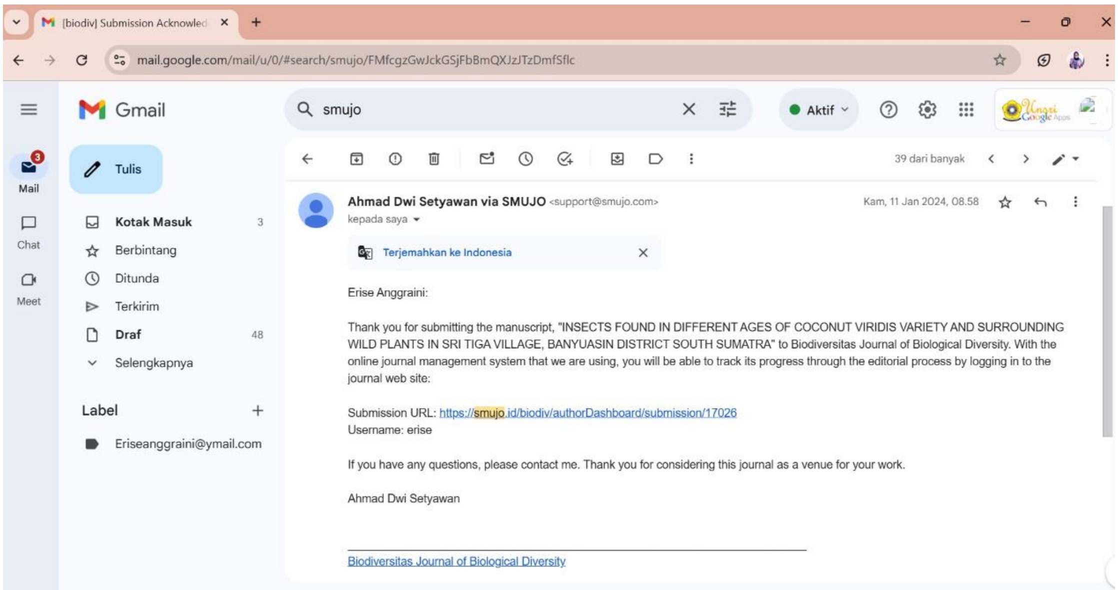

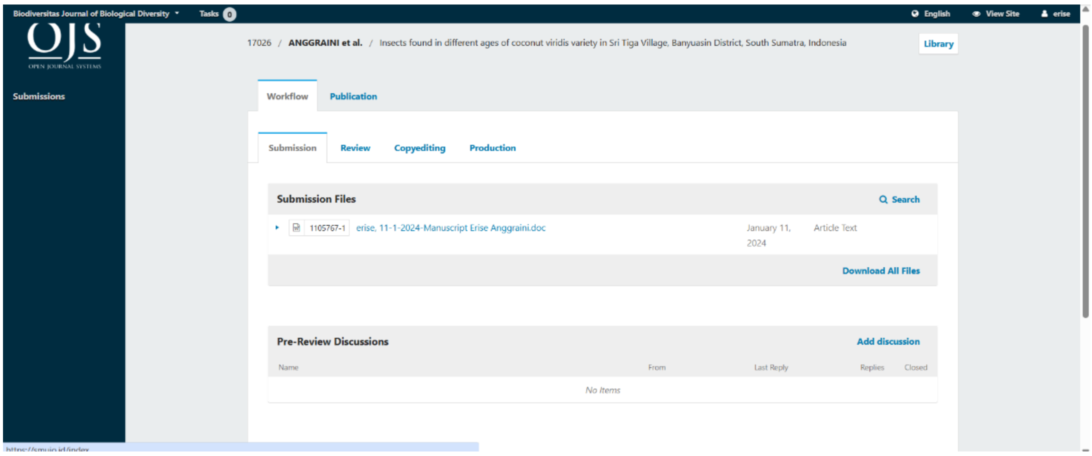

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INSECTS FOUND IN DIFFERENT AGES OF COCONUT VIRIDIS VARIETY AND SURROUNDING WILD PLANTS IN SRI TIGA VILLAGE, BANYUASIN DISTRICT SOUTH SUMATRA

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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.

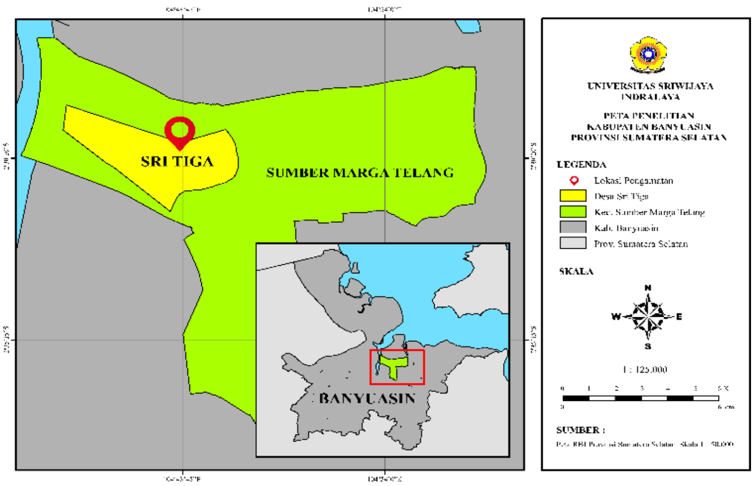

Figure 1. Sampling location

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:

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

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	3.20×10^{-1}	1.54^{ns}	-
Hemiptera						
Aspidiotus destructor	173.33a	116.33b	96.00b	3.62×10^{-3}	31.24^{*}	1.55
Nipaecoccus nipae	256.33a	265.67a	18.00b	5.16×10^{-5}	276.40^{*}	2.07
Planococcus sp.	50.67a	44.33a	27.67b	58.7×10^{-4}	80.55^{*}	0.54
Hymenoptera						
Aphis cerana	5.67a	4.33b	0.00c	3.13×10^{-5}	355.22^{*}	0.25
Cotesia congregata	30.00a	25.33b	18.00c	6.14×10^{-4}	78.70^{*}	0.35
Dolichoderus thoracicus	113.33a	103.67a	81.33b	45.1×10^{-3}	27.78^{*}	0.81
Oecophylla sp.	98.00a	87.33a	60.33b	1.15×10^{-3}	56.91^{*}	0.75
Polistes carnifex	4.00a	2.33b	0.00c	4.52×10^{-4}	92.12^{*}	0.38
Lepidoptera						
Metisa plana	16.33a	13.67ab	10.00b	2.64×10^{-2}	10.31^{*}	0.68
Pteroma pendula	20.67a	16.67ab	13.00b	6.15×10^{-3}	23.50^{*}	0.48
Pteroma plagiophleps	24.00a	19.00ab	14.00b	6.78×10^{-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	9.09×10^{-3}	18.98^{*}	0.71
Eumorphus westwoodi	12.33a	8.33b	3.00c	3.21×10^{-4}	109.67^{*}	0.42
Isoptera						
Captotermes sp.	18.00a	13.67b	0.00c	3.52×10^{-5}	335.07^{*}	0.53

Orthoptera						
Conocephalus sp.	17.00a	12.00b	10.00c	38.9×10^{-4}	99.47*	0.24
Dianemobius fascipes	16.67a	13.00b	9.00c	6.50×10^{-5}	246.00*	0.17
Tettigidea lateralis	10.67a	8.33ab	6.67b	8.19×10^{-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).

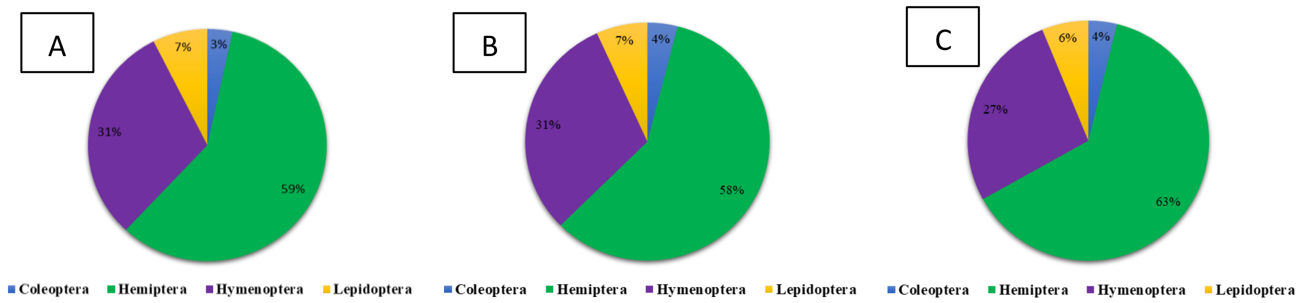

Figure 2. Abundance of insects found in coconut trees at: A) 8 years old, B) 5 years old, C) 2 years old.

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).

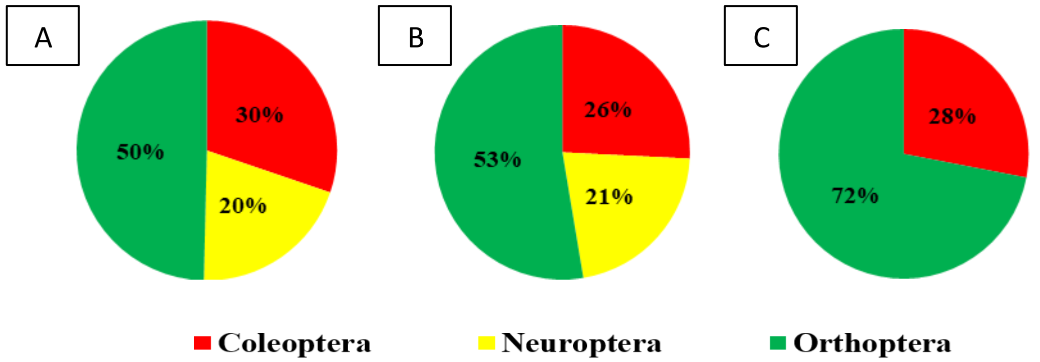

Figure 3. Abundance of insects on wild plants around coconut trees at different age of coconut: A) 8 years old, B) 5 years old, C) 2 years old.

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).

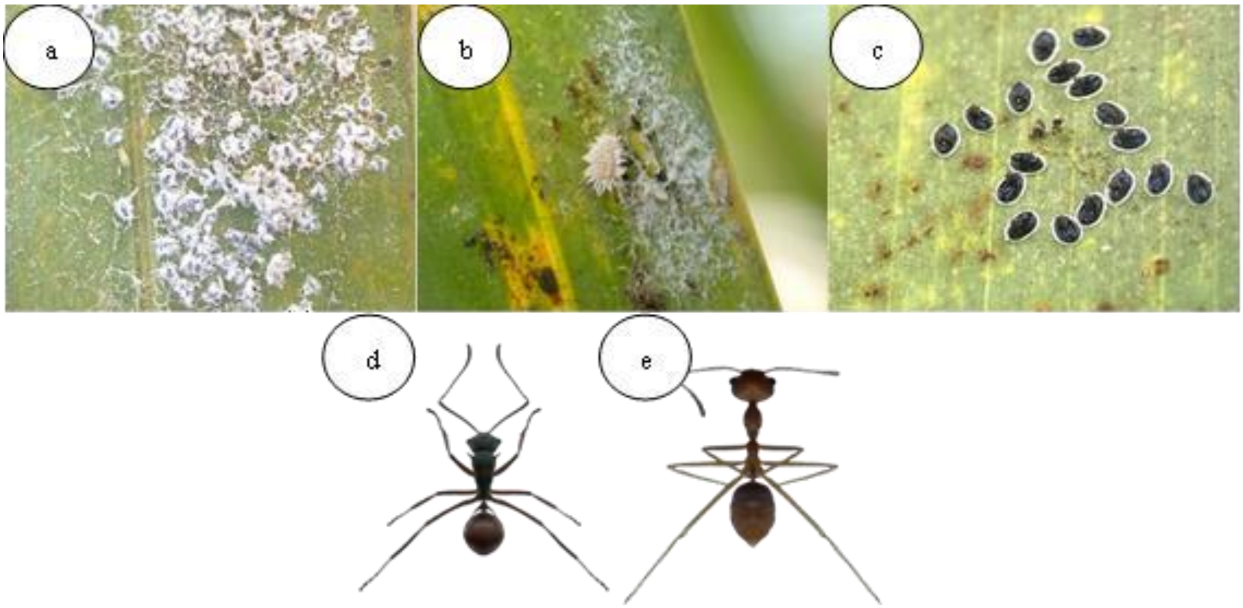

Figure 3. The dominant insects are found on coconut plants and surrounding plants. *Aspidiotus destructor* (a), *Nipaecoccus nipae* (b), *Aleurocanthus* sp. (c), *Polyrhachis dives* (d) dan *Oecophylla* sp. (e)

