INSECT DIVERSITY AND COMPOSITION DURING THE WET AND DRY SEASONS IN THREE FOREST TYPES OF JOHOR, MALAYSIA

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ABSTRACT

The insect diversity and abundance in three forest types namely: Endau Rompin (pristine lowland forest) Gunung Ledang (pristine highland forest) and Bukit Soga (degraded lowland forest) in Johor, Malaysia were studied. The study focused on 10 common insect orders. The objectives are (1) to investigate the composition and abundance of insect morphospecies in three forest types; (2) to compare the composition and abundance of insect morphospecies in the wet and dry seasons in three forest types; and (3) to determine the dominant insect of the study sites. There were four sampling methods employed as baited pitfall traps, aerial net, manual collection and sweep net. The sampling methods were employed three days in each location. The different insects sampled, were higher during the wet season as compared to the dry season (diversity and abundance). Although Bukit Soga lowland a degraded forest had the highest diversity of 52; and abundance of 112,081 individuals, it had the lowest Shannon weiner index of species diversity and lowest evenness of (H'1.09 and evenness of 0.28). Gunung Ledang, had lowest species diversity of 32 and abundance of 1,695 individuals but had the highest H' of 2.34 and highest evenness of 0.68. Endau Rompin had 46 species diversity and abundance of 70,821individuals and H'of 1.17and evenness of 0.30. In highland forest the most diverse dominant insects were the butterflies (Lepidoptera: Rhopalocera). Meanwhile ant, (Hymenoptera: Formicidae) was more diverse in lowland forest than the highland forest. In all the three locations, ant was most abundant. Since Jaccard similarity index was low between Gunung Ledang and Bukit Soga (0.22); and between Gunung Ledang and Endau Rompin (0.27) it is concluded that altitude had a greater effect on insect diversity. This is supported by a two ways ANOVA analyses that showed insect diversity and abundance between the two lowland forests (Endau Rompin and Bukit Soga) and highland forest (Gunung Ledang) are significantly different. Difference between the lowland forests was not significant. Generally, effect of wet and dry seasons has no clear impact on diversity but abundance was higher during wet season especially for ants (Hymenoptera: Formicidae).

ABSTRAK

Kepelbagaian serangga dan kelimpahan bagi tiga jenis hutan iaitu: Endau Rompin (hutan tanah rendah tidak terganggu) Gunung Ledang (hutan tanah tinggi tidak terganggu) dan Bukit Soga (hutan tanah rendah terganggu) di Johor, Malaysia telah dikaji. Kajian ini memberi tumpuan kepada 10 order serangga biasa. Objektifnya adalah (1) untuk menyiasat komposisi dan kelimpahan morfospesies serangga bagi tiga jenis hutan; (2) untuk membandingkan komposisi dan kelimpahan morfospesies serangga pada musim basah dan kering bagi tiga jenis hutan; dan (3) untuk menentukan serangga yang dominan di kawasan kajian. Empat kaedah persampelan telah digunakan iaitu perangkap lubang berumpan, jarring udara, koleksi manual dan jarring sapuan. Kaedah persampelan dilakukan tiga hari untuk setiap lokasi. Serangga adalah berbeza semasa musim hujan berbanding musim kemarau di tiga lokasi (kepelbagaian dan kelimpahan) pada musim basah dan kering di tiga lokasi yang dikaji. Walaupun Bukit Soga ialah hutan tanah rendah terganggu, ia mempunyai kepelbagaian tertinggi 52; dan kelimpahan 112.081 individu. Namun, ia mempunyai nilai terendah bagi Indeks Kepelbagaian Spesies Shannon Weiner dan Indeks Kesamarataan terendah (H'1.09 dan kesamarataan 0.28). Gunung Ledang mempunyai kepelbagaian spesies paling rendah 32 dan kelimpahan 1,695 individu tetapi mempunyai tertinggi H' 2.34 dan tertinggi kesamarataan 0.68. Endau Rompin mempunyai 46 spesies dan 70,821individu. Namun, ia mempunyai H'1.17 dan kesamarataan 0.30 dalam kalangan tiga jenis hutan. Di hutan tanah tinggi serangga paling dominan ialah rama-rama (Lepidoptera: Rhopalocera). Sementara itu, semut (Hymenoptera: Formicidae) adalah lebih pelbagai di hutan tanah rendah berbanding hutan tanah tinggi. Dalam kalangan tiga lokasi, semut adalah yang paling melimpah. Dapat disimpulkan bahawa ketinggian mempunyai kesan yang lebih besar ke atas kepelbagaian serangga dan kelimpahan, kerana Indeks Persamaan Jaccard antara dus hutan tanah rendah (Endau Rompin dan Bukit Soga) dengan Gunung

Ledang.adalah rendah. Ini disokong oleh analisis ANOVA dua hala yang menunjukkan kepelbagaian serangga dan kelimpahan di antara hutan tanah rendah (Endau Rompin dan Bukit Soga) dan hutan tanah tinggi (Gunung Ledang) adalah signifikan; sedangkan perbezaan antara dua hutan tanah rendah tersebut tidak signifikan. Secara amnya, musim tidak mempengaruhi kepelbagaian dan kelimpahan serangga kecuali bagi semut (Hymenoptera: Formicidae) yang sangat melimpah di musim hujan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

a	=	The number of species in site A
b	=	The number of species in site B
asl	=	Above sea level
BS	=	Bukit Soga
CBD	=	Conversion on Biological Diversity
C_j	=	Jaccard similarity
COR	=	Center For Research
cm	=	Centimeter
D	=	Dry
DFR	=	Deramakot Forest Reserve
DVCR	=	Danum Valley Conservation Reserve
E	=	Evenness index
f	=	Family
FSTPi	=	Faculty of Science, Technology and Human Development
GL	=	Gunung Ledang
GPS	=	Geographical Positioning System
H'	=	Shannon's diversity index (species' richness)
ha	=	Hectares
j	=	The number of species found at both sites
KCFR	=	Kebun Cina Forest Reserve
LN	=	Natural logarithm
LUX	=	Light
m	=	Miter
mm	=	Millimeter
m	=	Morphospecies
Pi	=	the proportion of individuals sample in the ith species
RH	=	Humidity
S	=	The total number of species in a location
SFR	=	Sepilok Forest Reserve

