# DIVERSITY OF PHASMID (ORDER: PHASMATODEA) AT HUTAN LIPUR BUKIT BAKAR, MACHANG, KELANTAN


**by**

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## DECLARATION

I declare that this thesis entitled "Diversity of Phasmid (Order: Phasmatodea) at Hutan Lipur Bukit Bakar, Machang, Kelantan" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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**APPROVAL**

"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Applied Science (Natural Resources Science) with Honors"

Signature : _____

Name of Supervisor : _____

Date : _____

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**Diversity of phasmid (Order: Phasmatodea) at Hutan Lipur Bukit Bakar, Machang, Kelantan**

## ABSTRACT

Hutan Lipur Bukit Bakar is located in Machang, Kelantan and the forest is one of the Permanent Reserved Forest (PRF) in Peninsular Malaysia. The diversity of phasmid was studied at three sampling point of Hutan Lipur Bukit Bakar, Machang, Kelantan. The study was carried out for 21 days in Hutan Lipur Bukit Bakar from July to August started from 0900 to 1700 hours using sweep net at Trail 1, 2 and 3. Then at night, light trap was been set up at 1900 to 0200 hours at the same sampling point as in a day. A total of 10 species from three families with 28 individuals were recorded. The overall value of Shannon-Wiener diversity index (H') for the phasmid was high at Trail 2 with the value of 1.64. The most dominant species at Hutan Lipur Bukit Bakar is *Abrosoma johorensis* with nine individuals from family Aschiphasmatidae. *Abrosoma johorensis* and *Abrosoma xiuyuae* from family Aschiphasmatidae are the most abundant species of phasmid at Trail 1. Meanwhile, the most abundant species at Trail 2 are *A. johorensis* (Family: Aschiphasmatidae) and *Ramulus nematodes* (Family: Phasmatidae). Next, the abundance of species at Trail 3 is recorded one individual per one species. Family Aschiphasmatidae was the most abundant family with 13 individuals from the Trail 1, 2 and 3. The overall value of Shannon-Wiener Diversity Index (H') indicates the value of 1.80 which is considered fairly diverse meanwhile the Pielou's Evennes Index (J') is 0.78 which almost reached complete evenness in species distribution. For further research in the future, different time of duration in sampling the diversity of phasmid at Hutan Lipur Bukir Bakar can be applied in order to gain more different variety of species at the study area.

**Kepelbagaian phasmid (Order: Phasmatodea) di Hutan Lipur Bukit Bakar, Machang, Kelantan**

## ABSTRAK

Hutan Lipur Bukit Bakar terletak di Machang, Kelantan dan merupakan salah satu daripada Hutan Simpan Kekal (HSK) di Semenanjung Malaysia. Kepelbagaian phasmid dipelajari di tiga titik pensampelan Hutan Lipur Bukit Bakar, Machang, Kelantan. Kajian ini dilakukan selama 21 hari di Hutan Lipur Bukit Bakar dari Julai hingga Ogos bermula dari 0900 hingga 1700 jam dengan menggunakan jaring penyapu di Denai 1, 2 dan 3. Kemudian pada waktu malam, perangkap cahaya telah dipasang pada 1900 hingga 0200 jam malam di titik pensampelan yang sama seperti di siang hari. Sejumlah 10 spesies dari tiga famili dengan 28 individu telah direkodkan. Nilai keseluruhan indeks kepelbagaian Shannon-Wiener (H') untuk phasmid adalah tinggi pada Denai 2 dengan nilai 1.64. Spesies paling dominan di Hutan Lipur Bukit Bakar adalah *Abrosoma johorensis* dengan sembilan individu dari famili Aschiphasmatidae. *Abrosoma johorensis* dan *Abrosoma xiuyuae* dari Famili Aschiphasmatidae adalah spesies phasmid yang paling banyak di Denai 1. Sementara itu, spesies paling banyak di Denai 2 adalah *A. johorensis* (Famili: Aschiphasmatidae) dan *Ramulus nematodes* (Famili: Phasmatidae). Seterusnya, spesies di Denai 3 merekodkan satu individu bagi satu spesies. Famili Aschiphasmatidae adalah famili paling banyak dengan 13 individu dari Denai 1, 2 dan 3. Nilai keseluruhan Indeks Kepelbagaian Shannon-Wiener (H ') menunjukkan nilai 1.80 yang dianggap agak pelbagai manakala Indeks Kesamarataan Pielou (J') diperoleh adalah 0.78 yang hampir mencapai kesempurnaan lengkap dalam pengagihan spesies. Untuk penyelidikan selanjutnya pada masa akan datang, tempoh yang berlainan dalam penyampelan kepelbagaian phasmid di Hutan Lipur Bukir Bakar boleh digunakan untuk mendapatkan lebih banyak kelainan spesies di tempat kajian.

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| PRF | Permanent Reserved Forest |
| GPS | Global Positioning System |
| UMK | Universiti Malaysia Kelantan |
| IUCN | International Union for Conservation of Nature |
| NL | Not Listed |
| SWDI | Shannon-Wiener Diversity Index |
| PEI | Pielou's Evennes Index |
| km | Kilometre |

## LIST OF SYMBOLS

| | |
|---|---|
| % | Percentage |
| H’ | Value of Shannon-Wiener Index |
| J’ | Value of Pielou’s Evennes Index |
| $H_{max}$ | The maximum value of Shannon-Wiener Index |
| Pi | Proposition of the ith species |
| ln | Natural logarithm of Pi |
| S | Total number of species |
| ˚C | Temperature **(**Degree Celcius) |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Study

Stick insects and leaf insects are classified under the order Phasmatodea. The name of the order acquired from Latin word *"Phasma"* means phantom, apparition, spectre or ghost. The majority of phasmid species camouflaging themselves as stick and leaves in the dense vegetation even some of it is brightly coloured as *Oreophoetes peruana* (Abercrombie, Baker, & Bragg, 1980). The earliest described Malaysian species are *Marmessoidea rosea* which is found in 1973 and also known as *Mantis rosea* from "India Orientali" and *Heteropteryx dilatata* are found in 1798 currently known as *Phasma dilatatum* (Brock, 1999).

Phasmid of most countries are poorly studied (Brock, 1999). Most studies that have been done were focused on their behavior such as courtship and their physiology. There is very little research done and journal published about phasmids diversity. Phasmid (stick and leaf insects) needs a lot more study and attention because they are one of the unique insects that can imitate atmosphere around them. Then, the most obvious reason to study them is that within this group there are some of the largest, longest, heaviest and most beautiful insects in the world and yet they are amongst the least known insects (Francis, 2005). Diversity of phasmid consists about 3000 described species of

mainly tropical and subtropical insects (Klug & Bradler, 2006). Cranbrook and Edward (1994) estimated the occurrence of 2,900 stick insects species worldwide of which 300 species have been recorded from Borneo. Phasmid around the world usually feed at night and the only way to really know of its occurrence is to search at night (Priddel, Carlile, & Humphrey, 2003).

South East Asia has been developed at a very rapid rate. Many forests have been cleared for housing and other development projects. In the meantime, the possible way to ensure the ecosystem in intact is by understanding the life habitats and natural history of the insects as many as possible. Accurate documentation, description and indeed captive breeding where possible will ensure continued public interests and the survival of these insects (Francis, 2005).

Tropical forest is a forest which it has a high regular rainfall and the low rainfall occurred no more than two months. The forest has completely closed canopy of trees that block the entrance of sunlight to the forest floor and discourage the growth cover of the forest floor (OECD, 2001). Tropical forest is one of the homes of animal such as insects where their habitats are less disturbed because of the area is protected area where people need permission to enter the area. There are three tropical forests in Kelantan which are Bukit Bakar, Jeram Linang and Lata Tujuh (JPSM, 2016). Hutan Lipur Bukit Bakar is situated within the Bukit Bakar Forest Reserve. It is nine km away from Machang Town.

