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Relationship between Bagworm Pteroma Pendula Joannis (Lepidoptera: Psychidae) Populations, Parasitoids, and Weather Parameters in Oil Palm Plantation

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Abstract

A study on interactions between bagworm *Pteroma pendula* Joannis (Lepidoptera: Psychidae) populations with parasitoids and weather conditions was carried out at a smallholder oil palm plantation in Hutan Melintang, Perak, Malaysia from January 2011 until December 2011. Samplaing was performed monthly and parasitoids emergence were observed daily. The findings showed that eleven parasitoid species were identified parasitizing the bagworms. The top three parasitoids were *Goryphus bunoh* (Hymenoptera: Ichneumonidae), *Eupelmus catoxanthae* (Hymenoptera: *Eupelmidae*), and Eurytoma sp. (Hymenoptera: Eurytomidae). Bagworms and parasitoids populations were not correlated with weather parameters. The parasitoid populations in this study were relatively low. However, parasitoids were dependent on the bagworms and their populations could have be adversely affected by other factors. The parasitism potential in controlling bagworms need to be investigated further in order to establish their use as biocontrol agents.

Keywords: bagworm, *Pteroma pendula*, oil palm, parasitoids, population fluctuation, weather parameters, Hutan Melintang, biocontrol agents

1. Introduction

Bagworm is one of the most destructive pests in Malaysia's oil palm plantations. About 33-40% of crop loses can be caused by bagworm infestations (Basri, 1993). According to previous studies, *P. pendula* Joannis, 1929, is ranked as the second most economically important pest of oil palm in Malaysia after *Metisa plana*. However, it has been recorded as the dominant bagworm species infesting oil palm plantations in several areas (Ho, 2002; Norman & Basri, 2010; Cheong, Sajap, Hafidzi, Omar, & Abood, 2010). Ho (2002) also reported that *P. pendula* has higher reproductive potential than *Metisa plana*. There are about 31 species of agricultural crops and shade plants have been identified as host plants of this bagworm species (Ahmad & Ho, 1980; Norman, Robinson, & Basri, 1994). The susceptibility of a wide range of host plants and high reproductive potential can result in serious outbreaks whenever the environment is favourable.

In most commercial plantations, chemical control has become the primary control mechanism in managing bagworm outbreaks (Hasber, 2010) as compared to smallholdings due to the high cost of pest management using pesticides. Hence, an ecologically-based control method is more suitable as this would reduce costs and lead to minimal ecological disturbance, besides providing an ambient environment for the survival of natural enemies of the pests.

The parasitoids are an important group of natural enemies that survive on nectar of beneficial plants as source of food (Yusdayati, 2008; Norman & Basri, 2010), while their life cycles are dependent on their preferred hosts. In oil palm plantations, many species of parasitoids have been found parasitizing the bagworms that attack oil palms (Basri, Norman, & Hamdan, 1995). Bagworm-parasitoid interactions are highly influenced by presence of beneficial plants surrounding the plantation areas (Yusdayati, 2008; Norman & Basri, 2010) and the availability of bagworms as host (Cheong et al., 2010). However, the relationship may be influenced by weather conditions. The effect of weather on the bagworm-parasitoid relationship is not known. Thus, this study was carried out to investigate abundance as well as the relationship between bagworms *P. pendula* and parasitoids with weather parameters in a smallholder oil palm plantation.

2. Materials & Methods

2.1 Study Site

An oil palm plantation owned by a smallholder in Hutan Melintang, Perak, Malaysia was chosen as the study site. The area was covered by approximately five hectares of oil palms aged between four to six years old. Numerous weeds together with beneficial plants were observed in the surrounding areas. Pesticides spraying had been irregular and damaged symptoms caused by bagworms were observed throughout the plantation.

2.2 Sampling

Sampling was performed on 20 randomly identified palms that were marked. Two fronds (middle and lower fronds) from each marked tree were cut using a frond cutter and the leaflets were collected together with bagworm larvae and pupae. All leaflet samples were placed in wooden cages (50 x 30 x 30 cm), covered with muslin cloth for ventilation and brought back to the laboratory for analysis.

2.3 Sorting and Identification

The numbers of bagworm larvae and pupae were recorded. Ten bagworm larvae were transferred into each (11.5 x 9.5 x 6.0 cm) plastic cups containing fresh oil palm leaflets as food source and covered with muslin cloth for ventilation, while a same number of bagworm pupae were placed separately into similar plastic cups. Both sets of cups were observed daily for parasitoids emergence. Upon emergence, parasitoids were transferred individually into glass vials using aspirator and supplied with 60% sucrose as food source (Basri, Simon, Ravigadevi, & Othman, 1999). Identification of each species was carried out according to several references including Parator v1.0-A diagnostic tool for the identification of parasitoids and predators for bagworms and nettle caterpillars in oil palm (Malaysia Palm Oil Board [MPOB], 2002), Handbook of common parasitoids and predators associated with bagworms and nettle caterpillars in oil palm plantations (Norman, Basri, & Zulkefli, 1998), and Hymenoptera of the world-An identification guide to families (Goulet & Huber, 1993) while the numbers were recorded. The above steps were carried out monthly from January until December 2011. Monthly weather data including rainfall, temperature, and humidity were obtained from the Nova Scotia Climatological Station (Malaysia Meteorology Department) located 5 km from the field. The data on numbers of bagworms and parasitoids were analysed using regression. Correlation analysis between number of parasitoids and bagworms with weather parameters was performed using Pearson Correlation analysis at 0.05 significance level.

