THE EVALUATION OF BAGWORM, *METISA PLANA* (LEPIDOPTERA: PSYCHIDAE) INFESTATION AND BENEFICIAL PARASITOIDS IN OIL PALM *(ELAEIS GUINENSIS)* PLANTATIONS IN FELDA GUNUNG BESOUT 2, PERAK, MALAYSIA

SARAH THAER MUKHLIF ALRAJEH

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ABSTRACT

Oil palm *(Elaeis guinensis)* plantation is one of the economic pillars of countries rich in biodiversity in tropical regions. In oil palm plantation, pests and diseases are the major problems that cause low production in oil palm. Bagworm, *Metisa plana* (Lepidoptera: Psychidae) are the most destructive pest in oil palm plantations in Malaysia, resulting in high yield losses of up to 43% over two years after infestation. Therefore, this study was aimed to examine bagworm infestations, their damaging impacts based on bagworm stages, and the damages occurred in the oil palm plantations in Felda Gunung Besout 2. A total of 57 palm trees were systematically selected, and bagworm and parasitoid samples were collected from several selected areas in two stages. At first stage, nine (9) fronds were randomly picked from each tree. The severity of bagworm infestations was measured based on the severity scale of damage symptoms caused by bagworms. At second stage, parasitoids were collected from the same oil palm trees by hand and with yellow sticker traps before being identified in the laboratory. The results showed that infestation rates in the selected oil palm plantations were 50.9%, 31.6%, 4% and 3.5%, which were rated as high, moderate, low, and very low, respectively. The results also showed stage-seven bagworms were the most destructive pest, followed by stage-one, six, and five. According to the result, several potential parasitoids were identified with the highest Eulophidae: *Tetrastichus sp.*, which belong to the Hymenoptera order. These findings will provide great information for planters and researchers about the bagworm stages and their impacts on the infection rates in oil palm plantations. Thus, enabling a more effective biological control to reduce or eliminate bagworms from oil palm plantations in total.

PENILAIAN INFESTASI BAGWORM, *METISA PLANA* (LEPIDOPTERA: PSYCHIDAE) DAN PARASITOID YANG BERMANFAAT DI LADANG-LADANG KELAPA SAWIT FELDA GUNUNG BESOUT 2, PERAK, MALAYSIA

ABSTRAK

Perladangan kelapa sawit (*Elaeis guinensis*) merupakan salah satu cabang ekonomi yang penting untuk negara-negara di kawasan tropika yang kaya dengan biodiversiti. Dalam penanaman kelapa sawit, serangga perosak dan penyakit merupakan masalah yang telah menjejaskan pengeluaran kelapa sawit. Bagworm, atau *Metisa plana* (Lepidoptera:Psychidae) merupakan serangga perosak yang paling memudaratkan di ladang-ladang kelapa sawit di Malaysia di mana pengeluaran kelapa sawit merosot sehingga 43% dalam tempoh dua tahun selepas berlakunya infestasi. Oleh itu, kajian ini dijalankan untuk mengkaji infestasi bagworm, impak kerosakan mengikut fasa-fasa bagworm, dan kerosakan yang terjadi pada tanaman di Felda Gunung Besout 2. Sebanyak 57 pokok kelapa sawit dipilih secara sistematik; dan sampel-sampel bagworm dan parasitoid dikutip dari beberapa kawasan dalam dua fasa. Pada fasa pertama, sembilan (9) pelepah dikutip secara rawak dari setiap pokok. Tahap kerosakan infestasi bagworm diukur berdasarkan skala kerosakan mengikut gejala-gejala kerosakan. Pada fasa kedua, spesimen parasitoid dikutip dari pokok-pokok kelapa sawit yang sama dengan tangan dan perangkap-perangkap dengan pelekat kuning sebelum dikenal pasti di makmal. Dapatan menunjukkan kadar infestasi pada pokok-pokok kelapa sawit adalah 50.9%, 31.6%, 4%, dan 3.5% yang berada pada tahap tinggi, sederhana, rendah, dan sangat rendah, masing-masing. Dapatan juga menunjukkan bagworm fasa tujuh adalah serangga perosak yang paling merosakkan, diikuti dengan bagworm fasa satu, enam dan lima. Dapatan turut menunjukkan beberapa jenis parasitoid telah dijumpai, terutama Eulophidae*: Tetrastichus sp* yang tergolong dalam kumpulan Hymenoptera. Dapatan kajian ini dapat memberikan informasi berguna kepada para penanam dan penyelidik mengenai fasa-fasa bagworm dan impak mereka terhadap kadar infestasi di ladang-ladang kelapa sawit. Oleh itu, kawalan secara biologi dapat dijalankan dengan lebih berkesan agar perosak tanaman jenis bagworm ini dapat dikurangkan atau dibasmi dengan sepenuhnya di ladang kelapa sawit.

