ASIAN JOURNAL OF AGRICULTURE
Volume 9, Number 2, December 2025
Pages: 472-481
E-ISSN: 2580-4537
DOI: 10.13057/asianjagric/g090214

Comparative biology of bagworm larvae (*Metisa plana*) fed on oil palm (*Elaeis guineensis*) and malabar melastome (*Melastoma malabathricum*)

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Manuscript received: 18 March 2025. Revision accepted: 4 September 2025.

Abstract. *Anggraini E, Istiqomah H, Irsan C, Herlinda S, Muslim A, Suwandi. 2025. Comparative biology of bagworm larvae (*Metisa plana*) fed on oil palm (*Elaeis guineensis*) and malabar melastome (*Melastoma malabathricum*). Asian J Agric 9: 472-481.* *Metisa plana* Walker, 1883 (Lepidoptera: Psychidae) is a significant defoliator in oil palm plantations, and the weed *Melastoma malabathricum* L. (malabar melastome) is believed to act as an alternative host, potentially maintaining pest numbers. This study assessed the comparative biology of *M. plana* larvae raised individually on oil palm and malabar melastome leaves in a laboratory setting. Recently emerged larvae ($n = 10$ per treatment) were observed for leaf area consumption, larval bag form, developmental time, and survival rates. The results indicated that larvae consuming malabar melastome had a substantially greater leaf area consumption during instars 1-3 (up to 11.44 ± 0.96 cm^2) compared to those fed on oil palm (8.91 ± 0.58 cm^2; $p < 0.05$), with the differences becoming non-significant from the 4th instar forward. The total duration of larval development was roughly 109 days on Malabar melastome and 103 days on oil palm, with no statistically significant difference ($p > 0.05$), while survival rates above 80% on both hosts. The length of larval bags exhibited substantial variation in the early instars ($p < 0.01$), but remained comparable in subsequent stages, and pupal weight was not assessed. The findings affirm that *M. malabathricum* serves as an appropriate alternate host for *M. plana*, underscoring the necessity for integrated weed management to avert malabar melastome from functioning as a reservoir, thereby enhancing the efficacy of pest management measures in oil palm ecosystems.

Keywords: Bagworm, host plant suitability, insect larval development, *Metisa plana*

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is one of the most significant plantation crops in Indonesia (Purnomo et al. 2020). The oil palm is the most productive vegetable oil crop, playing a crucial role in both the country's economy and global edible oil production (Tabe-Ojong et al. 2023). Beyond vegetable oil production, oil palm derivatives are widely utilized in the food, textiles (lubricants), cosmetics, pharmaceuticals, and biodiesel industries. Furthermore, detritus from palm oil mills, including coir, shells, and empty palm bunches, can be utilized as organic fertilizer and biofuel, contributing to the sustainability of the industry (Murphy et al. 2021).

Despite its economic importance, the productivity of oil palm can be threatened by the presence of various pests (Sulaiman and Talip 2021). The insect defoliators of oil palm primarily consist of lepidopteran larvae, including limacodids, nymphalids, psychids, and elachistids (Egonyu et al. 2022). Bagworms (Lepidoptera: Psychidae) are among the most destructive pests in oil palm plantations, capable of causing severe defoliation and significant yield losses (Wood and Kamarudin 2019a). *Metisa plana* Walker, 1883; *Pteroma pendula* de Joannis, 1929; *Mahasena corbetti* Tams, 1928; and *Dappula tertius* (Templeton, 1847) are among the most prevalent bagworm species in oil palm plantations (Wood and Kamarudin 2019b). Bagworms are particularly challenging to control due to their portable bag (Sugiura 2016). The larvae create the bag using their own silk and plant materials, which serve as a physical barrier against natural enemies and environmental hazards (Rhainds et al. 2009; Sugiura 2016). Bagworm species have the potential to reach epidemic levels, characterized by a persistent increase in their population beyond the normal range. This uncontrolled population can lead to severe defoliation, causing the lower and middle layers of the canopy to appear grey and resulting in a significant decline in overall yield (Lelana et al. 2022). Among bagworm species, the infestation of *M. plana* is the most severe and widespread in oil palm plantations, causing extensive damage due to its high survival rate and prolonged life cycle (Basri et al. 2022).

High survival rates and prolonged life cycles of insects may be influenced by the presence of alternative host, particularly weeds (Kumar et al. 2021). The alternative hosts provide additional food sources for the pest. Malabar melastome has been reported to attract a wide range of insect taxa, including members of the orders Hymenoptera, Coleoptera, and Hemiptera (Ataa et al. 2017), and thus plays an important ecological role by providing nourishment and habitat for numerous insect species. Insects locate host plants through a combination of chemical cues, such as volatile organic compounds that signal suitability for feeding or oviposition (Serdo and Degaga 2023), and visual traits, including color, morphology, and texture, which aid in host recognition (Arnold et al. 2016). Malabar melastome, a member of the Myrtaceae family (Mustaqim 2020), is characterized by its distinctive pink flowers and bell-shaped, dark purple edible fruits (Omar et al. 2012). This species is commonly found in oil palm plantations in South Sumatra, Indonesia, where its presence may provide an alternative food source that supports *M. plana* survival. Preliminary field observations have indicated that *M. plana* larvae actively feed on malabar melastome leaves (unpublished data), suggesting a possible ecological association.