3. Results and discussion

3.1 Bagworm (P. pendula) Population

The results showed that most of the bagworms *P. pendula* at the time of sampling were already in the pupal stage. This was perhaps due to the selection of middle and lower fronds where most pupae inhabit rather than larvae which keep moving in search of non-infested fresh leaflets.

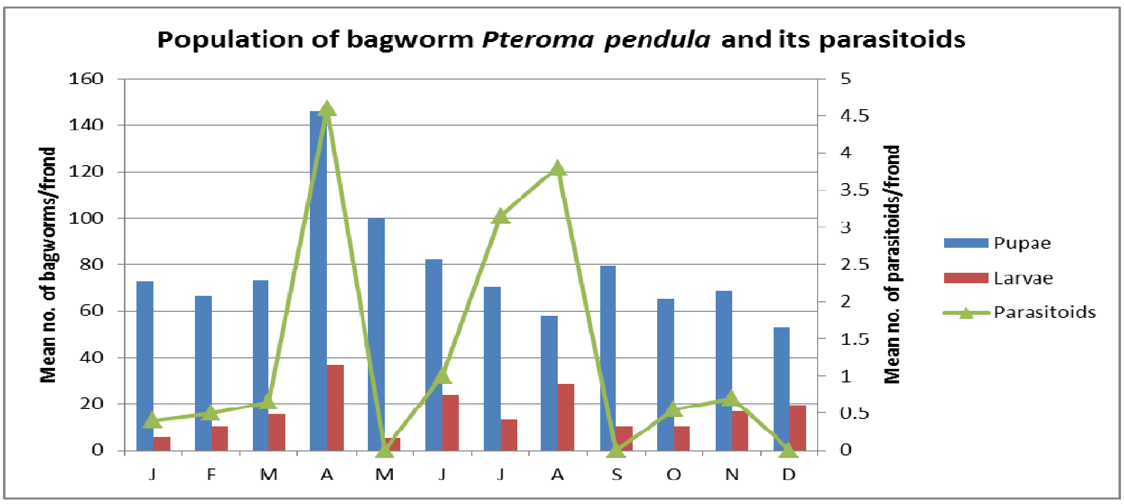

Figure 1. Graph of monthly populations of bagworm *P. pendula* and its parasitoids

The results showed that bagworm populations fluctuated throughout the year (Figure 1). All empty bags were excluded from this analysis. The highest number of total pupae and larvae (alive and dead) were recorded in April (3652 individuals) followed by June (2129 individuals) and May (2106 individuals). Results showed significant correlation between populations of bagworms and parasitoids (P = 0.0074; r = 0.7266). However, there was no correlation with all weather parameters (Table 1). Cheong et al. (2010) also did not observe any significant relationship between *P. pendula* and rainfall. Therefore, other factors could be responsible for the fluctuation in bagworm populations in the study site. One such factor could be the form of the shelter offered by the interconnecting frond canopy, which consequently protects the bagworm from direct sunlight or heavy rainfall. Visual observations showed bagworms resting under oil palm leaflets which provide protection from rain drops. The data on rainfall volume however did not indicate the number of rainy days in a month and irregular rainfall pattern could also contribute to the insignificant correlation with weather. The incidence of high numbers of bagworm larvae being washed-out by rain drops on frequent rainy days per month could affect bagworm populations.

Other plausible explanations include the polyphagous nature of *P. pendula*, poor management of bagworm infestations by smallholders due to high cost of pesticides, and the mono-cropping system in oil palm plantations which favours bagworm infestations (Cheong et al., 2010).

3.2 Parasitoid Populations

Observations over the one year period revealed relative abundance of parasitoids during the months of April (4.6/frond), July (3.15/frond), and August 2011 (3.8/frond). There were individual occurrence recorded during the other months, except in May, September, and December (2011) when they might survive on alternate hosts as source of food. Eleven species of parasitoids emerged from the bagworms (Table 2). In total, *Goryphus bunoh* was the highest in number, followed by *Eupelmus catoxanthae*, and *Eurytoma* sp. However, *G. bunoh* only occurred during a period of five months (March, April, June, July, August 2011) with the highest number in April (125.32), while regular emergence was observed throughout the year for *E. catoxanthae*. The reason for these differences may be attributed to parasitism efficiency in host searching ability and egg limiting factors that hinder parasitism activity. Interactions between these processes; host numbers encountered, matured egg numbers over parasitoid's lifespan, and oviposition behaviour can influence the number of eggs laid by female parasitoids during their lifetime (Varone, Bruzzone and Logarzo, 2007) and consequently affecting parasitism.