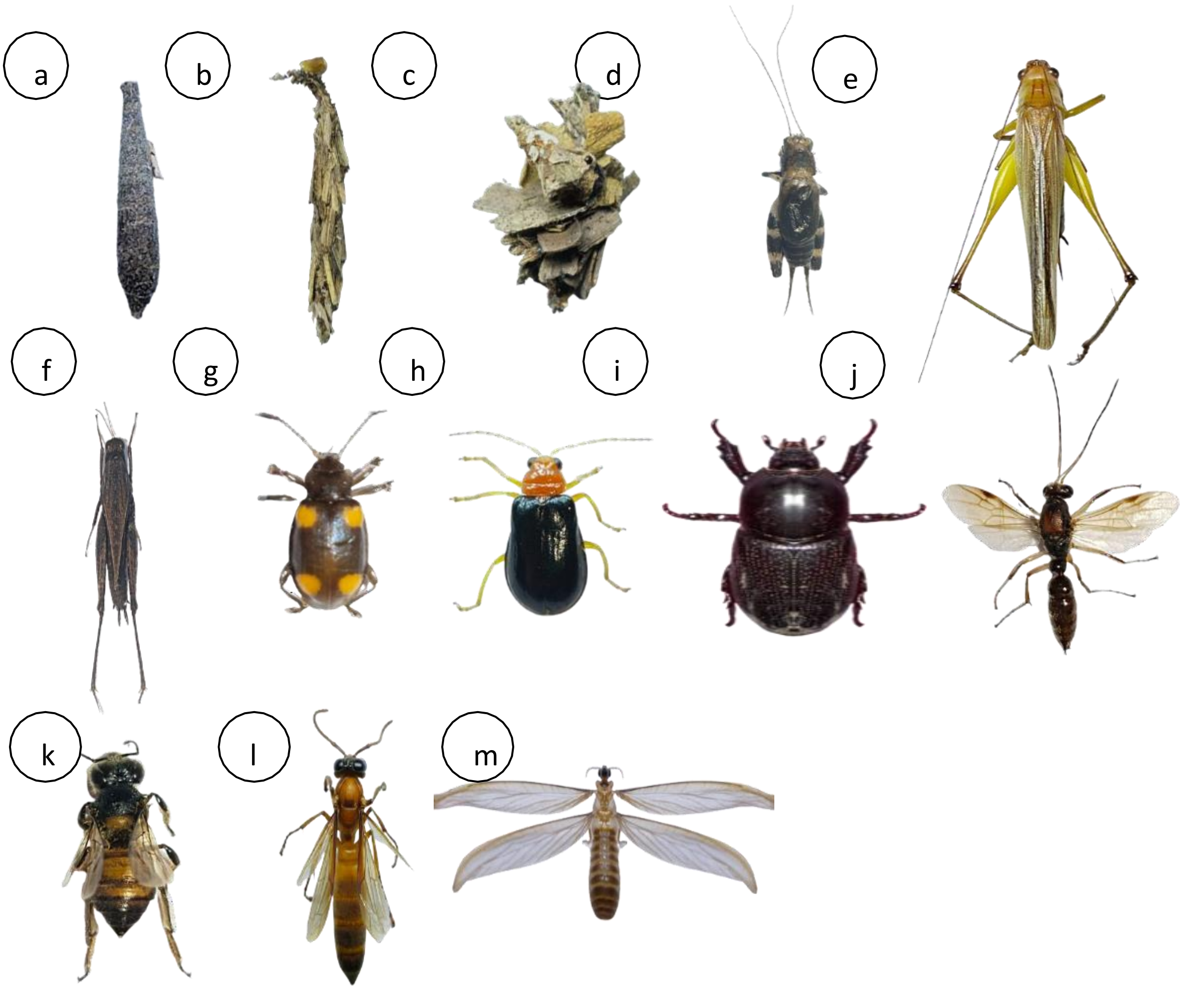

Figure 4. The non-dominant insects are found on coconut plants and surrounding plants. *Pteroma pendula* (a), *Cenephora hirsuta* (b), *Metisa plana* (c), *Dianemobius fascipes* (d), *Conocephalus* sp. (e), *Tettigidea lateralis* (f), *Eumorphus westwoodi* (g), *Aulacophora* sp. (h), *Oryctes rhinoceros* (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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This manuscript has too many national references to be published in Biodiversitas. Reference list should consist of at least 20 citations which 80% of international scientific journals published in the last 10 years (2014-2024), and a maximum of 10% references from national publication. Also, please follow the guidance for reference writing (https://smujo.id/biodiv/guidance-for-author) and use the abbreviaton for journal's name.

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Biodiversitas Journal of Biological Diversity

January 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"

No.	Location in manuscript	Reviewers' suggestion	Our response
1		This manuscript has too many national references to be published in Biodiversitas. The reference list should consist of at least 20 citations, which 80% of international scientific journals published in the last 10 years (2014-2024), and a maximum of 10% references from national publications. Also, please follow the guidance for reference writing (https://smujo.id/biodiv/guidance-for-author) and use the abbreviation for the journal's name.	We already change the reference, 6 references were from local authors. 29 references were from overseas

Best regards,

Corresponding author,

Erise Anggraini

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,

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- ☑ 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).
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- ☑ The text adheres to the stylistic and bibliographic requirements outlined in the Author Guidelines.
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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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Novelty:

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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

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.

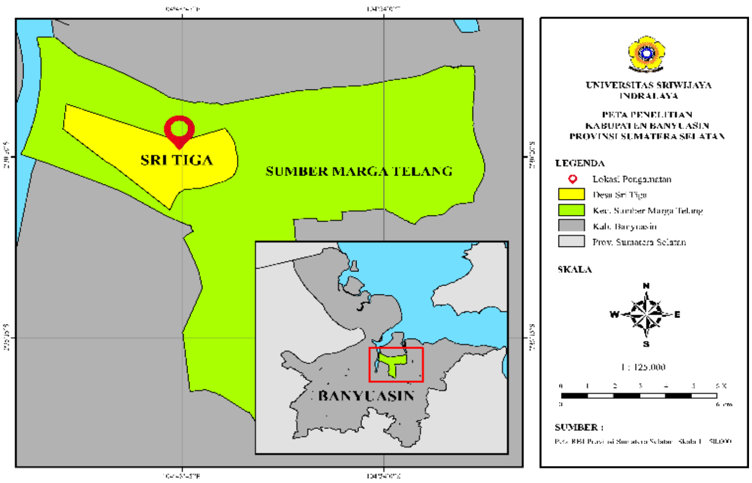

Figure 1. Sampling location

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	3.20×10^{-1}	1.54^{ns}	-
Hemiptera						
Aspidiotus destructor	173.33a	116.33b	96.00b	3.62×10^{-3}	31.24^{*}	1.55
Nipaecoccus nipae	256.33a	265.67a	18.00b	5.16×10^{-5}	276.40^{*}	2.07
Planococcus sp.	50.67a	44.33a	27.67b	58.7×10^{-4}	80.55^{*}	0.54
Hymenoptera						
Aphis cerana	5.67a	4.33b	0.00c	3.13×10^{-5}	355.22^{*}	0.25
Cotesia congregata	30.00a	25.33b	18.00c	6.14×10^{-4}	78.70^{*}	0.35
Dolichoderus thoracicus	113.33a	103.67a	81.33b	45.1×10^{-3}	27.78^{*}	0.81
Oecophylla sp.	98.00a	87.33a	60.33b	1.15×10^{-3}	56.91^{*}	0.75
Polistes carnifex	4.00a	2.33b	0.00c	4.52×10^{-4}	92.12^{*}	0.38
Lepidoptera						
Metisa plana	16.33a	13.67ab	10.00b	2.64×10^{-2}	10.31^{*}	0.68
Pteroma pendula	20.67a	16.67ab	13.00b	6.15×10^{-3}	23.50^{*}	0.48
Pteroma plagiophleps	24.00a	19.00ab	14.00b	6.78×10^{-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	9.09×10^{-3}	18.98^{*}	0.71
Eumorphus westwoodi	12.33a	8.33b	3.00c	3.21×10^{-4}	109.67^{*}	0.42
Isoptera						
Captotermes sp.	18.00a	13.67b	0.00c	3.52×10^{-5}	335.07^{*}	0.53
Orthoptera						
Conocephalus sp.	17.00a	12.00b	10.00c	38.9×10^{-4}	99.47^{*}	0.24
Dianemobius fascipes	16.67a	13.00b	9.00c	6.50×10^{-5}	246.00^{*}	0.17
Tettigidea lateralis	10.67a	8.33ab	6.67b	8.19×10^{-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).

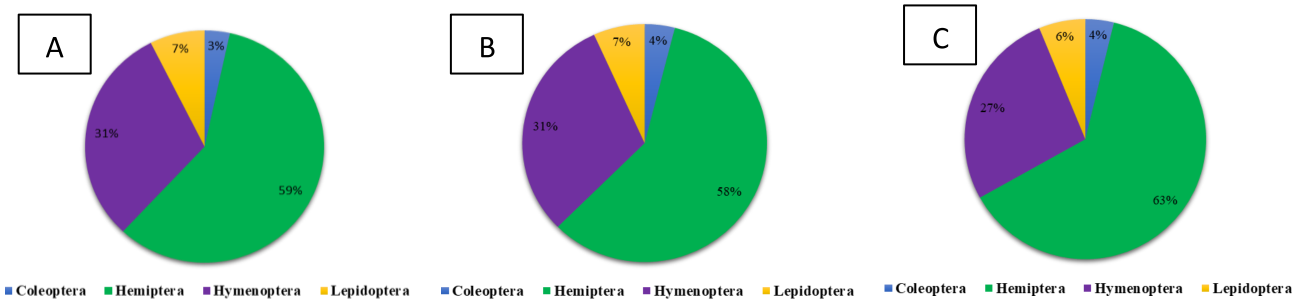

Figure 2. Abundance of insects found in coconut trees at: A) 8 years old, B) 5 years old, C) 2 years old.

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).

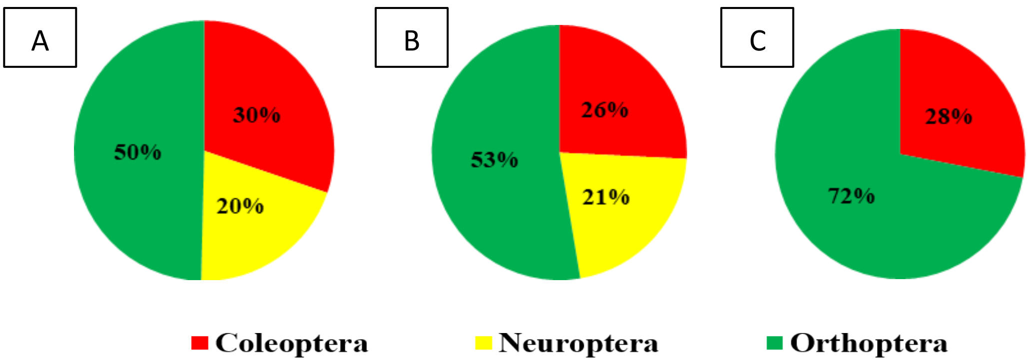

Figure 3. Abundance of insects on wild plants around coconut trees at different age of coconut: A) 8 years old, B) 5 years old, C) 2 years old.

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).

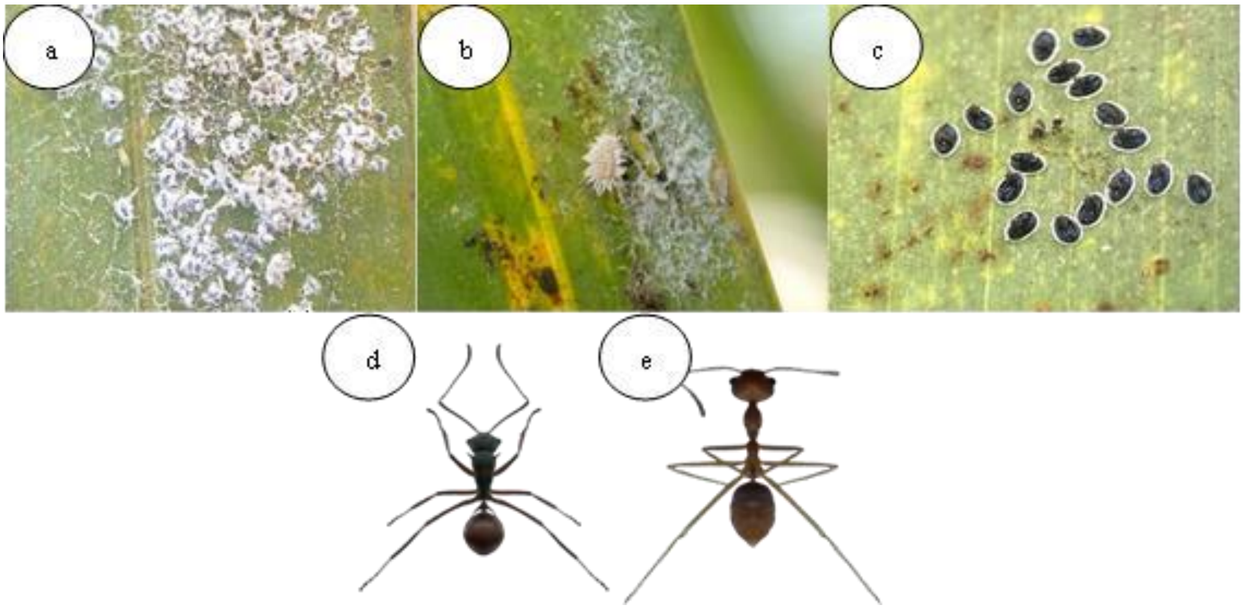

Figure 3. The dominant insects are found on coconut plants and surrounding plants. *Aspidiotus destructor* (a), *Nipaecoccus nipae* (b), *Aleurocanthus* sp. (c), *Polyrhachis dives* (d) dan *Oecophylla* sp. (e)

