



RESEARCH ARTICLE

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Population Distribution of the Bagworm *Pteroma pendula* Joannis There are oil palm plants (*Elaeis guineensis* Jacq.) in the Begerpang Plantation of PT.PP London Sumatra Indonesia Tbk.

Resty Fadhilah Yollanda^{1,*}, Ahmad Saleh¹, Makhrani Sari Ginting¹

Abstract

The bagworm *Pteroma pendula* is a major pest of oil palm plantations and can significantly reduce crop productivity. This study was conducted in Division 03 of Begerpang Estate, PT PP London Sumatra Indonesia Tbk, on three-year-old oil palm plants. The research employed a field survey method through population censuses on selected sample palms and six surrounding palms. Infestation levels were categorized as light, moderate, and severe, with a total of 105 sample palms selected across these categories. The observed parameters included the number of eggs, larvae, pupae, and adult population density on the fronds, and the distribution pattern of larvae on the apical, middle and basal sections of the fronds. The results showed that the population of *P. pendula* increased with increasing infestation severity. The average population density under light infestation ranged from 0.0 to 2.2 individuals per frond, while moderate infestation ranged from 6.1 to 8.2 individuals per frond, and severe infestation reached 14.1-39.2 individuals per frond. The population on the sample palms was higher than that on the six surrounding palms, with mean larval populations of 53.2 and 44.2 larvae, respectively. In contrast, the surrounding palms harbored only 20.5 and 18.5 larvae on average. Larval activity was predominantly concentrated in the apical section of the fronds, accounting for 53.9-66.7% of the total population, compared with the middle and basal sections of the fronds. The results indicated that the sample palms were the primary centers of infestation. In contrast, the six surrounding palms could not fully represent the sample palms because of significant differences in population density. Larval activity was predominantly concentrated at the apical section of the fronds, suggesting that this area is the most suitable site for population monitoring. These findings provide a basis for the development of an Early Warning System (EWS) to support effective bagworm management in oil palm plantations.

Keywords: Defoliation, Early Warning System, Infestation, Monitoring, Population Density

1. Introduction

Oil palm (*Elaeis guineensis* Jacq.) is a strategic Indonesian plantation commodity that generates the largest foreign-exchange earnings from the agricultural sector and provides livelihoods for millions of people in plantation communities. However, its productivity is often hampered by pest attacks, particularly by leaf-eating pests, which can significantly reduce yields (Kamarudin & Basri Wahid, 2010; Priwiratama et al., 2019). One important leaf pest is

the bagworm *Pteroma pendula* Joannis (Lepidoptera: Psychidae), which can produce up to eight generations per year because of its short life cycle (Lubis et al., 2024).

Pest attacks cause transparent holes in the leaves and can lead to severe defoliation, characterized by leaves that dry out and appear burned. Leaf loss can reach 46.6%. Priwiratama et al. (2019) reported that 87.45% of oil palm plants were attacked by *P. pendula*, with an attack intensity of 58.04%, resulting in reduced photosynthetic capacity

*Correspondence: restyfadhilah25@gmail.com

1) Institut Teknologi Sawit Indonesia - Jl. Willem Iskandar, Kenangan Baru, Kecamatan Percut Sei Tuan, Kabupaten Deli Serdang, Sumatera Utara 20371, Indonesia

and disrupted vegetative growth. Damage at this stage can slow plant development and reduce future production potential (Hutauruk, 2024; Sigalingging et al., 2025).

Several studies have examined *P. pendula* in oil palm. For example, Priwiratama et al. (2019) investigated the impact of *P. pendula* attacks on oil palm productivity, while Zen et al. (2021) emphasized the importance of an early warning system (EWS) for pest control. However, these studies have not examined differences in *P. pendula* population distribution between sample trees and surrounding trees, information that is important for field census activities. This study addresses that gap by analyzing the population and distribution of *P. pendula* on sample trees and six surrounding trees in three-year-old oil palm plantations. The findings may provide more accurate information to support monitoring, early warning systems, and pest-control decision-making in oil palm plantations.

