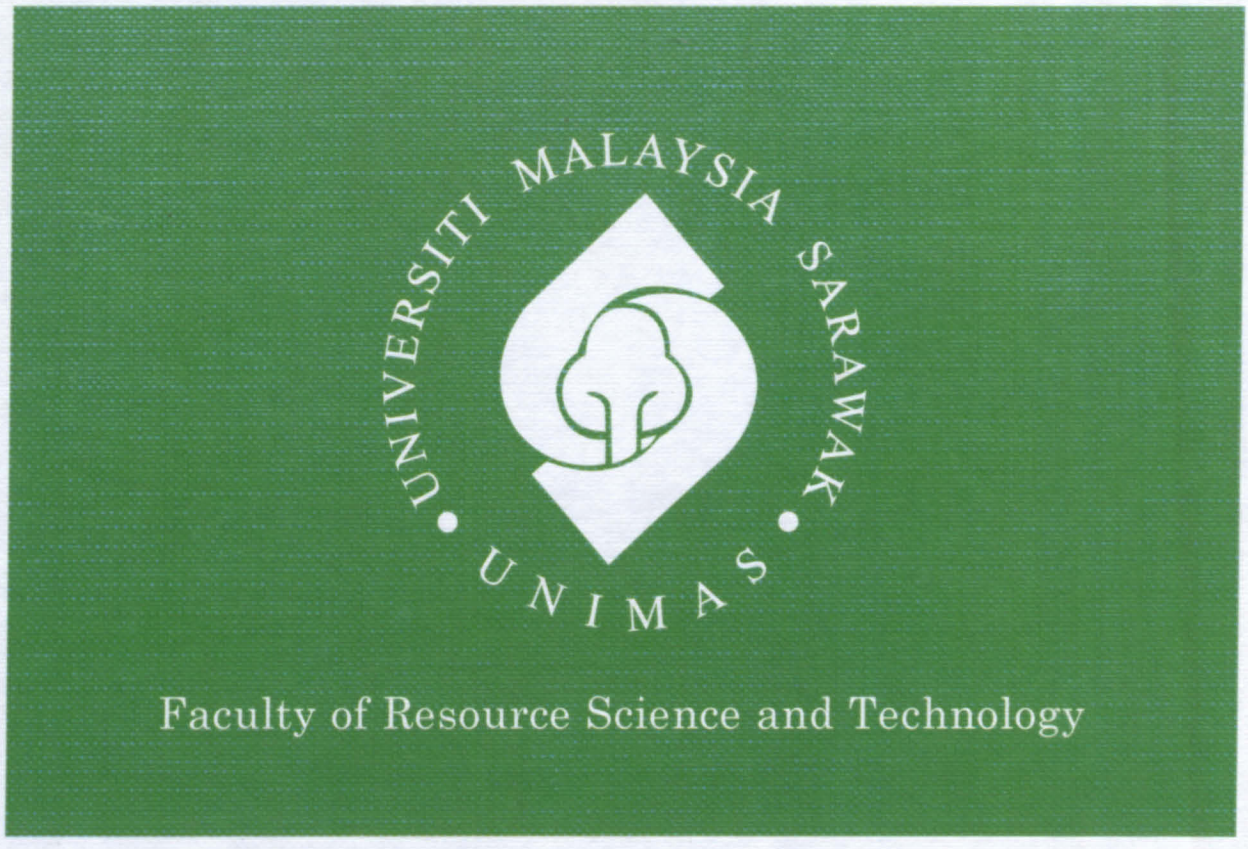

Comparative Study on Moths (Heterocera: Arctiidae) Diversity in Selected Oil Palm Plantation and Fragmented Forest

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2015

UNIVERSITI MALAYSIA SARAWAK

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I NUR JIN ANYAH BINTI ZARIMIN 38024

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LIST OF ABBREVIATIONS

UNIMAS	Universiti Malaysia Sarawak
FRST	Faculty of Resource Science and Technology
GPS	Global Positioning System
HCV	High Conservation Values
cm	Centimeter
km	Kilometer
m	Meter
W	Watt
sp.	Species
No.	Number

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Comparative Study on Moths (Heterocera: Arctiidae) Diversity in Selected Oil Palm Plantation and Fragmented Forest

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ABSTRACT

A study on species diversity of arctiid moths was carried out in oil palm plantation and fragmented forest of PPB Oil Palm Plantation, Miri. The main method was by using four modified Pennsylvanian light traps that left functioning from 6.30 p.m to 10.30 p.m. A total of 34 species and 638 individuals from four subfamilies were recorded. Overall, the subfamily Lithosiinae represented by the highest species number followed by Syntominae, Arctiinae and Aganainae. Eight species identified as endemic to Borneo while six rare species was also captured in this study. The Shannon- Weiner diversity indices (H') for each fragmented forest and oil palm plantation were same which were 2.840. There was higher number of total abundance and species abundance of arctiid moths in fragmented forest rather than in oil palm plantation. However, indices indicated that there was no significant difference between the study sites due to the higher number of shared species were identified.