## 1.1 Problem Statement

There is no data regarding the diversity of phasmid in Kelantan especially at Hutan Lipur Bukit Bakar, Machang, Kelantan. Many people also tend to overlook the existence of the phasmid. Sometimes, people just do not know the presence of them in their environment. Phasmid is an important to the environment as they are significance phytophagous insects that can balance ecosystem of the environment. The study is needed to be done to determine their diversity that exists in Kelantan for more exposure of it to public.

## 1.2 Objective

The objective of this study is to determine the diversity of phasmid at Hutan Lipur Bukit Bakar, Machang, Kelantan.

## 1.4 Scope of Study

This study was focused on the diversity of the phasmid where the two factors of it need to be considered which are the species richness and the abundance of the phasmid. These were determined by using several methods such as sweep net and a light trap. This research was limited to the order of Phasmatodea (Stick Insect) found in Hutan Lipur Bukit Bakar, Machang, Kelantan.

## 1.5 Significance of Study

The significance of doing this study is to determine the diversity of phasmid exists in Hutan Lipur Bukit Bakar, Machang, Kelantan. The study can contribute to the development and conservation of the study area. Then, it may lead to the entotourism activity in that area. Besides, this research can provide an useful information about the diversity of phasmid in the future. Finally, it can contribute to the insect's data in Kelantan and collection of insect's specimen at Natural Resources Museum of Universiti Malaysia Kelantan.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Morphology of Phasmid

Phasmid morphology resembles sticks or leaves. Figure 2.1 below shows the basic features of typical phasmid (Bragg, 1997). Phasmids have a long body, either a cylinder shape or flattened. They are often quite large and can reach a length of over 20cm (Walkabout, 2018). The phasmid body divided into three parts which are head, thorax and abdomen. The head carries the paired of antennae and a pair of large compound eyes. The pair of antennae is covered with sensory hairs which is important for helping the phasmid to detect its surroundings. Antennae are often slender and long (Brock, 1999).

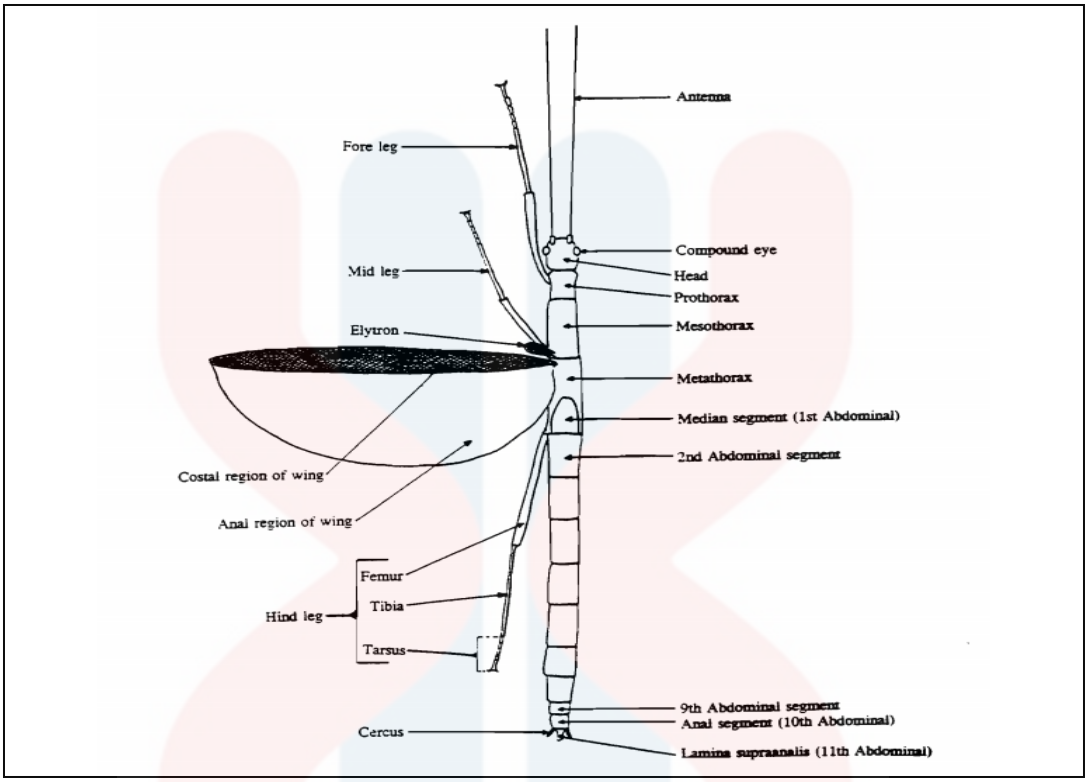


**Figure 2.1**: The basic features of typical phasmid (Source: Bragg, 1997)

The thorax consists of three segments which are prothorax, mesothorax and metathorax. Prothorax is the shortest segment which carries the fore legs while mesothorax is the second segment of the thorax and usually the longest segment which carries the middle leg and fore wings if present. The last segment is metathorax where it is usually shorter than the mesathorax and may be fused with the first abdominal segment. It also carries the hind legs and hind wings if present. The shape of thorax may be varies according to the species but it is often very long and stick-like. The legs are often long and slender (Brock, 1999).

Then, the abdomen consists of ten segments on the upper dorsal surface including the first segment which may be fused with the metathorax. There are eight visible segments on the ventral surface in the male and seven in the female. The final abdominal segment has a pair of terminal segmented appendages which is called cercus (Brock, 1999).

**2.2 Behaviour of Phasmid**

Phasmid is a phytophagous insects and very detailed about the species of plant they consumed (Francis, 1997). Most species of the phasmid only feed on a certain species of plants. Destruction of the plants will result to the extinction of phasmid and will not found at a clear site anymore. Destruction of forest trees is an important causes of the loss of some of our indigenous stick-insect species as the food plant they consumed are cleared (Francis, 1997). There are also some of the phasmid known as carnivorous insects (James, 2018).

Phasmid utilize various defensive strategies to escape from a predator or to deter a possible predator. Their defense mechanism can be derived into two categories which are passive and active. The passive defenses are cryptic coloration, mimicry and nocturnal habit while active defenses include production of strong smelling secretion and flash colour coloration which is a method of defense where they flash their colorful wings in an attempt to ward off their predator (Bragg, 2001). Their natural camouflaging behavior makes them difficult to be detect by the predator but there are many species that have a secondary line of defense in the form of toxic secretion and startle displays.

This species is nocturnal for adults and diurnal for nymphs (Baker, 2008). Its commonly play dead when handled during daytime. However, tenacious handling can causes them to "wake up" and walk away. If the abdomen of the phasmid is gripped at this stage, the bright red wings will flash open and usually being held open for quite sometimes. Phasmid have the ability to regenerate a member when accidentally (or voluntarily) lost and this is called autotomy. This event occurs when the leg is taken by a predator or the leg is broken in a specialized zone. The phasmid can thus escape, usually by simply leaving the leg to fall. This lost leg will be regenerated when the insect molts (Brock, 2018).

### 2.3 Life Cycle of Phasmid

Phasmid has three life stages which are eggs, nymphs and adults. Phasmid is said to undergo an incomplete metamorphosis where there is no development of pupa as in butterflies. Stick insects can reproduce both sexually, with normal pairing of the sexes or in parthenogenetically from unfertilized eggs. The offspring of the latter are usually females only (Brock, 1999).