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MPOB	Malaysian Palm Oil Board
mm	Millimeter
%	Percentage
ºC	Celsius
VIF	Variance inflation factor
S	Stage
N	North
E	East
Ha	Hectares
GPS	Global Positioning System
No.	Number
SPSS	Statistical Package for the Social Sciences
GIS	Geographic Information System
3D	Three Diminutions
SD	Standard Deviation
FFB	Fresh Fruit Bunches
CPO	Crude Palm Oil

CHAPTER 1

INTRODUCTION

1.1 Research Background

Oil palm *(Elaeis guinelnsis)* planting is one of the economic pillars of countries rich in biodiversity in tropical regions (Ghazali et al., 2016). It is similar to date palms, which are known in Arab countries, which produce sweet date fruits rich in sugars, but the oil palm is rich in vegetable oils and fats instead of sugars. With the increasing rate of oil palm expansion, insect pest infestation such as bagworms in oil palm plantation has become a primary concern among stakeholders (Foster et al., 2011; Syari Jamian et al., 2017).

Recently, with the large-scale planting of oil palm, bagworm (Lepidoptera: psychidae) is considered as the most destructive insect pest on oil palm that occurs in most oil palms plantation areas in Malaysia (Dong et al., 2017; Syari Jamian et al., 2017; N. Kamarudin & Arshad, 2006). A damage of 50% for oil palm plantation by pests (i.e. bagworm pests) will cause a yield decline of around 43% over the next two years (N. Kamarudin & Arshad, 2006; Woittiez et al., 2017). Even a lower damage such as 10-13% of bagworm infestation can also cause a similar yield loss (N. Kamarudin et al., 2017; N. Kamarudin & Arshad, 2006). Besides, the major pests consist of three species in Malaysia causing the outbreaks, including *Mahasena corbetti*, *Metisa plana* and *Pteroma pendula (Lepidoptera: Psychidae)* (N. Ahmad et al., 2020; N. Kamarudin & Arshad, 2006).

According to the increasing bagworm attacks, the Malaysian Palm Oil Board (MPOB) carried out a survey in 1985 for outbreaks over (1981 – 1985) (Mohamed et al., 2020). An inevitable concern remains about the problems caused by a bagworm on palm oil in 2014 (Ramie et al., 2004). This survey presented, there was a consensus that the bagworm had become a more serious pest (Mohamed et al., 2020). And if this scenario cannot controlled, then it will cause plant death (Salim et al., 2015).

Moreover, the bagworm can be caused damage in the emerged leaves of the palm, which is the growing point of the palm tree (Woittiez et al., 2017). This means that the growing point should produce more leaves because there will be a flower at the base of each frond. However, bagworm caused damage to the growing point where there will be no frond as well as no flowers. Moreover, the available bagworm

insect grows through seven instars. The bag is continually enlarged throughout development as the larva undergoes seven instars (M. Mat et al., 2008). Moreover, they consist mostly of females with a high mating success in the upper tree crown (Rhainds & Sadof, 2009; Yang & Karban, 2019). Therefore, there is an essential need to evaluate and highlight bagworm stages and their impact on the incident of oil palm plantation.

Therefore, the production of fruits will be reduced, which is a source of oil; thus, the production of oil and its quality will be decreased as well (Barcelos et al., 2015). For this great damage caused by the bagworms, farmers used common practices to eliminate bagworms using chemical applications, which causes serious environmental pollution (N. Ahmad et al., 2020; Zhou et al., 2014). However, the excessive use of pesticides and insufficient awareness of the negative effects they cause, led to a major pollution of air, water and soil, which may adversely affect human health (Al-Zaidi et al., 2011). Moreover, pesticides caused damage to living organisms such as the natural enemies (parasites and predators), which weaken their role in the process of natural control and leads this to a serious imbalance in the environment (Cabello et al., 2012; Thakur et al., 2020). Also, pesticides caused great damage to non-targeted animals such as birds and bees. In addition, the improper use of pesticides has led to the emergence of resistance to pesticides from insect pests (Al-Zaidi et al., 2011; Cabello et al., 2012). Thus, leading to the outbreak of new pests that did not already exist (Zhou et al., 2014).

According to that, the risks and disadvantages caused by the chemical pesticides, as well as to eliminate the pests in a conscious way, biological control was used to eliminate the insect's pests (Foerster et al., 2015; Zhou et al., 2014). According to (Cardinale et al., 2003; Fazal et al., 2012), benefit insects are known to be an excellent tool for the biological control of insect pests. Insects such as parasitoids serve an important role in regulating bagworm populations in oil palm plantations (Cheong et al., 2010). Moreover, there are many natural enemies in the oil palm plantation (Gray & Lewis, 2014). Further investigations also need to highlight and evaluate potential parasitoid in oil palm plantation.