Key words: Arctiidae, species diversity, Modified Pennsylvanian light traps, fragmented forest, oil palm plantation

ABSTRAK

Satu kajian mengenai kepelbagaian spesies kupu-kupu arctiid telah dijalankan di ladang kelapa sawit dan di pecahan hutan PPB Oil Palm Plantation, Miri. Kaedah kajian ialah dengan menggunakan empat perangkap cahaya Pennsylvanian yang diubahsuai serta dibiarkan berfungsi dari jam 6.30 hinggan 10.30 malam. Sejumlah 55 spesies dan 638 individu telah direkod dalam kajian ini. Keseluruhannya, subfamili Lithosiinae merupakan jumlah spesies yang tertinggi dan diikuti dengan subfamili Syntominae, Arctiinae dan Aganainae. Lapan spesies telah dikenalpasti sebagai spesies endemik di Borneo sementara enam spesies yang jarang dijumpai telah ditangkap dalam kajian ini. Indeks kepelbagaian Shannon- Weiner (H') bagi setiap pecahan hutan dan ladang kelapa sawit adalah sama 2.840. Limpahan jumlah dan limpahan spesies di pecahan hutan lebih tinggi dari ladang kelapa sawit. Namun demikian, indeks menandakan tiada perbezaan yang bermakna diantara kedua-dua tempat kajian disebabkan oleh banyak spesis yang dikongsi telah dikenalpasti.

Kata kunci: Arctiidae, kepelbagaian spesies, pecahan hutan, ladang keapa sawit, perangkap cahaya Pennsylvania yang diubahsuai

1.0 INTRODUCTION

Diversity simply defined as the total number of different items and their relative frequency (Aslam, 2009). In biological diversity, these selected items arranged in order at many different levels that organized from a complete ecosystem and followed to the basic molecular of heredity in the form of chemical structure (Aslam, 2009). Thus, the term actually encompasses differ ecosystems, relative abundance, level of species and genes. According to Aslam (2009), diversity is one of the main characteristic of the population with multi-species.

More than 50%, as known of animal species, are insects. It is the second largest in the world and the diverse which is the class of Insecta, order Lepidoptera (Aslam, 2009). Arctiid belongs to suborder Heterocera and superfamily Noctuoidea. Arctiids represent roughly 6% of lepidopteran species diversity worldwide (William, 2009). Approximately over, 11,000 species has been described. There are five subfamilies of arctiid moths can be found in Borneo which are Lithosiinae (Holloway, 2001), Arctiinae, Syntominae, Euchromiinae and Aganainae (Holloway, 1988).

According to FAO Corporate Document Repository (2002), fragmented forest occurs when a continuous and a large size forests are divided into smaller blocks, either by roads, clearing for agriculture, urbanization, or other human development. According to Emily *et al.* (2008), oil palm plantation were supporting low of forest species. There were huge differences in species composition between the fragmented forest and oil palm plantation (Emily *et al.*, 2008).

Moth plays a role in the ecosystem and beneficial either indirectly or directly to the environment and human (Common, 1990). Arctiid moths was selected in this study because of its contributing in the process of pollination for herb plants and native species. According to Common (1990), arctiid moths also is a scavenger which is fed on a variety of organic materials include the dead leaf and followed by steps of broken-down to humus. In addition, immature stages and adult moth play the important part which is as food sources for insectivorous lizards, birds, marsupials, bats and bird (Common, 1990).

Thus, the primary objective in this study was to study the diversity of arctiid moths in selected oil palm plantation and fragmented forest. This study also aimed to compare the diversity of arctiid moths between the two selected areas which were selected fragmented forest and oil palm plantation. It would be interesting to investigate whether there is any significant difference between the species diversity of arctiid moths in oil palm plantation and fragmented forest. Results from this study would contribute some additional information about the arctiid moths and their crucial role in ecosystems.