The first stage is eggs where it is usually laid singly and often simply dropped to the ground by the female. The number of eggs laid varies from species to species but it is rarely less than 100 and sometimes over 2,000 for each female. Eggs are vary in size and shape which is from small perfectly round structures to long cigar shaped structures with elaborate markings (Brock, 1999). Many phasmid eggs resemble seeds and have hard capsules. The difference in the incubation period of the eggs between species is vary but sometimes the related genera often have a similar period. Some species often take over a year to hatch but there are some species that only take as little as a month (Brock, 1999).

Next, the second stage of the phasmid is nymph where newly hatched phasmid is known as first-instar nymph which often resembles miniature versions of adults. They eat leaves according to their specific foodplants and grow at varying pace depending on species (Brock, 1999). While still in their first instar, they grow longer than their original size but once the nymphs cannot grow anymore, the moulting process will occur. At the first moult, the phasmid becomes a second-instar nymph and so on until reaching an adult stage of life. The usual number of moults made during the nymphal stage is from four to eight with male is often making one less moult than female (Brock, 1999). Generally, female phasmid have 6 larval instars while the males have 5 larval instars (Brock, 1992).

The last stage of life cycle of the phasmid is an adult stage. The main responsibility of adults is to continue the species where it is the stage of the phasmid to reproduce a new offspring. Many species of the phasmid can reproduce by parthenogenesis where it is refer to the ability of female to lay fertile eggs without the present of male (Brock, 1999). The rare occurrence of the adult phasmid is the ability of some adults to change colour within short period of time as an hour but most adults are unable to change colour. The reason of the changes is not known but it is believe that the changes in humidity or other condition may be the cause (Brock, 1999). Overall, the entire life cycle of the phasmid may take a several months to several years depending on the species (Tilgner, 2006).

## 2.4 Diversity of Phasmid in Malaysia

Approximately 2,500 species of Phasmida have been described throughout the world, where they are common in tropical and subtropical countries (Brock, 1999). Based on the book written by Francis (2005) entitled Phasmid of Peninsular Malaysia and Singapore, there are 119 species of phasmid found in West Malaysian and Singapore including two undescribed subspecies and unidentified species of stick and leaf insects. There are two suborder of phasmid found which are Anareolatae and Areolatae. The family under suborder Anareolatae is Heteronemiidae and Phasmatidae. The subfamily under Heteronemiidae consists of four subfamilies which are Heteronemiinae, Lonchodinae, Necrosciinae and Pachymorphinae. Then under Phasmatidae family, there are two subfamilies described which are Phasmatinae and Platycraninae.

Besides, there is suborder Areolatae where consists of three families which are Aschiphasmatidae, Bacillidae and Phylliidae. The subfamilies described under Aschiphasmatidae family are Aschiphasmatinae and Korinninae. Then, subfamily under Bacillidae family is Heteropteryginae.

According to Brock (1999) who wrote the book entitled Stick And Leaf Insects of Peninsular Malaysia and Singapore, there are 102 species of phasmid recorded and 47 of them are endemic to Peninsular Malaysia. Most of the localities that Brock has studied are Cameron Highlands, Genting Highlands, Tapah Hills, Fraser's Hills, Penang Hills and Taman Negara in Pahang.

## 2.5 Importance of Phasmid

In term of economic importance, in the temperate zone, phasmids are not abundant enough to cause injury to their host plant. However, in the tropics, some species of phasmid are known to cause economic losses to shrubbery, shade trees and also defoliating a forest trees (Meyer, 2016). Stick insects have been reported as crucial phytophagous pests of timber and agricultural since 1880s in Australia, China, North America and Pacific Islands (Baker, 2015). Stick insects are herbivores that enjoy dining on the leaves of deciduous trees and shrubs such as oak, rose, rhododendron, ivy, eucalyptus, apple and strawberry. Species from the subfamily Lonchodinae could possibly be important in limiting plant growth and become a crop pest in certain circumstances (Bragg, 1992). Their feeding activity may be beneficial because they prune foliage and encouraging new plant growth. They lower the growth of early successional plants such as weedy areas, grassland and many more by consuming them and at once this activity may sustained the forest recycling (Cipollini, 2017).

The importance of phasmid as herbivores has attracted some interest as they can reach plague numbers and may cause severe damage to forests. Such herbivores exerting strong pressure and may be a key agents in maintaining forest dynamics and ecosystem stability (Lowman, 1984; Brokaw, 1985; Schowalter, 1985; Brown et al., 1987).

# CHAPTER 3

# MATERIALS AND METHOD

## 3.1 Study Site

The location of the study was carried out at Hutan Lipur Bukit Bakar, Machang, Kelantan. Hutan Lipur Bukit Bakar is one of the Permanent Reserved Forests (PRF) in Peninsular Malaysia. Hutan Lipur Bukit Bakar was then gazetted as the recreational forest (Norashikin, Aziz & Latiff, 2015).

The area of this forest is 3.14 hectares located in the Ulu Sat Permanent Reserved Forests. It is located at 5° 43' 27.9516" N, 102° 15' 35.0676" E. The collection of the phasmid was collected at three different sampling points which are Trail 1, Trail 2 and Trail 3. The coordinate for each sampling point was recorded by using Global Positioning System (GPS) version Garmin 72H. The study was conducted for 21 days from July to August 2018. Figure 3.1 shown below is the maps of the Hutan Lipur Bukit Bakar in Machang, Kelantan.