SUNR	=	Sustainable Uses of Natural Resources
TEMP	=	Temperature
ER	=	Endau Rompin
UTHM	=	Universiti Tun Hussein Onn Malaysia
W	=	Wet
YBA	=	Yenku Block A
USA	=	United State of America
–	=	Absent
✓	=	Present
∑	=	Summation
>	=	Greater than
<	=	Less than

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 The Insects

Insect diversity and abundance play significant roles in the functioning of terrestrial and freshwater ecosystems. Insects affect the nutrient and energy flow of ecosystems in many ways; most essentially as decomposers. Burnie (2005) noted that insects are attractive animals, they outnumbered humans by over a billions times, and they make up over a half of all the animal species on the earth. Moreover, many insects are to be revealed, scientists believe; and have recognized more than one million species. Also, they categorized insects into groups known as orders. Within each order, they shared the same form and features. The major orders include Hymenoptera, Hemiptera, Diptera, Coleoptera, Lepidoptera, Odonata, and Orthoptera.

BarbosaI *et al.*, (2005) pointed out that the distribution of the insect orders in all habitations are extensive, globally. Besides, insects constitute the most varied group of organisms on the planet. The insects are grouped together with other animals sharing the same characteristics of the phylum Arthropoda; except for some unique characters absent in other animals (Akunne, Ononye & Mogbo, 2013). In addition, insects range in size from less than 1mm to 20cm in length, the common being less than 2.5cm, and some of the largest insects are living in the tropics. Insects are so many and so diverse that the study of this single group is a major field of biology called entomology. Insects consist of the most diverse and the attractive group of multicellular organisms on the earth, and they contribute significantly to most ecological functions such as pollination, nuisance control, decomposition, and maintenance of wildlife species (Losey & Vaughan, 2006). According to Weisser & Siemann (2004), within terrestrial ecosystems, insects functions as herbivores, pollinators, seed disperser, predators, parasites, detritivores or ecosystem engineers.

According to Akunne *et al*. (2013) who opined that insects could benefit humans by providing products preferred for human use. It may be a primary source; probably the most valued primary resources insects provide are honey, silk, royal jelly (bee milk), beeswax, as well as their bodies for human consumption and experimentation; and other very important product of the insects. By interacting with elements of our environments to yield the beneficial intermediary resource.

1.2 Tropical ecosystems

Insects are important natural capitals, particularly in the tropical rainforest ecosystems. They play an essential role, efficiently as pollinators and natural/biological pest control agents. Meanwhile, some insect species are significant pointers in ecosystem management (Rosina *et al.,* 2014). Agro-biodiversity, in addition, provides other essential ecosystem goods and services as well as maintaining habitats for pollinators as well as other useful insects. As soil engineers, insects reduce soil water overflow (Musgrave, 2013), and furthermore said, soil organic substances provides the necessary nutrients and can as well as raise biodiversity of soil microbes.

Samways (2005) pointed out that insects are the major modifiers and controllers of the physical state of abiotic and biotic materials. In this manner, they may be regarded as ecosystem engineers. According to Stewart, New & Lewis (2007), in addition to the provision of food to other organisms, insects are also food for humans. They furthermore noted that insect pollinators are necessary for more than 65% of the world's angiosperm species. Insect are fundamental regulators of other organisms, principally other insects, and plants as such; they can provide both direct benefits to human welfare during regulation of crops pests and victims through crop damage. Insect are major contributors to decomposition of vegetable and animal resources from the dung beetles that bury dung, carrion beetles and flies that feed on dead animals, termite, and leafcutter. Several insects are detritus feeders that break down dead plant and animal tissue and return it to the surroundings as excretory products or as a food item for other aquatic animals. Very few are highly voracious and feed on fish, tadpoles also are other larger creatures (Willian, 2000).

Nichols *et al.* (2008) noted that in terrestrial ecosystems, insects play important ecological roles in diverse ecological processes which include nutrient cycling, seed dispersal, bioturbation, and pollination. Furthermore, they pointed out that wherever insect is directly applicable to humans, this ecosystem frequently functions, which supply important as well as economically beneficial ecological unit services. Concluded, that they are as well major prey for a lot of vertebrates and of course for many invertebrates, including other insects. They provide a large food source. Even in fresh water, the function of insects is pivotal, with the fly-fishing industry to name one, being built on the useful role of insects as food.

1.3 Statement of the problem

Since Malaysia prides an effort to conserve its tropical rainforests; it is always good to have a basic understanding of the richness of it biodiversity as dictated by the convention on biological diversity (CBD, 1992) of which Malaysia is one of the signatories. This work is one of such kind that will be contributing to understanding how different types and degree of disturbances affect insect's diversity and abundance. The effect of seasons on insect's diversity was also investigated. Secondly, it was realized that there are not many entomologists in Adamawa state of Nigeria. Insects play significant roles in the life of peoples in sectors such as agriculture, medical as well as providing for important ecological services like being pollinators, decomposers, soil modifiers and so forth. Young people of Nigeria always consider insects as bad organisms. So there is a real need of trained entomologist that can contribute to raising awareness of the people of Nigeria about the usefulness of insects and the need to conserve them. This research has provided some basic training in the making of an entomologist for Nigeria. These three tropical rainforests were selected because of their differences in altitude, the vegetation type and the degree of disturbances. ER is at the lower altitude and is one of the big tropical rainforest of unspoiled lowland with a diverse amount of undisturbed natural vegetation in Peninsular Malaysia. Gn Ledang is at the highest elevation also a big tropical rainforest of unspoiled highland tropical rainforest with diverse types of flora and fauna species of undisturbed natural vegetation. However, visitors come across a pine forest, river, streams and waterfall various composites throughout their journey. Bkt Soga is at the lower altitude and is a small hill lowland tropical rainforest with less diverse vegetation and highly disturbed natural vegetation.

1.4 Objectives of the study

The research specifically has the following objectives:

(a) To investigate the composition and abundance of insect morphospecies in the three forest types.