Pest population census is the basis for control decisions. Observations are usually conducted on the 9th, 17th, and 25th fronds, referring to the standard guidelines of the Palm Oil Research Center (PPKS). However, information on differences in *P. pendula* populations between sample trees and surrounding trees remains limited, even though this information is important for improving the Early Warning System (EWS) (Zen et al., 2021). So far, monitoring has been carried out on only one sample tree per hectare without considering population variation in surrounding trees, which may produce less representative estimates. Logically, the mechanism of larval dispersal through silk threads on intersecting fronds (Siallagan et al., 2022) means populations are not always uniform between trees. A more detailed understanding of population distribution will improve the efficiency of EWS and the long-term Integrated Pest Management (IPM) program. Plant pest attacks are one of the limiting factors for oil palm productivity. (Fauzana et al., 2024). This study aims to: (1) determine the population of *P. pendula* on the 9th, 17th, and 25th fronds in sample trees and six surrounding trees based on the level of attack category; (2) analyze population differences between fronds and between trees in one observation unit; and (3) determine the distribution pattern of pests at the tip, middle and base of the frond as a reference for monitoring after control.

2. Material and Methods

2.1. Place and Time of Research

The research was conducted in Division 03 of Begerpang Plantation of PT. PP London Sumatra Indonesia Tbk., Naga Timbul Village, Tanjung Morawa District, Deli Serdang Regency, North Sumatra Province, in January–February 2026. The location is in block 23113002 with an area of 27.48 Ha planted with TBM oil palm in the 2023 planting year. Geographically, the research location is at coordinates 3°28'00"N and 98°48'45"E° with an altitude of ± 80–130 meters above sea level (masl).

2.2. Research Materials and Tools

Materials included oil palm plants (planted in 2023), *P. pendula* pests, research block area maps, ziplock plastic bags (10 × 15 cm) to collect pest samples, and label paper. The equipment used includes stationery, documentation cameras, observation sheets, minor sets to open *P. pendula* bags, iron or wooden hooks to lower the fronds, red (severe attacks), yellow (moderate attacks), and green (light attacks) ribbons for marking sample trees, 10-liter box containers for sample storage, plastic chairs, and Microsoft Excel software for data processing.

2.3. Research methods

This type of research is quantitative descriptive with field observation methods. Data were collected through two sources: (1) primary data in the form of direct census results of pest populations on sample trees and surrounding trees; and (2) secondary data in the form of plantation information from the company (area size, census history, pest control data, rainfall data).

2.4. Research Procedures

The research procedure was carried out in four stages. First, a survey of the research site was conducted to confirm the existence of the research object. Second, the research location (block) was determined using the company's global census data to identify blocks infested with *P. pendula*. Third, the census was conducted, and sample trees were selected using purposive sampling based on three infestation categories (light = 1–5 pests/tree; moderate = 6–10 pests/tree; severe = >10 pests/tree) (Syed, R. A. and Saleh A., 1991). In each category, 5 sample trees were identified along with 6 surrounding trees, marked with colored ribbons. Fourth, direct observation and sampling of the *P. pendula* population were carried out using the following treatments:

PE 1 = 9th, 17th and 25th fronds

PE 2 = 8th, 16th and 24th fronds

Each leaf sheath is divided into three sections (section 1 = base, 2 = middle, 3 = tip) and two side sections (A = top, B = bottom). Pests are collected, placed in labeled plastic bags, and stored in a container box.

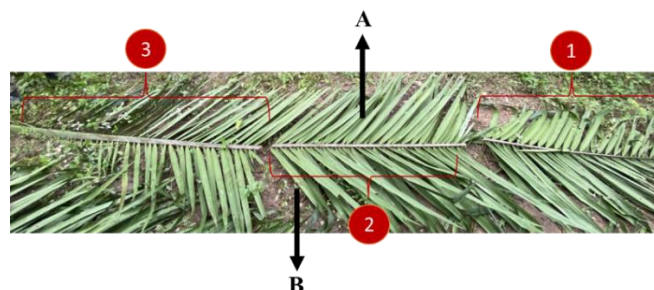


Figure 1. Leaf Section to See Population Distribution

2.5. Observation Parameters

The parameters observed in this study include: (1) the number of *P. pendula* eggs in the female's pouch; (2) the number of live and dead larvae per leaf stalk and per tree; (3) the population density of *P. pendula* on the main sample tree and six surrounding trees; (4) the activity habits and distribution patterns of the pest based on position on the leaf stalk (tip, middle, base); and (5) the population differences between the main sample tree and the surrounding trees.

