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Identification of the Nettle Caterpillar in Smallholding Oil Palm Plantation Cultivated on Peatland in Ogan Ilir, South Sumatra, Indonesia

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This research focused on a particular geographical region (Ogan Ilir, South Sumatra), which may lack comprehensive documentation in other studies concerning the nettle caterpillar. This localized study contributes significant insights to the current literature. Peatlands are distinct ecosystems characterized by particular environmental circumstances. The relationship between the nettle caterpillar and oil palm cultivation in this ecosystem is potentially novel, enhancing comprehension of pest dynamics and ecological condition in peatland areas.

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Erise Anggraini

Identification of the Nettle Caterpillar in Smallholding Oil Palm Plantation Cultivated on Peatland in Ogan Ilir, South Sumatra, Indonesia

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Abstract. Nettle Caterpillars is a primary problem in oil palm cultivation. Severe caterpillar infestations can impede plant growth, result in production loss, and cause mortality. 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. 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 leaves until just the veins remain. Additional indications of the attack include perforations in the leaves, leaving just the veins intact. 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.

Key words: nettle caterpillar, oil palm, peatland

Running title: nettle catterpillar species found in oil palm plantation

INTRODUCTION

Indonesia is primarily an agriculture-based nation with extensive plantations, where palm oil stands out as one of the key commodities (Idris et al., 2020). The growth and productivity of oil palm are influenced by two main types of factors: external elements like climate and soil, and internal aspects specific to the oil palm plant, such as variety (Meijaard et al., 2020). Following palm oil, other plantation crops like cocoa, rubber, and sugarcane are projected to emerge as major export products in Indonesia. As the leading producer of palm oil globally, Indonesia surpasses both Malaysia and Brazil, supplying approximately 59% (or 4.8 million tons) of the world's palm oil demand (Setiyowati et al., 2015).

Oil palm plantations, like other industrial plantations, face considerable challenges from pests. These pests are classified according to 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 caterpillar and bagworms. Oil Palm Leaf-Eating Caterpillars (UPDKS), such as *Setothosea asigna, Setora nitens, Darna trima, Darna diducta*, and *Darna bradley* (Lepidoptera Order: Limaconidae family), are known to cause considerable damage to oil palm plantations (Riady et al., 2020). Nettle caterpillars ravage the leaves, creating holes or completely consuming them, which leaves only the leaf skeleton. The reduction in leaves can severely impair the photosynthesis process in oil palm trees, leading to a significant decline in fruit production (Falahudin & Septriani, 2023). In fact, oil production may drop by as much as 30% due to nettle caterpillar infestations (Ardi et al., 2018). Nettle caterpillar is particularly prevalent in oil palm plantations in South Sumatra Province, where it can consume up to 400 cm² of leaf tissue during its lifecycle. A single attack from nettle catterpillar can lead to a production decrease of up to 70%, while a second attack within the same year can cause a decrease of up to 93% (Gani et al., 2019).

Since oil palm plantations play a pivotal role in the agricultural landscape of South Sumatra, particularly in the Ogan Ilir region, where extensive areas have been cultivated on peatland. While the economic benefits of oil palm cultivation are significant, these plantations are vulnerable to various pests that can negatively impact productivity and sustainability. Among these pests, the nettle caterpillar, known for its voracious feeding habits, poses a considerable threat to the health of oil palm trees. The identification and understanding of the nettle caterpillar's biology, behavior, and impact on oil palm cultivation are crucial for developing effective pest management strategies. This study aims to identify the nettle caterpillar found in private oil palm plantations within peatland region. This research can provide valuable insights that can mitigate insect pest-related losses and sustainably enhancing oil palm productivity in the peatland region.

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. Identification of the species was conducted in the Entomology Laboratory, Faculty of Agriculture, Universitas Sriwijaya. The survey was conducted by direct observation on 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.

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.

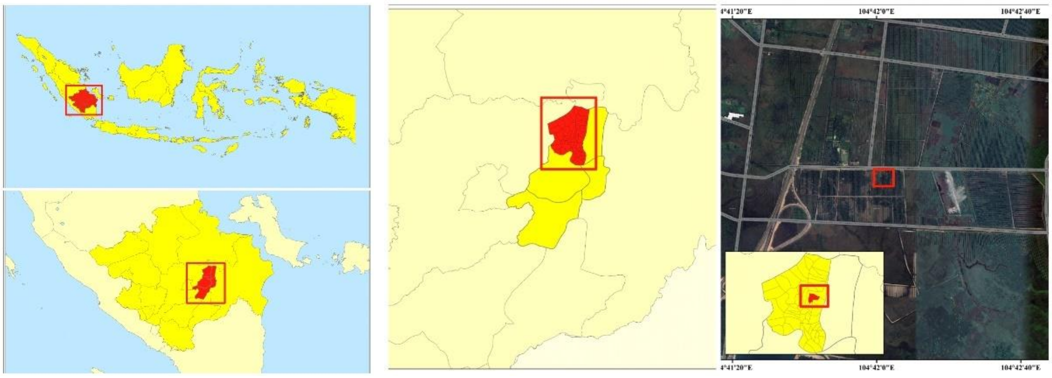

Figure 1. The sampling location was in Palem Raya, Ogan Ilir District, South Sumatra, Indonesia. The samples were taken from oil palm plantation.

RESULT AND DISCUSSION

Morfologi ulat api yang ditemukan

There are three species of nettle caterpillars found on the observed oil palm plantation: Setora nitens, Birthosea bisura, and Parasa lepida. Generally, these three nettle caterpillar species have similar colors, which are yellowish-green. However, each of these caterpillars has distinct morphological characteristics. The species *S. nitens* has a morphological characteristic of yellowish-green color with two coarse spines on its head and posterior, and it also features blue coloration running from the caput to the abdomen (Figure 1.a). The species 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 of its circle (Figure 1.b). The third species, P. lepida, has 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 1.c).

Figure 1. *Setora nitens* (a), *Birthosea bisura* (b), *Parasa lepida* (c).

Total number of nettle caterpillar species identified on 100 nettle plants

Three species of nettle caterpillars were identified in the field. This investigation involved observations of 100 oil palm trees. Three types of nettle caterpillars were observed on three occasions, producing diverse outcomes (Table 2). In the three observations, the species *S. nitens* exhibited the highest total number of caterpillar individual, ranging from 143 to 218 individuals per 100 plants. The species *P. lepida* was with 15 individuals per 100 plants observed in the second observation, but it was absent in the first and third observation. The species *B. bisura* was the least often encountered, with merely 6 individuals per 100 plants, recorded solely during the initial observation.

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

	Number of nettle caterpillar (individual) in the observation -		
Species	First observation	Second observation	Third observation
Setora nitens	218	164	143
Birthosea bisura	6	0	0
Parasa lepida	0	15	0

Average number of nettle caterpillar species per instar found on per 100 oil palm trees

The three species observed were in different instar stages (Table 3). The species *S. nitens* was found in larvae instar stages 1 to 6, with a dominance of instar 6, with average 78.67 individuals. The species *B. bisura* was only found in instar phases 3 and 4 on the 100 oil palm trees, with 1 individual in each stage. Meanwhile, the species *P. lepida* was found in larvae instar stages 1 and 5, with 1.67 individuals and 3.33 individuals, respectively.

Table 3. Average number of nettle caterpillar species per instar found on per 100 trees

	Average number of nettle caterpillar					
Species	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

Average size of nettle caterpillar species per instar found on 100 trees

The three species observed had different sizes at each of their instar phases (Table 4). The species *S. nitens* had a size of 0.60 cm in instar 1 and a size of 2.53 cm in instar 6 (Figure 2). The species *B. bisura* was not found 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 with a size of 1.70 cm (Figure 3). Meanwhile, the species *P. lepida* was observed with a size of 0.50 cm in instar 1 and a size of 2.00 cm in instar 5 (Figure 4).

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

	Size of nettle caterpillar at instar (cm)					
Species	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 2. Larvae sizes of the *Setora nitens* species found; instar 1 (a), instar 2 (b), instar 3 (c), instar 4 (d), instar 5 (e), instar 6 (f).