(b) To compare the composition and abundance of insects morphospecies in the wet and dry seasons in the three forest types.

(c) To determine the dominant insect group in the study sites.

1.5 Research hypothesis

The hypothesis was tested at a significance level of 0.05 to compare the three study sites:

H_o: There is no significant difference of species diversity and abundance amongst the three sites.

H_a: There is significance difference of species diversity and abundance among the three sites.

1.6 Scope of the study

In this investigation, the researcher focused on the identification of the various insect groups based on the characteristics mainly up to the family level. They were collected during the wet and dry seasons in three forest types in Johor. The study sites chosen for the research were:

(a) The pristine tropical lowland forest Endau Rompin in Mersing

(b) The pristine highland forest Gunung Ledang, in Ledang and

(c) The degraded lowland forest Bukit Soga Park in Batu Pahat

Not all insect groups were studied. The only common orders: Odonata, Orthoptera, Dictyoptera, Isoptera (including termites), Hemiptera, Coleoptera, Diptera, Lepidoptera, Hymenoptera and some wingless insect groups (Apterygota) were analysed to morphospecies. Insects were collected below the canopy. These were insects that were within the reach of the aerial nets/traps.

CHAPTER 2

LITERATURE REVIEW

2.1 Distribution of Insects

Stiling (2012) defined the overall total of species as the species' richness and the overall total of individuals (of a species), termed as the species' abundance. In this thesis, the term distribution is associated with three aspects. Firstly, it describes the kinds of insect groups occurring at a specific site on the basis of proportions relative to the groups/orders. Secondly, it also reflects on the species' richness of the site. Thirdly, it relates each species/morphospecies to individual numbers or abundance of the species. According to Bruno *et al*. (2011) distribution describe the pattern of occurrence of species. However, different types of disturbances to the forest may cause the distribution pattern to be unpredictable.

2.1.1 Insects composition

Insects lives in abundance worldwide; the larvae require a moist environment of some kind and found on all continents including the Antarctica (Evans, Grarrison & Schlager, 2004). Some species can tolerate a broad range of conditions while others are very sensitive to the environment. According to Corbet (1999) opined that the accurate size of species' diversity remains not known, estimates range from 1.4 to

1.8 million species, possibly present on the earth. The estimated organism species of the world representing less than 20%, and with only about 20,000 new species of all organisms being described each year, so most species likely will remain not described for many years unless the species' descriptions increase the rate (Grimaldin & Engel, 2005). Additionally, they said about 850,000 – 1,000,000 of all described species are insects. Insects dominate in terms of numbers of described species, with an estimated 600,000 – 795,000 species included for Coleoptera, Diptera, Hymenoptera, and Lepidoptera.

Table 2.1 showed that in terms of species' composition, Coleoptera > Hymenoptera > Diptera > Lepidoptera; worldwide. However, at each site, due to the different environments, including occurrences of food plants or prey, composition of insect species was different. As pointed out by Savopoulous *et al.*, (2012), topsoil humidity and botanic edges are obvious, heavy-duty bio-indicators disturbing the species' composition in the ecosystem. According to Grimaldin & Engel (2005) they reported that the comparison of the estimated number of species in four largest insect orders. Showed that the described species, with an approximately number of 300,000 - 400,000, 90,000 -150,000, 100,000 -125,000 and 110,000 -120,000 such that Coleoptera > with an average description of species of 2,308 followed by Hymenoptera > with an estimated rate (species) 1,196, Diptera > with 1,048 and Lepidoptera with 642 average description rate (species / year).

2.1.2 Insect diversity

Diversity is a measure of the number of species' present. However, diversity also includes a measure of evenness (a measure of disparity among the number of individuals representing each species' present) (Foottit & Adler, 2009). All levels of the organization showed that biodiversity refers to the diversity of insects and biome, for this reason, samples' diversity. As such biodiversity encompasses structural mechanisms, as well as the functional components. This means involving the ecological and evolutionary processes through which genes, species, and ecosystems interact with one another and the environment (Hunter, 2002). A combination of a number of species and relative abundance describes species' diversity.

According to Watt, Stork & Bolton (2002) who reported that for the canopy ant, the different techniques totalled the effect of plantation in two set of plots sampling were established subjected to complete forest clearance and partial manual or mechanical clearance which was linked to uncleared reference forest plot. They furthermore said that the leaf litter ants, which totalled the effect of forest disturbances at different levels along a gradient primary forest and complete clearance approximately. Previous study by Bambaradeniya & Amerasinghe (2004) noted that the rice wet phase field harbor a diverse aquatic group of animals. Furthermore, that, the insects and spiders mainly inhabit the vegetation. For instance, the ponds, marsh and the streams-dwelling living organisms settle to survive in rice field because they are adapted to tolerate the changes drastically in the rich field of ecosystem and the attainability of settler to contiguous aquatic habitats.

2.1.3 Insect abundance

Some insects occur in a huge number, e.g. termites and ants; some very few for instance, beetles. According to Fergnani, Sackmann & Cuezze (2008) noted that the ants (order: Hymenoptera) are abundant insects and are considered significant in ecosystem functioning. Ants have diverse ecological roles, comprising nutrient cycling, and seed dispersal and population regulation in other insects. In addition, numerous studies have displayed that ant assemblages are sensitive to changes in environmental conditions. The abundance of insects and distribution are regulated by numerous biotic and abiotic factors and interactions. Insect abundance is important because it regulated the ecosystem of insect communities. Insects are connected with numerous biotic and other peculiar adaptations, in addition, plastic responses (Savopoulous *et al.*, 2012). The occurrence and abundance of insects may directly reflect environmental changes (Wahizatul, Long & Ahmad, 2011). They furthermore noted that indicators species are those taxa species identified to be primarily sensitive to precise environmental factors. Therefore, their occurrences or abundance changes might directly reflect the environmental changes.