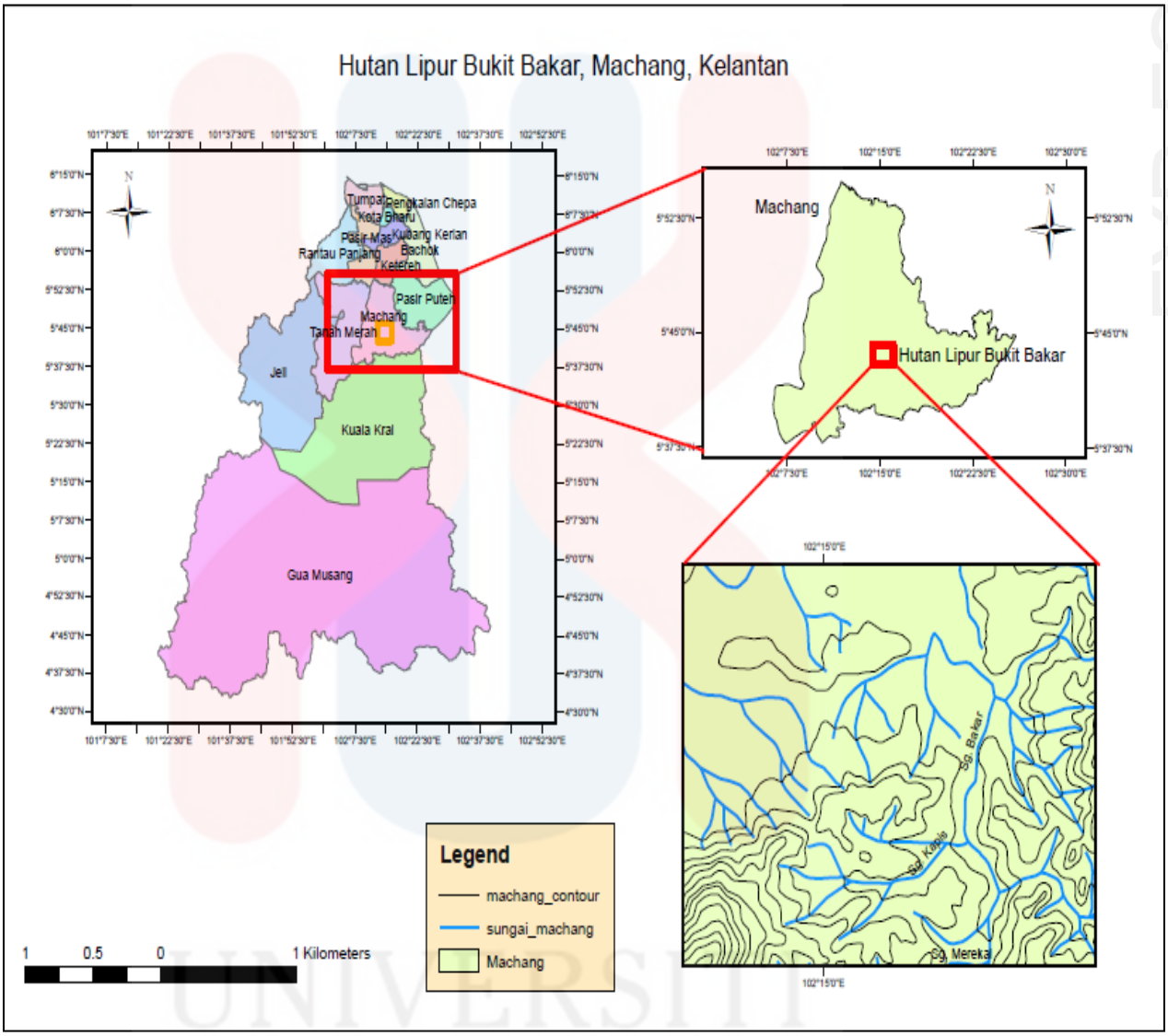


**Figure 3.1**: Maps of the Hutan Lipur Bukit Bakar (Source: ArcGis, 2018)

### 3.2 Apparatus and Materials

Table 3.1 shows the apparatus and materials that were used in collecting and identifying the species of phasmids. The phasmid sampling was done at Hutan Lipur Bukit Bakar as a fieldwork while preservation of the phasmid was done both at study area and the Biochemisty and Microbiology lab and then the specimen was deposited at Natural Resources Museum in Universiti Malaysia Kelantan (UMK).

**Table 3.1** : List of apparatus and materials

| EXPERIMENT / PROCESS | APPARATUS & MATERIALS | IMPORTANCE |
|---|---|---|
| Phasmid sampling | - Sweep net | - Manual method to catch the phasmid. |
| | - Light trap<br>- Torch light | - Method to catch phasmid during night. |
| Preservation | - Chloroform<br>- Killing Jar | - Material used to kill the phasmid. |

### 3.3 Methods

There are two ways of collecting the phasmid which are by manual and trap. The manual ways of catching the phasmid is by using sweep net at day. Then, there is also method using light trap during night for collecting the phasmid.

The phasmid collected underwent a preservation process which they were killed using chloroform in a killing jar. After all the preservation process was done, the species identification of phasmid was identified.

Finally, the diversity of phasmid was determined using several formula of data analysis.

#### 3.3.1 Phasmid Sampling

a) Sweep Net

Sweep net sampling was done during daytime which required walking along the nature trail. The sweep net was made from heavy material like canvas that can be dragged through thick vegetation without being ruined. Sweep nets was used to sweep through vegetation to collect random insects that not easily seen and it is very suitable for phasmid which is always camouflaged themselves to the environment (Macgown, 2016). Figure 3.2 shows below is the process of phasmid sampling using a sweep net.

**Figure 3.2**: The process of phasmid sampling using sweep net

b) Light Trap

The installation of light trap required some light from a portable battery that will cover about 100 meters of the forest and can also attract insects from up to several kilometers away (New, 2010). This method was done between 1900 hours to 0200 hours where someone has to be there to observe the insects that attracted to the light trap since the insects may run away. Figure 3.3 shows below are the light trap installed using a white fabric and portable battery (12V 7.2 AH Sealed Lead Acid Batteries) and light from bulb (12V 5W DC LED White Bulb).

**Figure 3.3**: Light trap installed using white fabric and portable battery

Searching around the surrounding vegetation also has been done as some insect especially phasmid may not directly sit on the enlighted surface but on the slightly enlighted shrubs nearby (Conle, 2004). The process of searching around the vegetation near the light trap was done carefully as every single corner of the vegetation needed to be checked because some phasmid may be rest under the leaves where it is impossible to spot it at one glance. This process was using torchlight as a tool to search the phasmid. Figure 3.4 below showed the process of searching around vegetation using torchlight.

**Figure 3.4**: The process of searching vegetation nearby light trap

### 3.3.2 Preservation Process

Chloroform was used in a killing jar to kill the phasmid. The preservation of the phasmid was first conducted at the fieldwork at Hutan Lipur Bukit Bakar, Machang, Kelantan. The phasmid was mounted on a setting board. Then, the sample of the phasmids were preserved using traditional method by sunlight but not too direct and too long to avoid discoloration. After the fieldwork was done, the samples of phasmid were dried preserved at 40˚C in a drying cupboard. The phasmid was dried preserved based on their size where the large one will be dry for two days and small one will be for one day at 40˚C. Colour preservation is often better at the recommended temperature level (Bragg, 1990). A data label is important for future references hence the specimen was labeled with the information such as the date of the collection, location, species name and collector.

### 3.3.3 Species Identification Process

For gender identification, normally female phasmid is much bigger than male phasmid and almost all females have no wings but the wings in male phasmid are present. For other morphological of phasmid was determined by referring to a book from Francis (2005) and Brock (1999) where the identification of phasmid was identified by using illustration and keys identification from the author respectively. All the phasmid was labeled and kept in the Natural Resources Museum of Universiti Malaysia Kelantan.

### 3.3.4 Data Analysis

The collected data of phasmid was analyzed by using a species accumulation curve to determine whether sufficient data had been collected or not (Aris, Zakaria, & Arumugam, 2017). Then, the species richness was assessed by calculating the total number of the species caught in each area (Equation 3.1). The relative abundance was calculated to identify the evenness of the distribution of individuals among species in a community (Equation 3.2). Besides, the diversity indices such as Shannon Wiener diversity index (H) (Equation 3.3) was used to identify the abundance and evenness of the species present. Hence, the evenness was calculated using Pielou's Evennes Index as below (Equation 3.4).

Species Richness = Total number of species caught …….... (Equation 3.1)

Relative Abundance = $\frac{\text{Total number of individuals per species}}{\text{Total number of individuals}}$ …… (Equation 3.2)

Shannon-Wiener Diversity Index (H') = -sum ($P_i$ ln [$P_i$]) …… (Equation 3.3)

$P_{i} = \frac{\text{Individuals of a species}}{\text{Total number of individuals' overall}}$

Pielou's Evenness Index (J') = $\frac{H'}{Hmax}$……. (Equation 3.4)

$H_{max}$ = ln s

(s = total number of species)

# CHAPTER 4

# RESULT AND DISCUSSION

## 4.1 Phasmid Assemblage

In this study, order Phasmatodea is phasmid which is categorized under two sub-order which are Areolatae and Anareolatae. Under sub-order Areolatae, there is one family called Aschiphasmatidae while sub-order Anareolatae, there are two families which are Phasmatidae and Heteronemiidae. Family Aschiphasmatidae has the same amount of species with family Phasmatidae which is three species while family Heteronemiidae recorded four species throughout the study. Therefore, the total species that has been recorded during this research was 10 species with 28 individuals.

All the collected phasmid was obtained by doing the manual collection during day using sweep net. There are no results of phasmid for light trap. Light trap was however not very sufficient for phasmid (Conle, 2004). According to Brock and Hasenpusch (2009), a light trap is useful to catch the winged phasmid that attracted to the light and it is usually the one that shows up is male phasmid but only occasionally females turn up. In this study, there are only a few of winged phasmid that are collected. This explained

that Hutan Lipur Bukit Bakar is lack in diversity of winged phasmid. Mostly, the phasmid that have found was wingless species.