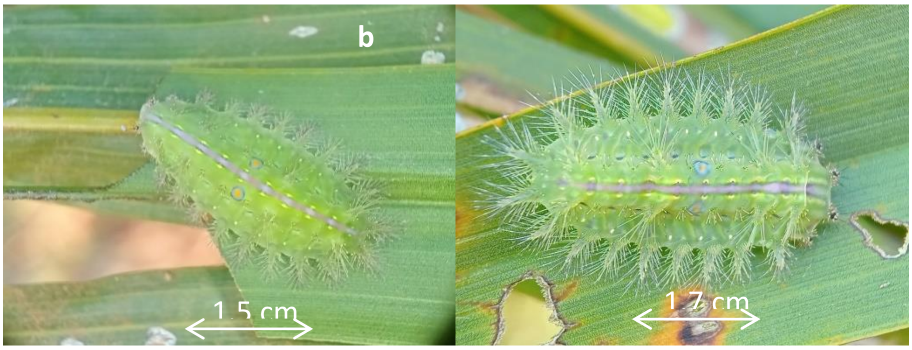

Figure 3. Size of *B. bisura* larvae found: a) instar 3, b) instar 4

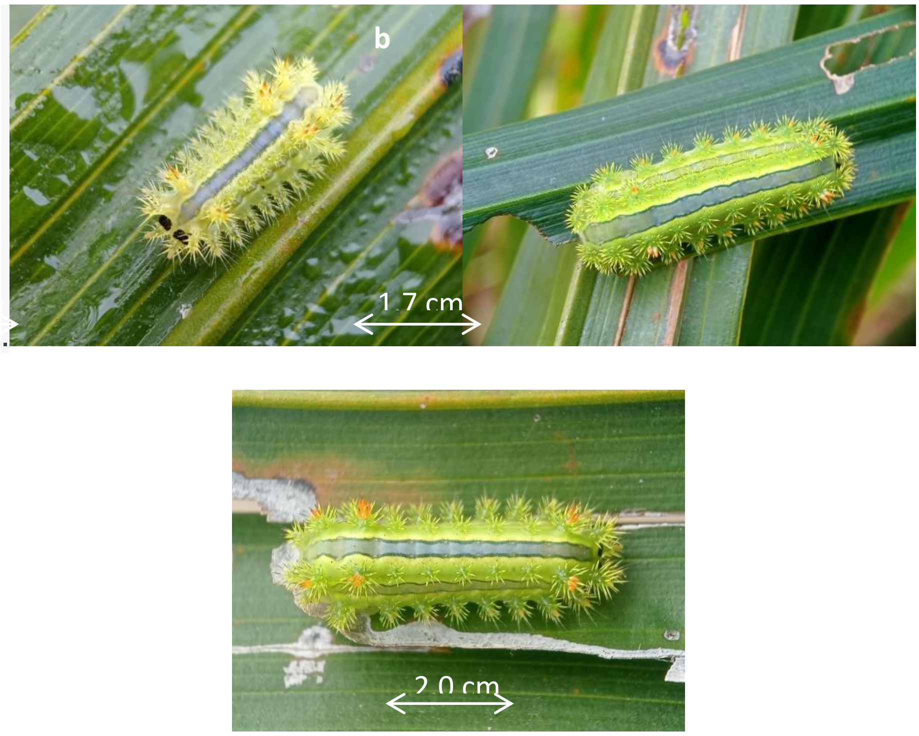

Figure 4. larvae sizes of *Parasa lepida:* Instar 1 (a), instar 4 (b), instar 5 (c).

Distribution map of nettle caterpillars in the Field

This map illustrates the distribution of nettle caterpillars observed during three separate observations. 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 map shows that *S. nitens* is the most widely distributed species at the research location from the first to the third observation, with the majority of distribution points marked by green circles. In contrast, *B. bisura* was only found at a few points (red circles) during the first observation, with no sightings in the second and third observations. Meanwhile, *P. lepida* was only found at a few points (blue circles) during the second observation, with no sightings in the first and third observations.

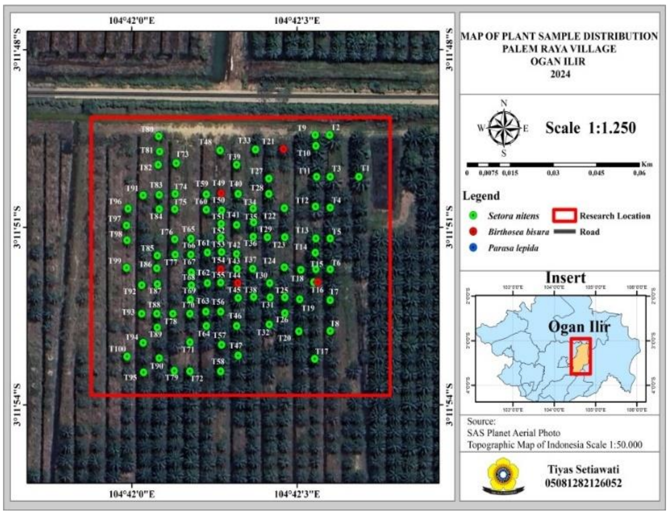

Figure 5. Distribution map of nettle caterpillars in the first observation

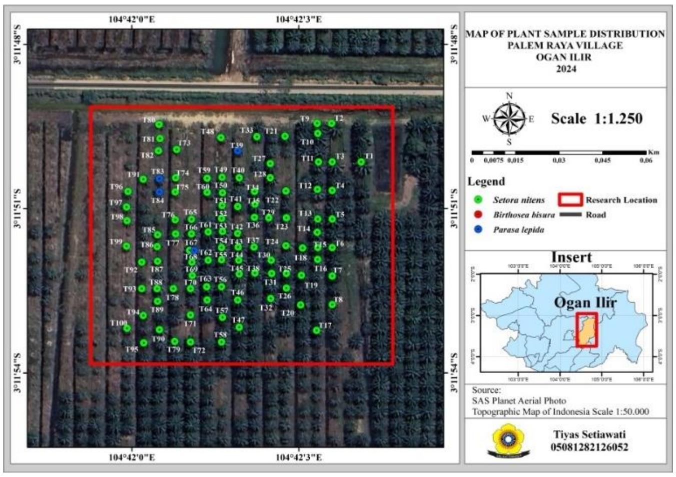

Figure 6. Distribution map of nettle caterpillars in the second observation

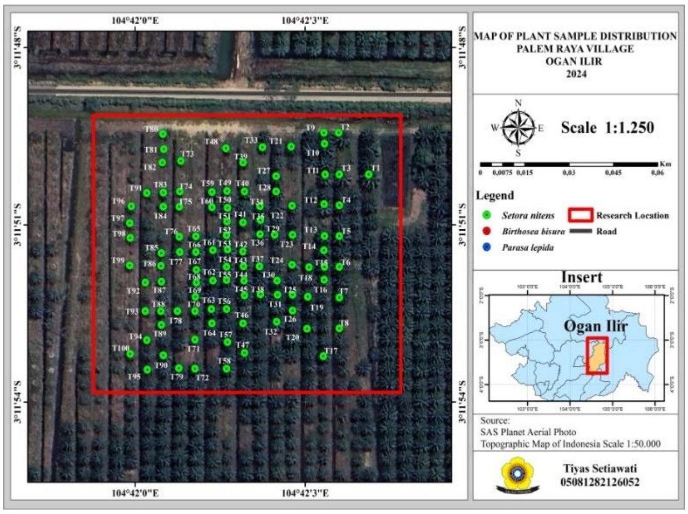

Figure 7. Distribution map of nettle caterpillars in the third observation

Intensity, percentage, and symptoms of nettle caterpillar attacks

High levels of nettle caterpillar attacks on oil palm land significantly affect plant growth. Based on the observations made, the percentage of nettle caterpillar attacks reached 100%, indicating that these attacks need to be controlled. The severity levels averaged 57.75 in the first observation, 51.75 in the second observation, and 49.25 in the third observation. The severity of the nettle caterpillar attack decreased from the second to the third observation, which is attributed to the decline in the nettle caterpillar population during the second and third observations. If high levels of nettle caterpillar attacks are not managed, they can disrupt the fruit growth process because the caterpillars damage the leaves and hinder the plant's photosynthesis process.

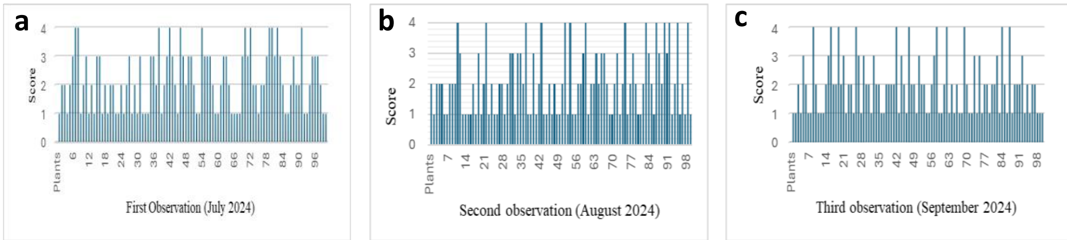

Figure 8. Score of nettle caterpillar attack intensity per 100 oil palm trees in a) first observation (July 2024), b) second observation (August 2024), c) third observation (September 2024).

Tabel 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 Sample Analysis

The soil sample analysis was conducted at the Phytopathology Laboratory of the Department of Plant Pests and Diseases, Faculty of Agriculture, Universitas Sriwijaya. The soil analysis aimed to assess the soil pH, temperature, and humidity, as the pupae of nettle caterpillar were present in the soil since the observed oil palm plantation planted in peatland area. The suitable temperature for nettle caterpillar ranges from 25-30°C, and based on the analysis that has been conducted, the temperature is 28°C (Table 6), indicating a high population of nettle caterpillar.

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
		392 ppm
2	Salt	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

According to this study, three species of nettle caterpillars were found in the oil palm plantation at private oil palm plantation, Palem Raya, Pemulutan Barat District, Ogan Ilir Regency, South Sumatra. The species identified were *Setora nitens* (Figure 1a), *Birthosea birula* (Figure 1b), and *Parasa lepida* (Figure 1c). Among the three species, *S. nitens* was the most commonly found. During the observations, only nettle caterpillars in the larval stage were encountered. The larvae of *S. nitens* have a yellow-green coloration on their bodies, which typically changes to reddish just before the pupal stage. *S. nitens* has two coarse hairs on its head and two longer coarse hairs on the posterior part, with a longitudinal blue-purple line on the dorsal side (Novita et al., 2024). The larvae of *B. birula* are entirely green, featuring a distinctive pair of dark blue eye spots with a yellow-orange center (Leong, 2015). Meanwhile, *P. lepida* has a yellowish-green color, with small sharp setae on its body and a green line on the dorsal lateral surface (Yamazaki et al., 2007).