2.1.4 Importance of insects

Insects play an important role in the natural world. They feed on decaying organic matter, cleaning away animal droppings and removing dead bodies (Burnie, 2005). Insects in forest litter derived vegetation material and changes particle size, and soil moisture is important influences on the micro-distributions of subterranean organisms. The litter habitat, comprising of decaying wood, leaf litter, carrions, and dung, is an integral part of the soil system. Summarizing from Gullan & Cranston (2010) said briefly the significance of insects are as follows:

(a) Insect species are prominent in nutrient recycling, leaf-litter as well as wood degradation, fungi dispersal, decomposition of carrion, dung disposal, and soil turnover.
(b) Insects pollination and seed dispersal also determine plant propagation.
(c) Insects determine ecological structural maintenance through phytophagy,including seed feeding and plant community composition.
(d) Nourishment for insectivorous vertebrates includes many birds, mammals, reptiles and fish
(e) Insects regulate community structure and population through transmission of diseases of large animals, predation and parasitism of smaller ones.

Akunne *et al*. (2013) opined that insects can benefit humans by providing products preferred for human usage. Probably the most valued primary resources insects provide are: honeys, beeswax, propolis and royal jelly, silk, bodies for human consumption and experimentation. Agro-biodiversity provides other essential ecosystem goods and services as it maintains habitats for pollinators and useful insects. By reducing soil water overflow Musgrave (2013) in addition, said soil organic substances provide the necessary nutrients and can as well as raise biodiversity of soil microbes. Healthy soil creates healthy ecosystems and provides important ecological components of the environment, for this reason protecting crops from pests. Insects are refer to as small creatures which are significant to human welfare, particularly for the reason that they pollinate our food crop plants, also control the population of others, the predation and parasitism are harmful insect therefore, they serve as food for other animals. There are many insect that are also harmful to humans interest as they usually feed on plant crops and a lot of them also carries important diseases affecting humans and domestic animals (Fauziah *et al*., 2011).

Stewart *et al*. (2007) pointed out that insects ecological roles are in pollination, decomposition, seed dispersal, protection and the provision of food to other organisms. In addition, insect pollinators are necessary for more than 65% of the world's angiosperm species. Insects are fundamental regulators of other organisms, principally other insects, and plants as such; they can provide both direct benefits to human welfare during regulation of crops pests and victims through crop damage. The insect is a major contributor to decomposition of vegetable and animal resources from the dung beetles that bury dung, carrion beetles and flies that feed on dead animals, termite, and the Leafcutter ants. Animal pollination is significant to the sexual reproduction of numerous crops, and the majority of vegetation are significant for providing calories and micronutrients for humans (Klein *et al*., 2007). In addition, they said; the decline of pollinating species can lead to a parallel decline of plant species.

According to Nichols *et al.(*2008) in terrestrial ecosystems, insects play important ecological roles in diverse ecological processes that include nutrient cycling, seed dispersal, bioturbation, and pollination. In addition, they pointed out that wherever insect is directly applicable to humans, this ecosystem frequently functions; which supply important as well as economically beneficial ecological unit services.

Flies also play a helpful role as scavengers, parasites and predators of other insects, pollinators, food for predators, indicators of water quality, and tools for scientific research (Foottit & Adler, 2009). Some insects are important as biological control agents of weeds and other insects as an indicator of water quality, for example, midge larvae recognized as bloodworms are indicators of polluted water. As an experimental animal, much of our knowledge of animal genetics and development has been acquired using the fruit fly, *Drosophila melanogaster* as an experimental subject (Evans *et al*., 2004). Foottit & Adler (2009) stated that, insects manufacture by-products as honeydew. When insects died, they provide cadavers that maintain other species. According to Kolb (2011), insects are the greatest abundance and are important as a group in the phylum Arthropoda, class Insecta.

2.2 Disturbances to forest ecosystems

In Peninsular Malaysia, the pristine lowland dipterocarp most of the forests have been garnered for timber and profit making crops (Manshor *et al*., 2012). According to Mustafa *et al.* (2011) who said that majority of the degraded tropical forestry was unblemished in the 1970s and 1980s of urban improvement and agriculture, particularly oil palm, and rubber plantations.

A finding by Benedick *et al*. (2006) indicated that isolation is one of the significant negative factor affecting species' richness in the forest. Habitats fragmentation was showed to destroy the interactions amongst insect species including herbivores (Hill *et al*., 2011). They further substantiated showing that fragmentation can also lead to trophic cascades and that the remnants of forest were rising concerned that could not be viable in the lengthier term. Tropical rain forest edges influence are related to the island nature (Fiedler *et al*., 2007), and the rain forest edge are the ecological boundaries characterized by very steep gradient from the forest interior to the surrounding exposed vegetation. Abiotic factors including light, temperature, humidity, rainfall and wind spread have manifold effects on the vegetation.

Forest disturbance affect bee and butterfly species diversity thus affecting pollination (Kambach *et al*., 2013). Forest disturbance had long been identified as a significant factor affecting rain forest ecologies. The same way that physical changes such as the humidity, temperature, and light intensity influences butterfly species in a disturbed habitat (Benedick, 2001). A finding by Hariyati & Hakim (2012) said that today, a portion of tropical forest had fast degraded and caused many species endangered. As reported in a case of tropical forest disturbances, the two main factors were natural and human factors. Deforestation in Peninsular Malaysia had been principally due to the expansion of rubber and oil palm plantation from 1960s in the early to mid-20th century.

Peninsular Malaysia showed that the decline of forest area was more slowly from 1980s to 2000 that it had been earlier (Razali & Shahwahid, 2009), forest change cover in Peninsular Malaysia showed that widely deforestation begins from 1970 to 1982. Though, from 1982 forward that deforestation slowed down, as a result, that the oil palm plantation area continued to expand. The principal effect of deforestation was the change of forest to oil palm plantation. Later, indicating the expansion of the oil palm was no longer the effect of deforestation (Miyamoto *et al.*, 2004). It is assumed that globally the problem of deforestation showed that there has been a decreased of diversity in the changing forest. Previous finding by Watt *et al.* (2002) reported that the temperate and tropical rain forests have confirmed that deforestation has a dramatic influence on ant diversity. According to Schowalter (2013), certain factors affect ecosystem services such as human factor through anthropogenic disturbances and the introduction of invasive species. Such anthropogenic disturbances include harvesting and replanting, road construction, soil disruption and river impoundment. Furthermore, that the effect of such disturbances on insect diversity and abundance which reflect on the degree of direct and indirect factors that are similar to those of natural factors.