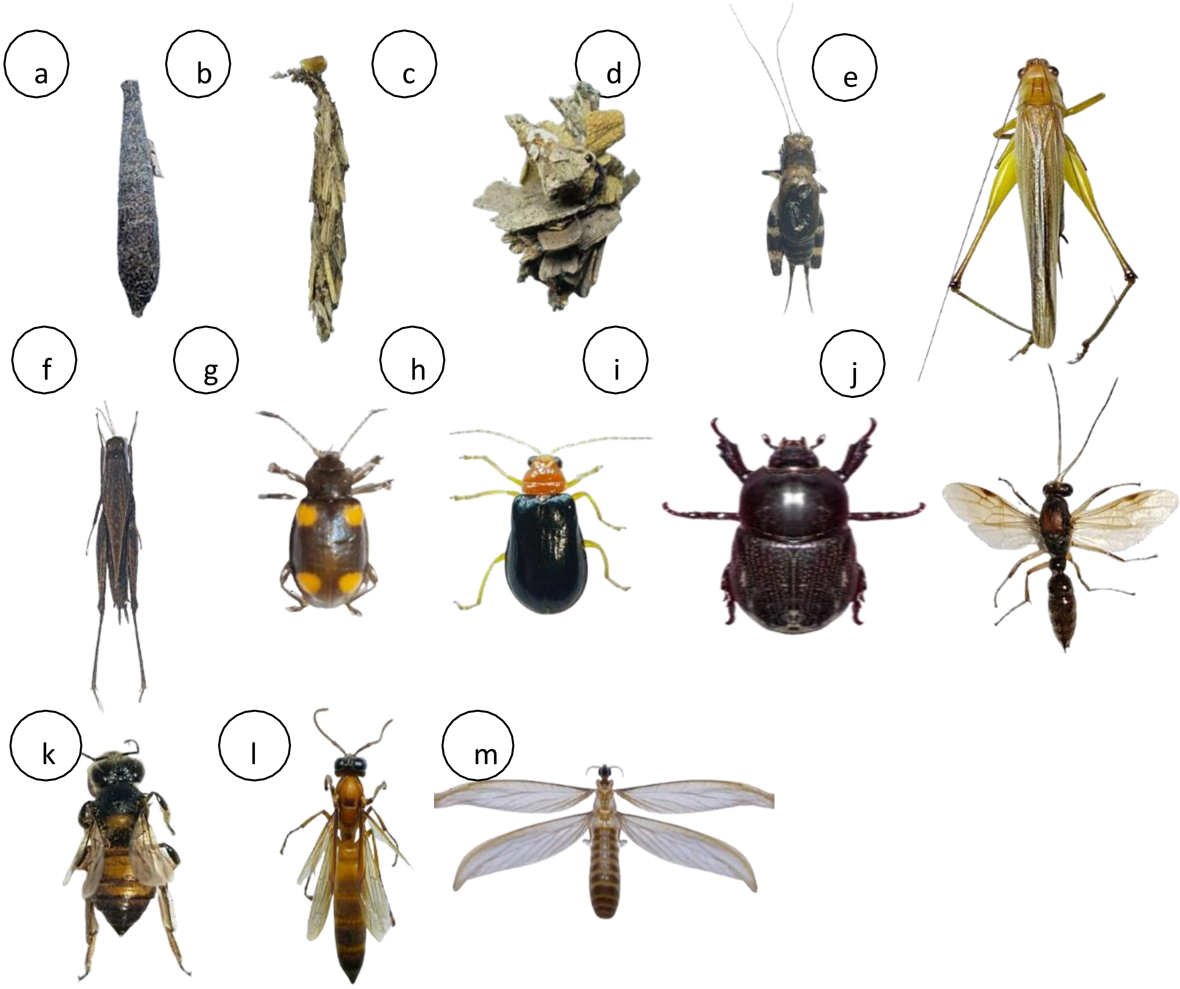

Figure 4. The non-dominant insects are found on coconut plants and surrounding plants. *Pteroma pendula* (a), *Cenephora hirsuta* (b), *Metisa plana* (c), *Dianemobius fascipes* (d), *Conocephalus* sp. (e), *Tettigidea lateralis* (f), *Eumorphus westwoodi* (g), *Aulacophora* sp. (h), *Oryctes rhinoceros* (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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3. Bukti konfirmasi review kedua dan hasil revisi kedua

(22 Januari 2024)

33 dari banyak

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Dear author,

Please follow the guidance for reference writing (https://smujo.id/biodiv/guidance-for-author).

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Recommendation: Revisions Required

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Our decision is: Revisions Required

Reviewer A:

Dear author,

Please follow the guidance for reference writing (https://smujo.id/biodiv/guidance-for-author).

Regards

Recommendation: Revisions Required

Identification of the nettle caterpillar in smallholding oil palm plantation cultivated on peatland in Ogan Ilir, South Sumatra, Indonesia

Abstract. Nettle caterpillars are a major pest in oil palm plantations, posing a significant threat to the productivity and sustainability of this crop. These voracious leaf-feeding caterpillars can cause severe damage, hindering plant growth, reducing fruit production, and even leading to the mortality of oil palm trees. This study aimed to identify the species of caterpillars that inflict damage, their physical traits, population densities, and the symptoms of their attacks. This study employed direct observation and documentation of caterpillar species in the field. Observations were conducted to assess the extent of damage inflicted by caterpillars in the field. Subsequently, document using a camera, collect field samples, and examine the behavior of the caterpillars found in 100 palm oil trees. This investigation identified three species of caterpillars: *Setora nitens*, *Birthosea bisura*, and *Parasa lepida*. These three species of caterpillars typically exhibit similar coloration but possess distinct morphological traits. The *S. nitens* species predominates among the largest number of species. Caterpillars consume both young and mature oil palm leaves, remaining only in the midrib. Additional indications of the attack include perforations in the leaves. The incidence of caterpillar assaults may attain 100.00%, accompanied by an attack rate of 57.75%. This study concludes that three primary species of nettle caterpillar were identified in oil palm plantations, exhibiting indications of damage classified as fairly severe. Thus, effective management of nettle caterpillars is crucial to maintaining the productivity and profitability of oil palm plantations.

Keywords: *Birthosea bisura,* morphological traits**,** *Parasa lepida,* pest attack*, Setora nitens*

Running title: Nettle Caterpillar in oil palm plantation

INTRODUCTION

Indonesia is predominantly an agriculture-based nation, with extensive plantations that significantly contribute to its economy. Among these, palm oil is one of the primary commodities (Jafari et al., 2017), playing a crucial role in both domestic and international markets.– The cultivation and productivity of oil palm are influenced by two main factors: external factors, such as climate and soil, and internal factors, which include the genetic variety of the oil palm plant (Meijaard et al., 2020). While palm oil remains the leading agricultural export, other plantation crops like cocoa, rubber, and sugarcane are expected to become significant contributors to Indonesia's export economy in the coming years. Indonesia is the world's leading palm oil producer, surpassing other major suppliers like Malaysia and Brazil, accounting for approximately 59% (or 4.8 million tons) of the global palm oil supply (Tandra et al., 2022; Varkkey, 2018). This dominant position highlights the strategic importance of maintaining high productivity and addressing challenges that could threaten the industry's sustainability.

One of the major challenges confronting oil palm plantations is the prevalence of pests, which can substantially hinder productivity. Pests affecting oil palms are classified based on the specific parts of the oil palm they affect, which include leaf and shoot feeders, trunk feeders, bunch feeders, and root feeders (Setiyowati et al., 2015). Among the most significant leaf-eating pests are nettle caterpillars, moth caterpillars, and bagworms (Mazuan et al., 2021). Oil palm leaf-eating caterpillars, including species *Darna trima, Setothosea Asigna, Setora nitens, Ploneta diducta*, and *P. bradleyi*, are known for causing extensive damage to oil palm plantations (Corley and Tinker, 2015).

Nettle caterpillars intensely feed on oil palm leaves, frequently perforating them or entirely consuming the leaf blades, leaving only the midrib. This substantial loss of leaf area significantly compromises the plant's photosynthetic capacity, resulting in a notable decline in its overall health and productivity (Priwiratama et al., 2018). As the leaves are the primary site of photosynthesis, the reduction in leaf area directly impacts the plant's energy production, which in turn affects fruit development. Studies have shown that infestations by nettle caterpillars can reduce oil palm production by 70%, and if a second infestation occurs within the same year, the decline can escalate to as much as 90% (Tawakkal et al., 2019). Notably, it was reported that up to 2,000 larvae were found per frond in one outbreak, with some plants experiencing up to a 60% reduction in leaf area over several days (Kamarudin et al., 2017). Rapid and widespread damage makes nettle caterpillars one of the most destructive pests to oil palm plantations. These infestations not only impact immediate crop yields but can also lead to long-term harm to the sustainability of plantations. The implementation of effective pest management strategies is crucial to minimize the impact of nettle caterpillars on oil palm plantations.

In South Sumatra, oil palm farming holds a crucial position in the agricultural landscape, particularly in the Ogan Ilir district, where ~~large~~ large-scale plantations are established on peatlands. While these plantations provide significant economic benefits, they are highly vulnerable to pest infestations, including nettle caterpillars. Effective pest management strategies are essential to ensure the long-term economic and environmental sustainability of oil palm plantations in peatland areas. Understanding the biology, behavior, and ecological impact of nettle caterpillars is essential for developing targeted and sustainable pest control methods. This study aimed to identify the nettle caterpillar species present in private oil palm plantations within South Sumatra’s peatland areas. By providing a detailed analysis of the caterpillars’ lifecycle, feeding habits, and ecological role, the research will offer valuable insights into pest management practices that can help reduce crop losses and improve the long-term productivity of oil palm plantations in the region. Ultimately, this research seeks to contribute to the sustainability of oil palm farming in South Sumatra, ensuring that the industry can thrive while preserving the integrity of peatland ecosystems.

MATERIALS AND METHODS

Study area

This research was carried out from August 2024 to its conclusion. The research was conducted at a private oil palm plantation in Palem Raya, Ogan Ilir, South Sumatra (Figure 1). Identification of the species was conducted in the Entomology Laboratory, Faculty of Agriculture, Universitas Sriwijaya. The survey was conducted by direct observation of 3 years of DxP Sriwijaya 5 variety at the private oil palm plantation in Palem Raya village. Infestation levels induced by nettle caterpillars were evaluated using field observations. The results were subsequently recorded with a camera.

Figure 1. The sampling location is in Palem Raya, Ogan Ilir District, South Sumatra, Indonesia. The samples were taken from oil palm plantations.

Procedures

Observation and sampling method

At the time of specimen collection, the pest was in the larval stage. The larvae found on the oil palm leaves were collected and then placed in a box container to be brought to the laboratory for identification. The description of the pest and the damage observed were based on the pests attacking the oil palm crops, from the initial symptoms of infestation to the advanced symptoms caused by the nettle caterpillars. The intensity of the infestation was assessed visually based on the symptoms of the nettle caterpillar attack. In each plot, 100 plants were observed. The plants that showed signs of infestation were counted one by one, and then the total number of infested plants was recorded. The formula used to calculate the intensity of the nettle caterpillar pest infestation was applied using a specific formula.

The intensity of pest attack (%)

The observation of pest attack intensity was conducted visually based on the symptoms of the nettle caterpillar infestation. In each plot, 100 plants were taken for observation. The plants that showed signs of infestation were counted one by one, and then the total number of infested plants was recorded. The formula used to calculate the intensity of the nettle caterpillar pest infestation was applied using the following formula:

$$I = \frac{n}{N} \times 100\ \%$$

Description
I = Intensity of Attack by nettle caterpillars (%)
n = Number of plants infested by nettle caterpillars
N = Total number of plants observed

Table 1. Criteria for categories of nettle caterpillar attack intensity.

Scale	Presentation of attack intensity (%)	Category
0	0	Normal
1	0-25	Light
2	25-50	Moderate
3	50-90	Severe
4	≥ 90	Very Severe

Level of attack

The level of attack refers to the level of infestation based on the number of pests found on the fronds of the observed oil palm plants. The critical threshold for this nettle caterpillar pest is 5 individuals per plant. The levels of nettle caterpillar infestation are as follows:

1. < 2 individuals/frond: Light
2. 2-4 individuals/frond: Moderate
3. 5 individuals/frond: Severe (requires management)

Data Analysis

Data analysis was conducted using Microsoft Excel software to process the raw data obtained in the field, which was then presented in the form of tables.

RESULTS AND DISCUSSION

The morphology of nettle caterpillars

The oil palm plantation hosts three distinct species of nettle caterpillars: *Setora nitens* Walker, *Birthosea bisura* Moore, and *Parasa lepida* Cramer.~~–~~ These caterpillars share a generally yellowish-green coloration, but each exhibits its ~~own~~ unique morphological characteristics. *S. nitens* has a yellowish-green color with two coarse spines on its head and posterior, as well as blue coloration extending from the head to the abdomen (Figure 2.a). *B. bisura* is characterized by a green color with a pale dorsal line running along its body, an oval, flattened body shape, and two blue and white spots on the central part (Figure 2.b).~~–~~ *P. lepida*~~,~~ displays a pale green or bright yellow coloration with three green stripes running along its body and six orange spines on each end of its body (Figure 2.c).

Figure 2. Setora nitens (a), Birthosea bisura (b), Parasa lepida (c).

The total number of nettle caterpillar

Three species of nettle caterpillars were identified during observations conducted on 100 oil palm trees. These observations, carried out on three separate occasions, revealed variations in the presence and abundance of the caterpillar species (Table 2). Among these, *S. nitens* was the most abundant, with population counts ranging from 143 to 218 individuals per 100 plants across the three observation periods. *P. lepida* was only recorded during the second observation, with 15 individuals per 100 plants, and was absent in the first and third observations. *B. bisura* was the least frequently encountered species, appearing only in the initial observation with 6 individuals per 100 plants.

Table 2. Total number of nettle caterpillar species found on 100 oil palm plant

Species	Number of nettle caterpillars (individual) during observation		
	First observation	**Second observation**	**Third observation**
Setora nitens	218	164	143
Birthosea bisura	6	0	0
Parasa lepida	0	15	0

The average number of nettle caterpillar species per instar

During the study, the three species were observed at different larval instar stages (Table 3). *S. nitens* was found in instars 1 to 6, with instar 6 being the most prevalent, with an average of 78.67 individuals. *B. bisura* was found only in instar stages 3 and 4 on the 100 oil palm trees, with a single individual recorded at each stage. Meanwhile, *P. lepida* was present in instar stages 1 and 5, with averages of 1.67 and 3.33 individuals, respectively.