In this study, three species of nettle caterpillars (Lepidoptera: Limacodidae) were found in the field with varied results, conducted with three observations in different month. The species of nettle caterpillar most commonly found across the three observations was *Setora nitens*. In the first observation, the number of individuals of this species reached 218, which slightly decreased in the second observation to 164 individuals and further decreased to 143 individuals in the third observation. *Parasa lepida* ranked second in the number of individuals found; in the first and third observations, no individuals of this species were found. However, in the second observation, 15 individuals per 100 plant stems were successfully identified. *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. The limited number obtained was due to various factors, including low survival ability, high predation, or limited food source availability (Falahudin & Septriani, 2023).

The three species of nettle caterpillars found in each observation were at different instar phases of larvae. The *S. nitens* larvae found were in instars 1-6, dominated by instar 6 with an average of 78.67. This indicated that this species dominated at the later instar phases due to high survival rates and better adaptation at that stage (Gani et al., 2019). *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. The high incidence of nettle caterpillar attacks in oil palm plantations affects the growth process of the plants. Based on observations, the severity level of nettle caterpillar attacks recorded an average of 57.75 in the first observation, 51.75 in the second observation, and 49.25 in the third observation. The severity level decreased because the number of populations found in the second and third observations also declined, categorizing the second observation's nettle caterpillar attack as severe and the third as moderate. To control the insect pests commonly use chemical insecticides; however, continuous and indiscriminate application can lead to negative impacts such as the death of natural enemies, residue issues, and environmental pollution (Gani et al., 2019).

Symptoms of the attack observed in the field were evident on the leaves of the oil palm plants, including signs of burning, elongated holes in the leaf fronds, and leaf fronds being stripped from the bottom up, leaving only the leaf ribs or midribs. Nettle caterpillars typically attack older oil palm leaves. High populations of nettle caterpillars can result in the complete consumption of oil palm leaf fronds, leaving only the midribs. Indeed, nettle caterpillars can also consume the epidermis of leaf sheaths (Ardi et al., 2018). The symptoms caused by these attacks can disrupt the photosynthesis process because the leaves become dry, and the leaf sheaths hang, ultimately leading to the failure to form fruit bunches for 2-3 years (Simanjuntak et al., 2020). Control measures commonly used to manage nettle caterpillars include the application of chemical insecticides. Some active ingredients frequently used include deltamethrin, cypermethrin, lambda-cyhalothrin, acephate, and fipronil (Priwiratama et al., 2018). The application of these active ingredients is usually done using a fogger, a pest control tool that transforms liquid pesticides into vapor and then sprays it onto the plants (Krisna et al., 2023). However, the use of these broad-spectrum active ingredients can be detrimental to beneficial insects such as parasitoids, predators, and pollinators, like the pollinator beetle *Elaeidobius kamerunicus*. If the population and activity of this beetle are disturbed, the pollination process becomes incomplete, resulting in a low percentage of fruit formation (Puspitarini, 2015). Therefore, environmentally friendly control measures are necessary, such as using natural enemies like Eocanthecona furcellata, which has the capability to prey on various species of caterpillars, including Lepidoptera, Coleoptera, and Heteroptera (Gani et al., 2019).

According to the results of soil analysis conducted, temperature and humidity significantly affect the population of nettle caterpillars in the field. According to Lubis et al. (2021), at temperatures ≤ 15˚C and ≥ 40˚C, nettle caterpillars struggle to survive, whereas development is faster within the temperature range of 25-30˚C. In addition to temperature, humidity also impacts the breeding, growth, development, and activity of insects both directly and indirectly (Agustina, 2021). In the analysis performed, the temperature in the observed oil palm plantation was 28˚C, which triggered a high population of nettle caterpillars in the plantation.

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

Author(s) name:

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This research focused on a particular geographical region (Ogan Ilir, South Sumatra), which may lack comprehensive documentation in other studies concerning the nettle caterpillar. This localized study contributes significant insights to the current literature. Peatlands are distinct ecosystems characterized by particular environmental circumstances. The relationship between the nettle caterpillar and oil palm cultivation in this ecosystem is potentially novel, enhancing comprehension of pest dynamics and ecological conditions in peatland areas.

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Erise Anggraini

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

ERISE ANGGRAINI[1,2♥], TIYAS SETIAWATI[1], SITI HERLINDA[1], CHANDRA IRSAN[1], MULAWARMAN[1], NUNI GOFAR[2,3], · A MUSLIM[1], WEI HONG LAU[4]

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Manuscript received: DD MM 2024 (Date of abstract/manuscript submission). Revision accepted: 2024

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.

Key words: *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 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.

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:

4. < 2 individuals/frond: Light
5. 2-4 individuals/frond: Moderate
6. 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.

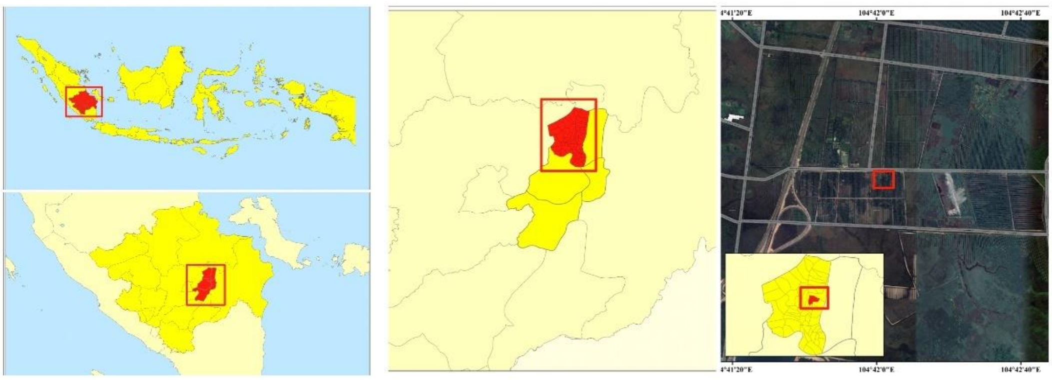

Figure 1. The sampling location is in Palem Raya, Ogan Ilir District, South Sumatra, Indonesia. The samples were taken from oil palm plantations.

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 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 stage 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).