2.3 Forests in Malaysia

There are different types of forest ecosystems in Peninsular Malaysia comprised of lowland dipterocarp forest, upper dipterocarp forest, Hill Dipterocarp forest, Montane Oak forest, Montane Ericaceous forest and peat swamp forest. A finding by Salleh (1993) noted that the lowland, hill and upper dipterocarp forests, with higher limit of 1, 200m asl, all which constitute about 85% of the forested area in Malaysia. These three tropical rainforest types are biologically highly diverse. In the lowland dipterocarp forest, for instance, a total number of 820 species of trees over 1cm diameter at breast height were recorded in a 50 ha area.

Malaysia has a total land area of about 32.86 million ha, around 72% of which are under forest and tree plantations. About 4.2 million ha of tree plantations and 19.4 million ha of forest account. Approximately, 11.2 ha of the permanent forest reserves and are embarked as production forest. In the tropics, the total land area has been reduced from 1935 million ha in 1980 to 1882 million ha in 1990. Reforestation rate is only from 1.9 to 5.0 million ha yearly in comparison in 1988 only 4.4 ha of natural forests are under sustained management (Mohammed & Othman, 2002). Malaysia is listed as one of the 14 major deforested country; by over 250,000 ha of Malaysia forest were deforested yearly (Morrow & Talip, 2001).

According to Mustafa *et al*. (2011) who reported that most of the dipterocarp forests in Malaysia (the description showed that about 85% of the forested areas in the country) were commonly composed of tree species from the genera of Dipterocarpus, Anisoptera, Dryobalanops, Hopea, Shorea and Parashorea. According to Salleh (1993) additionally, he said further the number of species is nearly a third of the total number of tree species discovered in Peninsular Malaysia.

The family Dipterocarpaceae, the most significant timber family in the Southeast Asian region, dominated the three dipterocarp forest types. The dipterocarps were the most important group of timber trees in Malaysia. However, such timbers produce Meranti and Keruing. The vegetation of the highland forest locations is mostly laurels, oaks, conifers, myrtles and the plants from the family known as "Theaceae" (Manshor *et al*., 2012). Gn Ledang is the highest mountain in peninsular Malaysia with different types of vegetation. Peh *et al*. (2011) noted that ecologists categorize cloud forests as critical habitats for conservation of high level endemism. The family Dipterocarpaece dominate tropical rain forest in Malay Peninsula, Borneo, Java and Sumatra. Outdoor of this core ever wet area gradually the tree dipterocarp decline in diversity and abundance (Corlett & Primack, 2005).

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This research involved the sampling of insect specimens in the field, followed by curation, preservation and identification of the insects collected from the family and morphospecies level. This was recorded on the field data sheet which was used for the duration of the sampling period in the field (see Appendix C) and sorting data sheet (see Appendix D) was also used for the period of sorting the insect specimen in the Center for Research - Sustainable Uses of Natural Resources (COR-SUNR); UTHM. First of all, requesting for permission to collect the insect specimen and later, approval was given from the national park agency in order to collect the insect specimen in the field (see Appendix A and B). Later, several samplings were carried out during the wet months of November, 2013 to February, 2014 and dry months of May to June, 2014. The three sites were chosen based on the different characteristics. The highland forest of GL has very different vegetation types and cooler climate. Two lowland forests were chosen: the pristine ER and heavily degraded BS. This chapter foremost describes the three sample sites and later describes the various techniques used to sample insects, curates and describes the insects collected. In order to gauge the biodiversity of insects sampled from the three sites, the Shannon-weiner species index was calculated.

Shannon-wiener evenness index was used to compare the distribution pattern. Finally, to relate to the similarity of diversity of insects sampled from the three sites Jaccard similarity index was measured. To summarize the methodology, see Figure 3.1.