Table 3. The average number of nettle caterpillar species per instar found per 100 trees

Species	The average number of nettle caterpillar					
	Instar 1	**Instar 2**	**Instar 3**	**Instar 4**	**Instar 5**	**Instar 6**
Setora nitens	0.33	4.67	16.67	41.33	33.33	78.67
Birthosea bisura	0.00	0.00	1.00	1.00	0.00	0.00
Parasa lepida	1.67	0.00	0.00	0.00	3.33	0.00

The average size of nettle caterpillar species per instar

The three species observed exhibited different sizes at each of their respective instar stages (Table 4). *S. nitens* measured 0.60 cm at instar 1 and reached a size of 2.53 cm in instar 6 (Figure 2). *B. bisura* was absent in instars 1, 2, 5, and 6. In the field, only instar 3 of *B. bisura* was found, with a size of 1.06 cm, and instar 4 measuring 1.70 cm (Figure 4). Meanwhile, *P. lepida* was observed with a size of 0.50 cm at instar 1 and 2.00 cm at instar 5 (Figure 5).

Table 4. The average size of nettle caterpillar species per instar found on 100 trees

Species	Size of nettle caterpillar at instar (cm)					
	Instar 1	**Instar 2**	**Instar 3**	**Instar 4**	**Instar 5**	**Instar 6**
Setora nitens	0.60	0.87	1.09	1.74	2.00	2.53
Birthosea bisura	0.00	0.00	1.06	1.70	0.00	0.00
Parasa lepida	0.50	0.00	0.00	0.00	2.00	0.00

Figure 3. Larvae sizes of the *Setora nitens* species found: instar 1 (a), instar 2 (b), instar 3 (c), instar 4 (d), instar 5 (e), and instar 6 (f)

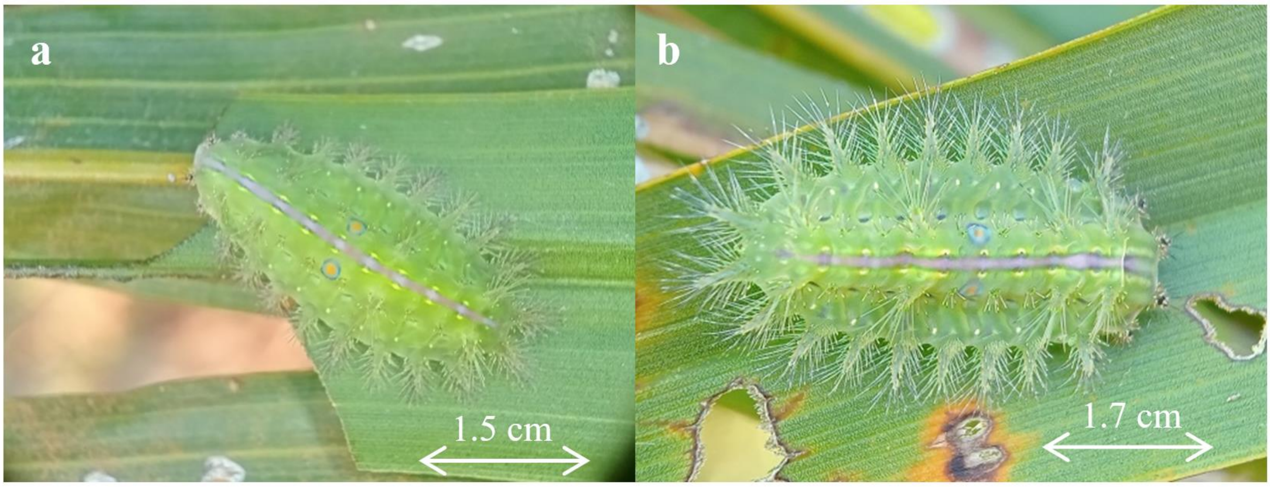

Figure 4. Size of *B. bisura* larvae found: a) instar 3, b) instar 4

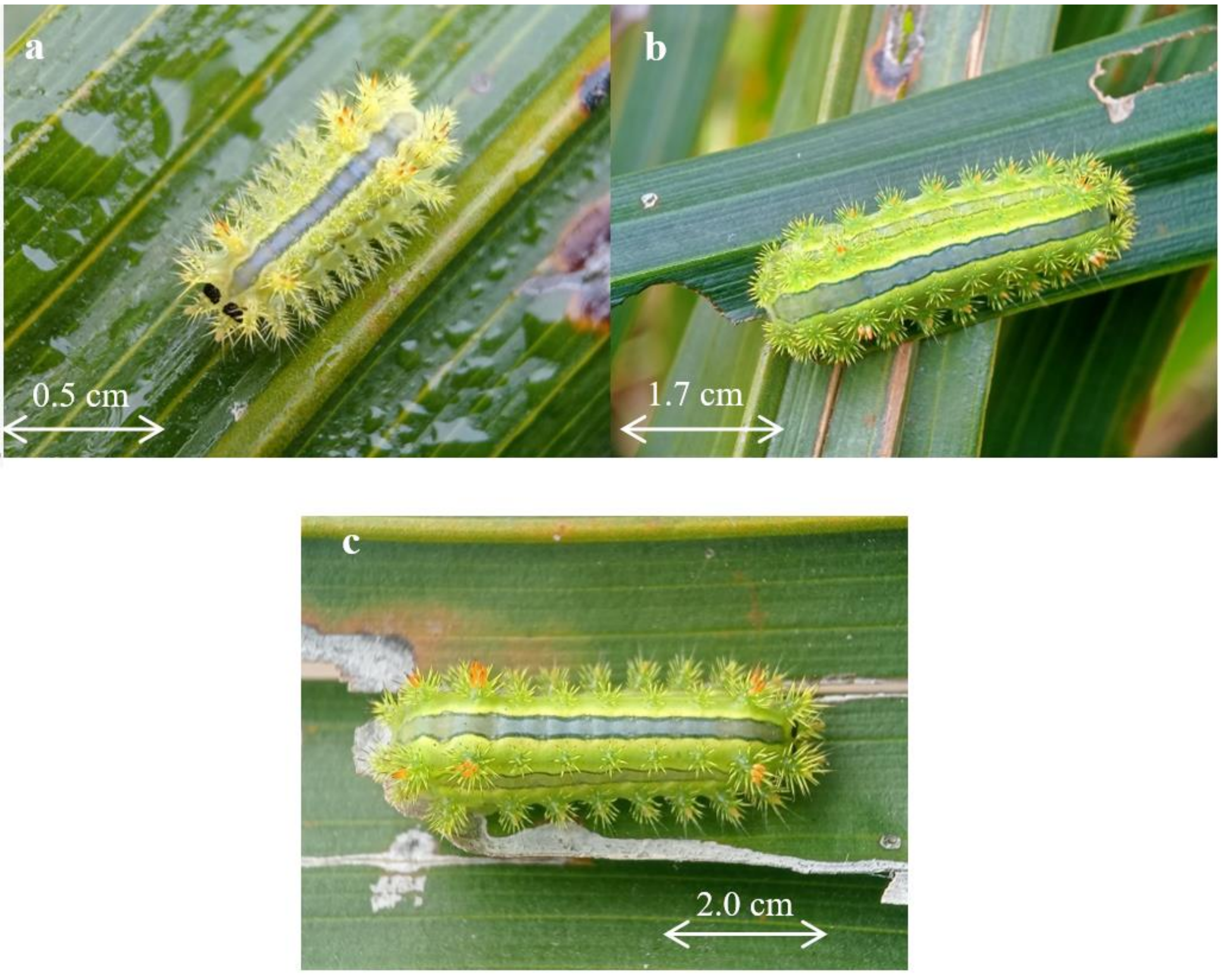

Figure 5. Larvae sizes of *Parasa lepida:* Instar 1 (a), instar 4 (b), instar 5 (c)

Distribution map of nettle caterpillars in the Field

This map illustrates the distribution of nettle caterpillars observed during three separate observations (Figure 6). According to the map legend, there are three identified species of nettle caterpillars: *Setora nitens* (represented by a green circle), *Birthosea bisura* (represented by a red circle), and *Parasa lepida* (represented by a blue circle). The distribution pattern shows that *S. nitens* is the most widespread across the research location from the first to the third observation, as indicated by the prevalence of green circles. In contrast, *B. bisura* was recorded at a few points (red circles) during the first observation, with no sightings in the second and third observations. Similarly, *P. lepida* was observed at limited locations (blue circles) during the second observation, with no occurrences noted in the first and third observations.

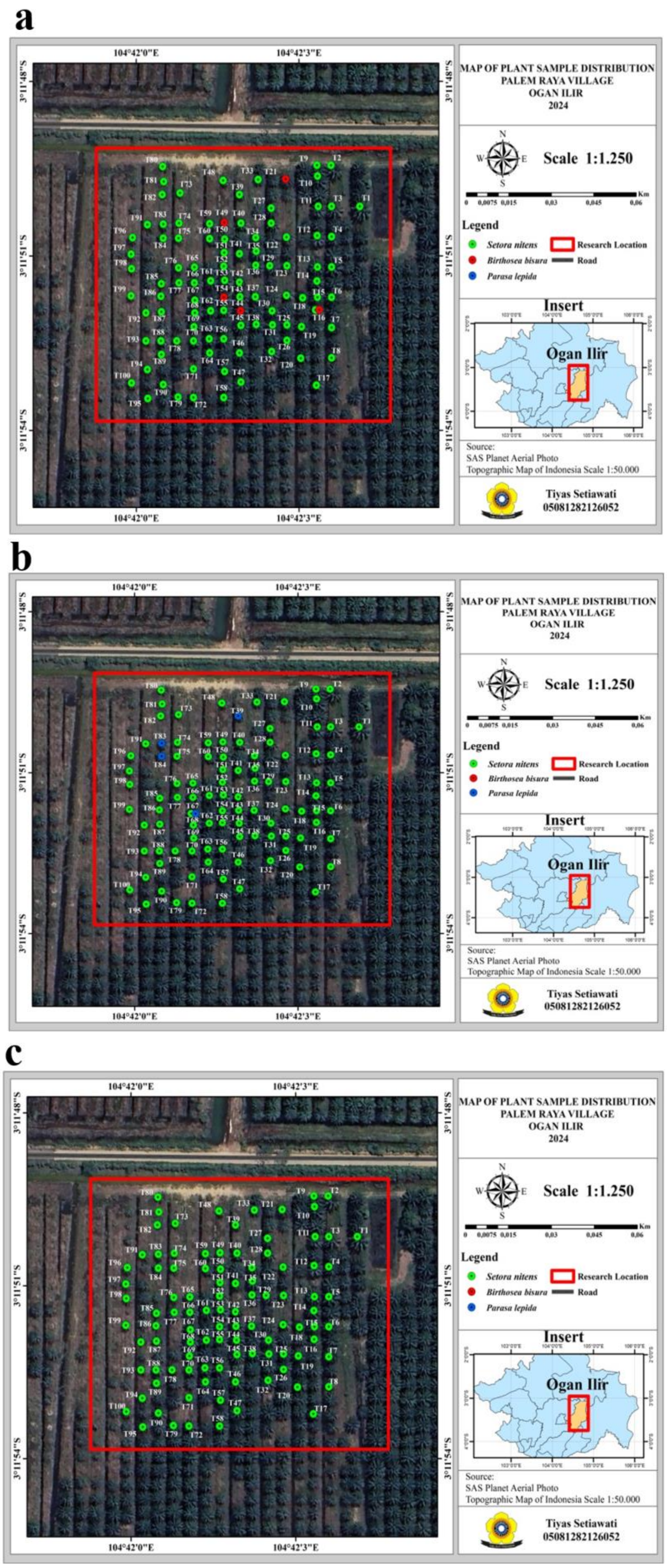

Figure 6. Distribution map of nettle caterpillars in the first (a), second (b), and third (c) observation

Intensity, percentage, and symptoms of nettle caterpillar infestations

The visual observation of pest attacks revealed variations in the intensity scores of nettle caterpillar infestations across the three observation periods (Figure 7). During the first observation, 37% of the observed plants recorded a score of 1 (indicating light intensity), followed by 29% with a score of 2 (moderate intensity), 27% with a score of 3 (severe intensity), and 12% with a score of 4 (very severe intensity). In the second observation, the distribution shifted slightly, with 37% of plants still at score 1, 33% at score 2, 16% at score 3, and 14% at score 4. By the third observation, scores of 1 and 2 were equal, each accounting for 38% of the plants, while 13% recorded a score of 3, and 11% recorded a score of 4.

Nettle caterpillar infestations on oil palm land have significantly affected ~~the~~ plant growth. Observations revealed that the percentage of nettle caterpillar attacks reached 100%, highlighting the urgent need for effective control. The severity levels of the attacks averaged 57.75 ~~at~~ in the first observation, 51.75 in the second observation, and 49.25 in the third observation (Table 5). The severity of the nettle caterpillar attack gradually decreased from the second to the third observation, attributed to the decline in the nettle caterpillar population over the same period. If these high levels of nettle caterpillar attacks are not adequately managed, they can disrupt the fruit growth process. The caterpillars damage the leaves, impairing the plant's ability to ~~photosynthesis~~ photosynthesize and thereby hindering its overall productivity.