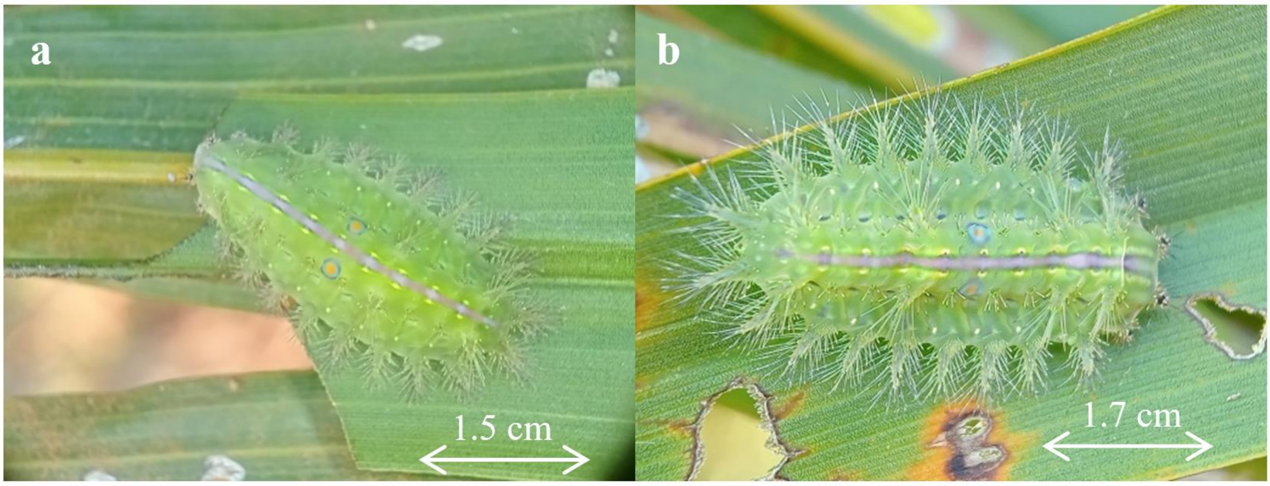

Figure 4. Size of *B. bisura* larvae found: a) instar 3, b) instar 4

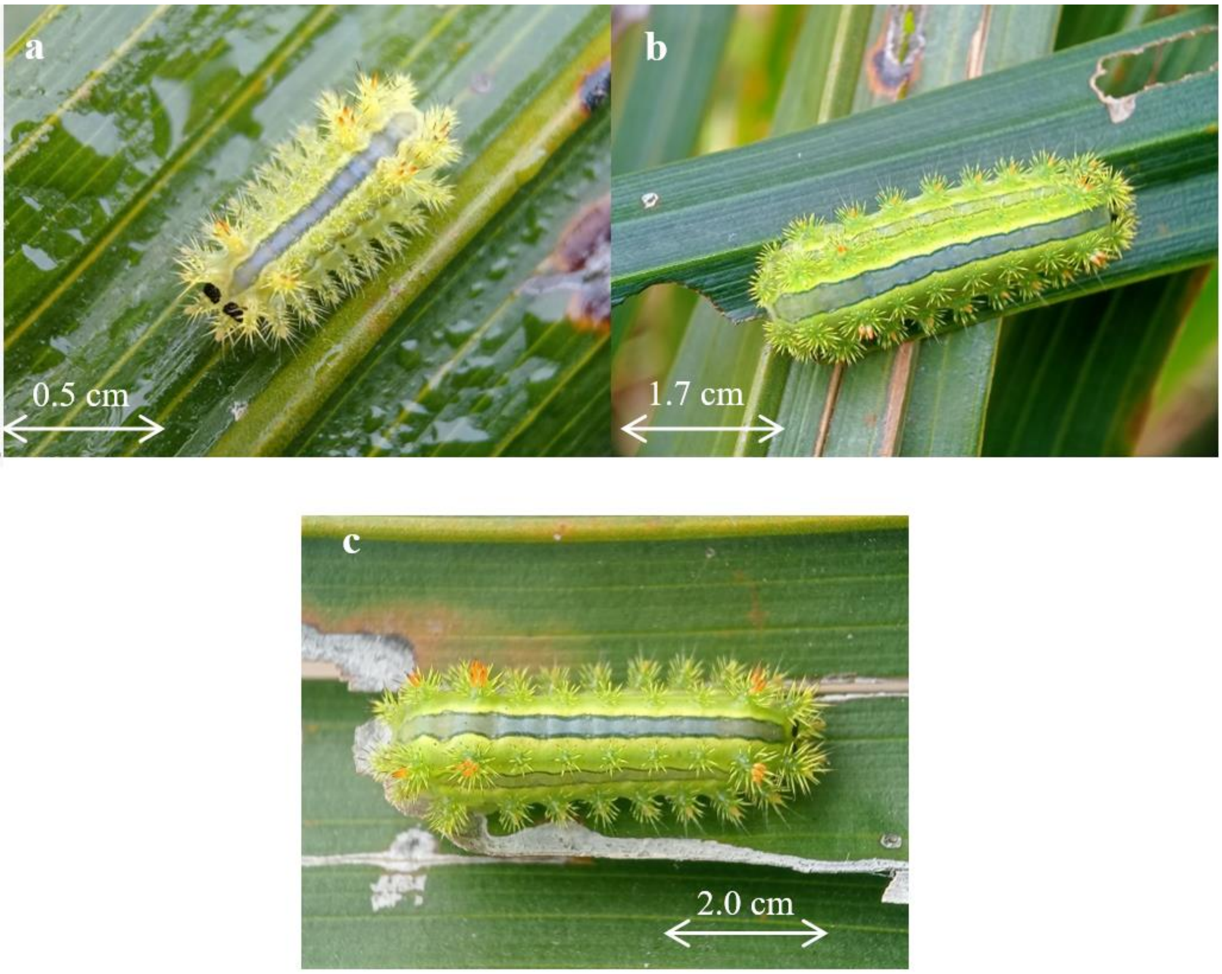

Figure 5. Larvae sizes of *Parasa lepida:* Instar 1 (a), instar 4 (b), instar 5 (c).

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.

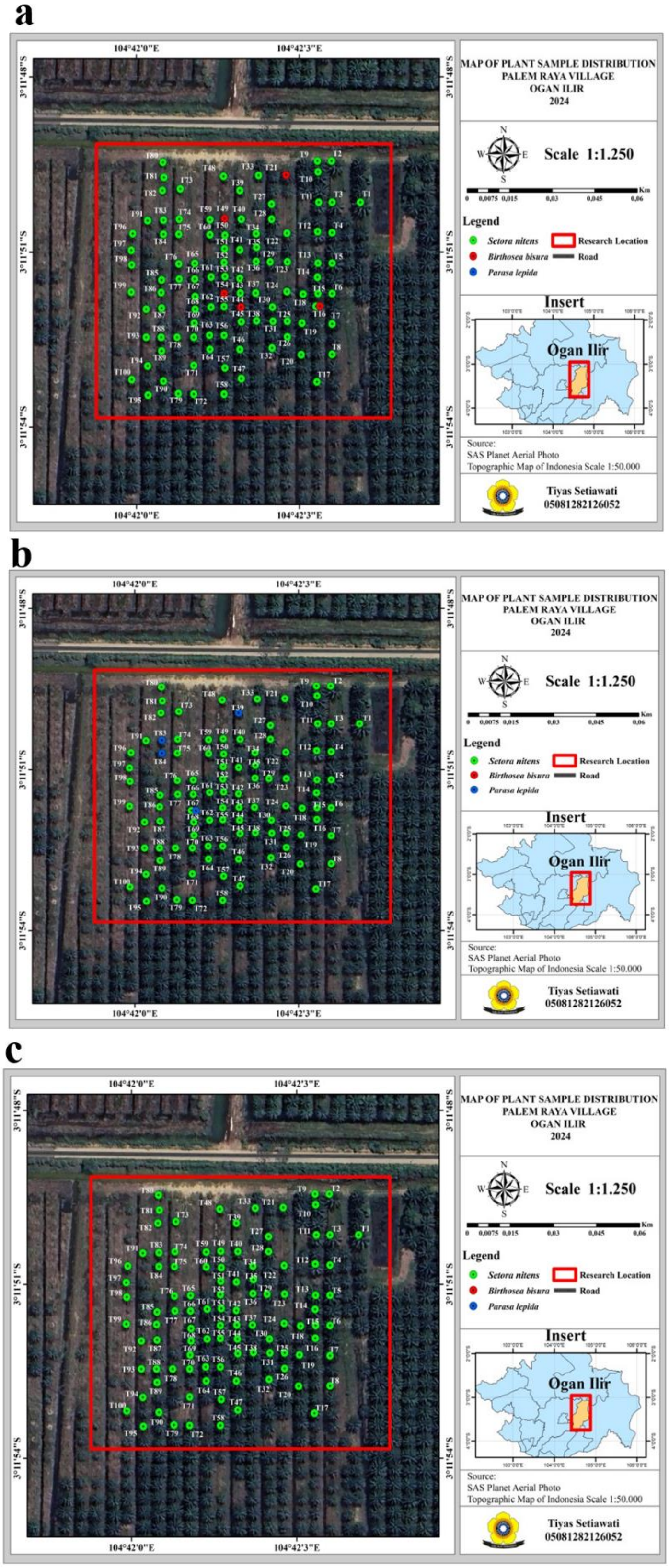

Figure 6. Distribution map of nettle caterpillars in the first (a), second (b), and third (c) observation

Intensity, percentage, and symptoms of nettle caterpillar infestations

The visual observation of pest attacks revealed variation 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 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 and thereby hindering its overall productivity.

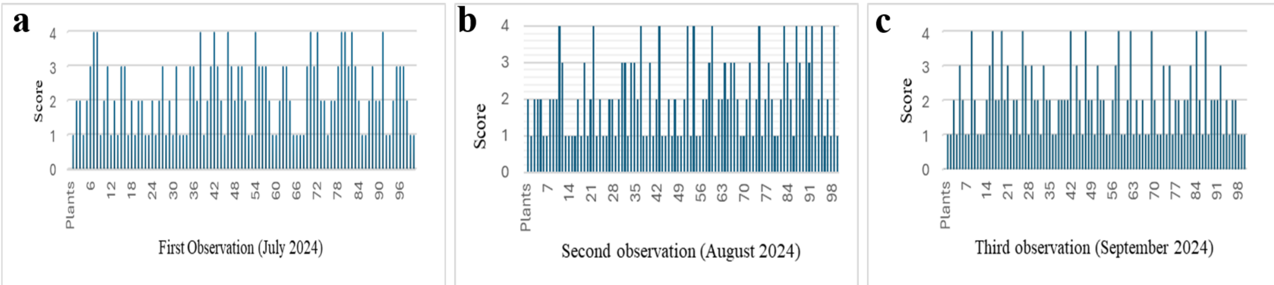

Figure 7. Intensity scores of nettle caterpillar attacks per 100 oil palm trees during: a) the first observation (July 2024), b) the second observation (August 2024), and c) the third observation (September 2024).

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 dorso-lateral 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 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 caterpillar 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 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 suggest 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 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 underscores the caterpillars' potential to disrupt photosynthesis. Zhang et al. (2022) reported that biotic disturbance significantly decreased the photosyntetic 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 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 careful use of selective insecticides results 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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3. Bukti konfirmasi review kedua dan hasil revisi kedua

27 Desember 2024

14 dari banyak

[biodiv] Editor Decision Eksternal Kotak Masuk ×

Smujo Editors via SMUJO <support@smujo.com> Jum, 27 Des 2024, 21.08
kepada saya

Terjemahkan ke Indonesia

Erise Anggraini:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Identification of the Nettle Caterpillar in Smallholding Oil Palm Plantation Cultivated on Peatland in Ogan Ilir, 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**. We are waiting for your revision in the system (https://smujo.id/biodiv), do not send it via email.

Our decision is: Revisions Required

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14 dari banyak

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28 December 2024

Dear Editors,
BIODIVERSITAS Journal of Biological Diversity

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

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

"Letter on responses to reviewers' comments and suggestions"

Line	Reviewers' suggestion	Our response

61	Add large	We already made the corrections.
119	Delete own	We already made the corrections.
153	Delete (,)	We already made the corrections.
188	Delete the	We already made the corrections.
190	Delete (at) change to (in)	We already made the corrections.
194	Correction the word of Photosynthesis	We already made the corrections.
232	Change though to however	We already made the corrections.
249, 266, 270, 275	Change this to it	We already made the corrections.
292	Remove a	We already made the corrections.