Species accumulation curve was plotted every day during the sampling day as it is important to record newly found species to indicate the rate of accumulation of collected species in the study area. The species accumulation curve that was plotted shows that the y-axis represents the species cumulative against x-axis which indicates the number of days sampling (Figure 4.1).

This research has been conducted for 21 days at three different sampling points which are Trail 1, 2 and 3. Based on Figure 4.1 below, the first day of sampling recorded 2 new species and second day, one new species was recorded and remain constant for 5 days and started to rise from day 7 to day 14. The species accumulation curve below explained that the collection of the phasmid for 21 days is enough as the curve likely to reach asymptotic level from days 14 until the end of sample collection which is day 21. This means that the number of phasmid species at sampling site did not increase and remain constant for 8 days and until the last day of sampling with a total of 10 species of order Phasmatodea.

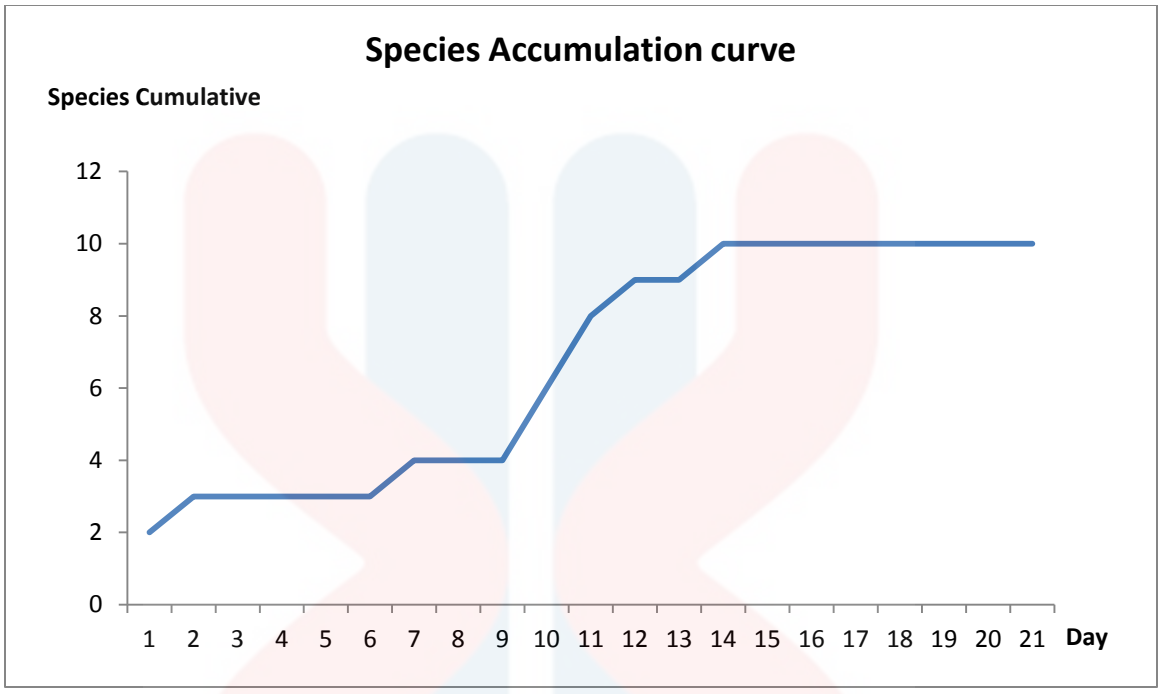


**Figure 4.1**: Species Accumulation Curve of Phasmid in Hutan Lipur Bukit Bakar

## 4.2 Diversity of Phasmid

The Table 4.1 below shows the list of collected sample in two sub-order which are Areolatae and Anareolatae. Rich assemblages of 28 individuals with 10 species were successfully identified. Sub-order Anareolatae (15 individuals) were found to be more large in number than sub-order Areolatae (13 individuals). However, family Aschiphasmatidae (sub-order Areolatae) recorded as the most dominant family with 46% based of the total individuals recorded.

**Table 4.1**: List of scientific name of phasmid

| Suborder / Family | Scientific Name | Number of Individuals | IUCN status |
|---|---|---|---|
| Suborder Areolatae | | | |
| Family Aschiphasmatidae | *Abrosoma johorensis* | 9 | Not listed |
| | *Presbistus peleus* | 1 | Not listed |
| | *Abrosoma xiuyuae* | 3 | Not listed |
| Suborder Anareolatae | | | |
| Family Phasmatidae | *Ramulus nematodes* | 7 | Not listed |
| | *Pharnacia chiniensis* | 1 | Not listed |
| | *Phobaeticus serratipes* | 1 | Not listed |
| Family Heteronemiidae | *Necroscia inflata* | 2 | Not listed |
| | *Sipyloidea sordida* | 1 | Not listed |
| | *Lopaphus langkawicus* | 1 | Not listed |
| | *Lonchodes brevipes* | 2 | Not listed |
| **Total** | | **28** | |

*Abrososma johorensis* (nine individuals) and *Ramulus nematodes* (seven individuals) are the most abundant species recorded in this study. Then, *Abrosoma xiuyuae* (three individuals) is the third most abundant species recorded and closely followed by *Necroscia inflata* and *Lonchodes brevipes* which recorded a total of two individuals respectively. The remaining five species founded recorded one individual respectively. *Abrosoma johorensis* was also the most abundant species in Gunung Ledang due to the highly density present of host plant *Clidemia hirta* and *Melastoma malabthricum* (Rabihah, Marwan & Azman, 2016).

Next, the IUCN Red List status is the world's most comprehensive inventory of the global conservation status of plant and animal species. IUCN is the platform to know the status of the extinction and higher risk of fauna and flora had to face nowadays. However, all the phasmid identified to species level collected at Hutan Lipur Bukit Bakar, Machang is under Not Listed (NL) category in the IUCN official website (IUCN, 2018).

Therefore, it is proved that all the phasmid species found in this study does not have enough recognition and study for the species.

Based on Figure 4.2 shows below is the percentage of species in three different families of order Phasmatodea at Hutan Lipur Bukit Bakar. The families are Aschiphasmatidae, Phasmatidae and Heteronemiidae. The highest percentage of species came from family Heteronemiidae with percentage of 40% which has recorded four species under this family. Then, the other two families recorded three species each with 30% of percentage.

In this study, family Heteronemiidae was found to be most dominant family based on species. According to Khaironizam et al. (2005), the family Heteronemiidae is the largest family of the phasmid which explained the most dominant species found at Hutan Lipur Bukit Bakar was under family Heteronemiidae.