2.0 LITERATURE REVIEW

2.1 Classification of Arctiid Moths

Moths are classified within the order Lepidoptera which is in one of the order that branched from the main class of Insecta and divide into the subclass of Endopterygota (Barlow, 1982). Moth then classified into two main suborders which are butterflies (suborder Rhopalocera) and moth (suborder Heterocera). Family Arctiidae is included in superfamily Noctuoidea. There are six separate families has been listed under superfamily Noctuoidea which are Artiidae, Ctenuchidae, Lithosiidae, Nyctemeridae, Pericopidea and Thyretidae (William, 2009).

Arctiid moths also were known as tiger moth, footmen, and woolly bears (William, 2009).Common name of footmen because it resembles thin and long abdomen when adult stage. Some of them often called tiger moth because it has the appearance of bold pattern and bright color such as orange, yellow and red. Some of them also refer as woolly bears because some resemble extremely hair in the larva stage (William, 2009).

2.2 Diversity of Arctiid Moths in Borneo

Borneo Island is a famous hot spot for biological richness in the Indo-Malayan region and the center of biodiversity's world (Nick & Cede, 2006). Borneo is also well-known for the present of larger insects of order Lepidoptera and becomes a home for most species of butterflies and moth (Nick & Cede, 2006). According to Nick and Cede (2006), 10 per cent of the species exists were listed as endemic species on the island and around 7,700 species are restricted in Sumatra, Java, Palawan, Borneo and Malay Peninsular.

In a study by Holloway (1998; 2001), 3,249 species of moths described in Borneo. There are 247 species of arctiid moths, 150 species from subfamily Lithosiinae (Holloway, 2001), 40 species from subfamily Acrtiinae and 55 species from subfamily Syntominae (Holloway, 1988).

In another study by Yoe (2009) in moth diversity at kerangas forest at Sarawak. She recorded 966 individuals of moths with 96 species are from the family Arctiidae. Among them, 45 species are from the subfamily Lithosiinae, five species from subfamily Arctiinae and three species from subfamily Syntominae (Yoe, 2009).

A research on moth diversity had been done by Chey (2010) at Maliau Basin, Sabah. A total of 355 species and 753 individuals were recorded. Among them, there are 41 species of arctiid moths, 38 species are from subfamily Lithosiinae, one species from subfamily Arctiinae and two species from subfamily Syntominae (Chey, 2010).

2.3 Morphology of Arctiid Moths

According to Barlow (1982), the morphology of an adult moth is clearly can be seen by the presence of light membranous wings that bears in two pairs and covered with the overlapping of scales. Barlow (1982) stated that the defining characteristics for the adult moth, which not occur in other order in class Insecta is the mouthpart are being modified into a coiled long proboscis.

Family Arctiidae has a variation in size which is from small to medium sized (Barlow, 1982). Usually, the male's arctiid moths will have the ciliate or bipectinate antennae. Instead for female Arciid moth, the bipectinate and ciliate antennae are absent or being reduced. In addition, there are many pedicels present at the base of the antennae. The properties of the proboscis are short and reduce (Barlow, 1982). Moreover, their palpi also short.

The subfamily Lithosiinae are narrow-winged with the appearance of thin abdomen with a very small size and easy to overlook (Barlow, 1982). Both sexes have filiform antennae. The presence of proboscis but short in size. The properties of Lithosiinae eyes are small and black in colour. Almost all the species are sexual dimorphism which is the males have a different appearance from the females (Barlow, 1982).

Members of subfamily Arctiinae are larger in size comparable to subfamily Lithosiinae. This subfamily showed hairy bodies. The properties of their wing colours tend to creamy yellow and white in color with a series of the darker spots (Barlow, 1982). According to Barlow (1982), the proboscis is usually a minute or absent. At their legs consist of small spurs and common lack of hair (Barlow, 1982). They presence of proboscis and their palpi are pointed and long. Both of male and female has bipectinate antennae, but the males resemble shorter branches than females. They have slender bodies and distasteful to birds. Their larvae resemble urticaceous and hairy and their pupae in light webs.