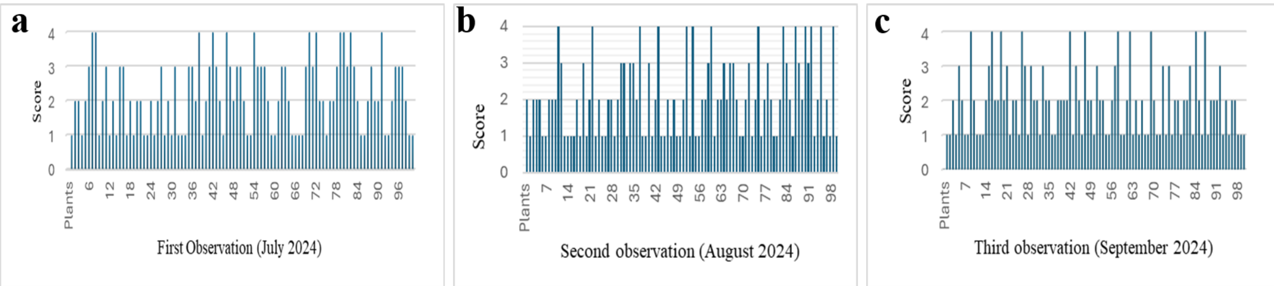

Figure 7. Intensity scores of nettle caterpillar attacks per 100 oil palm trees during a) the first observation (July 2024), b) the second observation (August 2024), and c) the third observation (September 2024)

Table 5. Intensity and percentage of nettle caterpillar attacks on 100 plants

Month observation	Attack intensity (%)	Percentage of attacks (%)
July 2024	57.75	100
August 2024	51.75	100
September 2024	49.25	100

Soil characteristics

The soil sample was analyzed at the Phytopathology Laboratory of the Department of Plant Pests and Diseases, Faculty of Agriculture, Universitas Sriwijaya. The soil analysis was conducted to assess pH, temperature, and humidity, as nettle caterpillar pupae were found in the soil of the observed oil palm plantation, which is situated in a peatland area. According to the conducted analysis, the temperature was 28°C, and humidity was 56.7% (Table 6), suggesting a favorable environment for the high population of nettle caterpillars.

Table 6. Results of soil characteristics analysis in oil palm plantation areas

No	Observed variable	Result (unit)
1	Electrical conductivity	666 us 0.66 ms
2	Salt	392 ppm 0.39 % 0.996 S.G
4	pH	3.79
5	N	51
6	P	164
7	K	157
8	Temperature	28 °C
9	RH	56.7 %
		429 us/cm
10	pH	6.3

Discussion

The study identified three species of nettle caterpillars in an oil palm plantation located in Palem Raya, Pemulutan Barat District, Ogan Ilir Regency, South Sumatra. These species were *Setora nitens*, *Birthosea bisuraa*, and *Parasa lepida*. Among them, *S. nitens* was the most commonly observed during the study, followed by *P. Lepida*, with *B. Bisura* being the least common. Interestingly, only the larval life stage of these caterpillars was encountered throughout the investigation. It suggests that either the timing of the observations coincided with the larval phase or that other stages, such as pupae and adults, were less conspicuous or occurred in more secluded habitats.

The larval stages of these species exhibited distinct morphological characteristics, facilitating their identification. The larvae of *S. nitens* exhibit a yellow-green coloration on their bodies that gradually transitions to reddish hues as they approach the pupal stage. These caterpillars can be distinguished by two coarse hairs on their head and two longer coarse hairs on the posterior part, with a longitudinal blue-purple line on the dorsal side. In contrast, the larvae of *B. bisura* are entirely green, featuring a distinctive pair of dark blue eye spots with a yellow-orange center. Meanwhile, *P. lepida* displays a yellowish-green coloration with small spiky setae and a green dorsolateral line during their first instar (Bhoye and Makode, 2024). These distinct morphological traits not only facilitate identification but also contribute to understanding their ecological roles and vulnerabilities (Madesh et al., 2024).

In this study, three species of nettle caterpillars (Lepidoptera: Limacodidae) were found in the field with varied results. The population dynamics observed over the three-month study period reveal that *S. nitens* consistently remained the most dominant species~~, though~~. However, its numbers slightly decreased from 218 to 164 individuals in the second observation and further decreased to 143 individuals in the third observation. This decreasing trend could be attributed to various environmental factors or predation pressures (Cheng et al., 2020). A previous study reported that the outbreak of nettle caterpillars is often sporadic, as most of the time, the pest population is suppressed by natural enemies such as parasitoids, predators, and pathogens (Loong et al., 2017). Further research on the specific natural enemies of *S. nitens* and their influence on its population levels would provide valuable insights for devising effective pest control strategies.

In contrast, *Parasa lepida* exhibited intermittent appearances, with individuals only recorded during the second observation. The sporadic pattern of these caterpillars suggests that their population dynamics may be affected by factors like their life cycle, which could be synchronized with seasonal environmental conditions (Schebeck et al., 2024). This irregularity highlights the importance of sustained, long-term monitoring to better comprehend the ecological requirements and behaviors of this species.

Birthosea bisura was the least commonly found nettle caterpillar species, with only 6 individuals per 100 plants identified in the first observation, and no individuals of this species were found in the second and third observations. Its complete absence in subsequent observations suggests that this species may be particularly sensitive to environmental fluctuations or competition with other nettle caterpillars. This rarity might also indicate that *B. bisura* has more specialized habitat or resource requirements, making it vulnerable to disturbances.

Analysis of the developmental stages (instars) of the three species provided further insights into their ecological dynamics. *S. nitens* larvae found were in instars 1-6, dominated by instar 6 with an average of 78.67. ~~This~~ It indicated that this species dominated at the later instar phases due to high survival rates and better adaptation at that stage. Conversely, *B. bisura* was found in instar phases 3 and 4 in 100 plant stems, with each having 1.00, while instars 1, 2, 5, and 6 were not found. For the *P. lepida* species, instars 1 and 5 were found in 100 plant stems, with counts of 1.67 and 3.33, respectively; instars 2, 3, 4, and 6 were not found. *B. bisura* and *P. lepida* were limited to earlier instars, suggesting lower survival rates or developmental constraints in these species. This finding suggests that later instars of nettle caterpillars exhibit better adaptation to environmental stressors. Mortality rates among the early larval stages are typically very high and extremely variable (Despland, 2018).

Soil analysis revealed that temperature and humidity significantly affect the population of nettle caterpillars in the field. An average plantation temperature of 25–30°C was found to favor rapid caterpillar development, aligning with Lubis et al. (2021). However, extreme temperatures greatly impact insects, affecting their biology, behavior, and populations. Extreme temperature damages the nervous system, muscles, and immunity, potentially causing coma and death. It also disrupts the growth, development, reproduction, and survival of insects (Zhou et al., 2024). In addition to temperature, humidity also impacts the survival, development, and population dynamics of insect pests (Jaba et al., 2020). These findings underscore the importance of considering climatic factors when developing pest management strategies, as changes in temperature and humidity can alter pest population dynamics and outbreak risks.

Over the three observations, the severity index of caterpillar damage decreased from 57.75 to 49.25, coinciding with the decline in caterpillar populations. ~~This~~ It suggests that natural processes, such as predation and environmental factors, may have contributed to the reduction in infestation levels. However, this decrease should not undermine the need for proactive management, as population resurgences could lead to renewed outbreaks and increased damage. The observed damage~~,~~ included leaf frond stripping, elongated holes, and epidermal consumption. The nettle caterpillar is a prevalent pest on both young and mature oil palm trees, frequently causing defoliation and leaf skeletonization (Zevika et al., 2024). ~~This~~ It underscores the caterpillars' potential to disrupt photosynthesis. Zhang et al. (2022) reported that biotic disturbance significantly decreased the photosynthetic rate by 34.8%. It can reduce growth potential and lead to prolonged reductions in yield due to the plants' impaired ability to produce fruit bunches for multiple years (Ikhsan et al., 2023). Prolonged infestations can have devastating consequences, as affected plants may fail to produce fruit bunches for 2–3 years (Simanjuntak et al., 2020). ~~This~~ It highlights the economic significance of these pests in oil palm cultivation and the urgency of developing effective management approaches.

The primary control strategy for nettle caterpillars in oil palm plantations relies on chemical insecticides, such as deltamethrin, lambda-cyhalothrin, cypermethrin, and others (Priwiratama et al., 2018; Rozziansha et al., 2023). While these methods effectively reduce caterpillar populations, they pose significant ecological risks, including unintended impacts on beneficial organisms such as parasitoids, predators, and pollinators (Sánchez-Bayo, 2021). Disruptions to pollinator populations can hinder pollination and fruit formation (Brunet and Fragoso, 2024). Therefore, environmentally friendly control measures are necessary. Natural enemies like *Eocanthecona furcellata* have the capability to prey on various species of caterpillars, including Lepidoptera, Coleoptera, and Heteroptera (Vanitha et al., 2018). Conserving and increasing natural enemies can reduce reliance on chemical insecticides and promote ecological balance (Yarahmadi and Rajabpour, 2024). Additionally, removing infested plants, improving plantation cleanliness, and using mixed cropping systems can also help lower caterpillar numbers by limiting their habitats and food. Integrating these approaches with the careful use of selective insecticides results in a more effective pest management while minimizing environmental damage. Effective management of pests like nettle caterpillars is crucial to maintaining the productivity and profitability of oil palm plantations. An integrated pest management (IPM) approach that combines biological, cultural, and selective chemical control methods, along with environmental monitoring and farmer education, can bolster the resilience of oil palm plantations to pest outbreaks while mitigating potential negative impacts (Green et al., 2020).

In conclusion, this study identified three key species (*S. nitens, P. lepida, and B. bisura*), along with their population dynamics, developmental stages, and impact on oil palm productivity, providing valuable insights for pest management efforts. While chemical insecticides are commonly used, their environmental risks call for more sustainable approaches like Integrated Pest Management. The study also emphasizes how environmental factors like temperature and humidity affect pest populations, highlighting the need for climate-sensitive strategies. By combining scientific research and practical methods, oil palm plantations can achieve long-term sustainability. Future research should explore innovative tools to further enhance pest control and support sustainable cultivation.

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4. Bukti konfirmasi review ketiga dan hasil revisi ketiga

(18 Juli 2024)

28 dari banyak

[biodiv] Editor Decision

Eksternal | Kotak Masuk ×

Smujo Editors via SMUJO <support@smujo.com> Kam, 18 Jul 2024, 18.10

kepada saya

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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.

Reviewer A:

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. 5I 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.

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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.

Identification of the nettle caterpillar in smallholding oil palm plantation cultivated on peatland in Ogan Ilir, South Sumatra, Indonesia

Abstract. Nettle caterpillars are a major pest in oil palm plantations, posing a significant threat to the productivity and sustainability of this crop. These voracious leaf-feeding caterpillars can cause severe damage, hindering plant growth, reducing fruit production, and even leading to the mortality of oil palm trees. This study aimed to identify the species of caterpillars that inflict damage, their physical traits, population densities, and the symptoms of their attacks. This study employed direct observation and documentation of caterpillar species in the field. Observations were conducted to assess the extent of damage inflicted by caterpillars in the field. Subsequently, document using a camera, collect field samples, and examine the behavior of the caterpillars found in 100 palm oil trees. This investigation identified three species of caterpillars: *Setora nitens*, *Birthosea bisura*, and *Parasa lepida*. These three species of caterpillars typically exhibit similar coloration but possess distinct morphological traits. The *S. nitens* species predominates among the largest number of species. Caterpillars consume both young and mature oil palm leaves, remaining only in the midrib. Additional indications of the attack include perforations in the leaves. The incidence of caterpillar assaults may attain 100.00%, accompanied by an attack rate of 57.75%. This study concludes that three primary species of nettle caterpillar were identified in oil palm plantations, exhibiting indications of damage classified as fairly severe. Thus, effective management of nettle caterpillars is crucial to maintaining the productivity and profitability of oil palm plantations.

Keywords: *Birthosea bisura*, morphological traits**,** *Parasa lepida*, pest attack, *Setora nitens*

Running title: Nettle Caterpillar in oil palm plantation

INTRODUCTION

Indonesia is predominantly an agriculture-based nation, with extensive plantations that significantly contribute to its economy. Among these, palm oil is one of the primary commodities (Jafari et al., 2017), playing a crucial role in both domestic and international markets. The cultivation and productivity of oil palm are influenced by two main factors: external factors, such as climate and soil, and internal factors, which include the genetic variety of the oil palm plant (Meijaard et al., 2020). While palm oil remains the leading agricultural export, other plantation crops like cocoa, rubber, and sugarcane are expected to become significant contributors to Indonesia's export economy in the coming years. Indonesia is the world's leading palm oil producer, surpassing other major suppliers like Malaysia and Brazil, accounting for approximately 59% (or 4.8 million tons) of the global palm oil supply (Tandra et al., 2022; Varkkey, 2018). This dominant position highlights the strategic importance of maintaining high productivity and addressing challenges that could threaten the industry's sustainability.

One of the major challenges confronting oil palm plantations is the prevalence of pests, which can substantially hinder productivity. Pests affecting oil palms are classified based on the specific parts of the oil palm they affect, which include leaf and shoot feeders, trunk feeders, bunch feeders, and root feeders (Setiyowati et al., 2015). Among the most significant leaf-eating pests are nettle caterpillars, moth caterpillars, and bagworms (Mazuan et al., 2021). Oil palm leaf-eating caterpillars, including species *Darna trima, Setothosea Asigna, Setora nitens, Ploneta diducta*, and *P. bradleyi*, are known for causing extensive damage to oil palm plantations (Corley and Tinker, 2015).