Sincerely yours,
Corresponding author,

Erise Anggraini

28 December 2024

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10	In what location, and at what time?	We already made the corrections.
14	100% of what? Some context is needed here	We already made the corrections.
21	Avoid using the term 'significant' unless you are referring to statistically significant differences Please adjust throughout the manuscript	We already made the corrections.
22	According to the Biodiversitas author guidelines, et al. should not be followed by a comma or in italics. Citations should look like this (Author et al. 2022). Please ensure that all citations are revised for consistency	We already made the corrections.

28	There is no comma required after the author as per the Biodiversitas citation style. Please check the author guidelines and revise citations accordingly	We already made the corrections.
33	Avoid using the term 'significant' unless you are referring to statistically significant differences Please adjust throughout the manuscript	We already made the corrections.
34	At current, there are many errors in the references as they don't seem to fit the format of Biodiversitas. Please see the author guidelines https://smujo.id/biodiv/guidance-for-author#:~:text=abstract%20200%20words.-,Manuscript%20of%20original%20research%20should%20be%20written%20in%20no%20more,%2Dstudy%20(can%20longer)	We already made the corrections.
56	Well considered here	We already made the corrections.
60	Provide information on study ethical review and approval	We already made the corrections.
61	Please state the actual dates of study	We already made the corrections.
64	What type of plants? What type of fertilizer and pesticide regime?	We already made the corrections.
65	Please explain how study sites were selected	We already made the corrections.
66	The figure is missing	We already made the corrections.
75	How was this done? How regularly? By whom? Please state the signs that were investigated. Did you count signs as the presence / absence of pests, or did you count them in population counts?	We already made the corrections.
76	How can you identify species based on signs?	We identified the nettle caterpillar based on the strip and color on their body
80	Sentence is repeated from above	We removed the sentence
91	Please cite the source of this	We already made the corrections.
101	Were any statistical tests run?	We just did descriptive analysis
113	The a, b and c should be before the scientific names The scientific names should be in brackets Please quote the source of the pictures	We already made the corrections.
123	This needs to be made clearer. Is this total, or total per plant? If total, this is on how many plants?	Total per 100 plants per observation
131	Per tree? Per plot? More information needed	Per 100 trees

	Please provide the range or standard deviation on all cases	
139	Please provide the range or standard deviation on all cases	We cant put the standard deviation because the total number of the insect was not same, and for the 1st instar we only got 1 larva.
160	The different observation periods need to be explained in the results	We already made the corrections.
178	These are quote unclear what are the 96 bars?	We changed to be the pie charts
182	But the study started in August according to the methods?	We already made the corrections
270	3 months is not sufficient to draw conclusions on population dynamics	We removed the word dynamics
283	Is a doi available (Bhoye and Makode, 2024)	This article has no DOI
294	Doi?	We already put the DOI in the reference

Sincerely yours,
Corresponding author,

Erise Anggraini

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

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Commented [JB7]: At current, there are many errors in the references as they don't seem to fit the format of Biodiversitas. Please see the author guidelines https://smujo.id/biodiv/guidance-for-author#:~:text=abstract%20200%20words.-,Manuscript%20of%20original%20research%20should%20be%20written%20in%20no%20more,%2Dstudy%20(can%20longer) 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.

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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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Commented [JB10]: Please state the actual dates of study

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Commented [JB12]: What type of plants? What type of fertilizer and pesticide regime?

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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:

7. < 2 individuals/frond: Light
8. 2-4 individuals/frond: Moderate
9. 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 a, b and c should be before the scientific names
The scientific names should be in brackets
Please quote the source of the pictures

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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Please provide the range or standard deviation on all cases

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)

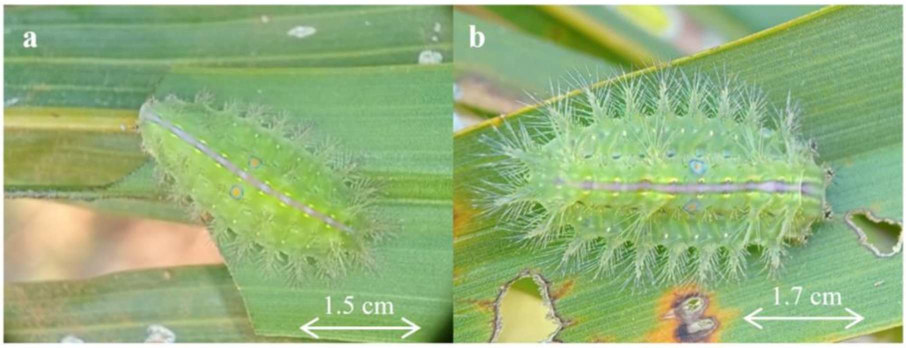

Figure 4. Size of *B. bisura* larvae found: a) instar 3, b) instar 4

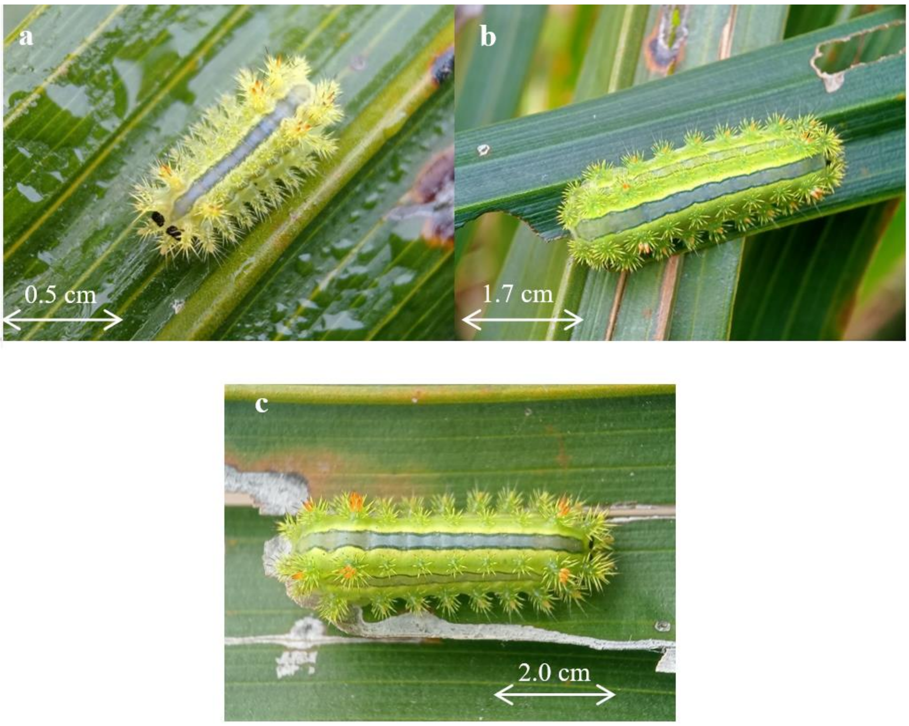

Figure 5. Larvae sizes of *Parasa lepida:* Instar 1 (a), instar 4 (b), instar 5 (c)

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.

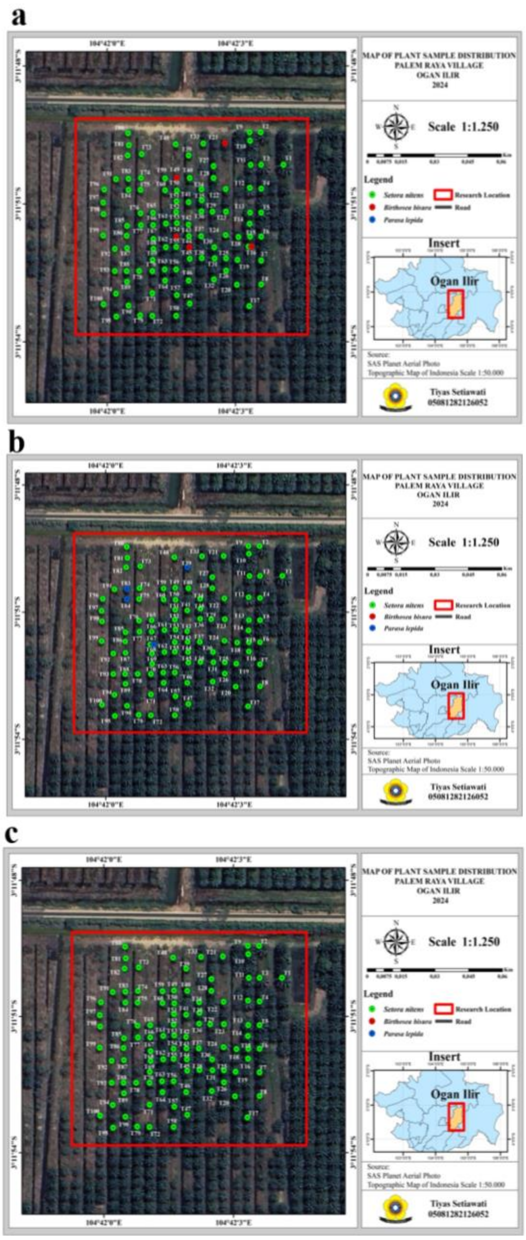

Figure 6. Distribution map of nettle caterpillars in the first (a), second (b), and third (c) observation

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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.

