Bagworm infestation on *Shorea balangeran* in the degraded peatland restoration plot

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Abstract. Restoration through re-vegetation activities is one of the solutions to recover degraded peatlands quickly. *Shorea balangeran* is one of the most promising species of Dipterocarpaceae that can be chosen for the degraded peatlands rehabilitation. The bagworm is one of the potential pests to damage the *S. balangeran* in Ogan Komering Ilir (OKI) regency. The objective of the study was to provide various information about bagworm insect pests on *S. balangeran*. Two measuring plots of 50 x 32 m laid on 2017 planted *S. balangeran* in agrosilvofishery based on integrated peat restoration pilot project. The variables observed were the number of attacked plants to calculate incidence and the number of attacked leaves in each observation unit (tree) using a scoring system to calculate the intensity. The data obtained were analyzed by descriptive quantitatively. The results showed that there were two species of bagworm in *S. balangeran*. The incidence of both bagworms was quite high, but the intensity of damage was still relatively mild. However, control measures for bagworms still need to be carried out.

1. Introduction
South Sumatra has approximately 1,374,566 ha of peat swamp forests, one of the largest areas in Sumatra. The peatland areas were distributed in five districts, namely Ogan Komering Ilir (OKI), Banyuasin, Musi Banyuasin, Muara Enim and Musi Rawas. Among these five districts, the largest area of peat swamp forest is in OKI, covering 697,866 ha. Unfortunately, about 673,460 ha (96%) of the area has been degraded [1]. A forest fire has been the driving force for the peat swamp degradation or impairment in the OKI. One of the rapid responses to restore degraded peat swamp forests is to carry out restoration activities through planting [2].

*Shorea balangeran* is one of the most promising Dipterocarpaceae species to rehabilitate degraded peatlands, as it is able to build symbiosis with endomycorrhiza to assist roots in absorbing P elements from the soil [3 - 5]. *S. balangeran* is an important component of peat swamp forests in Southeast Asia and belongs to the red meranti (heavy wood group). In Indonesia, *S. balangeran* is mostly found in Sumatra and Kalimantan, with the height reaching up to 30 m and diameter up to 60 cm. At present, the population of *S. balangeran* has declined due to over-exploitation [6].

In 2017, *S. balangeran* was planted in Kedaton Village, Kayu Agung Sub-District, Ogan Komering Ilir (OKI) Regency, South Sumatra Province, in the area of heavily degraded peat swamp
caused by repeated fires. One of the factors that often become a problem in rehabilitation activities is the presence of pests and diseases. If the presence of pests and diseases are not managed properly, it may cause severe damage to plants and even death. Among the severe pest attacks that bring serious damage and loss to plants, bagworm infestation on the plant is one of them. The attack of bagworm *Metisa plana* on oil palm by 10-13% leads to a decrease in oil palm production by 3-40% for two years [7]. The attack of bagworm *Pteroma plagiophelps* on sengon plants lead to its death [8]. Information about the bagworm attack on *S. balangeran* is essential to be studied especially in Kedaton, OKI, considering the potential damage of the bagworm attack. This area is suffering forest fire repeatedly, and so far, there is a lack of record about this phenomenon. The results of this study will provide information related to bagworm species, the damage characteristics, distribution, and the attacks category in a specific season. The information could be used as references to protect *S. balangeran* from severe bagworm damage attack, whether for rehabilitation, conservation, or plantation development purposes.

2. Methodology

2.1. Research site

The study was conducted in a 4-ha agro-silvofishery that integrated with a pilot project on a peat restoration plot with deep inundation characters (>50 cm) at the peak of the rainy season and 3.5 - 5.5 m peat depth. Oil palm plantation has been established since 2008 on the very deep peatlands (>300 cm) around the plot area. The peat swamp forest area experienced fires repeatedly in 2011, 2012, 2014 and 2015. Administratively, the study site is located in Kedaton Village, Kayu Agung District, Ogan Komering Ilir (OKI) Regency, South Sumatra [2].

2.2. Observations plots

The study observed two plots of 50 x 32 m consisting of 40 plants on each plot. Censuses were carried out on all plants in each observation plot with the percentage and intensity of the attack as the observed parameters. Observations were carried out in September and December 2018, as well as in May 2019. At the time of observation, the average height of *S. balangeran* was 183 cm, 211 cm, and 228 cm, while for the DBH were 1.1 cm, 2.3 cm, and 3.1 cm, respectively.