Nettle caterpillars intensely feed on oil palm leaves, frequently perforating them or entirely consuming the leaf blades, leaving only the midrib. This substantial loss of leaf area significantly compromises the plant's photosynthetic capacity, resulting in a notable decline in its overall health and productivity (Priwiratama et al., 2018). As the leaves are the primary site of photosynthesis, the reduction in leaf area directly impacts the plant's energy production, which in turn affects fruit development. Studies have shown that infestations by nettle caterpillars can reduce oil palm production by 70%, and if a second infestation occurs within the same year, the decline can escalate to as much as 90% (Tawakkal et al., 2019). Notably, it was reported that up to 2,000 larvae were found per frond in one outbreak, with some plants experiencing up to a 60% reduction in leaf area over several days (Kamarudin et al., 2017). Rapid and widespread damage makes nettle caterpillars one of the most destructive pests to oil palm plantations. These infestations not only impact immediate crop yields but can also lead to long-term harm to the sustainability of plantations. The implementation of effective pest management strategies is crucial to minimize the impact of nettle caterpillars on oil palm plantations.

In South Sumatra, oil palm farming holds a crucial position in the agricultural landscape, particularly in the Ogan Ilir district, where large-scale plantations are established on peatlands. While these plantations provide significant economic

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MATERIALS AND METHODS

Study area

This research was carried out from August 2024 to its conclusion. The research was conducted at a private oil palm plantation in Palem Raya, Ogan Ilir, South Sumatra (Figure 1). Identification of the species was conducted in the Entomology Laboratory, Faculty of Agriculture, Universitas Sriwijaya. The survey was conducted by direct observation of 3 years of DxP Sriwijaya 5 variety at the private oil palm plantation in Palem Raya village. Infestation levels induced by nettle caterpillars were evaluated using field observations. The results were subsequently recorded with a camera.

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Figure 1. The sampling location is in Palem Raya, Ogan Ilir District, South Sumatra, Indonesia. The samples were taken from oil palm plantations.

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Procedures

Observation and sampling method

At the time of specimen collection, the pest was in the larval stage. The larvae found on the oil palm leaves were collected and then placed in a box container to be brought to the laboratory for identification. The description of the pest and the damage observed were based on the pests attacking the oil palm crops, from the initial symptoms of infestation to the advanced symptoms caused by the nettle caterpillars. The intensity of the infestation was assessed visually based on the symptoms of the nettle caterpillar attack. In each plot, 100 plants were observed. The plants that showed signs of infestation were counted one by one, and then the total number of infested plants was recorded. The formula used to calculate the intensity of the nettle caterpillar pest infestation was applied using a specific formula.

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The intensity of pest attack (%)

The observation of pest attack intensity was conducted visually based on the symptoms of the nettle caterpillar infestation. In each plot, 100 plants were taken for observation. The plants that showed signs of infestation were counted one by one, and then the total number of infested plants was recorded. The formula used to calculate the intensity of the nettle caterpillar pest infestation was applied using the following formula:

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$$I = \frac{n}{N} \times 100\ \%$$

Description

I = Intensity of Attack by nettle caterpillars (%)

n = Number of plants infested by nettle caterpillars

N = Total number of plants observed

Table 1. Criteria for categories of nettle caterpillar attack intensity.

Scale	Presentation of attack intensity (%)	Category

0	0	Normal
1	0-25	Light
2	25-50	Moderate
3	50-90	Severe
4	≥ 90	Very Severe

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Level of attack

The level of attack refers to the level of infestation based on the number of pests found on the fronds of the observed oil palm plants. The critical threshold for this nettle caterpillar pest is 5 individuals per plant. The levels of nettle caterpillar infestation are as follows:

1. < 2 individuals/frond: Light
2. 2-4 individuals/frond: Moderate
3. 5 individuals/frond: Severe (requires management)

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Data Analysis

Data analysis was conducted using Microsoft Excel software to process the raw data obtained in the field, which was then presented in the form of tables.

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RESULTS AND DISCUSSION

The morphology of nettle caterpillars

The oil palm plantation hosts three distinct species of nettle caterpillars: *Setora nitens* Walker, *Birthosea bisura* Moore, and *Parasa lepida* Cramer. These caterpillars share a generally yellowish-green coloration, but each exhibits its unique morphological characteristics. *S. nitens* has a yellowish-green color with two coarse spines on its head and posterior, as well as blue coloration extending from the head to the abdomen (Figure 2.a). *B. bisura* is characterized by a green color with a pale dorsal line running along its body, an oval, flattened body shape, and two blue and white spots on the central part (Figure 2.b). *P. lepida* displays a pale green or bright yellow coloration with three green stripes running along its body and six orange spines on each end of its body (Figure 2.c).

Figure 2. Setora nitens (a), Birthosea bisura (b), Parasa lepida (c).

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The total number of nettle caterpillar

Three species of nettle caterpillars were identified during observations conducted on 100 oil palm trees. These observations, carried out on three separate occasions, revealed variations in the presence and abundance of the caterpillar species (Table 2). Among these, *S. nitens* was the most abundant, with population counts ranging from 143 to 218 individuals per 100 plants across the three observation periods. *P. lepida* was only recorded during the second observation, with 15 individuals per 100 plants, and was absent in the first and third observations. *B. bisura* was the least frequently encountered species, appearing only in the initial observation with 6 individuals per 100 plants.

Table 2. Total number of nettle caterpillar species found on 100 oil palm plant

Species	Number of nettle caterpillars (individual) during observation		
	First observation	Second observation	Third observation
Setora nitens	218	164	143
Birthosea bisura	6	0	0
Parasa lepida	0	15	0

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The average number of nettle caterpillar species per instar

During the study, the three species were observed at different larval instar stages (Table 3). *S. nitens* was found in instars 1 to 6, with instar 6 being the most prevalent, with an average of 78.67 individuals. *B. bisura* was found only in instar stages 3 and 4 on the 100 oil palm trees, with a single individual recorded at each stage. Meanwhile, *P. lepida* was present in instar stages 1 and 5, with averages of 1.67 and 3.33 individuals, respectively.

Table 3. The average number of nettle caterpillar species per instar found per 100 trees

Species	The average number of nettle caterpillar					
	Instar 1	**Instar 2**	**Instar 3**	**Instar 4**	**Instar 5**	**Instar 6**
Setora nitens	0.33	4.67	16.67	41.33	33.33	78.67
Birthosea bisura	0.00	0.00	1.00	1.00	0.00	0.00
Parasa lepida	1.67	0.00	0.00	0.00	3.33	0.00

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The average size of nettle caterpillar species per instar

The three species observed exhibited different sizes at each of their respective instar stages (Table 4). *S. nitens* measured 0.60 cm at instar 1 and reached a size of 2.53 cm in instar 6 (Figure 2). *B. bisura* was absent in instars 1, 2, 5, and 6. In the field, only instar 3 of *B. bisura* was found, with a size of 1.06 cm and instar 4 measuring 1.70 cm (Figure 4). Meanwhile, *P. lepida* was observed with a size of 0.50 cm at instar 1 and 2.00 cm at instar 5 (Figure 5).

Table 4. The average size of nettle caterpillar species per instar found on 100 trees

Species	Size of nettle caterpillar at instar (cm)					
	Instar 1	**Instar 2**	**Instar 3**	**Instar 4**	**Instar 5**	**Instar 6**
Setora nitens	0.60	0.87	1.09	1.74	2.00	2.53
Birthosea bisura	0.00	0.00	1.06	1.70	0.00	0.00
Parasa lepida	0.50	0.00	0.00	0.00	2.00	0.00

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Figure 3. Larvae sizes of the *Setora nitens* species found: instar 1 (a), instar 2 (b), instar 3 (c), instar 4 (d), instar 5 (e), and instar 6 (f)

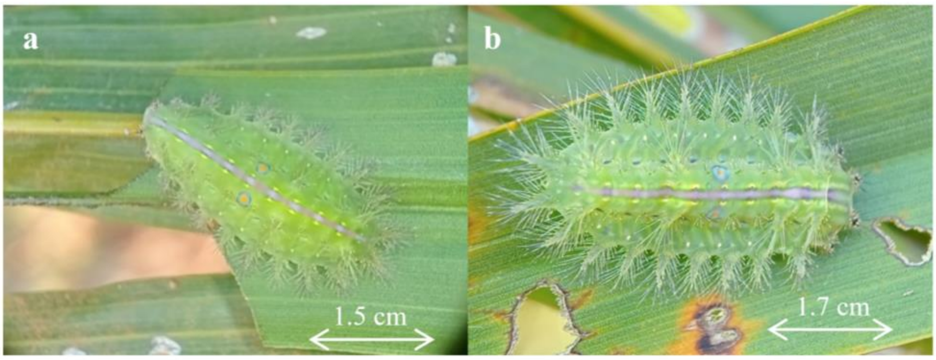

Figure 4. Size of *B. bisura* larvae found: a) instar 3, b) instar 4

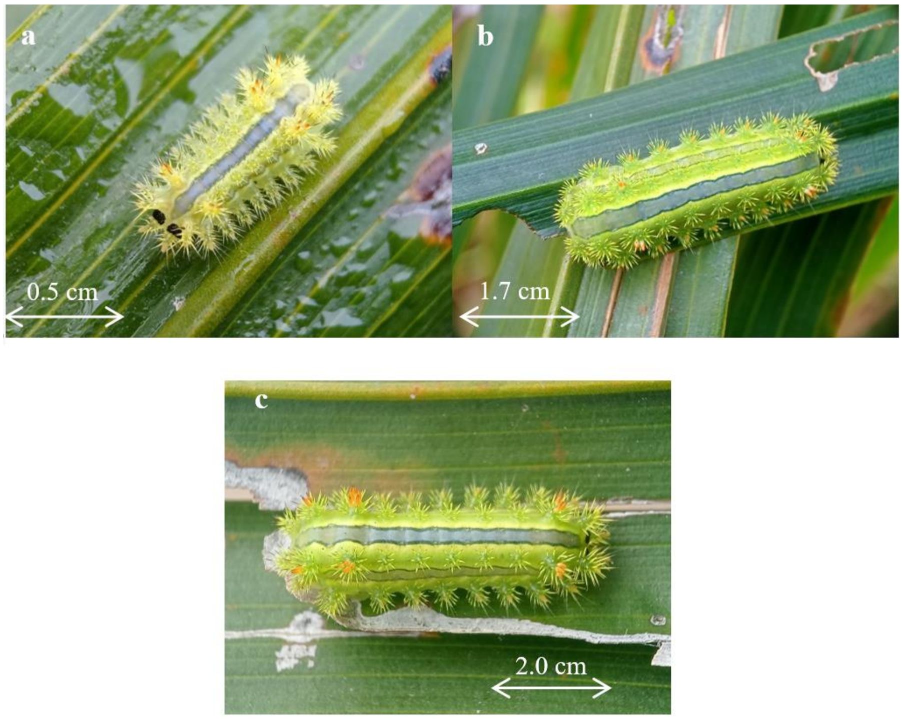

Figure 5. Larvae sizes of *Parasa lepida:* Instar 1 (a), instar 4 (b), instar 5 (c)

Distribution map of nettle caterpillars in the Field

This map illustrates the distribution of nettle caterpillars observed during three separate observations (Figure 6). According to the map legend, there are three identified species of nettle caterpillars: *Setora nitens* (represented by a green circle), *Birthosea bisura* (represented by a red circle), and *Parasa lepida* (represented by a blue circle). The distribution pattern shows that *S. nitens* is the most widespread across the research location from the first to the third observation, as indicated by the prevalence of green circles. In contrast, *B. bisura* was recorded at a few points (red circles) during the first observation, with no sightings in the second and third observations. Similarly, *P. lepida* was observed at limited locations (blue circles) during the second observation, with no occurrences noted in the first and third observations.

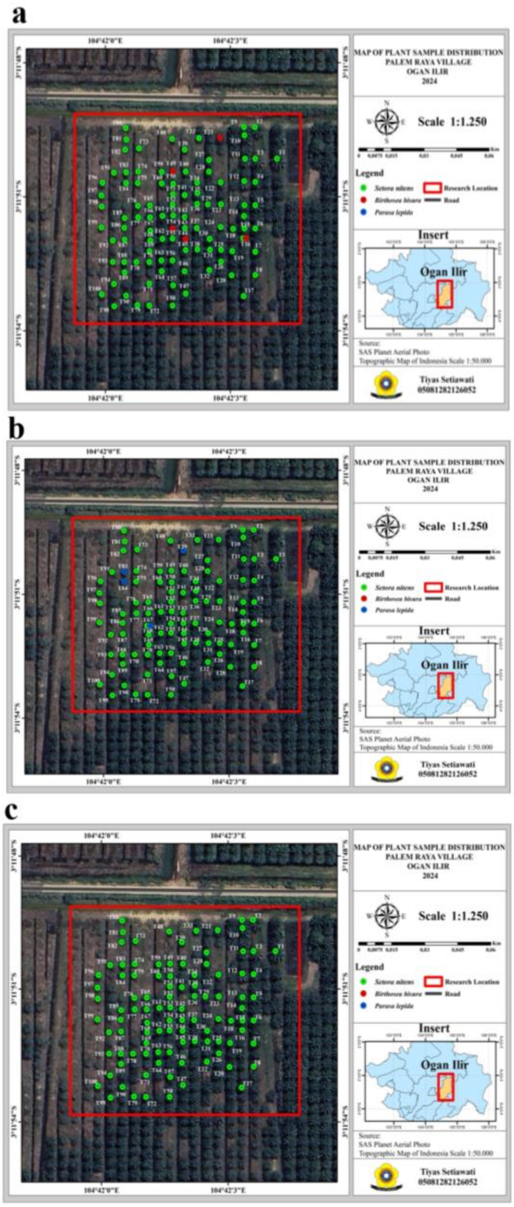

Figure 6. Distribution map of nettle caterpillars in the first (a), second (b), and third (c) observation

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Intensity, percentage, and symptoms of nettle caterpillar infestations

The visual observation of pest attacks revealed variations in the intensity scores of nettle caterpillar infestations across the three observation periods (Figure 7). During the first observation, 37% of the observed plants recorded a score of 1 (indicating light intensity), followed by 29% with a score of 2 (moderate intensity), 27% with a score of 3 (severe intensity), and 12% with a score of 4 (very severe intensity). In the second observation, the distribution shifted slightly, with 37% of plants still at score 1, 33% at score 2, 16% at score 3, and 14% at score 4. By the third observation, scores of 1 and 2 were equal, each accounting for 38% of the plants, while 13% recorded a score of 3, and 11% recorded a score of 4.