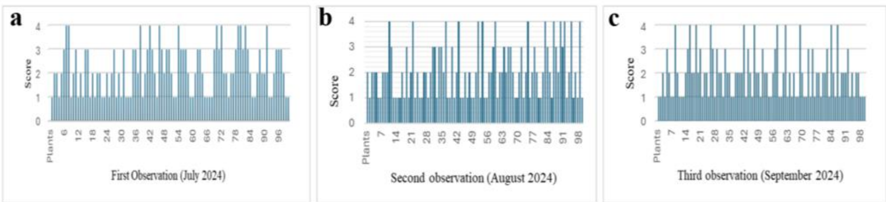

Figure 7. Intensity scores of nettle caterpillar attacks per 100 oil palm trees during a) the first observation (July 2024), b) the second observation (August 2024), and c) the third observation (September 2024)

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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

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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

Commented [JB29]: Please explain in the methods how these were recorded

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. 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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4. Bukti konfirmasi review ktiga dan hasil revisi ketiga

30 Desember 2024

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[biodiv] Editor Decision

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Sen, 30 Des 2024, 06.19

Terjemahkan ke Indonesia

Erise Anggraini:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Identification of the Nettle Caterpillar in Smallholding Oil Palm Plantation Cultivated on Peatland in Ogan Ilir, 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**. We are waiting for your revision in the system (https://smujo.id/biodiv), do not send it via email.

Our decision is: Revisions Required

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Reviewer A:

Dear Authors,

Thank you for submitting this manuscript that explores the species of nettle caterpillar found in oil palm trees. This is an interesting study with clear ecological implications and as such, there is some scope for publication.

There are some revisions required in order to consider this manuscript for publication. I have included specific feedback on the word document version of the manuscript, please find attached. Make sure that any changes to the manuscript are shown using highlighted text or tracked changes. Additionally, please address the following key areas when making revisions:

1. Sampling methods. Sampling information is currently unclear. Please explain how often the sample sites were studies, how large the trees were, what pesticide and fertiliser treatments were used, how the sample sites were selected, and be clear on the methods during sampling sessions. This is essential for study repeatability.

2. Dates of study and sample effort. There are different dates of sampling in the methods and the results. Please be clear on exactly how much sampling occured, and on which dates. This is essential for repeatability.

3. Citations. Please revise citations to ensure that they fit the journal style.

With these revisions, the work should be in a better position for future consideration.

Recommendation: Revisions Required

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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

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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).

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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 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.

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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:

10. < 2 individuals/frond: Light
11. 2-4 individuals/frond: Moderate
12. 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)

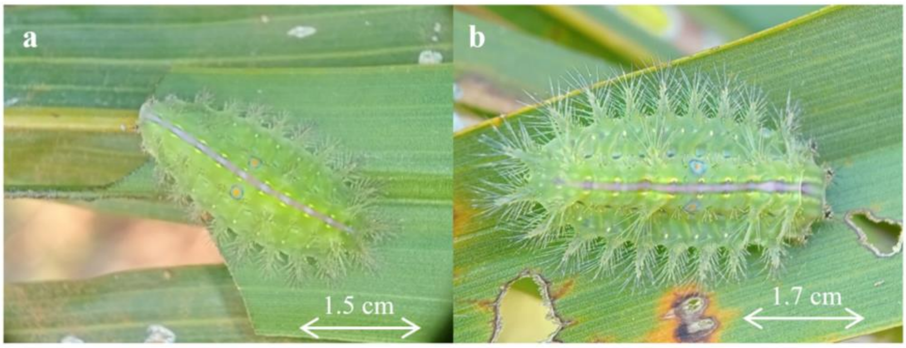

Figure 4. Size of *B. bisura* larvae found: a) instar 3, b) instar 4

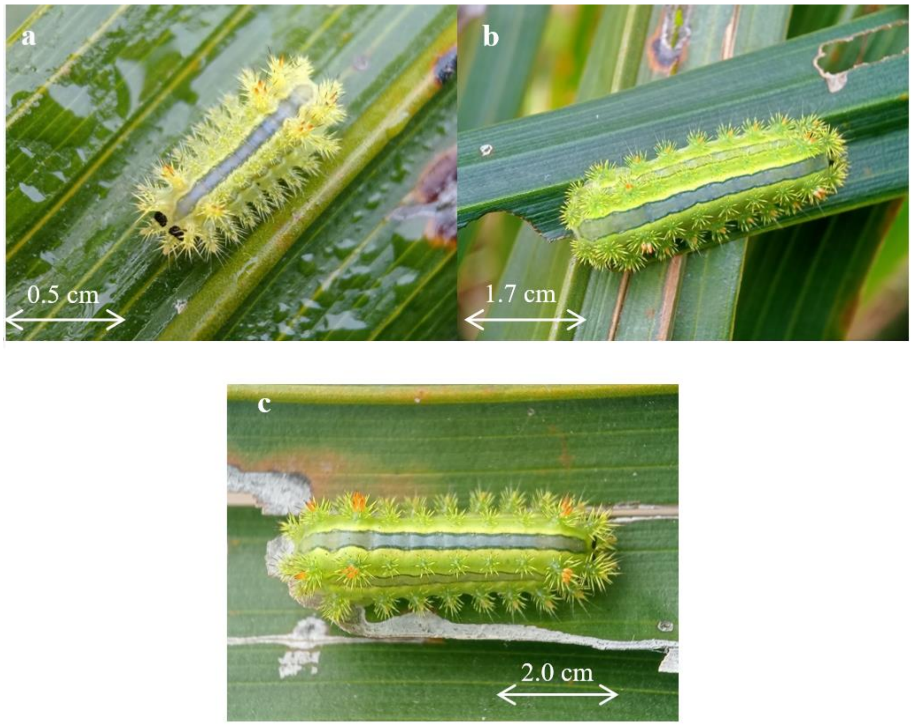

Figure 5. Larvae sizes of *Parasa lepida:* Instar 1 (a), instar 4 (b), instar 5 (c)

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.

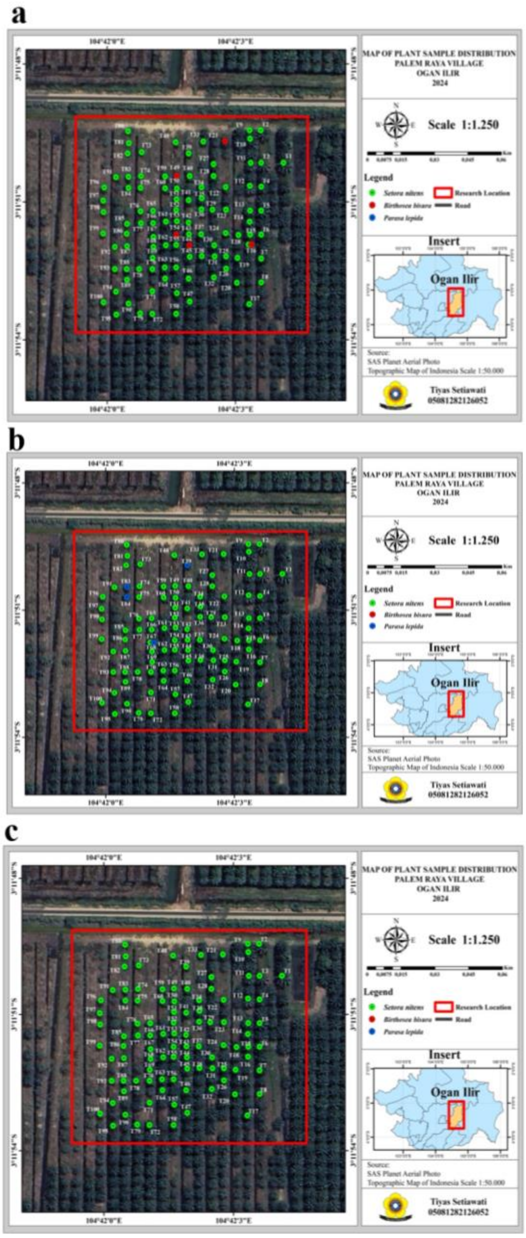

Figure 6. Distribution map of nettle caterpillars in the first (a), second (b), and third (c) observation

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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.

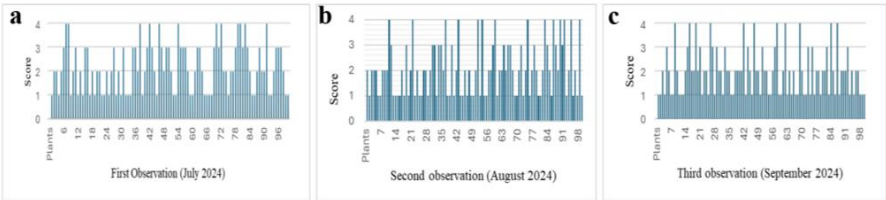

Figure 7. Intensity scores of nettle caterpillar attacks per 100 oil palm trees during a) the first observation (July 2024), b) the second observation (August 2024), and c) the third observation (September 2024)

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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

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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

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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. 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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5. Bukti konfirmasi uncorrected Proof, billing, accepted submission

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Our decision is to: Accept Submission

Letter of Acceptance:
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Best Regards,

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

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Abstract. *Anggraini E, Setiawati T, Herlinda S, Irsan C, Mulawarman, Gofar N, Muslim A, Lau WH. 2025. Identification of the nettle caterpillar in smallholding oil palm plantation cultivated on peatland in Ogan Ilir, South Sumatra, Indonesia. Biodiversitas 26: 36-44.* 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 identification of the nettle caterpillars found in oil palm plantation cultivated on peatland in Ogan Ilir, South Sumatera, Indonesia. 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% of nettle caterpillar infestation, 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*

INTRODUCTION

Indonesia is predominantly an agriculture-based nation, with extensive plantations that 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 (Varkkey et al. 2018; Tandra et al. 2022). 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 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* (van Eecke, 1929), *Setora nitens* (Walker, 1855), *Ploneta diducta* (Snellen, 1900), and *P. bradleyi* (Holloway, 1986), 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, Indonesia, 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 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 cultivated on peatland area. 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 in July, August, September 2024. The research was conducted at a private oil palm plantation in Palem Raya, Ogan Ilir, South Sumatra, Indonesia (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 8 years of DxP Sriwijaya 1 variety at the private oil palm plantation in Palem Raya Village. The sampling site was chosen due to the infestation of nettle caterpillars reported by the farmers. The observed area was not applied any insecticides. The observed oil palm trees received biannual fertilization with a phosphate fertilizer including two types of phosphate: one slow-release (17%) and one fast-release (14%). The nettle caterpillars found were captured and identified based on the stripes on their bodies.