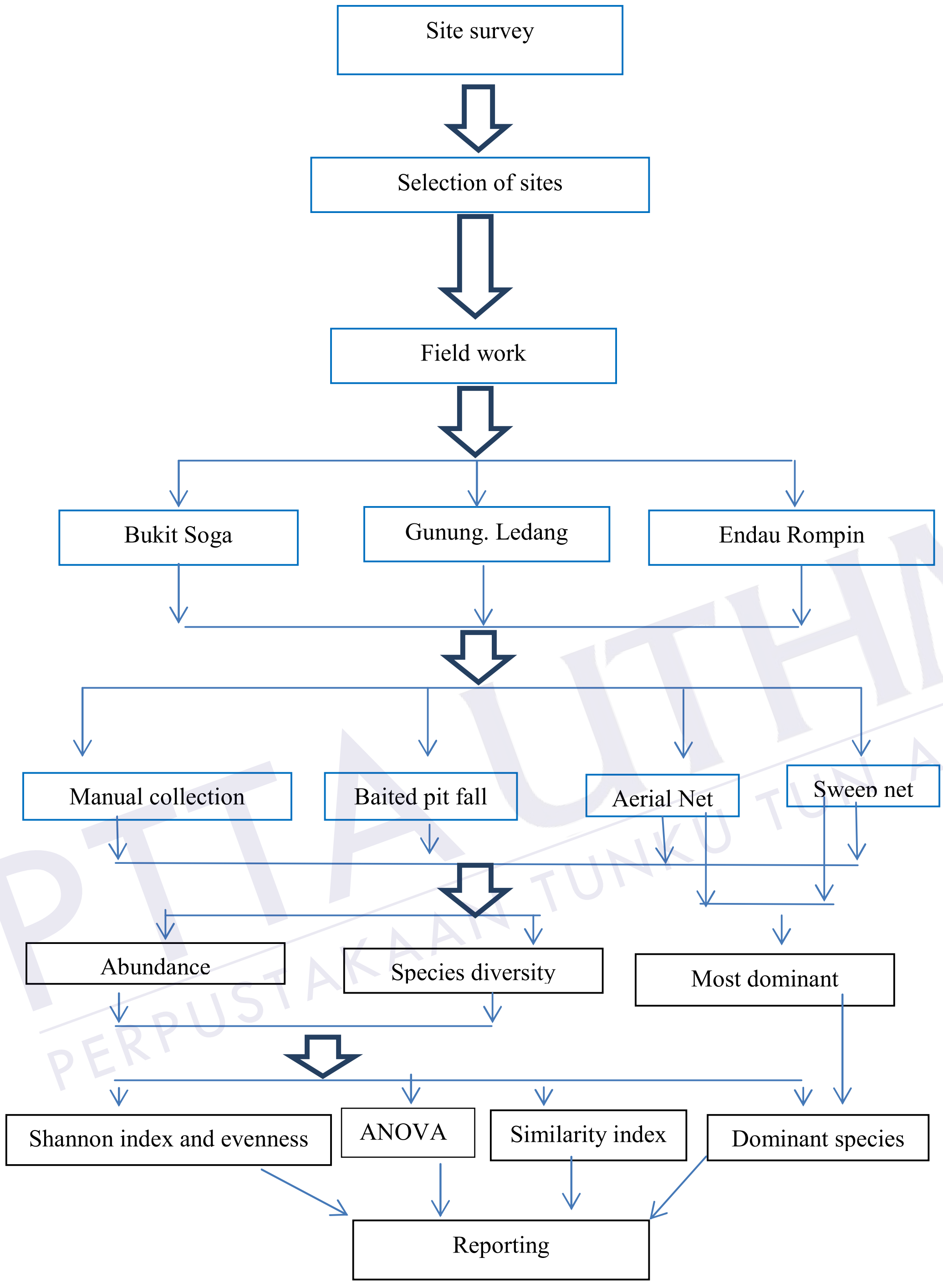


Figure 3.1: Workflow of the research

3.2. The three forest types studied

There are different types of forest types in Johor, Malaysia. This study focus on the three forest types:

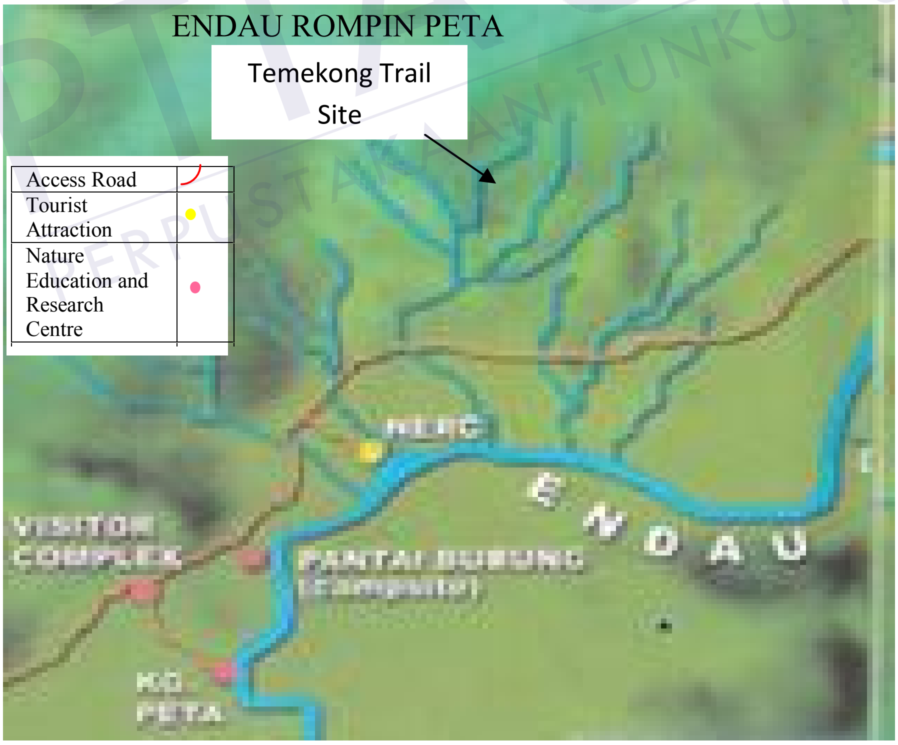
(a) Endau Rompin (ER) – a pristine, undisturbed primary lowland forest
(b) Gunung Ledang (LG) – a pristine montane forest
(c) Bukit Soga (BS) – a degraded lowland/hill forest.

Endau Rompin and Gunung Ledang are two protected areas in Johor, Malaysia.

3.2.1 Endau Rompin Mersing

The Endau Rompin (ER) located in the Mersing district of Johor. It occupies the northeast portion of Johor state. The elevation is 40 m asl and GPS reading of latitudes 02^0 31.69' N and longitudes 103^0 24.085' E. Peta is one of the gateways into the ER covering 19.562 ha, and it is one of the lingering big tracts of unspoiled lowland tropical rainforest with an enormous amount of undisturbed natural vegetation in Peninsular Malaysia. In addition, Selai is also the western gateway to the ER, which has an area of 29.343 ha, the overall total area of 48.905 ha. ER is one of the protected regions in Malaysia. ER received the highest amount of rainfall and the moistest with average rainfalls of more than 3,400mm a year in the area. The lowland is an area with an undulating topography and is mainly in the central and the northern part of the state.