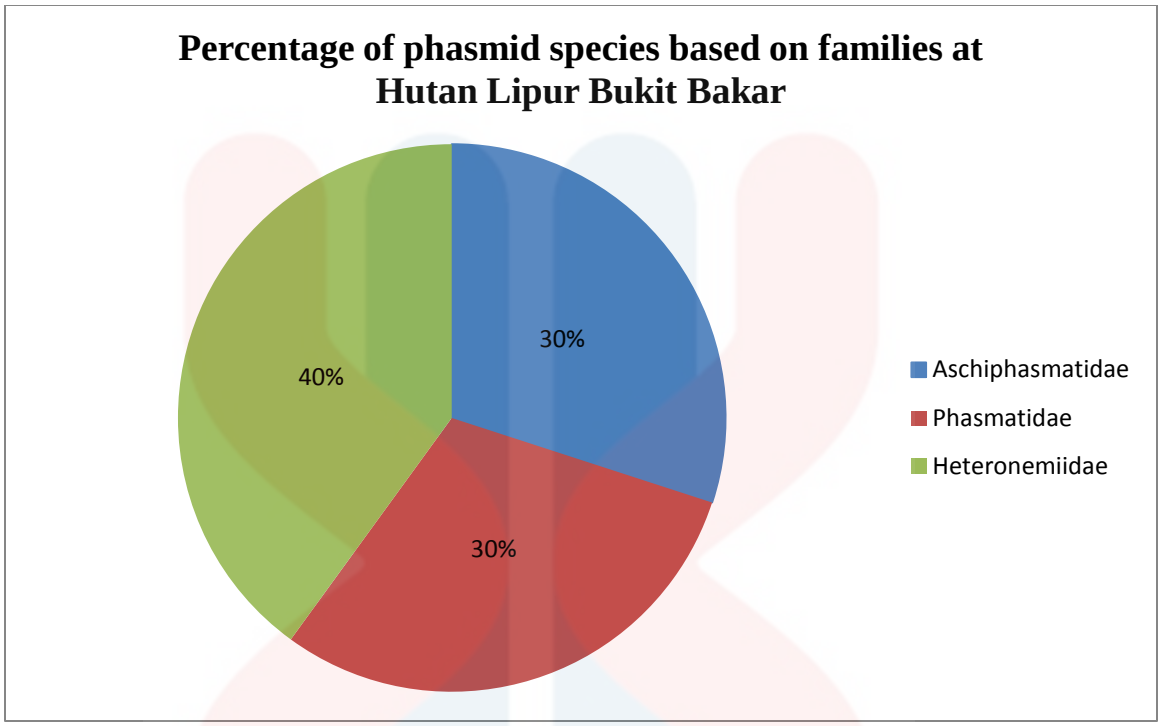


**Figure 4.2**: Percentage of phasmid species based on families at Hutan Lipur Bukit Bakar

The overall data that have been collected during 21 days of sampling at Hutan Lipur Bukit Bakar, Machang, Kelantan were analyzed using Shannon-Wiener Diversity Index and Pielou's Evennes Index. The results are shown as in Table 4.2 below.

**Table 4.2**: The value of overall diversity indices of phasmid at Hutan Lipur Bukit Bakar

| Index | Overall Value |
|---|---|
| Shannon-Wiener Diversity Index (H') | 1.80 |
| Pielou's Evennes Index (J') | 0.78 |
| $H_{max}$ | 2.30 |

Table 4.2 above explained that Shannon-Wiener Diversity Index (H') indicates the value of 1.80 which is considered fairly diverse because the value is much farther to reach the $H_{max}$ value which is 2.30. A higher value of the H' would means that the diversity is more diverse (Beals, Gross & Harrell, 2000).

The Shannon index increases as both the richness and the evenness of the community increase. The fact that the index is incorporates for both components of the biodiversity, it can be seen as both strength and a weakness. It is strength because it provides a simple and synthetic summary, but it is a weakness because it makes it difficult to compare communities that differ greatly in richness (Magurran, 2004).

According to Beals, Gross & Harrell (2000), the evenness is described as value in range of between 0 and 1 with 1 shows an absolute evenness. The Pielou's Evennes index of the study is 0.78 which is near to 1 range and this can be explained that the species present in this area is distributed evenly**.**

The overall calculation of Shannon-Wiener Diversity Index (H') and Pielou's Evennes Index (J') of phasmid species in Hutan Lipur Bukit Bakar was presented at Appendix A.

### 4.3 Comparison of Phasmid Diversity between Three Different Trails

The study was done at three different sampling which are Trail 1, 2 and 3. The elevation of Trail 1 is 49.5 metres and it is a mid-wet area compared to the other two trails. Then, the elevation of Trail 2 is 170.4 metres which is near to the water (river) and considered as a wet area. Lastly is Trail 3 which the elevation value is 56.2 metres and it is a hill area which considered as dry area.

A total abundance species is 28 individuals that were collected at Trail1, 2 and 3 at Hutan Lipur Bukit Bakar, Machang, Kelantan. *Abrosoma johorensis* was represented by nine individuals out of 28 that made its most abundance species with 32% higher than any phasmid species that was caught. The second most abundance phasmid at Hutan Lipur Bukit Bakar was *Ramulus nematodes* (7 individuals) which represented 25% of the abundance in the area followed by *Abrosoma xiuyuae* (3 individuals) with 11%. *Necroscia inflata* and *Lonchodes brevipes* recorded 2 individuals which covered 7% respectively. The remaining species collected has 1 individual recorded for each species which covered 4% in relative abundance of the area.

Based on the Table 4.3 below, there are a total of 10 species from 28 individuals that has found at three sampling trails (Trail 1, Trail 2 and Trail 3). There are three species that are found at Trail 1 which are *A. johorensis, Lopaphus langkawicus* and *A. xiuyuae*. Trail 2 shows the highest species among the other two trails which recorded seven species. While, Trail 3 showed the second most diverse species with five species recorded. It clearly showed that Trail 1 is the lowest diverse species compared to Trail 2 and Trail 3.

The Shannon-Wiener Diversity Index (H') and Pielou's Evennes Index (J') were calculated as a measure of diversity at three different trails (Trail 1, 2 and 3) at Hutan Lipur Bukit Bakar. The value of SWDI indicated that Trail 2 is the most diverse (H'=1.64) closely followed by Trail 3 (H'=1.61) and the lowest diversity index was Trail 1 (H'=0.85). Besides, the value of Pielou's Evennes Index (PEI) shows that Trail 3 is the most evenly distributed (J'=1.00) with a perfect score from ranging 0 to 1 which means that the species found at Trail 3 is distributed evenly in that area. Then, the second evenly distributed species was at Trail 2 (J'=0.84) and the least evenly was at Trail 1 (J'=0.77).

Therefore, it can conclude that Trail 2 is the most diverse species compared to Trail 1 and Trail 3. This was because Trail 2 is near to the river which may affect the diversity and existence of the phasmid at the area. However, the most evenly distributed species was at Trail 3 where the individuals of each species recorded the same amount.

**Table 4.3**: Number of individuals and species name at three sampling trails.

| **Scientific name** | **Trail 1** | **Trail 2** | **Trail 3** |
|---|---|---|---|
| **Family: Aschiphasmatidae** | | | |
| **Sub-family: Aschiphasmatinae** | | | |
| *Abrosoma johorensis* | 6 | 3 | 0 |
| *Presbistus peleus* | 0 | 1 | 0 |
| *Abrosoma xiuyuae* | 2 | 0 | 1 |
| **Family: Phasmatidae** | | | |
| **Sub-family: Phasmatinae** | | | |
| *Ramulus nematodes* | 0 | 6 | 1 |
| *Pharnacia chiniensis* | 0 | 1 | 0 |
| *Phobaeticus serratipes* | 0 | 1 | 0 |

**Table 4.3** (Continued)

| | | | |
|---|---|---|---|
| **Family: Heteronemiidae** | | | |
| **Sub-family: Necrosciinae** | | | |
| *Necroscia inflata* | 0 | 1 | 1 |
| *Sipyloidea sordida* | 0 | 0 | 1 |
| *Lopaphus langkawicus* | 1 | 0 | 0 |
| **Sub-family: Lonchodinae** | | | |
| *Lonchodes brevipes* | 0 | 1 | 1 |
| **Shannon-Wiener Diversity Index (H')** | **0.85** | **1.64** | **1.61** |
| **Pielou's Evennes Index (J')** | **0.77** | **0.84** | **1.00** |
| **Total number of species** | **3** | **7** | **5** |
| **Total number of individuals** | **9** | **14** | **5** |

Based on Table 4.3 above, major species that show the major abundance at Trail 1 was *Abrosoma johorensis* (6 individuals) followed by *Abrosoma xiuyuae* (2 individuals) while at Trail 2, the major abundance species recorded was *Ramulus nematodes* (6 individuals) followed by *A. johorensis* (3 individuals). Lastly, the number of individuals of species found at Trail 3 is distributed evenly with one individual for each species which are *A. xiuyuae, R. nematodes, Necroscia inflata, Sipyloidea sordida* and *Lonchodes brevipes.*

According to Francis & Goh (1999), *Abrosoma johorensis* was a new collected species found in Pulau Tioman, Pahang. This species may be found in the lowlands and low hills of Gunung Pulai, Gunung Ledang, Kota Tinggi, Johor and Pulau Tioman, Pahang in Peninsular Malaysia. This explained why *A. johorensis* was mostly found at Trail 1 in this study, it is because the elevation of Trail 1 is lower than the other two trails which is 49.5 metres.