2.3. Measurement of bagworms incidence and intensity

Incidence of an attack was obtained using the formula:

\[
P = \frac{A}{B} \times 100\%
\]

Remarks:
P : Incidence
A : The number of plants attacked in an observation plot
B : The total number of plants in an observation plot

Meanwhile, intensity (I) was obtained using the following formula:

\[
I = \frac{\sum (N_i \times V_j)}{Z \times N} \times 100\%
\]

Remarks:
I : Intensity
Ni : The number of plants attacked from each attack category
Vj : Scale value of each attack category
Z : The highest scale value of each attack category
N : The number of observed plants in each observation plot
Slightly modified scoring by [9] was used.
0 : Healthy
1: Mild (1-20%)
2: Moderate (21-40%)
3: Slightly Heavy (41-60%)
4: Heavy (61-80%)
5: Very Heavy (81-100%)

3. Result and Discussion
3.1. Insect pest species

The results showed that there were several species of leaf-eating insects attacking one and two years old *S. balangeran*, with the most dominant attack was by bagworm pest. Bagworm insect pest is a member of the Psychidae family and belongs to order Lepidoptera. The characteristic of bagworm is that it has their bags which made from silk and covered with leaf particles or other materials. This bag will continue to grow throughout the life of the larva.

Larvae stay in the bag until adult. The larvae will expel the head and part of the thorax (chest) from the pouch when eating and moving, while the abdomen (stomach) lives in the pocket [10, 11]. The bag has two holes, namely the anterior and posterior holes. Before the larvae become a cocoon, the two holes will close tightly, and the position of the larvae turns face down (posterior) [8]. Female moths’ shape is fixed like larvae, unable to fly, reduced wings and legs, while male moths have eyes, antennae and well-developed wings [12]. The life cycle of each species of bagworm insect varies from 3 to 7 months. Bagworm reproduces rapidly in a suitable environment so that a sudden population explosion possibly occurs [10]. Furthermore, [13] stated that the characteristics of these bagworms are wingless moths with high fecundity, spread through silk thread, highly polyphagous, maintain long life cycles, have short embryonic periods, experiencing parthenogenesis, and mostly unmarried female moths. The study observed two bagworm species attacking *S. balangeran* with different shapes and sizes of pockets. Based on [10] and research journals as references, the two species of bagworm were identified as *Cryptothelea* sp. and *Metisa plana*.

3.1.1. *Cryptothelea* sp. This bagworm owns a larger bag size than *Metisa plana* and *Pagodiella* sp. as the bag size approximately 4 cm. Various sizes of dried leaf pieces were pasted to the bag. This bagworm grows very fast, damages severely, and eats very fast. In a cocoon time, the bag appears smoother on the outer surface. The bagworm attacks meranti leaves, starting from the edge or center of the leaves. Young larvae bagworm eats the epidermis leaves, and subsequently, after adults, the bagworm eats all parts of the leaves. Bagworm attacks created damage, defects, and hole on the leaves (Figure 1). This bagworm found throughout Indonesia and Southeast Asia [10].

![Figure 1.](image.png)  
*Figure 1. Cryptothelea* sp. bagworm on the meranti plant (a) and the symptom of attack from *Cryptothelea* sp.(b).

3.1.2. *Metisa plana*. This bagworm insect owns a small bag size up to only 1.7 cm in length, covered by small pieces of round to rectangular dried leaves, rough and brown (Figure 2). According to [14], the larval instar reaches seven instars. At the time of the cocoon stage, the 15 mm bag looks smoother on the surface. Bagworm cocoon remains in a brownish-yellow bag. Cocoon stadium lasts for 25 days [15]. Male cocoon hangs like hooks on the lower surface of leaves [14]. The bagworm larvae attack
the leaves of *S. balangeran* by eating leaf mesophyll. Subsequently, the eaten leaves will dry out and fall, creating holes leaves. (Figure 2). Leaves would become fragile and have many hollows. It is also found on the attack of other plant species, including oil palm and cashew (*Anacardium occidentale*) [16] with similar symptoms to those of *S. balangeran*. In severe attacks, the leaves affected by *M. plana* become dry like burning because when the bagworm ate the leaf, they emit toxic fluid [17]. This bagworm species is one of the most important pest insects and most often appears in oil palm plantations due to its potential to reach the peak of attack [18]. This bagworm attack is the most detrimental because it causes a decrease in production [7, 19, 10].