Given these ecological associations and preliminary observations of *M. plana* feeding on malabar melastome, it is essential to investigate whether this plant functions as an alternative host capable of sustaining bagworm populations. The potential role of malabar melastome as an alternative host for *M. plana* has not yet been substantiated through empirical investigation. This aspect remains insufficiently understood, even though alternative hosts can act as reservoirs that maintain or augment insect pest populations during periods of reduced availability of the primary host, thereby reducing the effectiveness of current management strategies. To address this issue, the present study evaluates the life span of *M. plana* larvae when fed on Malabar melastome leaves in comparison with oil palm fronds. Clarifying the suitability of malabar melastome as an alternative host will enhance our understanding of *M. plana* population dynamics and support the development of more targeted and sustainable pest management strategies in oil palm plantations.

MATERIALS AND METHODS

Procedures

Preparation of experimental plants

Oil palm and malabar melastome were used as host plants in this study. Both plants were approximately six months old. The oil palm plants had developed five to six fronds. In order to maintain optimal growing conditions, the plants were cultivated in polybags and kept under a humidified canopy. This setup was designed to create suitable conditions for the survival of bagworms.

Insect collection and rearing

Metisa plana bagworms were originally collected from oil palm plantations in Muara Enim District, South Sumatra, Indonesia, and subsequently reared under controlled laboratory conditions. All individuals used in this experiment were obtained from rearing them in this laboratory to ensure consistency and prior adaptation to rearing conditions. To evaluate the feeding performance of *M. plana* on oil palm and malabar melastome, first-instar larvae from the laboratory colony were employed. Each first-instar larva was carefully transferred onto an individual experimental plant, with one larva assigned per plant, and each plant was maintained within a separate insect cage. To limit the danger of external microbial contamination, no antimicrobial agents or antibiotics were employed during the raising procedure. Sanitary conditions within the raising cages were upheld by regularly spraying the internal surfaces with 70% alcohol. Furthermore, before being utilized as larval feed, the surface of each plant leaf was delicately cleansed using distilled water to eliminate possible surface pollutants. These approaches were implemented to mitigate the risk of introducing foreign microorganisms while preserving the natural interactions among plants, microbes, and insects. Nonetheless, the possible existence of undiscovered microbes could not be completely ruled out under these circumstances.

Observations of Metisa plana *larval life span*

The observations of *M. plana* larvae life span were conducted in insect cages. During the rearing process, humidity levels within the enclosures were regulated using a 3-liter Ace Kris ultrasonic humidifier, which maintained consistent relative humidity suitable for larval development. The humidifier was operated for one hour per enclosure before being moved to another enclosure. The rearing of *M. plana* larvae was conducted under controlled laboratory conditions at 25-30°C with relative humidity maintained using an ultrasonic humidifier. The photoperiod was set to a 12:12 hour light: dark cycle, simulating natural day and night conditions. Larvae were individually placed on whole host plants, with each plant enclosed in a separate insect cage and provided with fresh plant material daily to ensure optimal nutrition and minimize stress. The rearing cages were left uncovered from 6:00 am to 6:00 pm to simulate the light phase (Figure 1.A), and then covered with black cloth from 6:00 pm to 6:00 am to simulate the dark phase (Figure 1.B), thereby establishing a 12:12 hour light: dark photoperiod that mimics the natural environment of *M. plana* larvae.

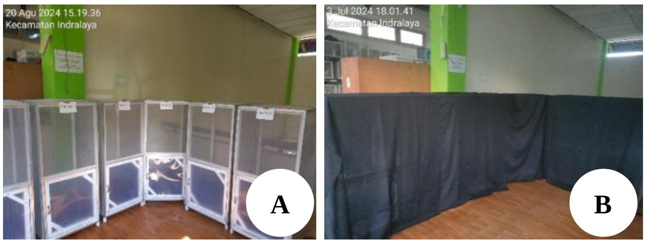

Figure 1. A. Rearing bagworms during the daytime, B. Rearing bagworms in the evening and night

Neonate bagworms (*M. plana*) obtained from the laboratory rearing process were used to observe larval lifespan in this study. Only newly emerged larvae (24 hours old) were selected and assigned to experimental treatments. One larva was placed on one plant, and each plant was enclosed in a separate cage, with 10 replicates per plant species. This study utilized whole host plants as the larval food supply. Daily, *M. plana* larvae were relocated to a freshly prepared, vigorous entire plant of the respective host species. The daily substitution guaranteed that the larvae consistently received new plant material, hence reducing fluctuations in leaf quality caused by withering or deterioration. The entire plants used for the experiment were of comparable age, size, and physiological state to ensure uniformity in food quality among treatments. The observations were conducted twice daily, once in the early morning and once in the late afternoon. A ruler was used to measure the larvae which were measured from the 1st instar stage until pupation. The measurements included the width and length of the larval bag. Additionally, the color and girth of the bag were observed in bagworms that consumed oil palm fronds and malabar melastome leaves.

Bagworm feeding capacity

The number of leaves consumed by the bagworm was determined by observing the symptoms or leaf perforations resulting from their feeding activity. The amount of leaf consumption was quantified by measuring the diameter of the eaten areas. A white paper was placed beneath the leaves to enhance contrast before photographing them. The visibility of the width of the consumed leaves was crucial for obtaining precise data. The BioLeaf application was utilized to calculate the width of the consumed leaves. An image depicting the width at which the bagworms fed was sent to the application, and the outcomes were promptly displayed. The degree of defoliation was recorded as a percentage (%). These measurements were taken daily to track the progressive feeding activity of the bagworms.

Data analysis

Prior to analysis, data on the lifespan of *M. plana* larvae were tested for normality using the Kolmogorov-Smirnov test and for homogeneity of variances using Levene's test. After confirming that the assumptions of normality and homoscedasticity were met, differences in lifespan between larvae fed on oil palm and malabar melastome were analyzed using an independent test at a significance level of $\alpha = 0.05$ with R software (version 4.3.2). The color and shape of the larval cases of *M. plana* were analyzed descriptively based on direct visual observations.