1.2 Problem Statement

Oil palm trees, like others plant, are exposed to diseases and pests (Beulé et al., 2018; Gitau et al., 2009; Shariffah-Muzaimah et al., 2020). In oil palm plantation, yield can be severely affected by pests that compete against the palm for nutrients, infect, or damage the palm (Verheye, 2010; Woittiez et al., 2017). Bagworms (Lepidoptera: Psychidae) are one of the important leaf-eating pests of oil palm in Malaysia and Indonesia (Hisham, 2012; Nurdiansyah et al., 2016). Infestations and outbreaks of bagworm have occurred in Malaysia for over five decades. It continues to be a problem today despite the fact that effective control measures are available (Loong & Chong, 2012). Crop losses, due to the extent of defoliation by a serious bagworm attack, are inevitable (Hanysyam et al., 2013). A moderate defoliation of about 10%-13% may cause a crop loss and decrease in production of oil palm about 33%-40%

(Hanysyam et al., 2013; Syari Jamian et al., 2017; N. Kamarudin & Wahid, 2010). Moreover, the extensive defoliation by a serious bagworm attack is inevitable in palm trees causing crop losses (Norman & Othman, 2016).

However, this study has not come across any other research that has exclusively determined the impact of the bagworm stages and their damage on the incidence of oil palm plantation. Therefore, this study will be determined which bagworm stage has a higher impact on oil palm damages.

The pesticides applied to agricultural lands affect non-target organisms and contaminate soil and water media (Da Marinho et al., 2020; Margni et al., 2002). Control of bagworms by insecticides, particularly in the later larval stages considered not successful, because it is not as effective when the bagworm close their bags (Rhainds & Sadof, 2009). Besides, the adult females, male and female pupae, and the eggs are completely concealed in the bags and are not affected by insecticides (M. Ahmad et al., 2013). Moreover, height of the plant is the problem for spraying insecticides as they attain more than 20 feet height within 15 years in irrigated plantations, though root feeding and stem injection are being practiced, it may pose residue problem (Kalidas, 2012). The efficacy of chemical pesticides tends to diminish over time. This is because any organism that manages to survive the initial application will pass on its genes to its offspring and a resistant strain will be developed.

The biological control of bagworm populations to the maintenance of local habitat complexity and farmland biodiversity (Syari Jamian et al., 2017). The parasitoids have been widely used in biological control programs and it showed parasitoids can be a good weapon to control Lepidoptera pests (De Oliveira et al., 2017; De Souza Tavares et al., 2009; Pijnakker et al., 2020). Due to it has a high capacity of parasitism (De Souza Tavares et al., 2009). Thus, this study will be evaluated the availability of the parasitoid in oil palm Perak plantation in order to provide clear guidelines and recommendations about the available natural enemies for other research that aim to control the oil palm plantation biologically to reduce or eliminate bagworm on oil palm Perak plantations.

1.3 Research Questions and Hypothesis

Five important questions are presented in this research as following:

1. What is the extent of the bagworm infestation in Felda Gunung Besout 2?
2. What are the damages of bagworm in Felda Gunung Besout 2?
3. What are the impacts of the bagworm stages on the incidence of Felda Gunung Besout 2?
4. Which bagworm stage has a higher impact on Felda Gunung Besout 2?
5. What is the availability of the parasitoid in Felda Gunung Besout 2?

Moreover, the hypothesis is presented as follows. Bagworm, Metisa plana is the most destructive pest in the oil palm plantation in Malaysia, which cause high yield losses up to 43%. The biological control can reduce the bagworm populations safely and efficiently using beneficial insects such as parasitoids and reduce the excessive use of pesticides which could cause environmental pollutions and damage to the non-target organisms.

1.4 Research Objectives

1- To evaluate the bagworm infestation in Felda Gunung Besout 2.
2- To determine the impact of the bagworm stages and their damage on Felda Gunung Besout 2.
3- To evaluate the potential parasitoid in Felda Gunung Besout 2.

1.5 Connections among Research Objectives and Questions

In this section, all the research questions have been answered by the research objectives. Each objective is linked to one or two questions. Table 1.1 below presents the connection amongst research objectives and research questions.

Table 1.1

Connection amongst research objectives and questions

Research objectives	**Research questions**
1. To evaluate the bagworm infestation in Felda Gunung Besout 2	1. What is the extent of the bagworm infestation in Felda Gunung Besout 2?
	2. What are the damages of bagworm in Felda Gunung Besout 2?
2. To determine the impact of the bagworm stages and their damage on Felda Gunung Besout 2	3. What are the impacts of the bagworm stages on the incidence of Felda Gunung Besout 2?
	4. Which bagworm stage has a higher impact on Felda Gunung Besout 2?
3. To evaluate the potential parasitoid in Felda Gunung Besout 2	5. What is the potential parasitoid in Felda Gunung Besout 2?

Table 1.1 shows, the first objective is answered the first two questions, the second objective is answered the third and fourth questions. Moreover, the third objective is answered the fifth question.