The body sized for subfamily Aganainae is medium-sized. They also have finely bipectinate or ciliated antennae (Barlow, 1982). Moths from the subfamily Aganainae have the following characteristics: structure of palpi are long, hairy and brightly coloured on the second segments of palpi, smoothly and up-pointed at the third segments, proboscis with large head and prominent eye (Barlow, 1982). Aganainae species generally bright in colour. Their eggs are laid in the form of clusters. The appearance of their larvae is smooth, bright in color, cylindrical in shape or banded. The pupae can be found in light of silk web. They prefer *Ficus* sp. (fig family) as the food source (Barlow, 1982).

2.4 Behaviour of Arctiid Moths

Defining characteristic of arctiid moths is the presence of metepisternal tymbal and visible laterally paired dorsal female pheromone glands (William, 2009). Tymbal organ is sound-reproducing organ. The adult of many night-flying arctiid moths species are able to produce a high- frequency sound. This is one of the signs from arctiid moths as a warning to the predatory bats that they are distasteful (Barlow, 1982).

The adult species from subfamily Lithosiinae are able to produce oily and distasteful secretion at their head in order to protect themselves from enemies (Barlow, 1982). They prefer to fall down and look like a dead moth into the vegetation instead of flies away when being disturbed. It made by combining with jump action, facilitated by long hind legs. According to Barlow (1982), it is generally folded their wing round the abdomen when at resting state.

For the subfamily Arctiinae, the adult has thoracic glands in yellow colour, which later will, produce acrid substances when they are being disturbed (Barlow, 1982). Most of the species in this family are having extremely warning of coloration by readily produce distasteful and acrid liquid from the thorax (Barlow, 1982).

2.5 Attraction to Light

One of the natural phenomenons is the attraction of insects to the light. Barlow (1982) stated that the ratio of females to males at 5% to 95% can be found in the presence of light area, which showed that the sexual phenomenon may be affected by light attraction. The gradient of light also important because based on the observation from Barlow (1982) on the ways of moth spiral flight, moth only attracted to the light but do not show any interest to fly directly to the moon.

There are also different theories that being forward recently. According to Barlow (1982), females from certain species will be able to attract the males that also come from the same species in the ecological of temperate climates with ranges maximum of 400 meters from base for mating. Based on experiments conducted by Laithwaite (1975), he uses European Vapourer Moth, *Orgyia antiqua*, the wingless female moth. He observed that the marked males was being released in the range of 100 yards and amazingly within minutes, the males can detect the location of virgin females and named as "smoke pattern" or also can be known as pheromones of wind-borne (Barlow, 1982).

2.6 Life Cycle of Moth

One of the elements that affected the successful in each animal is by the total number of offspring being produced (Mark, 1997). The genetic contents copied from generation to generation in order to make sure the successful individual will survive and selected in the process of natural selection (Mark, 1997). Lepidoptera will undergo the complete and complex metamorphosis (Barlow, 1982). A complete life cycle of a moth is shown by undergoing the complete of each stage that begin with eggs, followed by larvae, pupae and developed or an adult (Mark, 1997). The strategy of the life cycle varies in stages of the process of hatching to reproduction and relate with the external environment (Mark, 1997).

It is not relevant to an insect to be matured in a short period of time. The adult moth may be small in size, but still will produce a few eggs. According to Mark (1997), different species will have different size of adults and the generation time. Few of the moth only have a short of generation times and some can produce many eggs. In addition, large food sources need to keep for large eggs. A moth can produce a small quantity of a large egg (Mark, 1997). The small size of an egg will result in the small size of larvae, but can keep in huge number.

2.7 The relation between Arctiid Moths and Plant Diversity

Differ part of the plant will function as food sources for the larvae and adult moth (Mark, 1997). Almost 98% of larvae moths are herbivorous. According to Mark (1997), plant fluid will provide fuel to adult moth for flight action and as sources of nutrient for egg maturation.

Most of the moth will feed on vascular plants, which at the leaves or buds parts (Mark, 1997). Some of the species also focus on the flowers, bark, seeds and wood (Mark 1997). Leaf litter or other types of the dead plant such as woods also provide food sources for the moth. For subfamily Lithosiinae, the larvae fed on lichen and moss (Barlow, 1982). William (2009) stated that the larvae of Lithosiinae also feed on free-living algae and bryophytes. The larvae of subfamilies Arctiinae are feeding on the plant at low-growing and grasses. The slight of Arctiinae cocoon is spun among the leaf litter. According Barlow (1982), the Arctiinae larvae food-planted are generally restricted to the daisy family.