RESULTS AND DISCUSSION

Leaf area consumed by bagworm

The results showed that the instar phase of *M. plana* larvae influenced the area of leaf consumption. There was a significant difference of leaf area consumed by the 1st, 2nd and 3rd larval instars, whereas no significant differences were observed among the 4th, 5th, 6th and 7th instars. During the early instars (1st to 3rd), the larvae feeding on the malabar melastome consistently consumed significantly more leaf areas than those on oil palm. However, from the Instar 4 onwards, the differences were no longer significant, suggesting that as larvae matured, their feeding behaviour became similar regardless of the host plant. The highest consumption was recorded at the 3rd instar, where the larvae on the malabar melastome consumed 11.33 cm^2 in the morning and 11.44 cm^2 in the afternoon. Although slight variations were observed between the morning and afternoon observations, the overall trend remained similar (Table 1).

Bagworm feeding resulted in irregular holes or notches in the foliage, primarily on the adaxial surface rather than the abaxial surface of the leaves (Figure 2). The early feeding scars created by bagworms on plant tissue typically appeared as white or light-colored patches. The bagworms' consumption of leaves damaged the cellular structure and could strip away the outer layers, exposing the lighter interior tissue. Eventually, these areas might get discolor to brown as the plant tissue sustained injury and deteriorated. Additionally, bagworms' faeces were visibly present near their eating sites. These excretions generally appeared as small black pellets and accumulated on the leaves of infested plants.

Table 1. Average of the total leaf area consumed by *Metisa plana* larvae in oil palm and malabar melastome

Plant	**Average of the total leaf area consumed by *Metisa plana* larvae on oil palm and malabar melastome (cm^2 ± Standard of deviation)**						
	Instar 1	**Instar 2**	**Instar 3**	**Instar 4**	**Instar 5**	**Instar 6**	**Instar 7**
Observation in early morning							
Malabar melastome	7.48±0.90	8.72±0.47	11.33±0.95	10.19±0.40	9.24±0.39	9.9±0.35	9.3±0.31
Oil palm	3.72±0.37	6.94±0.88	7.18±0.57	8.3±0.69	9.18±0.36	10.64±1.51	8.19±1.03
P-Value	0.001*	0.02*	0.002*	0.80^{ns}	0.92^{ns}	0.65^{ns}	0.34^{ns}
Observation in late afternoon							
Malabar melastome	7.4±0.80	9.36±0.62	11.44±0.96	9.99±0.30	8.93±0.36	9.69±0.48	9.47±0.46
Oil palm	4.44±0.52	7.5±0.87	8.91±0.58	10.51±0.75	10.5±0.65	11.06±0.49	8.03±0.84
P-Value	0.008*	0.02*	0.04*	0.54^{ns}	0.05^{ns}	0.07^{ns}	0.17^{ns}

Note: ns = not significantly different, * = significantly different, at alpha 0.05 t-test

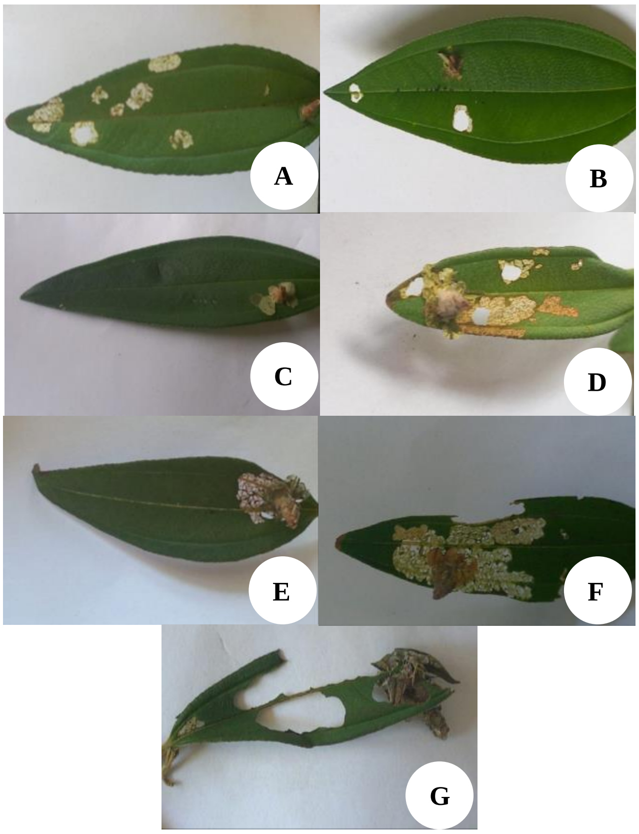

Figure 2. *Metisa plana* feeding on malabar melastome at: A. Instar 1, B. Instar 2, C. Instar 3, D. Instar 4, E. Instar 5, F. Instar 6, G. Instar 7