The total number of species at three different trails which are Trail 1, Trail 2 and Trail 3 has been collected with 10 species and has been identified under three different families (Aschiphasmatidae, Phasmatidae and Heteronemiidae). Figure 4.3 below shows the number of species found at each area. The highest number of species recorded belongs to the Trail 2 with 7 species (47%). It shows that Trail 2 is the most diverse area compared to the other two areas. Then, the second highest species recorded followed by area of Trail 3 with 5 species and hold 33% in percentage. The lowest number of species was at Trail 1 with 3 species recorded (20%).

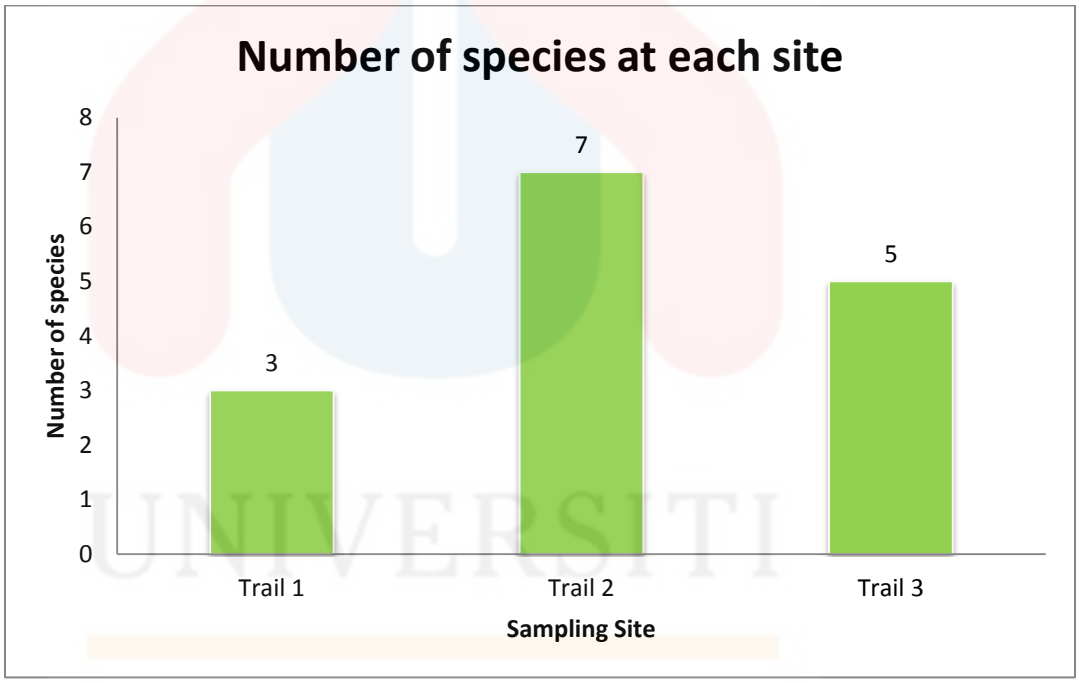


**Figure 4.3**: The bar chart for number of species at each site.

From the Figure 4.4 below, among the total collected of 28 individuals at three different areas, nine individuals was belong to Trail 1, followed by 14 individuals for Trail 2 and five individuals at Trail 3. The highest number of individual comes from Trail

2 with 14 individuals recorded and give percentage of 50%, closely followed by Trail 1 with nine individuals (32%) and Trail 3 with five individuals (18%) respectively.

Trail 2 show the highest number of individuals and species compared to the other area. Trail 2 is near to the river, which means that the diversity of phasmid at Hutan Lipur Bukit Bakar was attracted to the water more compared to the dry area (Trail 3) and mid-wet area (Trail 1).

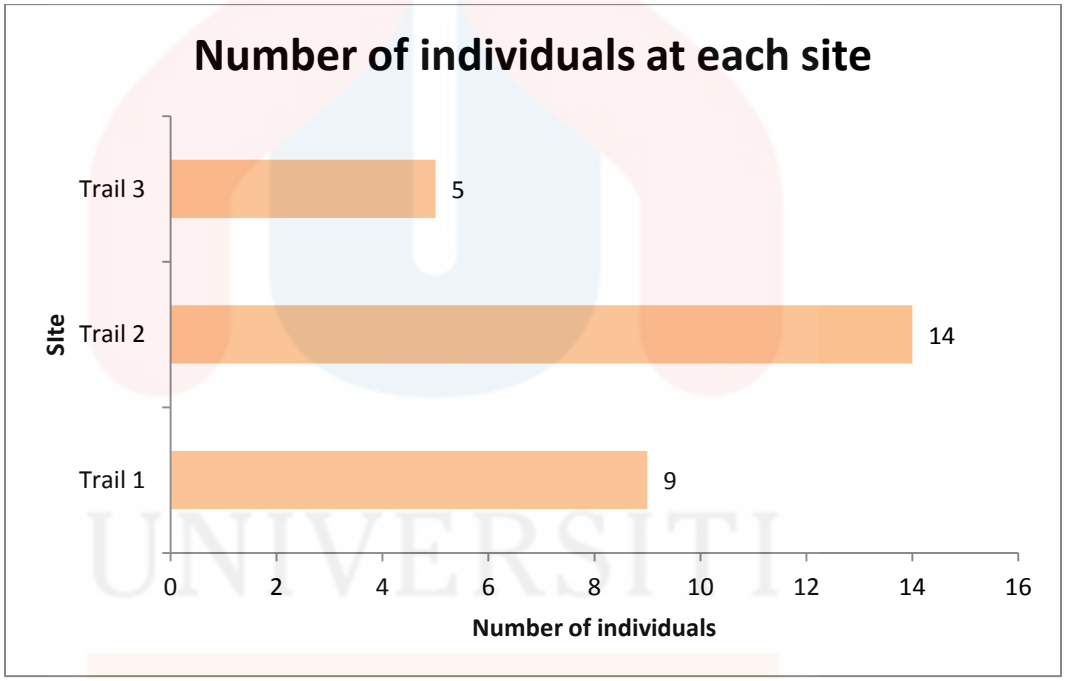


**Figure 4.4**: The bar chart of number of individuals at each site.

A total 28 individuals of 10 species representing three different families was successfully collected and identified in this study. The highest family species collected was Heteronemiidae (four species) followed by two other families (Aschiphasmatidae

and Phasmatidae) which recorded the same amount of species collected of three species respectively.

With a total of 10 species, the phasmid community of Hutan Lipur Bukit Bakar was expectedly low in species richness. Worldwide, the order Phasmatodea contains about 3000 described species that occur mainly in tropical regions (Whiting, Bradler & Maxwell., 2003) and also is species poor compared to other insect orders that are highly diverse in herbivores like Lepidopterans, Coleopterans, and Orthopterans. According to Bragg (2001), 10% of worldwide described phasmid was found in Borneo.