Moreover, family Arctiidae also plays a vital role in the ecosystem. According to Rodrigo *et al.* (2007), Artiid moth (*Cosmosoma auge*) was recorded as a pollinator for a herb plant, *Habenaria pleiophylla.* Some characteristics of this flower are multiflower, congested inflorescences, cylindrical and tall up to 90 cm tall. Rodrigo *et al.* (2010) stated that Arctiidae moth displayed a setting behavior which is by visiting 1 to 5 flowers. At each inflorescence, they spend time up to 30 seconds.

According to Ramadan *et al.* (2010), arctiid moth, *Secusio extensa*, also a potential biological control for *Senecio madagascariensis. Secusio extensa* moth was being selected as the most potential moth to be an agent of biological control for Madagascar fireweed. This flower is a common daisy-like and branching biennial herb. Its can grow upright to 50 cm height with yellow flowers.

2.8 Weather Condition

According to Barlow (1982), moth usually can be found between 7.30p.m to 8.00 p.m. However, there are also some species that fly and appear at late night such as families Saturniidae and Notodontidae (Barlow, 1982). Usually, the numbers of specimens being caught will decrease and slowly diminished after 2 a.m. (Barlow, 1982).

Barlow (1982) stated that the nature of the lunar cycle is one of the elements which will affect the time for collecting the moth. Even sometimes the other condition in meteorological is ideal, but it's rare to get the best catches when comes the nearly or in the bright full moon (Barlow, 1982). Barlow (1982) also stated that some favorable condition for better trapping night is a moonless night and thundery. The presence of little wind with heavy overcast and drizzle also give a higher chance to collect a higher number of moths (Barlow, 1982).

3.0 MATERIALS AND METHODS

3.1 Study Sites

This study was conducted at PBB Oil Palm Plantation that located at Miri, Sarawak. It was approximately 115 km along the Miri-Bintulu Road. Total sampling days for this study were 15 days, which were specifically six days for the first sampling and nine days for the second sampling. Two main estates selected as the main sampling regions were Segarmas Estate and Saremas Estate 2 (Figure 1). The Saremas Final Report (2009) stated that the residual forest along the ridges in Segarmas Estates and Sarames 2 Estates are important as a conservation area. This continuous forest belt had been identified as a high conservation value (HCV) site. Samplings conducted at selected oil palm plantation and selected fragmented forest for the each estate. The distance between the oil palm plantation area and forest area was 2m roughly.