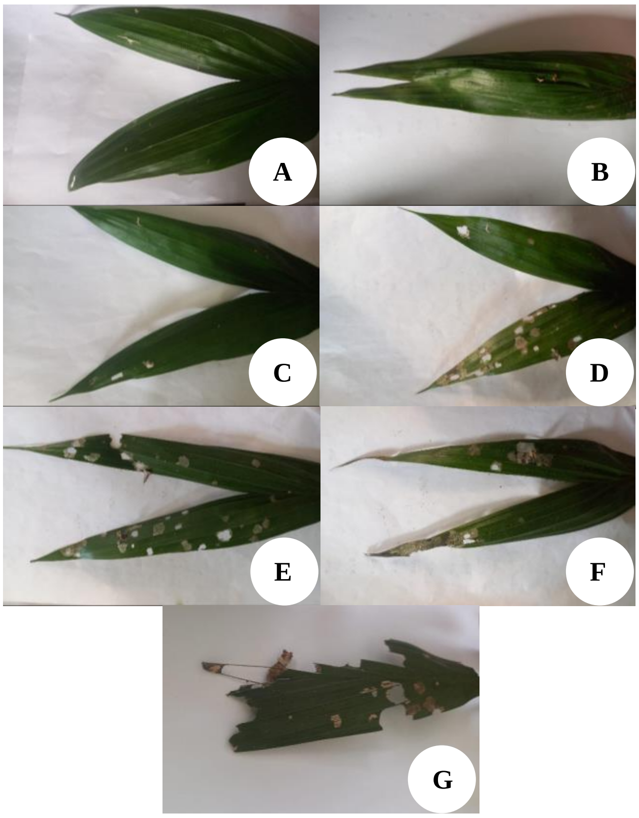

Figure 3. *Metisa plana* feeding on oil palm fronds at: A. Instar 1, B. Instar 2, C. Instar 3, D. Instar 4, E. Instar 5, F. Instar 6, G. Instar 7

Metisa plana predominantly consumed the adaxial surface of oil palm fronds (Figure 3). Feeding activity resulted in uneven apertures and indentations on the adaxial surface, while the abaxial surface exhibited minimal damage. Affected regions began wilting and discoloring as the leaf tissue degraded due to the feeding activities. *Metisa plana* larvae selectively consumed softer leaf tissue while preserving the tougher veins and structural components. This feeding behaviour led to the formation of a lacy or skeletal appearance on the affected fronds.

Larval bag length of *Metisa plana*

The results revealed that the lengths of the larval bags in *M. plana* instars 1 and 2, fed on oil palm fronds and malabar melastome leaves, were significantly different. However, the lengths of the larvae from instars 3 to 7 did not show significant differences based on the t-test analysis. Overall, *M. plana* larvae that consumed malabar melastome leaves developed longer larval bags compared to those that fed on oil palm fronds (Table 2).

Larval bag width of *Metisa plana*

The results showed that the bag widths of *M. plana* larvae at instars 1 and 2, which consumed oil palm fronds were significantly larger than those that consumed malabar melastome leaves. However, for the instars 3 to 7, the bag widths of *M. plana* that consumed *Melastoma malabathricum* L. leaves were similar to those that consumed oil palm fronds. Overall, the larval bag widths of *M. plana* were similar regardless of whether they fed on malabar melastome leaves or oil palm fronds (Table 3). Additionally, the average increase in larval bag width per instar remained relatively uniform, exhibiting a consistent and gradual expansion across all instar stages.

Color of *Metisa plana* bag larvae

The visual observation of *M. plana* bags revealed distinct differences in color and texture depending on the host plant. The larval bags on oil palm plants exhibited a darker color and a coarser texture, while those on the malabar melastome plants appeared lighter in color and had a smoother texture (Figure 4).

The visual observation of *M. plana* larvae revealed invisible differences in shape or color between those found on oil palm and malabar melastome leaves. Both larvae had the same pattern on their heads, a brown body, and an approximate body length of 0.9 cm (Figure 5).

The pupae of *M. plana* on oil palm and *M. malabathricum* leaves were similar. The male *M. plana* pupae developed outside the bag (Figure 6.A), whereas the female *M. plana* pupae remained inside the bag (Figure 6.B).

The male imago of *M. plana* underwent complete metamorphosis, emerging from the cocoon as a fully developed adult moth (Figure 7.A). Conversely, the female remained within her protective bag throughout the maturation phase (Figure 7.B).