2.6. Data analysis

Data were analyzed using Windows 11 Home Single Language software and Microsoft Excel 2019. Pest population density was calculated using the formula:

$$KP = \Sigma KH / TP$$

Description: KP = Population density; KH = Number of pests; TP = Number of trees observed (Daud, 2012). In addition to population density, the average number of live and dead larvae per leaf stalk and per sample tree was also calculated. The analysis results are presented in tables and graphs to facilitate interpretation of population differences between treatments and between attack categories.

2.7. Research Flowchart

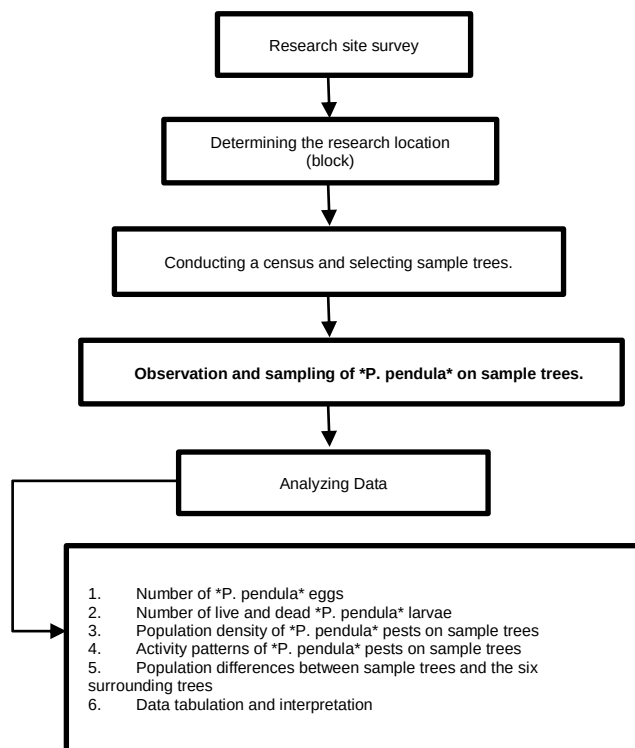


Figure 2. Research flow diagram

3. Results and Discussion

3.1. Condition General Research Location.

Study implemented in block 23113003, year Planting 2023, Division 03 Naga Timbul, Garden Begerpang PT PP

London Sumatra Indonesia Tbk. Rainfall affects the population of small larvae of *P. pendula*. Rainfall data for 2025–2026 are presented in Table 1.

Table 1. Rainfall Data for Kebun Naga Timbul 2025–2026

Information	Year			
	2025		2026	
	CH	HH	CH	HH
Average	251.58	9.25	90.75	7.25

Description: CH = Rainfall (mm); HH = Rainy Days (days). Source: Secondary Data from Begerpang Garden, 2026.

The average rainfall during the observation period (January–April 2026) was 90.75 mm/month with 7.25 rainy days, lower than the same period in 2025 (251.58 mm/month). When compared to the research location (Priwiratama et al., 2019), which has an annual rainfall ranging from 1,900–2,482 mm per year or equivalent to approximately 158–207 mm per month, the rainfall during this study (90.75 mm/month) was well below that range, which is approximately 42.5–56.3% lower. These drier conditions may increase the risk of *P. pendula* attacks by reducing natural mortality factors.

***P. pendula* Eggs.** Observation results showed that no *P. pendula* eggs were found in the sample trees in the light and moderate attack categories; eggs were found in the heavy attack category (276 eggs) during the observation period (Table 2).