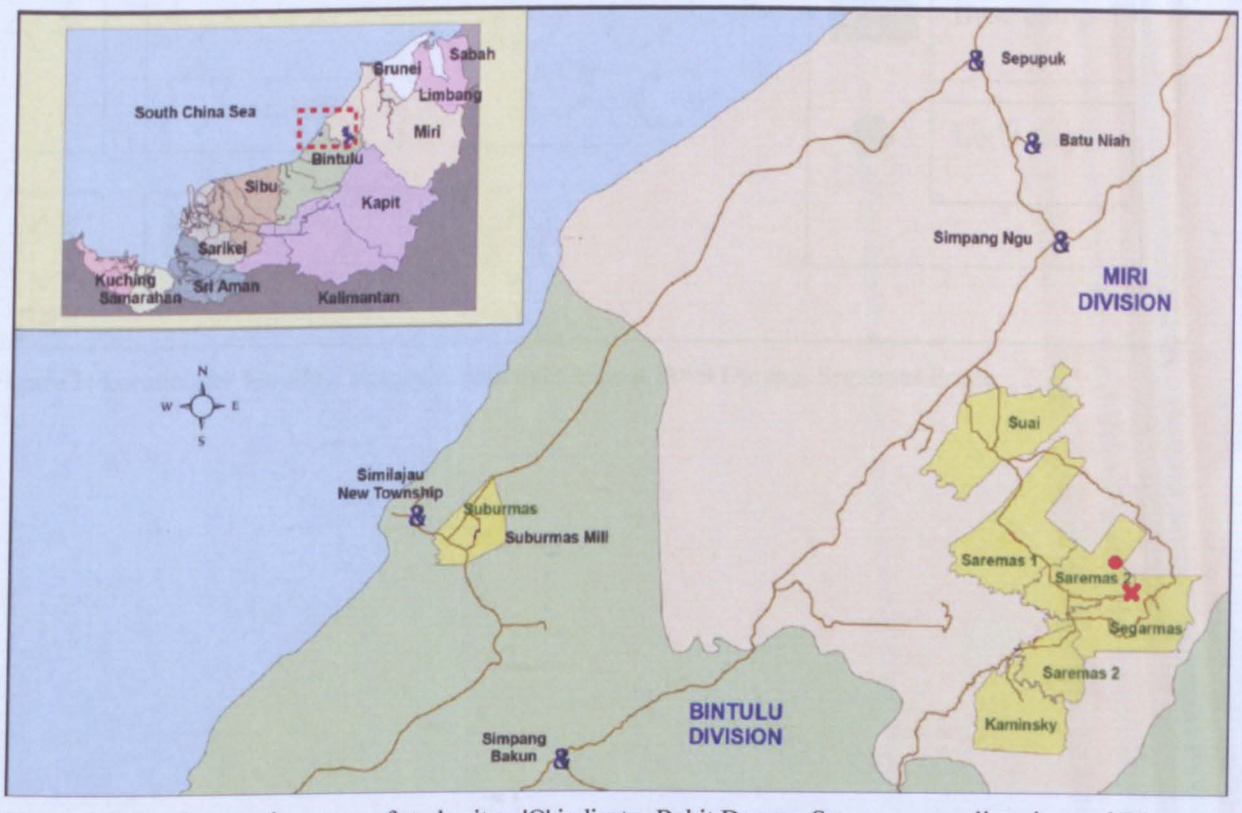

Figure 1. Map of two main estates of study sites. 'O' indicates Bukit Durang, Segarmas sampling sites and 'X' indicates HCV 4, Saremas 2 Estate sampling site. (Source: modified from Saremas Final Report).

The first sampling site was done in Bukit Durang, Segarmas (3 °28'8.21"N, 113 °48'23.864"E). Total areas of Segarmas Estate were 4727 ha. The sampling periods started on 24th August 2014 and finished on 29th August 2014.

According to Saremas Final Report (2009), there are some beneficial plants present in Segarmas Estate such as *Tunera* sp. Type of forest that be observed in Segarmas Estate is a secondary type of forest with many elongated and tall tree. Two light traps placed at oil palm plantations and at fragmented forest (Figure 2).