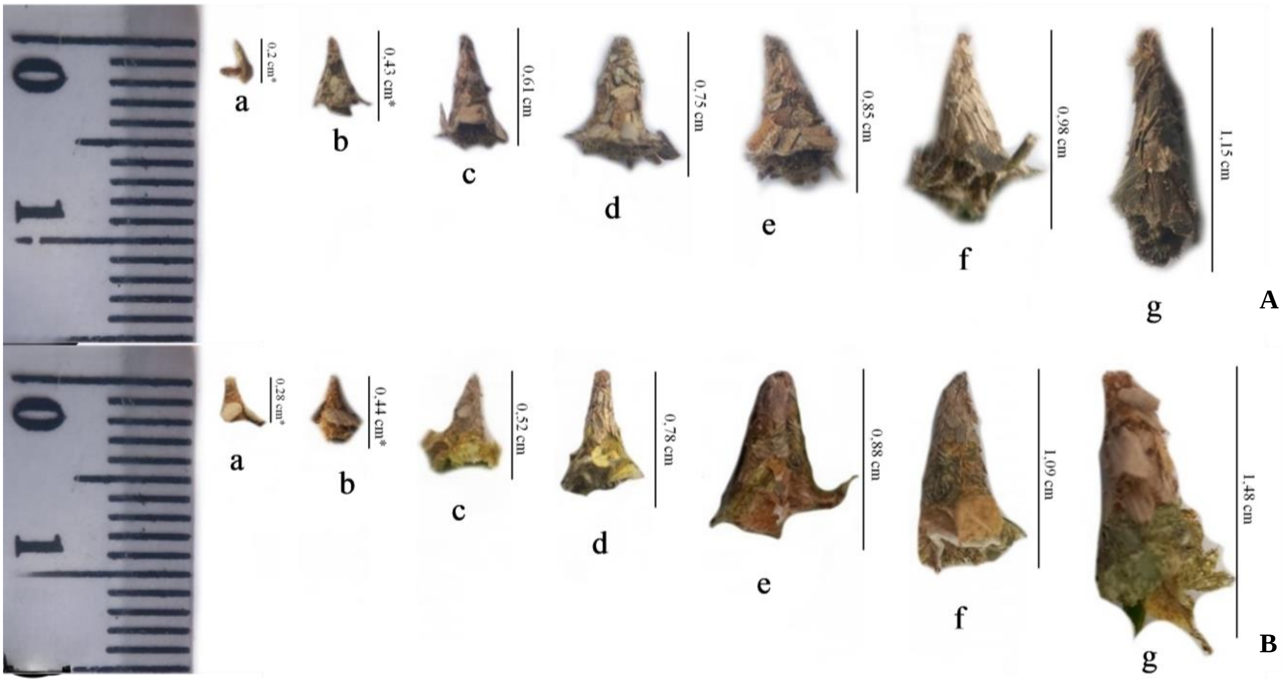

Figure 4. A. Color and size of bagworm *Metisa plana* larval bags on oil palm leaves, B. Malabar melastome leaves. Larval bags were arranged according to instar stage from left to right: a. 1st, b. 2nd, c. 3rd, d. 4th, e. 5th, f. 6th, g. 7th Instar

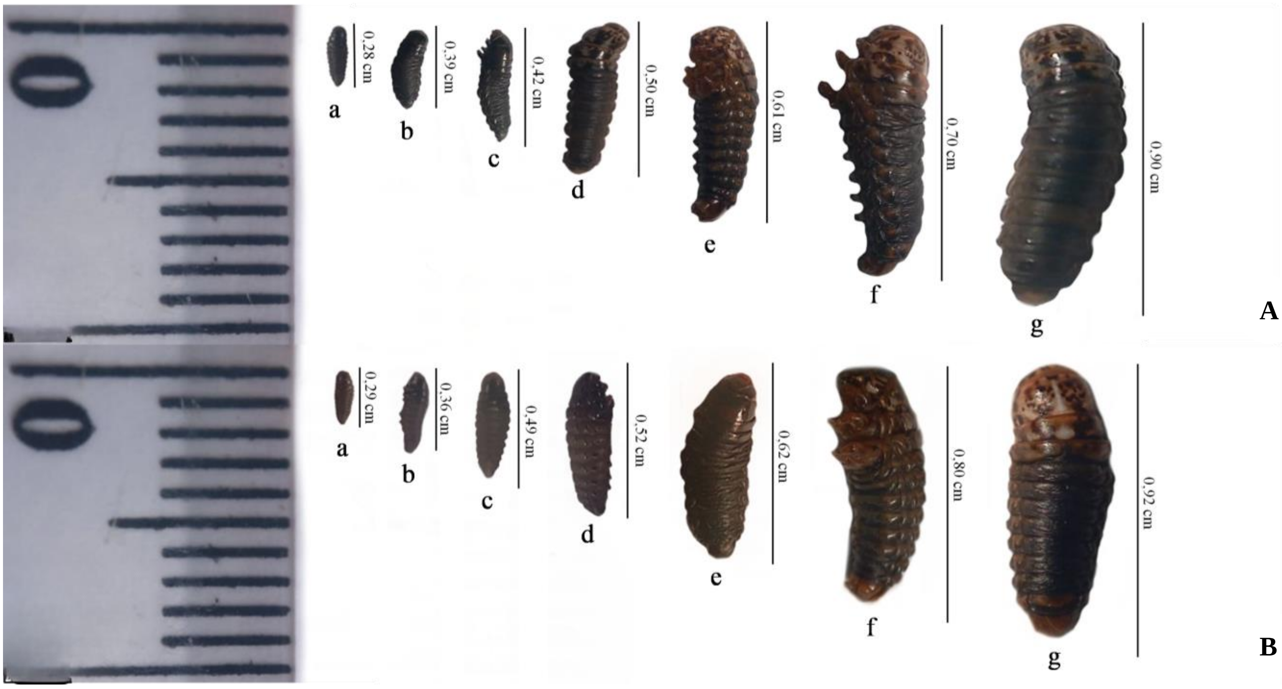

Figure 5. A. Color and size of *Metisa plana* larvae on oil palm, B. Malabar melastome. Larvae were arranged according to the instar stage from left to right: a. 1st, b. 2nd, c. 3rd, d. 4th, e. 5th, f. 6th, g. 7th Instar

Table 2. Average of the bag length of *Metisa plana* larvae that consumed oil palm fronds and malabar melastome leaves

Plant	Average of the bag length of *Metisa plana* larvae (cm ± standard of deviation)						
	Instar 1	**Instar 2**	**Instar 3**	**Instar 4**	**Instar 5**	**Instar 6**	**Instar 7**
Malabar melastome	0.31±0.01	0.52±0.02	0.63±0.02	0.78±0.02	0.88±0.02	1.02±0.04	1.17±0.04
Oil palm	0.26±0.00	0.43±0.01	0.61±0.01	0.75±0.02	0.85±0.03	0.98±0.02	1.15±0.03
P-Value	0.0006*	0.0002*	0.47^{ns}	0.26^{ns}	0.41^{ns}	0.37^{ns}	0.71^{ns}

Note: ns = not significantly different, * = significantly different, at alpha 0.05 T-test

Table 3. Average of bag width of *Metisa plana* larvae consumed oil palm fronds and malabar melastome leaves

Plant	**Average of bag width of *Metisa plana* larvae (cm ± Standard of deviation)**						
	Instar 1	**Instar 2**	**Instar 3**	**Instar 4**	**Instar 5**	**Instar 6**	**Instar 7**
Malabar melastome	0.31±0.01	0.43±0.02	0.48±0.02	0.52±0.01	0.53±0.01	0.56±0.01	0.6±0.01
Oil palm	0.25±0.01	0.35±0.01	0.44±0.02	0.48±0.02	0.54±0.01	0.57±0.01	0.6±0.00
P-Value	0.0008*	0.008*	0.27^{ns}	0.17^{ns}	0.66^{ns}	0.85^{ns}	1^{ns}