Nettle caterpillar infestations on oil palm land have significantly affected plant growth. Observations revealed that the percentage of nettle caterpillar attacks reached 100%, highlighting the urgent need for effective control. The severity levels of the attacks averaged 57.75 in the first observation, 51.75 in the second observation, and 49.25 in the third observation (Table 5). The severity of the nettle caterpillar attack gradually decreased from the second to the third observation, attributed to the decline in the nettle caterpillar population over the same period. If these high levels of nettle caterpillar attacks are not adequately managed, they can disrupt the fruit growth process. The caterpillars damage the leaves, impairing the plant's ability to photosynthesize and thereby hindering its overall productivity.

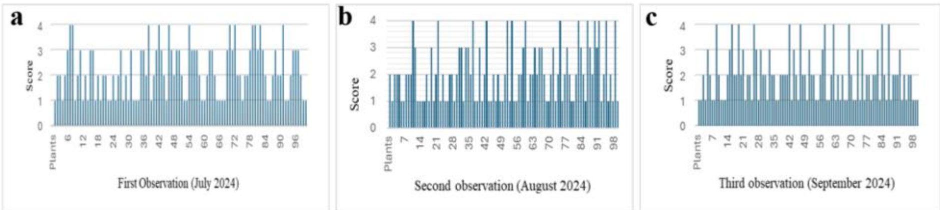

Figure 7. Intensity scores of nettle caterpillar attacks per 100 oil palm trees during a) the first observation (July 2024), b) the second observation (August 2024), and c) the third observation (September 2024)

Table 5. Intensity and percentage of nettle caterpillar attacks on 100 plants

Month observation	Attack intensity (%)	Percentage of attacks (%)
July 2024	57.75	100
August 2024	51.75	100
September 2024	49.25	100

Soil characteristics

The soil sample was analyzed at the Phytopathology Laboratory of the Department of Plant Pests and Diseases, Faculty of Agriculture, Universitas Sriwijaya. The soil analysis was conducted to assess pH, temperature, and humidity, as nettle caterpillar pupae were found in the soil of the observed oil palm plantation, which is situated in a peatland area. According to the conducted analysis, the temperature was 28°C, and humidity was 56.7% (Table 6), suggesting a favorable environment for the high population of nettle caterpillars.

Table 6. Results of soil characteristics analysis in oil palm plantation areas

No	Observed variable	Result (unit)
1	Electrical conductivity	666 us
		0.66 ms
2	Salt	392 ppm
		0.39 %
		0.996 S.G
4	pH	3.79
5	N	51
6	P	164
7	K	157
8	Temperature	28 °C
9	RH	56.7 %
		429 us/cm
10	pH	6.3

Discussion

The study identified three species of nettle caterpillars in an oil palm plantation located in Palem Raya, Pemulutan Barat District, Ogan Ilir Regency, South Sumatra. These species were *Setora nitens, Birthosea bisuraa*, and *Parasa lepida*. Among them, *S. nitens* was the most commonly observed during the study, followed by *P. Lepida*, with *B. Bisura* being the least common. Interestingly, only the larval life stage of these caterpillars was encountered throughout the

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The larval stages of these species exhibited distinct morphological characteristics, facilitating their identification. The larvae of *S. nitens* exhibit a yellow-green coloration on their bodies that gradually transitions to reddish hues as they approach the pupal stage. These caterpillars can be distinguished by two coarse hairs on their head and two longer coarse hairs on the posterior part, with a longitudinal blue-purple line on the dorsal side. In contrast, the larvae of *B. bisura* are entirely green, featuring a distinctive pair of dark blue eye spots with a yellow-orange center. Meanwhile, *P. lepida* displays a yellowish-green coloration with small spiky setae and a green dorsolateral line during their first instar (Bhoye and Makode, 2024). These distinct morphological traits not only facilitate identification but also contribute to understanding their ecological roles and vulnerabilities (Madesh et al., 2024).

In this study, three species of nettle caterpillars (Lepidoptera: Limacodidae) were found in the field with varied results. The population dynamics observed over the three-month study period reveal that *S. nitens* consistently remained the most dominant species. However, its numbers slightly decreased from 218 to 164 individuals in the second observation and further decreased to 143 individuals in the third observation. This decreasing trend could be attributed to various environmental factors or predation pressures (Cheng et al., 2020). A previous study reported that the outbreak of nettle caterpillars is often sporadic, as most of the time, the pest population is suppressed by natural enemies such as parasitoids, predators, and pathogens (Loong et al., 2017). Further research on the specific natural enemies of *S. nitens* and their influence on its population levels would provide valuable insights for devising effective pest control strategies.

In contrast, *Parasa lepida* exhibited intermittent appearances, with individuals only recorded during the second observation. The sporadic pattern of these caterpillars suggests that their population dynamics may be affected by factors like their life cycle, which could be synchronized with seasonal environmental conditions (Schebeck et al., 2024). This irregularity highlights the importance of sustained, long-term monitoring to better comprehend the ecological requirements and behaviors of this species.

Birthosea bisura was the least commonly found nettle caterpillar species, with only 6 individuals per 100 plants identified in the first observation, and no individuals of this species were found in the second and third observations. Its complete absence in subsequent observations suggests that this species may be particularly sensitive to environmental fluctuations or competition with other nettle caterpillars. This rarity might also indicate that *B. bisura* has more specialized habitat or resource requirements, making it vulnerable to disturbances.

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Analysis of the developmental stages (instars) of the three species provided further insights into their ecological dynamics. *S. nitens* larvae found were in instars 1-6, dominated by instar 6 with an average of 78.67. It indicated that this species dominated at the later instar phases due to high survival rates and better adaptation at that stage. Conversely, *B. bisura* was found in instar phases 3 and 4 in 100 plant stems, with each having 1.00, while instars 1, 2, 5, and 6 were not found. For the *P. lepida* species, instars 1 and 5 were found in 100 plant stems, with counts of 1.67 and 3.33, respectively; instars 2, 3, 4, and 6 were not found. *B. bisura* and *P. lepida* were limited to earlier instars, suggesting lower survival rates or developmental constraints in these species. This finding suggests that later instars of nettle caterpillars exhibit better adaptation to environmental stressors. Mortality rates among the early larval stages are typically very high and extremely variable (Despland, 2018).

Soil analysis revealed that temperature and humidity significantly affect the population of nettle caterpillars in the field. An average plantation temperature of 25–30°C was found to favor rapid caterpillar development, aligning with Lubis et al. (2021). However, extreme temperatures greatly impact insects, affecting their biology, behavior, and populations. Extreme temperature damages the nervous system, muscles, and immunity, potentially causing coma and death. It also disrupts the growth, development, reproduction, and survival of insects (Zhou et al., 2024). In addition to temperature, humidity also impacts the survival, development, and population dynamics of insect pests (Jaba et al., 2020). These findings underscore the importance of considering climatic factors when developing pest management strategies, as changes in temperature and humidity can alter pest population dynamics and outbreak risks.

Over the three observations, the severity index of caterpillar damage decreased from 57.75 to 49.25, coinciding with the decline in caterpillar populations. It suggests that natural processes, such as predation and environmental factors, may have contributed to the reduction in infestation levels. However, this decrease should not undermine the need for proactive management, as population resurgences could lead to renewed outbreaks and increased damage. The observed damage included leaf frond stripping, elongated holes, and epidermal consumption. The nettle caterpillar is a prevalent pest on both young and mature oil palm trees, frequently causing defoliation and leaf skeletonization (Zevika et al., 2024). It underscores the caterpillars' potential to disrupt photosynthesis. Zhang et al. (2022) reported that biotic disturbance significantly decreased the photosynthetic rate by 34.8%. It can reduce growth potential and lead to prolonged reductions in yield due to the plants' impaired ability to produce fruit bunches for multiple years (Ikhsan et al., 2023). Prolonged infestations can have devastating consequences, as affected plants may fail to produce fruit bunches for 2–3 years (Simanjuntak et al., 2020). It highlights the economic significance of these pests in oil palm cultivation and the urgency of developing effective management approaches.

The primary control strategy for nettle caterpillars in oil palm plantations relies on chemical insecticides, such as deltamethrin, lambda-cyhalothrin, cypermethrin, and others (Priwiratama et al., 2018; Rozziansha et al., 2023). While these methods effectively reduce caterpillar populations, they pose significant ecological risks, including unintended impacts on beneficial organisms such as parasitoids, predators, and pollinators (Sánchez-Bayo, 2021). Disruptions to pollinator populations can hinder pollination and fruit formation (Brunet and Fragoso, 2024). Therefore, environmentally friendly control measures are necessary. Natural enemies like *Eocanthecona furcellata* have the capability to prey on various species of caterpillars, including Lepidoptera, Coleoptera, and Heteroptera (Vanitha et al., 2018). Conserving and increasing natural enemies can reduce reliance on chemical insecticides and promote ecological balance (Yarahmadi and Rajabpour, 2024). Additionally, removing infested plants, improving plantation cleanliness, and using mixed cropping systems can also help lower caterpillar numbers by limiting their habitats and food. Integrating these approaches with the careful use of selective insecticides results in more effective pest management while minimizing environmental damage. Effective management of pests like nettle caterpillars is crucial to maintaining the productivity and profitability of oil palm plantations. An integrated pest management (IPM) approach that combines biological, cultural, and selective chemical control methods, along with environmental monitoring and farmer education, can bolster the resilience of oil palm plantations to pest outbreaks while mitigating potential negative impacts (Green et al., 2020).

In conclusion, this study identified three key species (*S. nitens, P. lepida, and B. bisura*), along with their population dynamics, developmental stages, and impact on oil palm productivity, providing valuable insights for pest management efforts. While chemical insecticides are commonly used, their environmental risks call for more sustainable approaches like Integrated Pest Management. The study also emphasizes how environmental factors like temperature and humidity affect pest populations, highlighting the need for climate-sensitive strategies. By combining scientific research and practical methods, oil palm plantations can achieve long-term sustainability. Future research should explore innovative tools to further enhance pest control and support sustainable cultivation.

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ACKNOWLEDGMENTS

The authors express their gratitude to the private oil palm plantations in Palem Raya, Ogan Ilir, South Sumatra, Indonesia, for permitting them to observe the insects residing in the coconut trees. This study was conducted as part of a research project led by Erise Anggraini under contract number 0098.047/UN9/SB3.LP2M.PT/2024.

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Commented [JB36]: There is scope to extend the number of references for this study

5. Bukti konfirmasi review keempat dan hasil revisi keempat

(10 Agustus 2024)

25 dari banyak

[biodiv] Editor Decision Eksternal Kotak Masuk ×

Smujo Editors via SMUJO <support@smujo.com> Sab, 10 Agu 2024, 07.07
kepada saya

Terjemahkan ke Indonesia

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

Reviewer A:

25 dari banyak

Reviewer A:

Review the modifications made in this paragraph for accuracy and relevance to the topic.
Figure 1 uses Indonesian.
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).
Please check that there are six (not seven) Orders in Tables 1 and 2 consisting of Coleoptera, Hemiptera, Hymenoptera, Isoptera, Lepidoptera, and Orthoptera
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.
Please check this sentence that Metisa plana and Pteroma pendula were doubled.
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.
It would be more fascinating if Table 5 added one column showing the individuals.
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.
These statements below do not necessarily require a response that would enrich the analysis and are for counterargument purposes.
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?
Have you considered the potential impact of seasonal variations on insect populations in the different age groups of coconut trees?
What about the possibility of other unidentified factors contributing to the varying insect populations in the different age groups of coconut trees?
What specific methods were used to identify the 12 insect species found in the study?
What were the specific findings related to the impact of different ages of coconut trees on the abundance of the identified insect species?

25 dari banyak

It would be more fascinating if Table 5 added one column showing the individuals.
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.
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What about the possibility of other unidentified factors contributing to the varying insect populations in the different age groups of coconut trees?
What specific methods were used to identify the 12 insect species found in the study?
What were the specific findings related to the impact of different ages of coconut trees on the abundance of the identified insect species?
Were there any recommendations provided in the study for mitigating the impact of the predominant insect pests on coconut plantations?
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.
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.
Acknowledge the potential impact of seasonal variations on insect biodiversity in the coconut plantation and discuss how this might affect the study's findings.

Recommendation: Revisions Required

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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

6. Bukti konfirmasi Uncorrected proof, Billing

(16 Agustus 2024)

24 dari banyak

[biodiv] New notification from Biodiversitas Journal of Biological Diversity

Eksternal | Kotak Masuk ×

Raisa N. Safira via SMUJO <support@smujo.com>   Jum, 16 Agu 2024, 13.12
kepada saya

Terjemahkan ke Indonesia

You have a new notification from Biodiversitas Journal of Biological Diversity:

You have been added to a discussion titled "Uncorrected proof" regarding the submission "Insects found in different ages of coconut viridis variety in Sri Tiga Village, Banyuasin District South Sumatra, Indonesia".

Link: https://smujo.id/biodiv/authorDashboard/submission/17026

Ahmad Dwi Setyawan

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22 dari banyak

[biodiv] New notification from Biodiversitas Journal of Biological Diversity

Eksternal | Kotak Masuk ×

DEWI NUR PRATIWI via SMUJO <support@smujo.com>   Sen, 19 Agu 2024, 11.09
kepada saya

Terjemahkan ke Indonesia

You have a new notification from Biodiversitas Journal of Biological Diversity:

You have been added to a discussion titled "BILLING" regarding the submission "Insects found in different ages of coconut viridis variety in Sri Tiga Village, Banyuasin District South Sumatra, Indonesia".