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. One plot area of oil palm trees that reported the caterpillar infestation was observed. The sampling of infested nettle caterpillar trees used purposive sampling, the total number of the observed trees was 100 trees per observation. The observation was done per month, July 2024, August 2024, September 2024. The plants that showed symptoms of infestation were calculated.

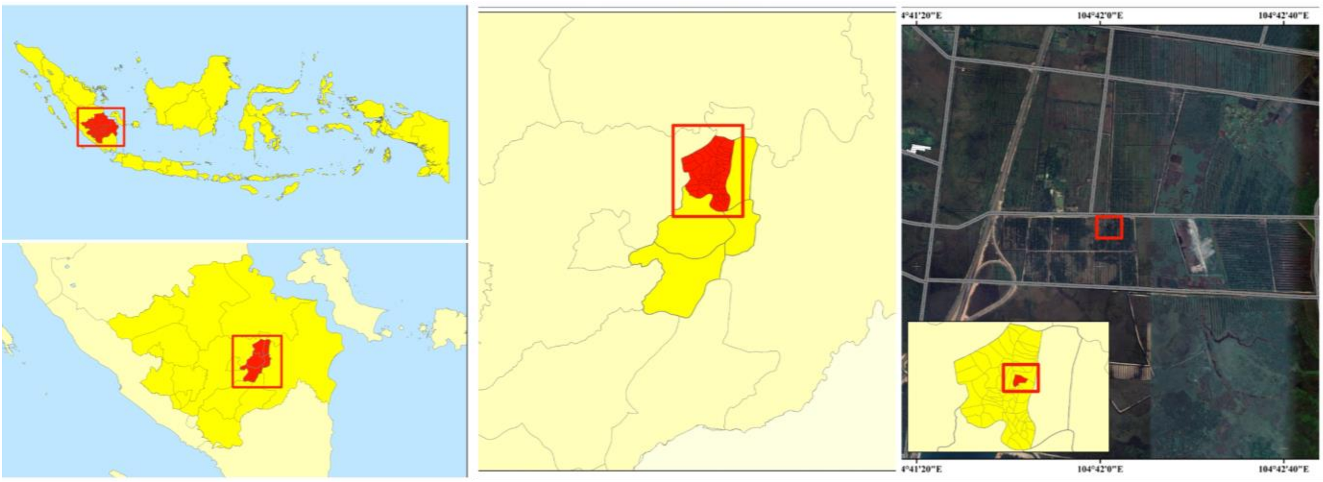

Figure 1. The sampling location is in Palem Raya, Ogan Ilir District, South Sumatra, Indonesia. The samples were taken from oil palm plantations

The intensity of pest attack (%)

The formula used to calculate the intensity of the nettle caterpillar pest infestation was applied using the following formula:

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

Where:
I : Intensity of attack by nettle caterpillars (%)
n : Number of plants infested by nettle caterpillars
N : Total number of plants observed

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 (Ikhsan et al. 2023). 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 (Table 1).

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. The data were analyzed using descriptive analysis. Soil samples from the cultivated oil palm were analyzed. The soil properties, including Electrical Conductivity (EC), salinity, pH, temperature, humidity (relative humidity, or Rh), and the levels of Nitrogen (N), Phosphorus (P), and Potassium (K), were monitored using a wireless Soil Moisture, Temperature, and NPK Data Logger sensor.

Table 1. Criteria for categories of nettle caterpillar attack intensity

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

RESULTS AND DISCUSSION

The morphology of nettle caterpillars

The oil palm plantation hosts three distinct species of nettle caterpillars: *Setora nitens*, *Birthosea bisura* (Moore, 1859), and *Parasa lepida* (Cramer, 1779). These caterpillars share a generally yellowish-green coloration, but each exhibits its unique morphological characteristics. *Setora 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). *Birthosea 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). *Parasa 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).

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 (July, August, September 2024). *Parasa lepida* was only recorded during the second observation, with 15 individuals per 100 plants, and was absent in the first and third observations. *Birthosea bisura* was the least frequently encountered species, appearing only in the initial observation with 6 individuals per 100 plants.

The average number of nettle caterpillar species per instar

During the study, the three species were observed at different larval instar stages (Table 3). *Setora nitens* was found in instars 1 to 6, with instar 6 being the most prevalent, with an average of 78.67 individuals. *Birthosea 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.

Figure 2. Nettle caterpillar in oil palm plantation of Ogan Ilir, Indonesia. A. *Setora nitens*; B. *Birthosea bisura*; C. *Parasa lepida*

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). *Setora nitens* measured 0.60 cm at instar 1 and reached a size of 2.53 cm in instar 6 (Figure 3). *Birthosea 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).

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), *B. bisura* (represented by a red circle), and *P. 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.

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 (July 2024), 32% 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 (August 2024), 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 (September 2024), 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 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.

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

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

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

Spesies	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

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

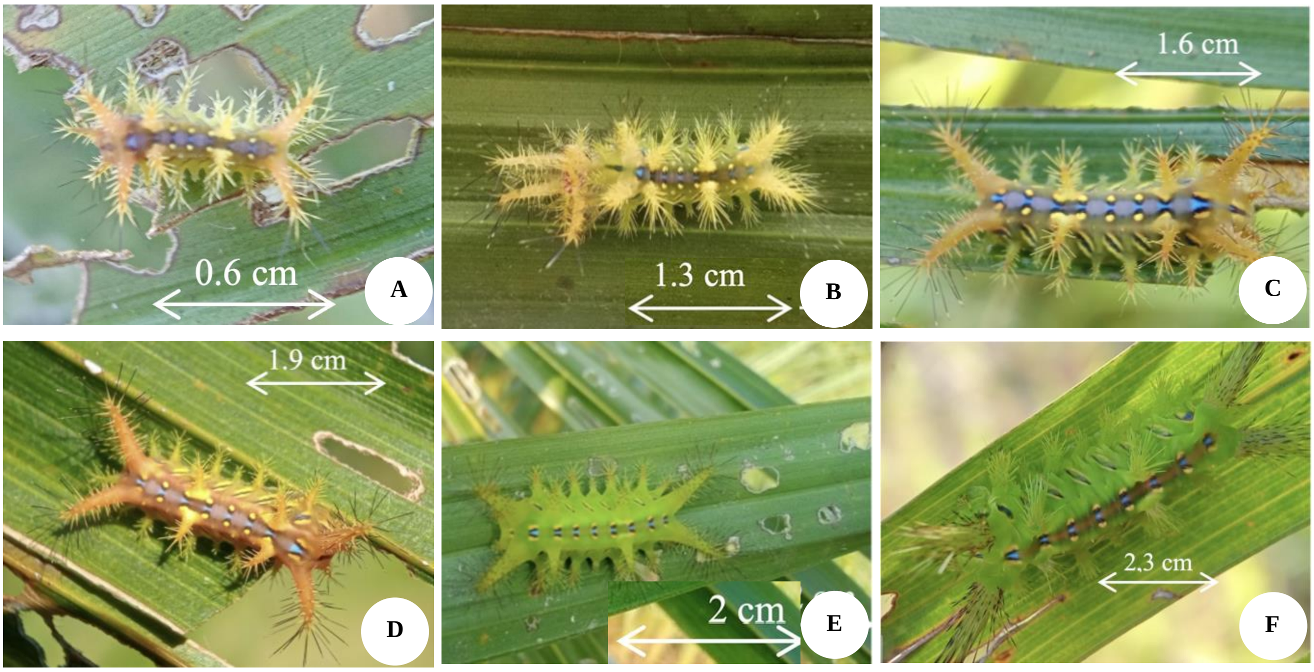

Figure 3. Larvae sizes of *Setora nitens*. A. 1st instar; B. 2nd instar; C. 3rd instar; D. 4th instar; E. 5th instar; F. 6th instar