Figure 3. *P. Pendula* eggs. Source: Primary Data, 2026

Population of Live Larvae and Dead Larvae of *P. pendula*. Observations showed the highest live larval population in the severe infestation category (994 individuals), while the lowest was in the mild infestation category (54 individuals) (Table 3). No dead larvae were found during the observations due to the high infestation and the lack of biological control measures. These results align with research (Priwiratama et al., 2019) reporting that

the *P. pendula* population explosion is dominated by the larval stage.

Table 2. Total *P. pendula* eggs in each attack category

Attack Level	Eggs (Average)
Light	0
Currently	0
Heavy	276



Figure 4. *P. pendula* larvae. Source: Primary Data, 2026

Table 3. Number of live larvae and dead larvae *P. pendula* in each attack category

Attack Level	Live Larvae (Average)	Dead Larvae (Average)
Light	54	0
Currently	110	0
Heavy	994	0

***P. pendula* pupae.** Pupae were found on the leaf stalks. Part lower with position hanging (Figure 5). The highest number of pupae was in the category weight (514 individuals), then in the category medium (99 individuals) and the lowest in the category light (47 individuals) (Table 4). The number of pupae indicates that the pest population has entered the phase of development and continues at the study location.

Imago population of *P. pendula*. Based on the observations, the highest number of *P. pendula* adults was found in the light-attack category, followed by the moderate-attack category, with the lowest number in the severe-attack category (Table 5). The adult population was highest in the light-attack category because adults begin to emerge during the early stages.

Table 3 and Figure 4 show that the live larval population was highest in trees with severe attacks, followed by trees with moderate attacks, and lowest in trees

with light attacks.



Figure 5. Pupa of *P. pendula*. Source: Primary Data, 2026

Table 4. Number of *P. pendula* pupae in each attack category

Attack Level	Pupa (Average)
Light	47
Currently	99
Heavy	514



Figure 6. Imago *P. pendula*. Source: Primary Data, 2026

Table 5. Number of *P. pendula* Imago in each attack category

Attack Level	Imago (Average)
Light	31
Currently	15
Heavy	2

Table 3 and Figure 5 show that young fronds (9) had no live larvae on lightly infested trees, indicating that the

attack was not ongoing. Meanwhile, medium- and heavily infested trees showed advanced damage to the young leaf stalks. This may be because several attacks had occurred previously.



P. pendula stages: (a) Larva, (b) Pupa, (c) Egg, (d) Imago just emerged from the pupa. Male, (e) Imago *P. Pendula*. Source: Primary Data, 2026.

3.2. Average Population Per Leaf

Table 3 and Figure 6 show that medium-sized fronds (17) had live larvae on lightly infested trees, indicating that the attack was ongoing. Meanwhile, medium- and heavily infested trees showed advanced damage to young leaf stalks. This may be because several attacks had already occurred and control measures were ineffective.

Table 3. Average Population per Leaf Stalk

Attack Level	Leaf sheath	Live larvae
		per leaf stalk
Light	9	0
	17	2.15
	25	1.65
	Average	1.27
Currently	9	6.35
	17	7.15
	25	7.9
	Average	7.13
Heavy	9	16.8
	17	37.55
	25	36.65
	Average	30.33

Source: Primary Data, 2026.

Table 3 and Figure 7 show that old fronds (25) had live larvae on infested trees. The larval population was higher on heavily infested trees than on lightly and moderately infested trees, indicating that the attack was ongoing. This may be because several attacks had occurred previously, control measures were ineffective, and the control system was inadequate. These results are inconsistent with those of Kamarudin and Basri Wahid (2010), who reported that the population of *P. pendula* under outbreak conditions can reach 60 live larvae per leaf sheath.