Link: https://smujo.id/biodiv/authorDashboard/submission/17026

Ahmad Dwi Setyawan

20 dari banyak

[biodiv] Editor Decision

Eksternal | Kotak Masuk ×

Team Support Smujo via SMUJO <support@smujo.com>

kepada saya, TESSIA

Kam, 22 Agu 2024, 10.59

Terjemahkan ke Indonesia

ERISE ANGGRAINI, TESSIA MASNITA SINAGA, CHANDRA IRSAN, SITI HERLINDA, AHMAD MUSLIM, HARMAN HAMIDSON, MARLIN SEFRILA, ASTUTI KURNIANINGSIH, DESI ARYANI, MIRZA ANTONI, ZAHLUL IKHSAN:

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".

Our decision is to: Accept Submission

LOA link https://smujo.id/loa/17026

Best Regards,

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

ERISE ANGGRAINI[1,2,♥], TESSIA MASNITA SINAGA[1], CHANDRA IRSAN[1], SITI HERLINDA[1], AHMAD MUSLIM[1], HARMAN HAMIDSON[1], MARLIN SEFRILA[3], ASTUTI KURNIANINGSIH[3], DESI ARYANI[4], MIRZA ANTONI[4], ZAHLUL IKHSAN[5]

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Manuscript received: 11 January 2024. Revision accepted: 17 August 2024.

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.

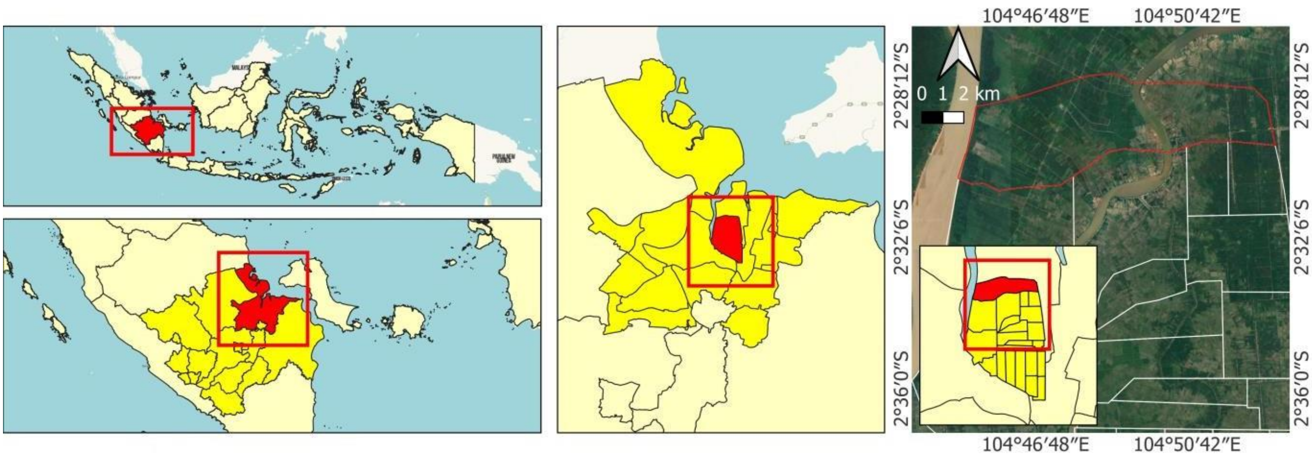

Figure 1. The sampling location is in Sri Tiga Village, Banyuasin District, South Sumatra, Indonesia. The samples are taken from different ages of the coconut viridis variety

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	3.20×10^{-1}	1.54^{ns}	-
Hemiptera						
Aspidiotus sp.	173.33a	116.33b	96.00b	3.62×10^{-3}	31.24^{*}	1.55
Nipaecoccus nipae Maskell 1893	256.33a	265.67a	18.00b	5.16×10^{-5}	276.40^{*}	2.07
Aleurocanthus sp.	50.67a	44.33a	27.67b	58.7×10^{-4}	80.55^{*}	0.54
Hymenoptera						
Apis cerana Fabricius 1793	5.67a	4.33b	0.00c	3.13×10^{-5}	355.22^{*}	0.25
Cotesia congregata Say 1836	30.00a	25.33b	18.00c	6.14×10^{-4}	78.70^{*}	0.35
Dolichoderus thoracicus Smith 1860	113.33a	103.67a	81.33b	45.1×10^{-3}	27.78^{*}	0.81
Oecophylla smaragdina Fabricus 1775	98.00a	87.33a	60.33b	1.15×10^{-3}	56.91^{*}	0.75
Provespa sp.	4.00a	2.33b	0.00c	4.52×10^{-4}	92.12^{*}	0.38
Lepidoptera						
Pteroma pendula de Joannis 1929	16.33a	13.67ab	10.00b	2.64×10^{-2}	10.31^{*}	0.68
Metura sp.	20.67a	16.67ab	13.00b	6.15×10^{-3}	23.50^{*}	0.48
Metisa plana Walker 1883	24.00a	19.00ab	14.00b	6.78×10^{-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

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	9.09×10^{-3}	18.98^{*}	0.71
Eumorphus westwoodi Guérin 1858	12.33a	8.33b	3.00c	3.21×10^{-4}	109.67^{*}	0.42
Isoptera						
Mactrotermes sp.	18.00a	13.67b	0.00c	3.52×10^{-5}	335.07^{*}	0.53
Orthoptera						
Conocephalus sp.	17.00a	12.00b	10.00c	38.9×10^{-4}	99.47^{*}	0.24
Dianemobius sp.	16.67a	13.00b	9.00c	6.50×10^{-5}	246.00^{*}	0.17
Tettigidea sp.	10.67a	8.33ab	6.67b	8.19×10^{-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

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

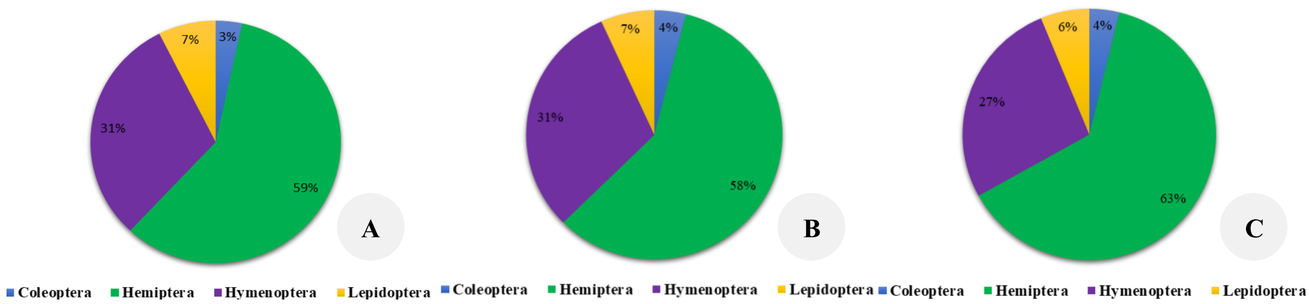

Figure 2. An abundance of insects was seen in coconut trees at three different stages of growth: A. 8-year-old coconut tree; B. 5-year-old coconut tree; and C. 2-year-old coconut tree

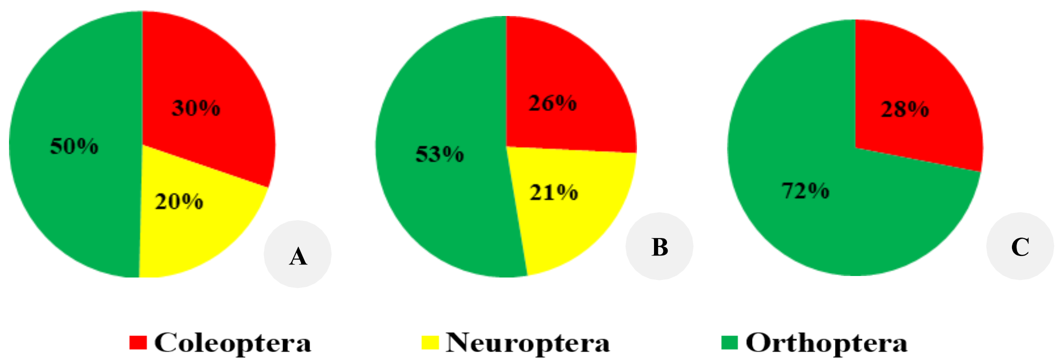

Figure 3. Abundance of insects on weeds around coconut trees at different ages of coconut: A. 8 years old; B. 5 years old; C. 2 years old

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* Fabricius 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.

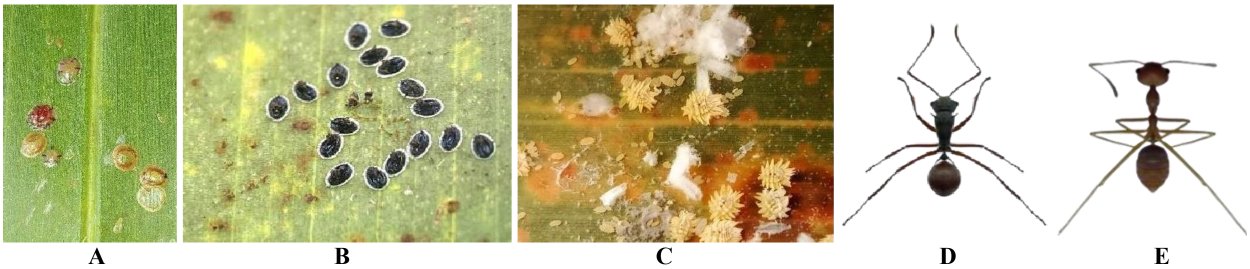

Figure 4. Coconut plants and surrounding plants host the dominant insects. A. *Aspidiotus* sp., B. *Nipaecoccus nipae*; C. *Aleurocanthus* sp.; D. *Polyrhachis* sp.; and E. *Oecophylla smaragdina*

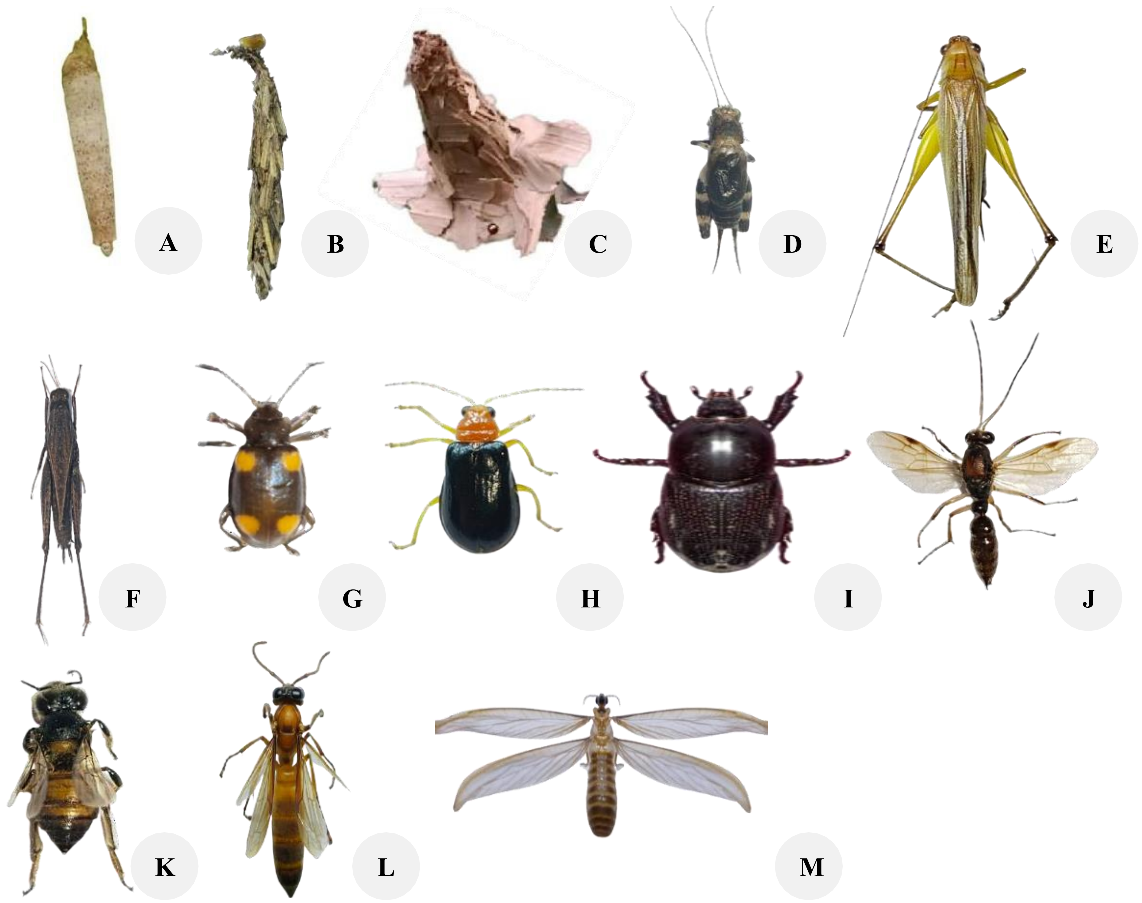

Figure 5. The non-dominant insects are found on coconut plants and surrounding plants. A. *Pteroma pendula*; B. *Metura* sp., C. *Metisa plana*.; D. *Dianemobius* sp.; E. *Conocephalus* sp.; F. *Tettigidea* sp.; G. *Eumorphus westwoodi*; H. *Aulacophora lewisii*; I. *Oryctes rhinoceros*; J. *Cotesia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