Note: ns = not significantly different, * = significantly different, at alpha 0.05 T-test

Table 4. Host Traits may potentially influencing larval performance

Trait	**Oil palm (*Elaeis guineensis*)**	**Malabar melastome (*Melastoma malabathricum*)**	**Observation in larvae**
Leaf texture	Tougher leaves with multicellular trichomes on adaxial and abaxial surfaces	Softer, less fibrous leaves	Early instars consumed more leaf area on melastome, likely due to easier penetration and less mandible effort needed
Trichomes (leaf hairs)	Branched tector trichomes (Luis et al. 2010)	Fewer reported physical barriers	Early instar larvae consumed less leaf material on oil palm, likely due to the presence of trichomes that may have acted as physical deterrents
Chemical defenses	Flavonoids and stilbenoids (Hassan et al. 2024)	Flavonoids and phenolic compounds (Azahar et al. 2019)	Similar compound types could explain comparable larval development and survivorship
Nutritional quality	Primary host - evolutionarily adapted	Alternative host - still suitable	Early instar development slower on oil palm, suggesting nutritional ease on melastome, but adaptation possible by later instars
Surface preference	Adaxial surface (smoother, thinner cuticle)	Adaxial surface	Similar feeding behavior on both hosts

Figure 6. *Metisa plana* pupae: A. Male, B. Female

Figure 7. *Metisa plana* imago: A. Male (0.8 cm), B. Female (1.20 cm)

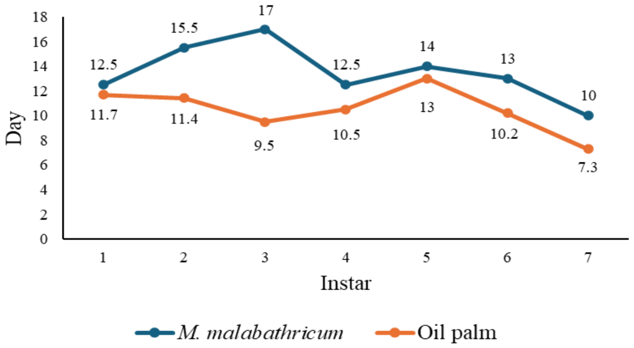

Figure 8. Life span of *Metisa plana* larvae on oil palm and malabar melastome plan

Life span of *Metisa plana* larvae on oil palm and malabar melastome plants

Metisa plana larvae feeding on malabar melastome plants exhibited a longer life span than that those fed on the oil palm plants at most instars (Figure 8). The longest development period for *M. plana* larvae on the malabar melastome occurred at the 3rd instar, lasting 17 days, while the shortest was at the 7th instar, requiring only 10 days. In contrast, the larvae feeding on the oil palm plants had their longest life span at the 5th instar, lasting 13 days, whereas the shortest life span was observed at the 7th instar whose development completed in 7.3 days. Overall, larvae had a slightly longer life span on *M. malabathricum* (days) compared to oil palm (days), suggesting that the host plant type influences the larval development and growth rate.

The feeding performance of larvae varied between oil palm (*E. guineensis*) and malabar melastome (*M. malabathricum*) (Table 4). Oil palm leaves exhibited greater toughness, featuring multicellular trichomes on both the adaxial and abaxial surfaces, while melastome leaves were softer and less fibrous. Consequently, early instar larvae ingested a greater leaf area on melastome, presumably due to less mandibular exertion required for penetration. Branched tector trichomes on oil palm (Luis et al. 2010) functioned as physical deterrents, diminishing eating by early instars in contrast to melastome leaves, which possessed less structural obstacles.

Regarding chemical defenses, both hosts possessed secondary metabolites, including flavonoids and phenolic/stilbenoid substances (Azahar et al. 2019; Hassan et al. 2024). The resemblance of these chemicals may elucidate why larval development and survivorship were often analogous among hosts. Developmental rates differed: larvae exhibited reduced growth on oil palm during the early instars, indicating more nutritional availability on melastome. However, in subsequent instars, larvae seemed to acclimate to oil palm leaves, reinforcing its status as the main host. Surface preference remained uniform across both hosts, with larvae mostly consuming the adaxial surface, characterized by a thinner and smoother cuticle. This suggests that surface selection behavior was consistent irrespective of the host plant.

Discussion

An oil palm is a major crop that is widely cultivated in Indonesia. During the cultivation of the plant, it is inseparable from the presence of pests, including the bagworm *M. plana*. *Metisa plana* feeds on oil palm leaves from nursery to mature plantations, causing severe damage that can significantly reduce yield (Beaudoin-Ollivier 2018; Thaer et al. 2021). Additionally, oil palm plantations often coexist with various weed vegetation (Vauzia et al. 2023). The oil palm plantations in South Sumatra are mostly grown alongside *M. malabathricum* weed. *Metisa plana* can also be found in the malabar melastome vegetation. This study examined the life span, feeding behaviour, and morphological characteristics of *M. plana* larvae feeding on oil palm fronds and malabar melastome leaves.

The results of this study indicated that *M. plana* larvae that ingested *M. malabathricum* leaves consumed a greater quantity of surface area than those that fed on palm fronds, particularly in the early instars. When *M. plana* larvae were in instars 1, 2, and 3, the larvae that fed on the malabar melastome were significantly different from those that fed on the oil palm fronds. This suggests that the malabar melastome may offer a more palatable or nutritionally favourable food source, at least during the initial larval stages. However, from the 4th instar onwards, there was no significant difference in feeding capacity being observed, implying that as the larvae got mature, they can adapt to consume the oil palm fronds more efficiently.