Based on the study of Khaironizam et al. (2005) which was conducted for seven months from April to October, the phasmid study in Southwestern Endau-Rompin National Park, Johor has relatively diverse phasmid with 24 species. The most common species was quite similar to this study which is *Necroscia inflata* that have found two individuals in Hutan Lipur Bukit Bakar. This is proved that the diversity of phasmid is the same in each month considered this study was done from July to August.

# CHAPTER 5

# CONCLUSION AND RECOMMENDATION

## 5.1 Conclusion

In conclusion, this study has identified that the species richness of phasmid (Order: Phasmatodea) at Hutan Lipur Bukit Bakar, Machang, Kelantan was 10 species which comprises from three different families, namely Aschiphasmatidae, Heteronemiidae and Phasmatidae. Family Heteronemiidae recorded the highest species found in the study area compared to the other two families. Meanwhile, *Abrosoma johorensis* is the most common species that have found in the study area with a total of 9 individuals with overall of 28 individuals found.

Besides, the Shannon-Wiener Diversity Index (H') indicates the overall value of 1.80 and is considered fairly diverse and means that Hutan Lipur Bukit Bakar is the area which is suitable for the community of phasmid diversity. The Pielou's Evennes Index (J') value is calculated to be 0.78 which almost reached the complete evenness in species distribution hence proving that Hutan Lipur Bukit Bakar is the area of well distributed species of phasmid diversity.

## 5.2 Recommendation

From the research, there are some recommendations that have been suggested based on the result collected. As the appearance of phasmid itself is unique even though the existence is poorly acknowledged by public, Hutan Lipur Bukit Bakar can organized an event or campaign to get to know the existence of phasmid well. For example, they can make a replant activity to community based on the host plant that phasmid consumed so that the diversity of phasmid can be conserved.

Besides, as the status of phasmid in IUCN portal is not listed, it shows that the study of the diversity of phasmid is not enough especially in Malaysia so University around Malaysia can encourages their student to involve in research of the phasmid so that the data of the diversity of phasmid in Malaysia can be improved and used for future study. Then, future study for the diversity of phasmid can be done in the future to collect a data related to the phasmid. Lastly, the different time of the research are highly suggested as some of the phasmid may only exist on certain month.

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## APPENDIX A

Calculation of Shannon-Wiener Diversity Index and Pielou's Evennes Index

**Table 1**: Shannon Wiener Diversity Index in Trail1,2 and 3.

| Scientific Name | No of Individuals | Relative Abundance (pi) | pi (ln pi) |
|---|---|---|---|
| *Abrosoma johorensis* | 9 | 0.32 | -0.36 |
| *Abrosoma xiuyuae* | 3 | 0.11 | -0.24 |
| *Lonchodes brevipes* | 2 | 0.07 | -0.19 |
| *Lopaphus langkawicus* | 1 | 0.04 | -0.12 |
| *Necroscia inflata* | 2 | 0.07 | -0.19 |
| *Pharnacia chiniensis* | 1 | 0.04 | -0.12 |
| *Phobaeticus serratipes* | 1 | 0.04 | -0.12 |
| *Presbistus peleus* | 1 | 0.04 | -0.12 |
| *Ramulus nematodes* | 7 | 0.25 | -0.35 |
| *Sipyloidea sordida* | 1 | 0.04 | -0.12 |
| Total | 27 | 0.96 | -1.80 |

Shannon Wiener Diversity Index (H'):

$$H' = -\text{sum}\ (P_i \ln [P_i])$$

$$H' = -\ (-1.80)$$

$$H' = 1.80$$

Pielou's Evennes Index (J'):

$$J' = H'/ H_{max}$$

$$J' = H'/ \ln S$$

$$J' = 1.80/\ln 10$$

$$J' = 0.78$$

## APPENDIX B

The figure below shows some of the species found at Hutan Lipur Bukit Bakar, Machang, Kelantan.

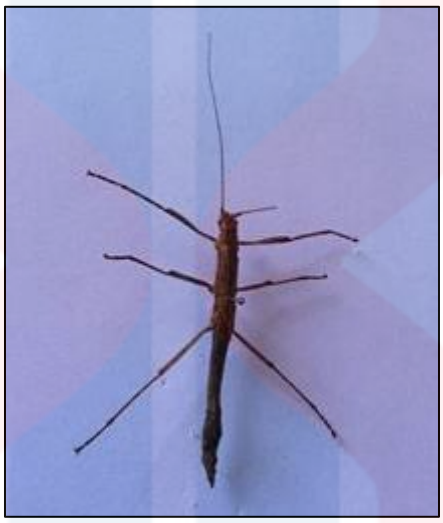

**Figure 1**: (*Abrosoma johorensis*, ♀) or commonly known as Winged Abrosoma.

**Figure 2**: (*Abrosoma johorensis*, ♂) or commonly known as Winged Abrosoma.

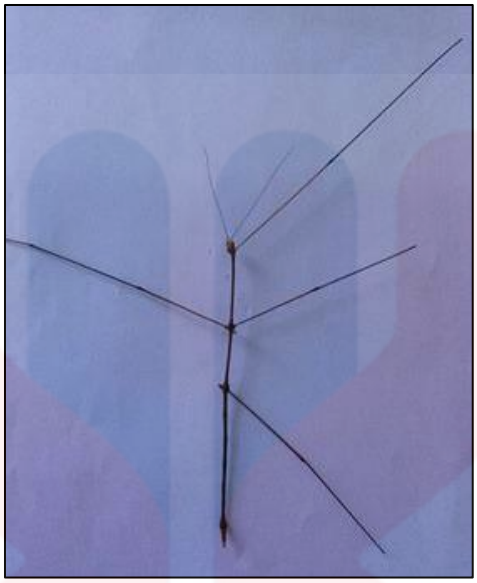

**Figure 3**: (*Ramulus nematodes*, ♂) or commonly known as Great Thin Stick.

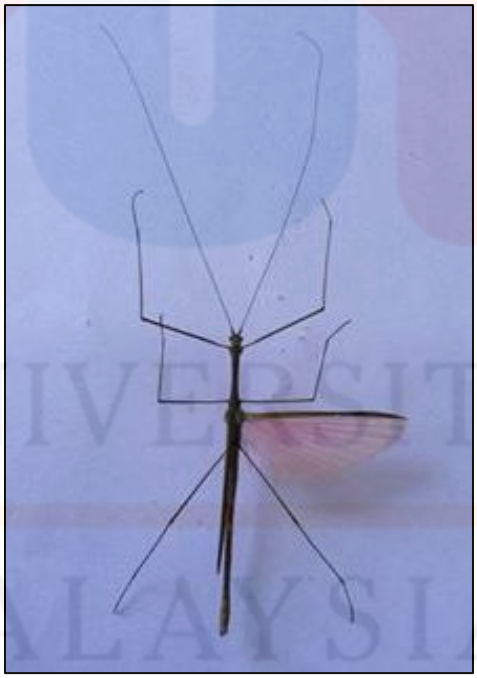

**Figure 4**: (*Necroscia inflata*, ♂) or commonly known as Green Flying Stick.

**Figure 4**: (*Presbistus peleus*, ♂) or commonly known as Green Striped Flying Stick.

**Figure 5**: (Lonchodes brevipes, ♀) or commonly known as Gray's Malayan Stick Insect.

## APPENDIX C

The table below shows the planning of Final Year Project (FYP I & FYP II).

**Table 1**: Planning of Final Year Project

| Activity | Date |
|---|---|
| Proposal Writing | February – April 2018 |
| Proposal Defences | May 2018 |
| Proposal Submission | June 2018 |
| Fieldwork Sampling | July – August 2018 (21 days) |
| Data Analysis | August – October 2018 |
| Thesis Writing | September – December 2018 |
| Thesis Presentation | December 2018 |
| Thesis Submission | January 2019 |