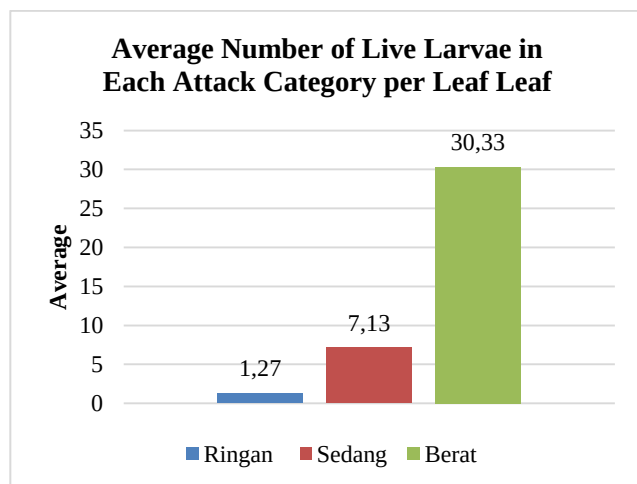


Figure 8. Average number of live larvae per attack

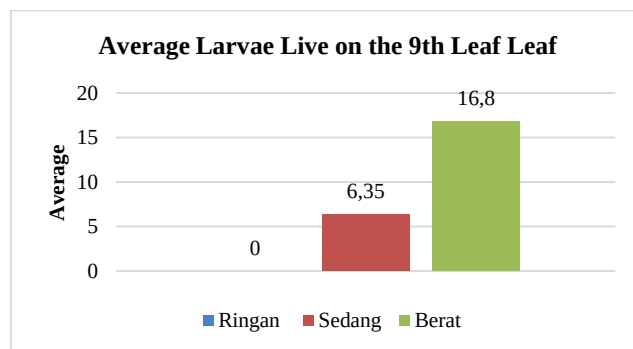


Figure 9. Average number of larvae living on the 9th leaf stalk

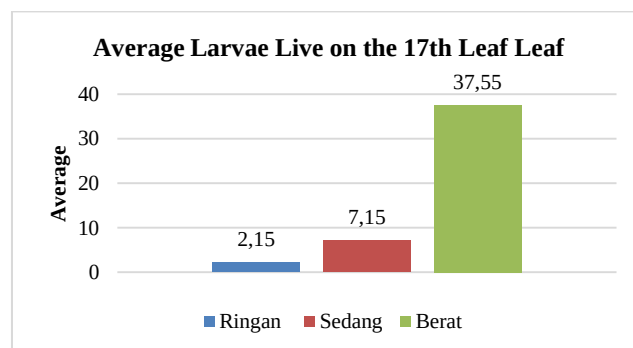


Figure 10. Average number of larvae living on the 17th leaf stalk

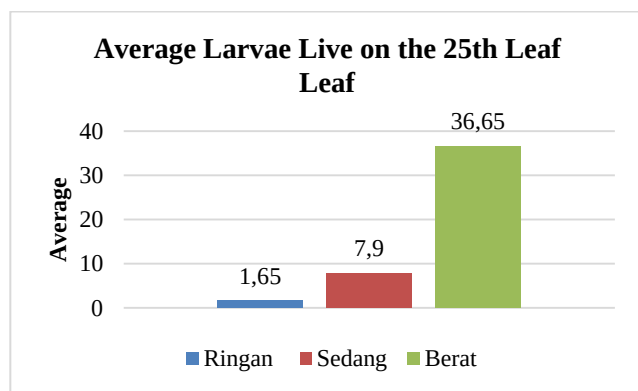


Figure 11. Average number of living larvae on the 25th leaf stalk

3.3. Average Population Per Tree sample

The highest population was found in the severe attack category, with an average of 26.8 individuals per tree in PE1 and 28.4 individuals per tree in PE2, the population obtained was larger than that of

The study (Murgianto et al., 2022) found the highest population of 5.62 larvae per leaf sheath. This difference is thought to be influenced by environmental conditions, the availability of natural enemies, plant age, and the level of infestation at each study location.

3.4. Population Density of *P. pendula* on the Main Sample Tree and Six Surrounding Trees

Population density in PE 2 was higher than in PE 1 in the light and moderate infestation categories. However, in the heavy infestation category, PE 1 had a higher average population density (14.9 individuals/tree) than PE 2 (13.5 individuals/tree). This difference is thought to be influenced by variations in microhabitat conditions, food availability, and the reproductive success rate of *P. pendula* in each observation plot.