Table 1. Correlation of bagworms and parasitoids with weather parameters

	Correlation with weather parameters (α = 0.05)		
	Rainfall	Temperature	Humidity
Bagworms	0.4618 (-0.2352)	0.2810 (0.3391)	0.6542 (-0.1444)
Parasitoids	0.3036 (-0.3244)	0.3538 (0.2939)	0.3633 (-0.2884)

Description: Number in brackets = correlation coeffision value (r). Correlation column shows probability (P) value; * = significant at α= 0.05.

Emergence of *G. bunoh* was very high in April as compared with the other months. As a primary parasitoid, it may have encountered hyper-parasitism by hyper-parasitoids which may have led to a drop in the population. Cheong et al. (2010) had reported *Pediobius imbrues* was the dominant hyper-parasitoid attacking *G. bunoh* and *Apanteles metesae.*The second highest parasitoid, *E. catoxanthae* emerged from bagworms ranging between 5.0-16.4 parasitoids per month. Eventhough the numbers were quite low, but it was stable as compared to *G. bunoh*. This is perhaps due to the facultative hyper-parasitic behaviour of *E. catoxanthae* (Basri et al., 1995) which attack bagworms as primary or hyper-parasitoids, and thus stabilizing its population. Hence, *E. catoxanthae* seems to have good potential for controlling bagworms.

Other parasitoids found on *P. pendula* in this study site were relatively low and irregular (*P. imbrues*, *A. metesae*, *Pediobius elasmi*, *Pediobius anomalus*, *Brachymeria carinata*, *Aphonogmus thylax*, *Tetrastichus sp.*, and *Elasmus sp.*) This is attributed to differences in parasitoids' lifespan which differs among species, which may not synchronised with the life length of their preferred host stages. Cheong et al. (2010) had reported that *P. imbrues* and *A. metesae* were the dominant parasitoid species, but the results obtained in this study revealed that interactions between primary and hyper-parasitoids may influence the presence of individual species.

3.3 Correlation Between Parasitoids, Bagworms and Weather Parameters

Correlations were significant between number of bagworms and *G. bunoh* and *A. metesae* ($P<0.05$), but not with other parasitoid species (Table 2). Weather parameters did not influence parasitisms by all parasitoid species (Table 1). This might occurred due to rainfall pattern that can be localised since the climatology station is more than 1 km radius. The regulation of parasitism activity also can be caused by factors such as pesticides spraying which at the same time may affect populations of parasitoids. Najib, Ramlah, Mazmira and Basri (2009) had reported a 100% mortality in beneficial insects 5 days after treatment with cypermethrin.

Presence of alternate host plant in the field can also contribute to parasitoids regulation as sources of nectar from certain species of flowering plants is important for establishment of a specific beneficial insect (Norman & Basri, 2010). Yusdayati (2008) claimed that different distances from beneficial plants did not affect parasitism of bagworms, but there were differences in percentage of parasitisms by parasitoids since they could move up to 175 meters from alternate host plants.

Table 2. Composition of parasitoids species found parasitizing *P. pendula*

Parasitoids	Compositons (%)	Correlation with bagworms
G. bunoh	38.78	<0.0001* (0.9172)
E. catoxanthae	20.22	0.4020 (0.2667)
Eurytoma sp	13.85	0.6518 (-0.1455)
P. imbrues	7.75	0.4833 (-0.2219)
A. metesae	7.20	*0.0481 (0.5603)
P. elasmi	4.71	0.3137 (-0.3181)
P. anomalus	2.77	0.2648 (-0.3499)
B. carinata	1.94	0.5211 (0.3371)
A. thylax	0.27	0.2942 (0.5133)
Tetrastichus sp	0.27	0.2942 (0.5133)
Elasmus sp.	0.27	0.2942 (0.5133)

Description: Number in brackets = correlation coeffision value (r). Correlation column shows probability (P) value; * = significant at $\alpha = 0.05$.

4. Conclusion

The results of the study suggest that incidence of *P. pendula* is affected by presence of parasitoids in the area rather than climatic parameters. The weather conditions did not affect parasitism activity of parasitoids, but the parasitoids were dependent on bagworm populations. However, population stability of these beneficial insects may be adversely affected by interactions with other external factors. It is suggested that this study should be conducted in longer time scale while considering microclimatic parameters with emphasis on crucial data including number of rainy days to understand further the relationship between the host and its parasitoids. Investigation on parasitism efficiency of the potential parasitoid species should also be considered to ensure establishment of these natural enemies as biological control agents of bagworms.

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