The temperature is around 27°C in the wet season while, approximately 28°C in the dry season. The relative humidity (RH) was about 90% in the wet and around 89% in the dry season. The light intensity was 94 lux in the wet season and 86 lux in the dry season. The forest has the famous huge fan palms (*Livingstona endauansis),* which is endemic to the region. Other fascinating plants include the climbing bamboo (*Rhopacoblaste)* and a walking stick palms (*Phydeorapis singaporensis)*. Many fungi play a significant role in the natural cycle as composers and return nutrients to the soil; they are not all destructive. Fungi are used for medicinal purposes. ER is a pristine primary lowland tropical rainforest with numerous types of


ENDAU ROMPIN PETA
Temekong Trail Site
Access Road
Tourist Attraction
Nature Education and Research Centre
NERC
VISITOR COMPLEX
PANTAI BURUNG
(Campsite)
KG. PETA
E N D A U

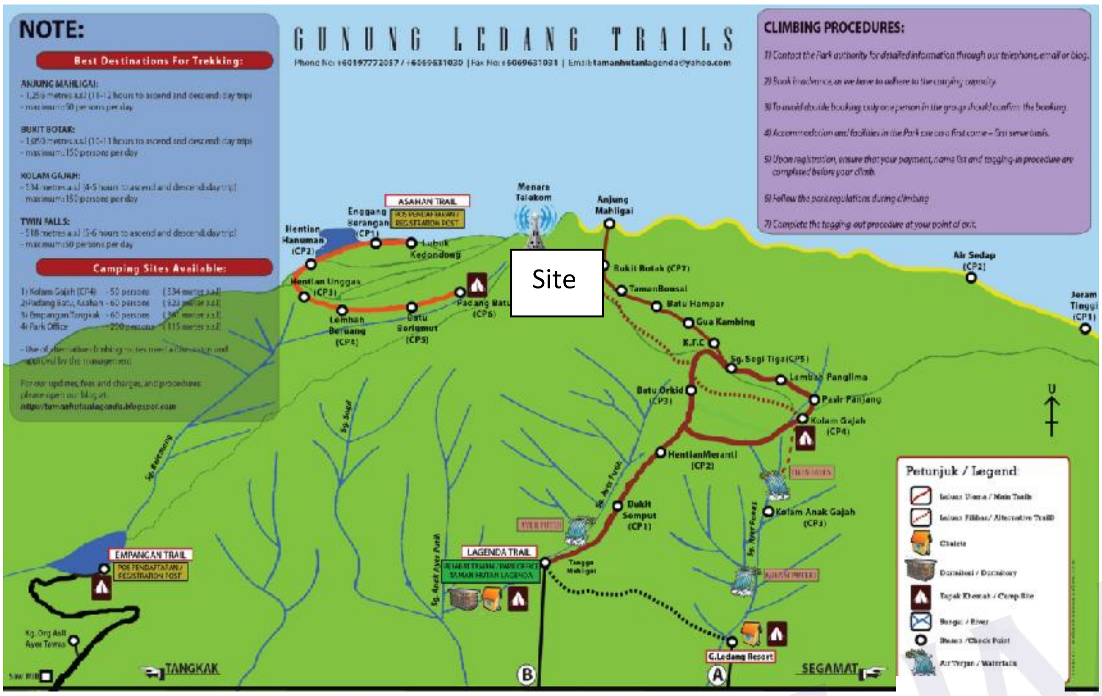
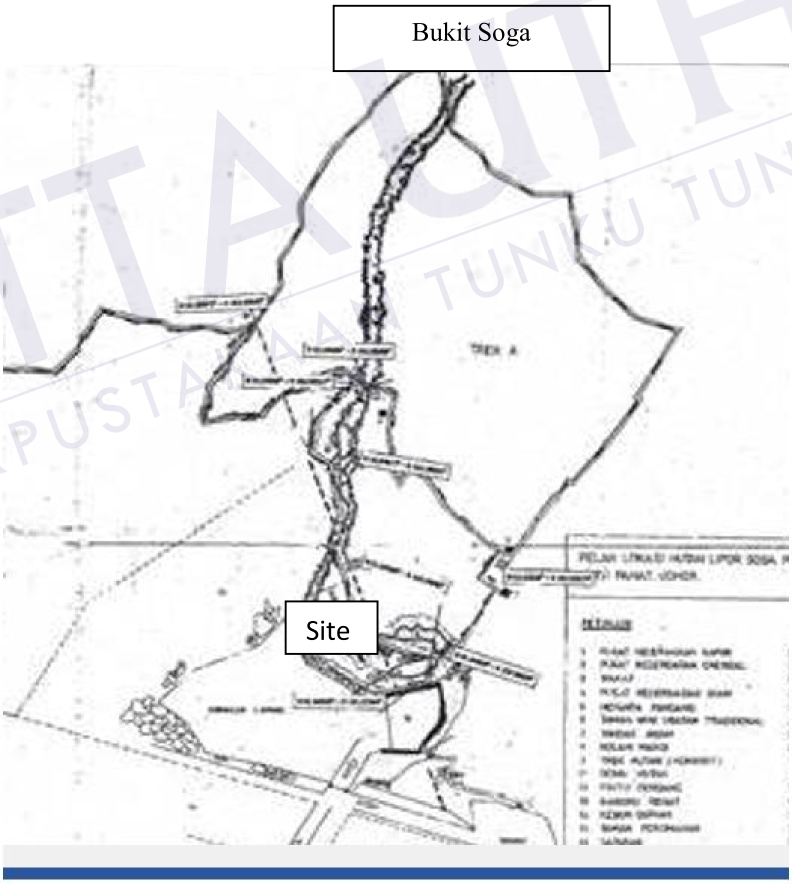


Figure 3.5: Site two - Map of GL

3.2.3 Bukit Soga, Batu Pahat

Bukit Soga is located in the district of Batu Pahat, in the state of Johor. BS is a small hill, covered by a heavily degraded lowland forest reserve. It’s occupied the Northeast portion at latitudes of 01^{0}50.976’ N and the longitudes of 012^{0}57.593’ E. BS is a small portion, the collection was conducted at the height of 62 m asl. The temperature (tempt) was about 28^{0}C in the wet season and around 29^{0}C in the dry season. The relative humidity (RH) was approximately 90% in the wet season and around 85% in the dry season. The light intensity was 57 lux in the wet season and 79 lux in the dry season. Figure 3.6 showed Bukit Soga a secondary lowland forest and Figure 3.7 showed the map. Several plant species found include *Elaerocarpus robustus, Durio sp*, *Cratoxylon formosum*, *Diospyros sp*, *Myristica*, and *Baccaurea sumatrana,* among others.


Bukit Soga
Site

BS forest reserve is a degraded lowland forest. Several common plants include *Elaerocarpusrobustus*, *Cratoxyyion formosum*, *Diospyros*, *Myristica* and *Baccaurea sumatrana*. The lowland forest influenced by sunlight, wind, and other elements. The BS had a water body (river) just before going into the forest, and it is good for the aquatic insect.