### 3.2. Bagworms incidence and intensity

The results of the incidence and intensity of the two bagworm species pests on 1-year-old *S. balangeran* are presented in Table 1.

| Observation Month | Bagworm species | September 2018 | December 2018 | May 2019 |
|-------------------|----------------|---------------|---------------|----------|
|                   | P (%)          | I (%)         | P (%)         | I (%)    |
| **Cryptothelea**  | 83.75          | 11.35         | 67.5          | 5.77     |
| sp.               |                |               |               |          |
| **Metisa plana**  | 35             | 7.63          | 43.75         | 5.63     |
|                   |                |               |               | 61.28    |
|                   |                |               |               | 1.18     |
|                   | 0              |               | 0             | 0        |

Table 1 showed that the incidence of these two bagworms was quite high, based on the criteria of [9]. *M. plana* bagworm infestation on the one-year-old plant was categorized as mild to slightly heavy, while *Cryptothelea* sp. infestation was heavy to very heavy attacks. The high incidence of bagworm pests was probably due to the limited availability of bagworm natural enemies in the area. Thus it was unable to suppress the development of bagworms. The limited availability of natural enemies is probably due to the limited vegetation in this newly opened area, which resulted in limited food sources, such as pollen and nectar. Besides, this limited vegetation can limit the alternative host for natural enemies to reproduce. This is by the statement of [20, 7] that the condition of the new area had very limited vegetation resulted in the lack of host of natural enemies. Another factor of the high incidence of pests is food availability; thus, the abundance of nutrients in young leaves will make bagworm survive and develop [13].

Table 1 also shows that the bagworm attack of *Cryptothelea* sp. is more dominant than the *M. plana* bagworm as indicated by a higher percentage of the incidence and intensity of *Cryptothelea* sp bagworm attacks than the *M. plana* bagworm at first (September 2018) and second (December 2018) observation. This condition is more clearly seen in the third observation (at the beginning of May 2019), in which only the *Cryptothelea* sp. bagworm attack was found. In contrast, the *M. plana* bagworm attack has missing. It shows that the environmental conditions at the planting location of *S. balangeran* in Kedaton Village, Kayu Agung Sub-district, OKI are more suitable for the development of *Cryptothelea* sp. than *M. plana*. 

![Figure 2. *Metisa plana* bagworm on the meranti plant (a) and the symptom of attack from *M. plana* (b).](image)
The high and low percentage of the pest incidence is thought to be influenced by rainfall factors that directly sweep away a large portion of small insect populations, including *M. plana* bagworm, while indirectly affecting the high and low humidity of the location [21]. Furthermore, [21] stated that the optimum temperature required by *M. plana* to develop at all stages is 25-30°C. The maximum temperature limit is 40°C. Optimum humidity ranges from 80 - 85%.

Although the level of crop damage is still a mild attack category, control measures are still needed, given the high percentage of bagworm occurrence and the status of bagworm pests, which include the important pests in some plants. Some ways to reduce or suppress the widespread attack of bagworms are collecting bagworms by hand or light traps, then destroy them when the population density and occurrence percentage are still mild. Using chemical insecticides is considered when the occurrence percentage and attack intensity are categorized as slightly heavy to heavy. Research by [22] showed that the application of contact chemical insecticides (Chlorantranilipole and Indoxacata) and systemic insecticides (Dinotefuran and Chlorothianidin) applied to the soil effectively reduced feeding rates and larval growth after 50 days of treatment and controlling bagworms in trees. The results of the study by [23] also showed that the Flubendiamide insecticide sprayed with plants effectively suppressed the bagworm population and was safe against non-target insects. 3) Using bio-insecticide extracts of tubal roots (*Derris elliptica*). The results of the study by [24] showed that tuba root (*D. elliptica*) extract with a concentration of 15 gr / 100 ml effectively caused the death of *M. plana* bagworm larvae. This technique is best applied when the occurrence percentage and attack intensity are moderate. Also, according to [25], economically, the cost of control through early detection is much lower than control after the pest spreads widely.

4. Conclusion
Two species of bagworms, namely *Cryptothelea* sp. and *M. plana*, were found in the one-year-old meranti (*S. balangeran*) plants in Kedaton Village, Kayu Agung District, OKI Regency. The incidences of both bagworms were quite high, but the level of damage was relatively mild. Nevertheless, control measures for bagworm infestation are still necessary to be conducted, considering that bagworms have a great potential of damage to the plantation. Control measures will be effective and efficient if carried out in an integrated way as early as possible. Therefore, regular monitoring activities are necessary so that the presence of pests can be detected at the earliest possibility.

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