The difference in feeding behaviour between host plants may be influenced by leaf structural defaces. Oil palm leaves possess multicellular and branched *tector* trichomes on their adaxial and abaxial surfaces of the leaves epidermis (Luis et al. 2010). Leaf trichomes play recognized roles in defending against insect herbivores, acting both as a physical barrier that obstructs herbivore movement and by facilitating chemical defenses. The trichomes may influence the early larvae's ability to ingest plant material. This result aligns with the research of Kariyat et al. (2018), which indicated that trichomes deterred the initiation of feeding by the 1st and 2nd instar caterpillars. Additionally, the 1st to 3rd instar caterpillars have not yet developed sufficiently strong mandibles (Wagner and Hoyt 2022). Therefore, the early instar larvae have a limited ability to digest tougher, fibrous plant material like the oil palm fronds. By the 4th instar, their mandible and gut have undergone physiologically matured, leading to no significant differences in feeding capacity at later stages.

The bagworm larvae demonstrated consistent feeding activity regardless of whether the observations were conducted in the early morning or late afternoon. This might occur because the larvae lived in a protective bag, the exposure to sunlight did not affect the activity of the bagworm. However, some studies have shown that bagworms tend to be more active under moderate light conditions (< 8000 fc) (Wood 2019b). They usually forage in the morning and evening when the temperature is optimal for *M. plana* larvae (Ahmad et al. 2021). The morning activity of the bagworms may be associated with the construction and maintenance of their bags (Khan 2020). The bagworms are recognized for their distinctive behaviour in creating and maintaining their protective bags, which are composed of plant components (Sugiura 2016). In the morning, they often increase their activity in collecting plant materials or fortifying their bags to enhance concealment and protection against predators (Khan 2020).

The physical characteristics of *M. plana* larval bags were influenced by the host plant. *Metisa plana* larvae feeding on the oil palm plants had bags with a yellowish-brown color and a sturdy tassel. In contrast, the larvae feeding on the malabar melastome leaves had bags with a yellowish-green color and a thinner, more delicate tassel. The variation in coloration of bagworm bags might be attributed to their dietary intake which likely contains unique pigments and secondary materials. The color may represent an aspect of an insect's physiology, indicating developmental stages, dietary changes, thermoregulatory adaptations, or immunological responses (Etheridge 2024). Despite the differences in bag colors, there were no significant morphological changes being observed in the larval body structure between the host plants. The larvae displayed a consistent blackish-brown body with a characteristic *batik* like pattern on the head, regardless of their diet. The differences in bag color likely resulted from the incorporation of host plant materials, affecting external structures without altering larval morphology. This distinction underscores the role of genetic and physiological regulation in maintaining internal body structures. For instance, a study on *Hyles lineata* (Fabricius, 1775) demonstrates that the larval color polymorphism follows a Mendelian inheritance pattern, suggesting a strong genetic basis for morphological traits (Francois and Davidowitz 2020). Research on black soldier fly larvae (*Hermetia illucens*) have shown their capacity to adapt to various food substrates via morphological and physiological alterations of the midgut, with structural and dimensional modifications occurring in response to the specific diet offered (Bonelli et al. 2020). Our study on *M. plana* supports this phenomenon, with larvae exploiting different host plants, an adaptability likely mediated by digestive system plasticity. Additionally, consistent body coloration and patterns serve adaptive functions such as camouflage or predator deterrence (Guerra-Grenier 2019).

According to the result of this study, the bag size was another variable affected by the host plant. *Metisa plana* fed on the oil palm plants appeared to be significantly smaller than those fed on the malabar melastome plants, particularly in the 1st and 2nd instars. However, from the 3rd instar onwards, the bag sizes were similar. This is because the malabar melastome plants were not the host plants for the bagworms. *Metisa plana* larvae required more time to adapt and therefore invested more in feeding and growth during the early stages. Conversely, the larvae feeding on their primary host plant (oil palm) has more stable growth and development because they do not require much food or adaptation to survive. This study also found that *M. plana* primarily fed on the adaxial surface of the leaves of both oil palm and malabar melastome. The adaxial surface often has a thinner cuticle and fewer trichomes than the abaxial surface, making it more palatable and easier for larvae to penetrate and consume (de Oliveira et al. 2021). In addition, feeding on the adaxial surface exposes larvae to more sunlight, potentially providing a warmer microenvironment that enhances metabolic and digestive processes (Tsuji et al. 2018).

The ability of *M. plana* to thrive on the malabar melastome as an alternative host plant aligns with the study conducted by Bawin et al. (2016) who demonstrated that the larvae of *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae) could develop on 12 cultivated or non-cultivated plants, including the species of the Solanaceae, Amaranthaceae, Convolvulaceae, Fabaceae, and Malvaceae families. Both oil palm and malabar melastome contain secondary metabolite compounds such as flavonoids (Azahar et al. 2019; Hassan et al. 2024). The similarity in chemical composition may explain why the malabar melastome serves as a suitable alternative host plant for *M. plana*. Despite different host plant species, there were no morphological changes being observed in *M. plana* larvae. The larval size and bag size were similar between *M. plana* larvae feeding on the malabar melastome leaves and those feeding on the oil palm fronds. *Metisa plana* larvae consistently displayed a light brown, batik-like head pattern and a blackish-brown body. The morphological differences in insects are typically species-specific. The difference in plant species in *M. plana* rearing only affected the bag color. The size bag and larvae of *M. plana* was similar, indicating that *M. plana* could adapt to different host plants without altering its basic form. According to Gérard et al. (2023) and Schroeder et al. (2018), some insect species exhibit minor variations in body size while maintaining their primary morphological characteristics.