Malaysia is a tropical country; generally, the annual rainfall is approximately 2,500 mm, occurring during the southwest monsoon with highest precipitation (Tan *et al*., 2015). According to Whitmore (1998), the climatic condition had fluctuated throughout periods of warm, that is rainy and cooler, drier. However, the tropical rain forest seasonal period was during freezing, the area was reduced and become more widely. Lowland tropics areas were both cooler as well as a lot drier in large areas of the tropics during the ice age period that occupied for the last 2 million years (Corlett & Primack, 2005). However, in numerous highland tropical areas the rainfall is high, and the temperatures is low, that made the areas probably unsuitable as "refuge" for organisms in the lowland tropical rain forest. Table 3.1 gives a brief characteristic of the three forest types.

Table 3.1: A brief characteristics comparison amongst the three forest types (ER, GL and BS)

Site	ER	GL	BS
Characteristics	About 85% of the land area was surrounded by trees. It is dominated by Dipterocarpaceae, *Anisoptera, Dryobalonps,Hopea, Shorea* and *Parashorea.*	The family Gleicheniaceae from the species *Dicranopteris linearis* is dominated lining the main trail.	The forest vegetation is dominated by Dipterocarpaceae.
	The diverse vegetation of flora and fauna species of *Aglaria, Cratoxylum formosum, Xanthophythum* etc	Has a diverse vegetation of flora and fauna include laurels, oaks, conifers, myrles from the family Theaceace.	Less diverse type of vegetation of flora and fauna species includes *Elaerocarpus rubustus, Durio sp, Cratoxylon formosum, Diospyros sp* and *Myristica* etc
	The ER lowland forest is at the lower altitude 40 m asl	Gn Ledang is at the highest elevation 1125 m asl	BS is at the lowest elevation 62 m asl
	No big buildings except small staff office, houses and visitors' apartment	No big building surrounded except small office and houses for staff and visitors	Many human settlement houses situated close to the entrance
	Low human density	Low human density	High human density
	Human disturbance very low, except tourism activities and researchers	Very low human disturbance except for tourism activities and researchers	High human disturbance, visitors at any time for jogging and many other recreational activities
	Plants grow very rapidly, and its leaf litter decomposed quickly	plants grow gradually, and its leaf litter is slow to decompose	Plants grow very fast, and its leaf litter easy to decomposed

3.3 Sampling procedure

Three times replication for each study site were carried out for each method from November, 2013 to June, 2014 in the wet and dry seasons (see Table 3.2). In addition, the duration for each study sites, four days were spent in the forest both in the wet and dry seasons. Since, for each site, collection was done two times (wet and dry seasons); the sampling duration totalled to 27 days.

Rainfall in Malaysia was characterized by two monsoon seasons the Southwest Monsoon from late May to September, and the Northeast Monsoon from November to March (Suri *et al.*, 2014). Malaysia is a country that usually had the highest and experienced continuous wet season. However in the year 2014, the temperature for the particular year was higher than average (Ministry of Science, Technology and Innovation, 2014) Furthermore, reported generally, the inter monsoon season has shown a lot of rainfall around other areas while, some places usually get dry condition. For instance, over Peninsular Malaysia areas of Southern Kedah such as Langkawi Island and bother of Selangor, received more than 60% rain from the actual total rainfall between 300 mm and 600 mm. But, in some other areas of Peninsular had received the normal rain fall. Peninsular Malaysia recorded the highest rainfall was 26 days as recorded at the Climatological station.

Table 3.2: Sampling schedules in each study sites

Study sites	Wet Season	Dry Season
Endau Rompin	18th - 21st February, 2014	23rd - 26th of June, 2014
Gunung Ledang	24th - 27th January, 2014	6th - 9th June, 2014
Bukit Soga	18th - 21st November, 2013	8th - 11th May, 2014

Four techniques were used namely: baited pitfall traps, aerial net, sweep net, and manual collection using fine tip forceps.The techniques were replicates three time for each collection both in the wet and dry seasons. These methods were chosen, in order to catch insect specimens in different habitation as showed in Table 3.3 below:

Table 3.3 Different habitats for a particular technique

Habitat	**Example of samples**	**Technique/method**
Ground and low-lying vegetation	Grasshoppers, cockroaches, mantids and beetles	Sweep net
Air	Butterflies, dragonflies bees	Aerial net
Ground dwelling, night and day active insects	Ants, termites, beetles, and cockroaches	Baited pitfall trap
Ground, trees, branches	Ants, termites, and cockroaches	Manual collection using forceps

The research design used in this study was the quantitative research design, which involves catching the insects in the forests by the use of the methods mentioned. The insect specimens counted and analysed, to get the species' richness and abundance.

3.3.1 Baited pitfall traps

The baited method according to Morrison (1998), attract insects; for example, ants which are scavenged and were attracted to the baits. The three baits used for this study includes tofu, fish, and sweet in order to attract the insects orders. The plot was marked 5m x 5m on the ground of the forest floor, 25 quadrants of 1m x 1m each were divided on the forest plot (Figure 3.8). Pitfall traps were dug by making round holes with a trowel and sinking a plastic cup in each pit. The cups with a diameter of 7cm, 15cm depth were placed in every pit.The holes are deep enough so that the rim of the cup is levelled the same as the ground. The liquid prepared detergent (1-tablespoon detergent: 1 litre of water was poured 1/3 way into the cup in the centre of every 1m x 1m quadrant).

A wire and baited were placed on each trap, and different baited were used randomly placed on each trap (see Figure 3.9). Most traps, for example, baited were used to capture only a subset of the total number of the insect fauna. The cups containers were shielded with a leave to cover the plastic cups from rainfall to escape rather than overflowing the cup containers in the soil. The pitfall traps were left for 24 hours, the following day, the pitfall content was poured into a tea sieve. A brush was used to pick out the specimens that have fallen into the traps; the insects were removed and put into 75% alcohol in a labelled pill box container and brought to the COR-SUNR. The insect specimens were sorted, curated and identified to morphospecies level.

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