3.5. Activity Habits and Distribution of *P. pendula* on Leaflets

Each leaf sheath is divided into three parts (1 = base, 2 = middle, 3 = tip) and two sides of the leaf (A = top, B = bottom)

Table 4. Habits Activity/distribution of *P. pendula* per leaf sheath

Position Leaf sheath	PE 1	PE 2	Total
End (1A+1B)	2157	1218	3375
Middle (2A+2B)	1467	722	2189
Base (3A+3B)	172	51	223

Source: Primary Data, 2026

The highest population was found at the tip of the leaf stalk (1A+1B) with a proportion of 56.8% in PE 1 and 61.2% in PE 2. Furthermore, the population in the middle of the leaf stalk (2A+2B) reached 38.6% in PE 1 and 36.3% in PE

2. In contrast, the lowest population was at the base of the leaf stalk (3A+3B), at only 4.5% in PE 1 and 2.6% in PE 2. These results are in line with research (Napiah et al., 2025) that reported that *P. pendula* populations tend to be concentrated in the active canopy and young leaves, which have better food quality.

3.6. Population Differences in the Sample Tree and 6 Surrounding Trees

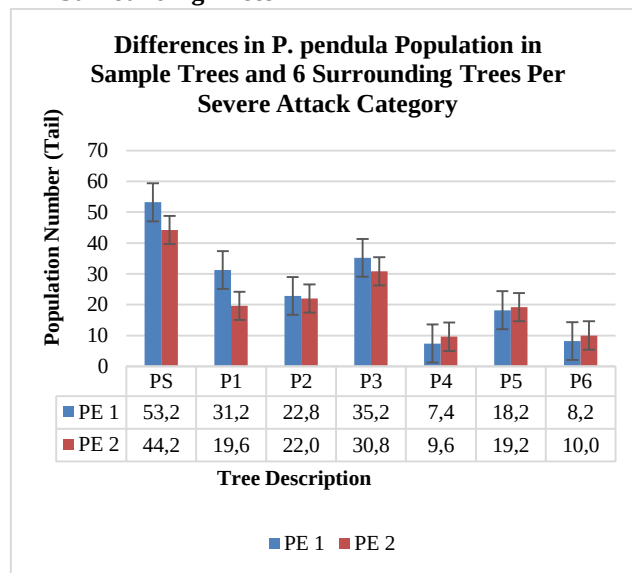


Figure 12. Population Differences in the Sample and 6 Trees Around It. Source: Primary Data, 2026.

P. pendula larvae in the sample tree (PS) were higher than in the six surrounding trees, with 53.2 larvae in PE1 and 44.2 larvae in PE2. Meanwhile, the average population of the six surrounding trees was only 20.5 larvae in PE1 and 18.5 larvae in PE2. This finding is in line with Anggraini et al. (2026), who reported that the distribution of *P. pendula* in oil palm plantations was clustered and uneven among trees. Furthermore, Johari et al. (2023) stated that larval density was the main indicator in the early detection system for bagworm attacks, while Murgianto et al. (2022) emphasized that the larval population census is the basis for control decisions. Therefore, six trees around the PS cannot directly replace the PS. After all, they have a population that is not representative of the PS, but can still be used as supporting census units and control targets in the Early Warning System (EWS), especially if the sample trees no longer show representative conditions because this pest can reproduce quickly and spread widely if not managed effectively. (Lubis et al., 2024).

4. Conclusion

Based on the research results, the following conclusions can be drawn that the population of *P. pendula* on fronds 9, 17, and 25 increased with increasing infestation severity. The average population ranged from

0.0 to 2.2 individuals per frond under light infestation, 6.1 to 8.2 under moderate infestation, and 14.1 to 39.2 under severe infestation. These findings indicate a close relationship between infestation severity and pest population density. Population levels differed between the sample tree (PS) and the six surrounding trees. The sample tree had the highest larval populations: 53.2 individuals (PE1) and 44.2 individuals (PE2). The corresponding averages for the six surrounding trees were only 20.5 individuals (PE1) and 18.5 individuals (PE2). This indicates that the sample tree is an infestation hotspot and a source of pest spread. Therefore, the six surrounding trees cannot serve as a proxy for the sample tree when monitoring attacks or planning control measures. P.

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