The observations revealed that the smaller pupae developed into males, while the larger pupae transformed into females. The observation that smaller pupae developing into males and larger pupae developing into females is a well-documented phenomenon in many insect species, particularly within the Lepidoptera order (Sánchez-Rosario et al. 2022). The result of this study also revealed that the male and female pupae could be differentiated by their position. The male pupae were situated outside the bag and suspended like hooks, whereas the female pupae remained within the bag. Male imagos emerged and flew outside the bag, whereas female imagos remained within the bag. The emerged imagos in oil palm and *M. malabathricum* plants showed no difference. The male imago emerged as a moth with blackish-brown wings and limbs. The female imago lacks the wings and limbs that characterize other moth species. Instead, they persisted in a maggot-like form and remained within the protective bags they had fashioned from silk and plant components. Conversely, the males devolved into flying moths with wings and pursued the females for mating. The male imago had a hairy black caput and body, while the female imago exhibited a dark brown caput and yellowish-brown body.

The rearing temperature for *M. plana* larvae ranged from 25-30°C in the morning and evening. The minimum, optimum and maximum temperatures for *M. plana* larvae were recorded at 15, 25, and 45°C, respectively. The air humidity also played a role in the life cycle of *M. plana* larvae. According to Morshed et al. (2020), temperature and humidity influence the growth, development, and activity of insects. The life cycle of *M. plana* from egg to adult in optimum temperature and suitable living environment averages 103.5 days (Johari et al. 2022). *Metisa plana* larvae underwent seven larval instars. In the malabar melastome, the 1st instar progressed to the 2nd instar in 9-16 days, while the 2nd instar lasted 14-17 days. The 3rd instar was the longest stage, lasting for 16-18 days, followed by the 4th instar (10-15 days), 5th instar (12-16 days), and 6th instar (11-15 days). The total duration from instars 1 to 7 was approximately 109 days. The time required for *M. plana* larvae to form pupae was between 8-12 days. On the oil palm, the 1st instar lasted 9-14 days, the 2nd instar 8-15 days, the 3rd instar 8-13 days, the 4th instar 8-15 days, the 5th instar 8-17 days, and the 6th instar 8-17 days, totaling approximately 103 days. Phytophagous insects, such as the *M. plana* can consume wild plants, where the immune benefits from the alternative host plants could help maintain polyphagy (Muller et al. 2015).

The observed differences in *M. plana* larval performance between oil palm (*E. guineensis*) and malabar melastome (*M. malabathricum*) appeared may be influenced by specific morphological and chemical characteristics of each host plant. The leaves of oil palm were tougher and more fibrous, with multicellular trichomes present on both the adaxial and abaxial surfaces, while *M. malabathricum* exhibited softer leaf tissues with fewer physical barriers. These structural differences likely contributed to the significantly greater leaf area consumed by early instar larvae (1st-3rd) on *M. malabathricum*, suggesting that the softer texture and reduced mechanical defenses facilitated easier feeding and mandible penetration. Additionally, the branched tector trichomes on oil palm leaves may have acted as deterrents to early larval feeding, consistent with findings by Kariyat et al. (2018).

Both host species contain flavonoids and other secondary metabolites, including stilbenoids in oil palm (Hassan et al. 2024) and phenolic compounds in *M. malabathricum* (Azahar et al. 2019), which may explain the similar larval survival rates (>80%) and overall development across treatments. Despite oil palm being the primary host, early instars exhibited slightly slower development compared to those on *M. malabathricum*, indicating potential differences in nutritional accessibility during early larval stages. Nonetheless, larvae from the 4th instar onward showed no significant differences in consumption or growth, suggesting physiological adaptation over time. Across both host plants, larvae consistently fed on the adaxial leaf surface, which is typically smoother and has a thinner cuticle, further supporting that surface characteristics may play a role in host selection but not exclusively determine performance. These results indicate that while *M. malabathricum* is not the primary host, its anatomical and chemical characteristics are sufficiently favorable to support the complete larval development of *M. plana*.

The comparable lifespan noted for *M. plana* larvae on both oil palm and malabar melastome (*M. malabathricum*) unequivocally indicated that *M. malabathricum* serves as an appropriate alternate host for *M. plana*. This discovery highlights the likelihood that uncontrolled populations of *M. malabathricum* in or near oil palm plantations may act as enduring reservoirs for *M. plana*, therefore maintaining pest populations despite a decrease in primary host availability. Alternative host reservoirs may undermine the efficacy of existing pest management strategies by facilitating pest survival and population recovery. Thus, these findings underscore the necessity of including weed management, particularly the control of alternate hosts such as *M. malabathricum*, in continuous pest surveillance and routine monitoring efforts. This integrated approach is crucial for interrupting the continuity of appropriate host plants and for improving the overall efficacy of integrated pest control (IPM) tactics in oil palm agroecosystems. Moreover, to comprehensively grasp the ecological implications and practical uses of these findings, subsequent study should include temporal replication over many seasons, as host plant quality and larvae development may fluctuate with environmental changes. Considering seasonal variations can enhance the understanding of host plant compatibility and larval biology, therefore enabling more effective and adaptive pest management options for sustainable oil palm plantation.

ACKNOWLEDGEMENTS

This research was sponsored by PT Syngenta Indonesia in collaboration with the Entomological Society of Indonesian for Fiscal Year 2024, in accordance with the contract no.: No.001/PEI-Palembang/I/2024, January 1, 2024, led by Erise Anggraini.

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