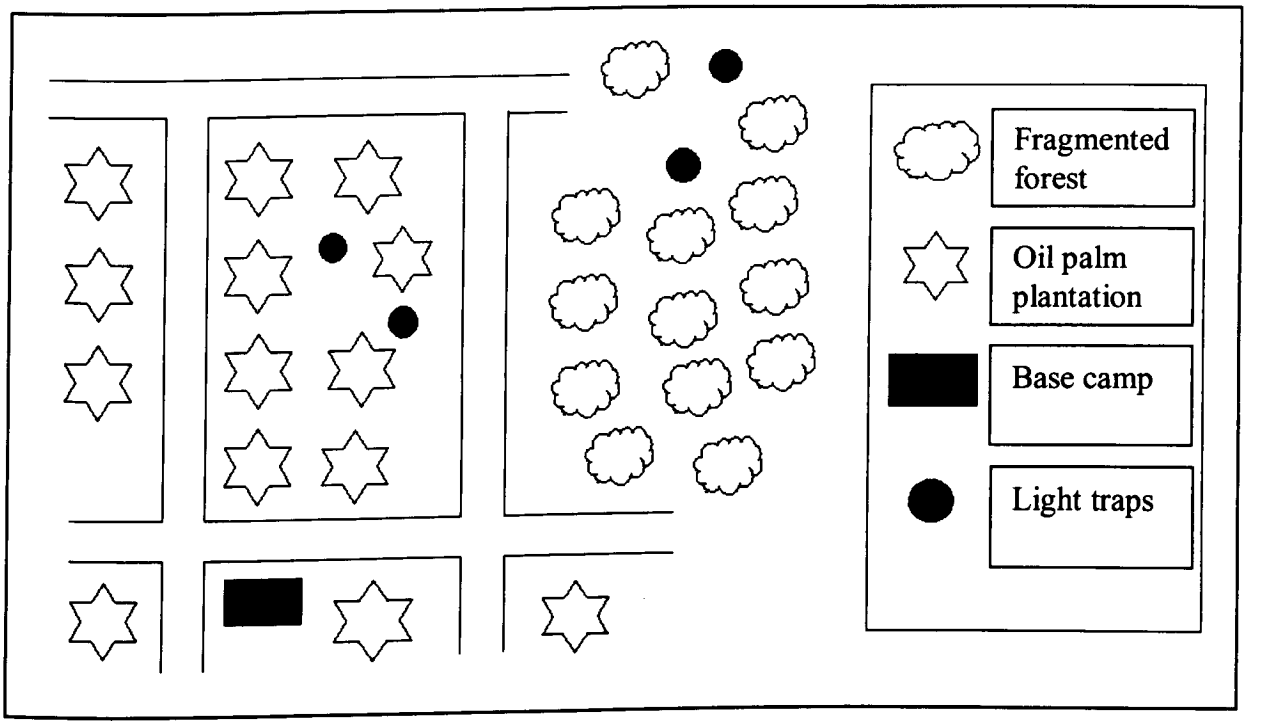

Figure 2: Location for Modified Pennsylvanian light traps at Bukit Durang, Segarmas Estate.

The second sampling site was carried out in the HCV 4, Saremas 2 Estate (GPS reading: 3 °31'18.611"N, 113 °45'23.484"E). In addition, the total areas for Saremas Estate were 4690 ha. The sampling periods for the second trips began on 4th February 2015 and end on 12th February 2015.

According to Saremas Final Report (2014), there were also beneficial plants mainly *Cassia cobanensis* and *Antigonon leptopus* were planted in order to minimize the use of the insecticide. The light traps were also placed at both oil palm plantation and at fragmented forest (Figure 3).

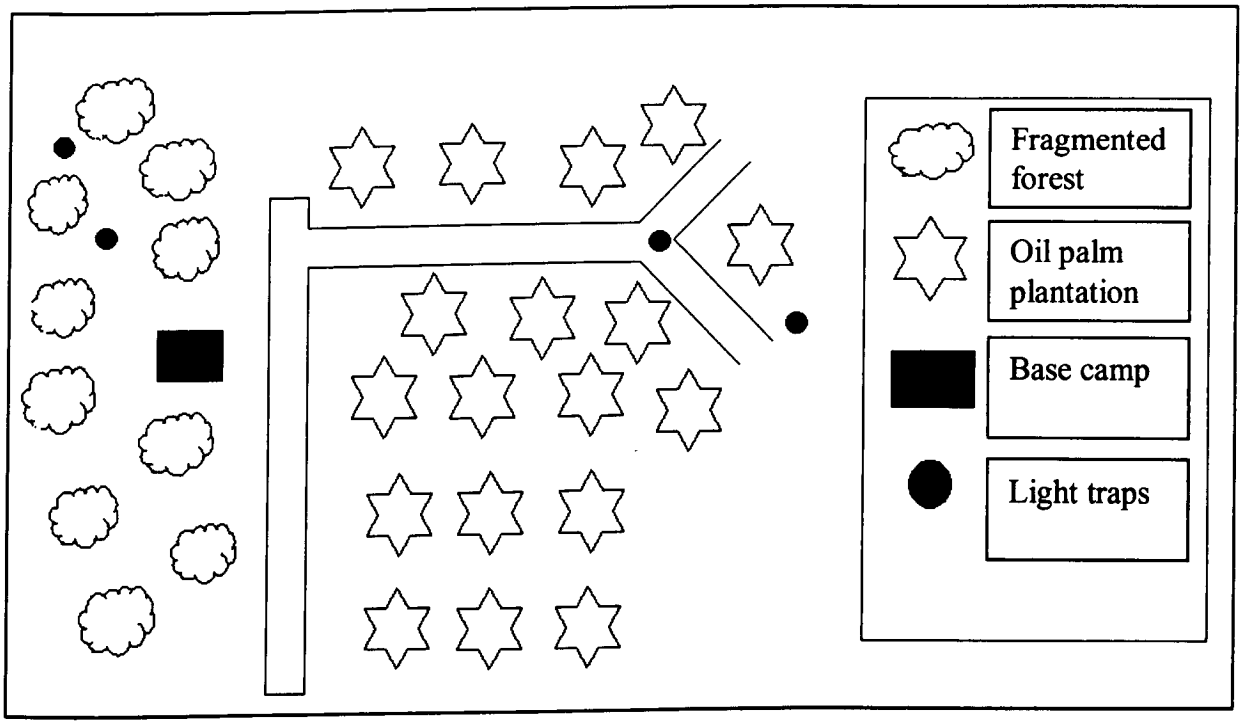

Figure 3. Location for Modified Pennsylvanian light traps at HCV 4, Saremas estate.