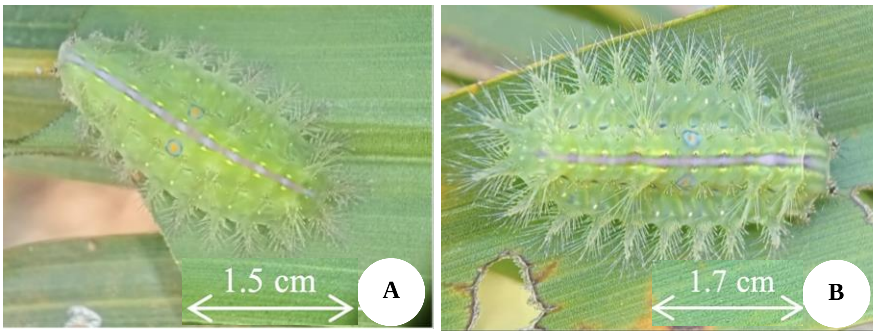

Figure 4. Larvae size of *Birthosea bisura*. A. 3rd instar; B. 4th instar

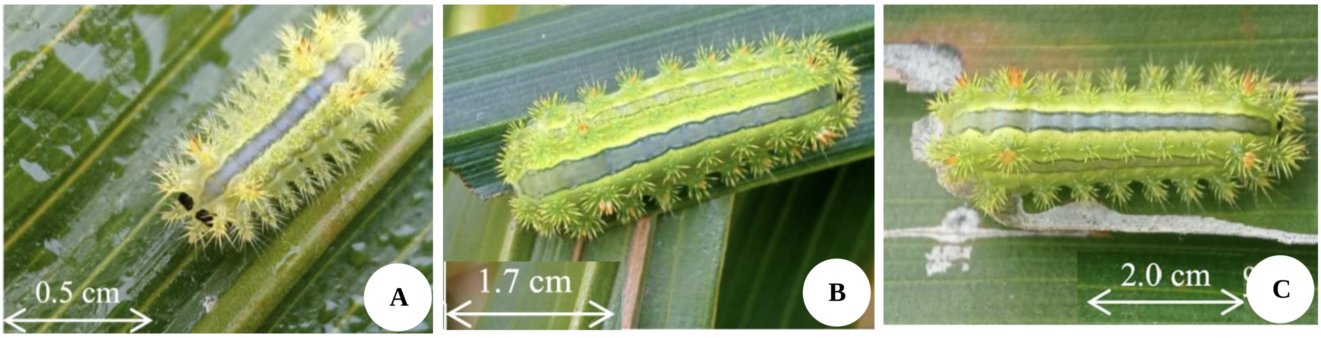

Figure 5. Larvae sizes of *Parasa lepida*. A. 1st instar; B. 4th instar; C. 5th instar

Soil characteristics

The soil sample was analyzed at the Phytopathology Laboratory of the Department of Plant Protection, Faculty of Agriculture, Universitas Sriwijaya, Indonesia. 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.

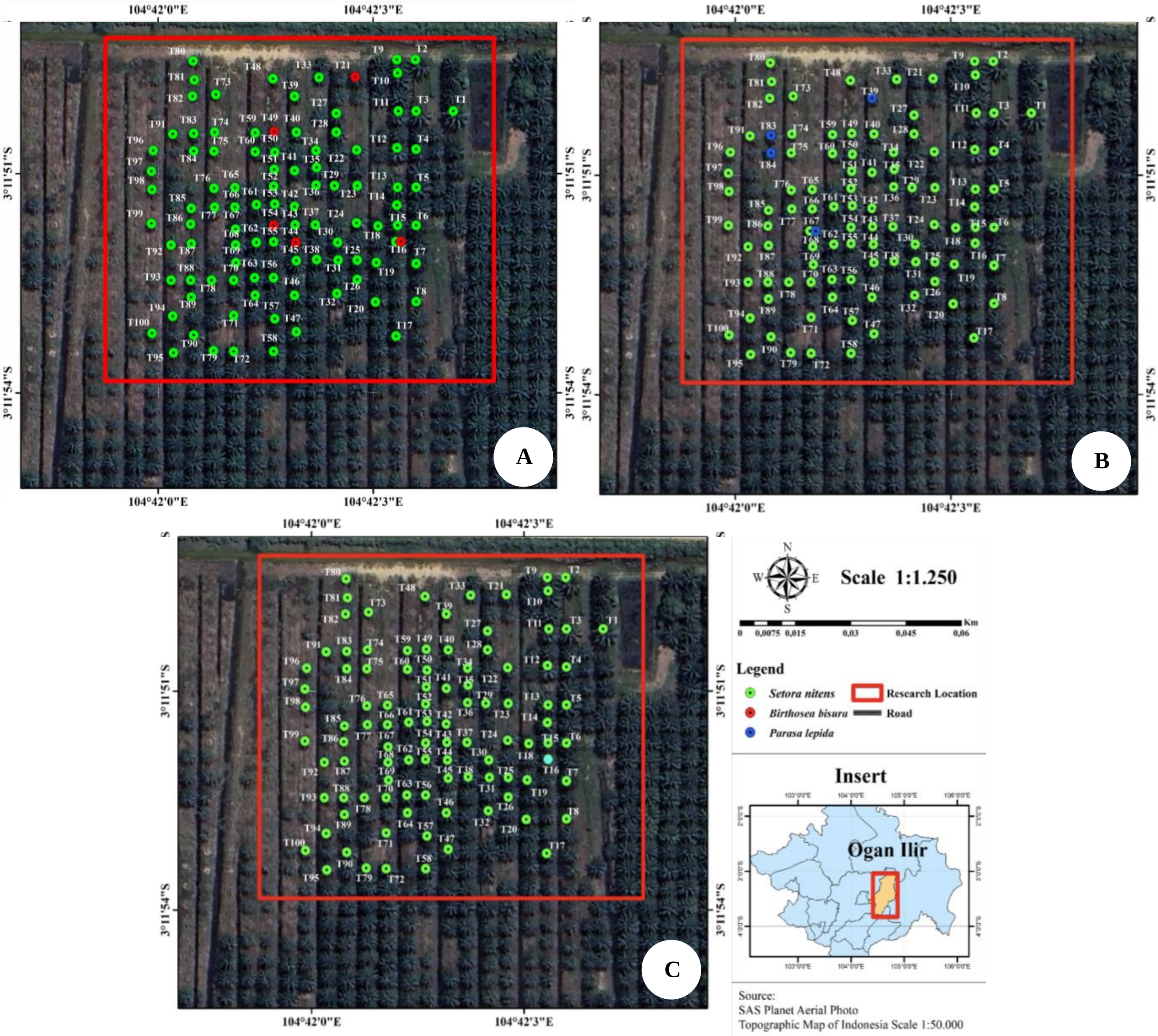

Figure 6. Distribution map of nettle caterpillars in oil palm plantation of Ogan Ilir, Indonesia. A. July 2024, B. August 2024, C. September 2024

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 *S. nitens*, *B. bisuraa*, and *P. 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. 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, *P. 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 that it is seasonal. This rarity might also indicate that *B. bisura* has more specialized habitat or resource requirements, making it vulnerable to disturbances. *Birthosea bisura* was reported as a less common of nettle catterpillar in Malaysia (Firdausi and Nuraini 2016).

Analysis of the developmental stages (instars) of the three species provided further insights into their ecological dynamics. *Setora 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. *Birthosea 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).

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

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

Observed variable	Result (unit)
Electrical conductivity	666 us
	0.66 ms
Salt	392 ppm
	0.39%
	0.996 S.G
pH	3.79
N	51
P	164
K	157
Temperature	28°C
RH	56.7%
	429 us/cm
pH	6.3

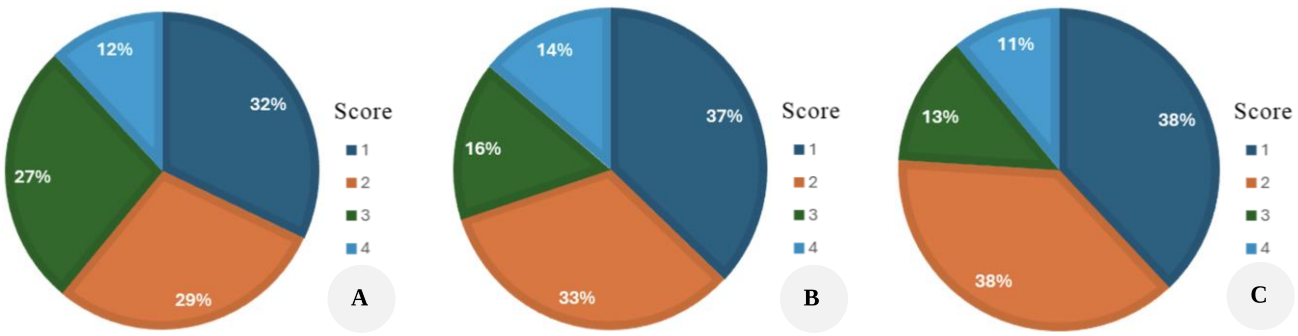

Figure 7. Intensity scores of nettle caterpillar attacks per 100 oil palm trees during A. July 2024; B. August 2024; C. September 2024

Soil analysis revealed that temperature and humidity may affect the population of nettle caterpillars in the field. An average plantation temperature of 24-35°C was found to favor rapid caterpillar development, aligning with Ruslan et al. (2019). 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). Nettle caterpillars, similar to several moth and butterfly species, undergo a complete metamorphosis comprising four distinct stages: egg, larva (caterpillar), pupa, and adult (Patade et al. 2022). Subsequent to feeding on their host plants, caterpillars frequently descend to soil to undergo pupation. The existence of these nettle caterpillars in oil palm trees cultivated on peatland indicates that these species may adapt to this environment. These findings underscore the importance of considering climatic factors when developing pest management strategies, as changes in temperature and humidity can alter pest population 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 and Lubis 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, 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 IPM. 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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