

**BUTTERFLY DIVERSITY IN LOK KAWI
BOTANICAL GARDEN AND KAWANG
FOREST NATURE CENTRE: BUTTERFLY
AS AN INDICATOR OF HABITAT
QUALITY IN BOTH AREAS**

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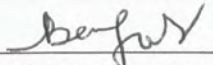


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CERTIFICATION

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ABSTRACT

BUTTERFLY DIVERSITY IN LOK KAWI BOTANICAL GARDEN AND KAWANG FOREST NATURE CENTRE: AS AN INDICATOR OF HABITAT QUALITY IN BOTH AREAS

A study on the habitat quality of butterfly was carried out at Lok Kawi Botanical Garden (LKBG) and Kawang Forest Nature Centre (KFNC). The modified line transect count method was used to record species composition and abundance of butterfly communities. The sampling period was carried out between February to April 2008 for fourteen days on each sites. The aim of this study was to gather information on butterfly's habitat quality at Lok Kawi Botanical Garden and Kawang Forest Nature Centre. Species diversity and fauna of butterflies was calculated using the Shannon-Wiener index (H), Margalef's index (D_M) and Simpson's index (D_s). A total of 624 individuals were recorded in this study which comprised of 78 species in five families. Three hundred twenty two (322) individuals were recorded in LKBG with forty four (49) species while three hundred two (302) individuals with fifty two (52) species in KFNC. One endangered species *Trogonoptera brookiana* was found in this study. This study indicates a Kawang Forest Nature Centre has more diverse butterfly compared than Lok Kawi Botanical Garden. Meanwhile, there was no difference between habitats in species diversity (Shannon-Wiener, Simpson or Margalef) over the whole sampling period (t-test; Shannon, $t = -1.46$, $df = 4$, $P = 0.22$, $SE = 0.1085$, LKBG mean = 1.67, $SE = 0.29$, KFNC mean = 1.83, $SE = 0.25$; Simpson, $t = -1.08$, $df = 4$, $P = 0.34$, $SE = 0.2368$, LKBG mean = 5.81, $SE = 1.70$, KFNC mean = 7.14, $SE = 1.26$; Margalef, $t = -0.27$, $df = 4$, $P = 0.80$, $SE = 0.26$, LKBG mean = 2.30, $SE = 0.68$, KFNC mean = 2.37, $SE = 0.79$). Twenty three (23) species with four hundred seventy six (476) individuals were recorded widely distributed in both sites, twenty six (26) species with fifty five (51) individuals found only in LKBG and 29 species with 97 individuals in KFNC. The most abundant family was Nymphalidae (52.56%), followed by Pieridae (16.67%), Lycaenidae (10.26%) Hesperidae (11.54%), and Papilionidae (8.97%). Five dominant species in this study were *Eurema hecabe* (13.6%), *E. lacteola* (8.8%), *E. sari* (7.4%), *Ypthima pandocus* (6.6%) and *Psolos fuligio* (5.8%).

ABSTRAK

BUTTERFLY DIVERSITY IN LOK KAWI BOTANICAL GARDEN AND KAWANG FOREST NATURE CENTRE: AS AN INDICATOR OF HABITAT QUALITY IN BOTH AREAS

Kajian ini adalah mengenai kualiti habitat kupu-kupu yang terdapat di Taman Botani Lok Kawi (LKBG) dan Taman Sejadi Kawang (KFNC) dengan menggunakan kaedah pengumpulan menggunakan jaring kupu-kupu secara manual transek yang diubahsuai. Kajian telah dijalankan selama 14 hari di setiap tempat kajian bermula antara bulan February sehingga April 2008. Shannon-Wiener index (H'), Margalef's index (D_M) dan Simpson's index (D_s) telah digunakan mengukur kualiti habitat kupu-kupu di kawasan kajian. Sejumlah enam ratus dua puluh empat (624) individu telah direkodkan dalam kajian ini yang mana melibatkan tujuh puluh Sembilan (78) spesis dan lima (5) famili. Tiga ratus dua puluh dua (322) individu dengan empat puluh sembilan (49) spesis telah direkodkan di Taman Botani Lok Kawi dan tiga ratus dua (302) individu dengan lima puluh dua (52) spesis telah direkodkan di Taman Sejadi Kawang. Kajian mendapati tidak ada signifikasi yang berbeza dalam habitat untuk Shannon-Wiener, Simpson dan Margalef (t-test; Shannon, $t = -1.46$, $df = 4$, $P = 0.22$, $SE = 0.1085$, LKBG mean = 1.67, $SE = 0.29$, KFNC mean = 1.83, $SE = 0.25$; Simpson, $t = -1.08$, $df = 4$, $P = 0.34$, $SE = 0.2368$, LKBG mean = 5.81, $SE = 1.70$, KFNC mean = 7.14, $SE = 1.26$; Margalef, $t = -0.27$, $df = 4$, $P = 0.80$, $SE = 0.26$, LKBG mean = 2.30, $SE = 0.68$, KFNC mean = 2.37, $SE = 0.79$). Sejumlah dua puluh dua (23) spesis dengan empat ratus tujuh puluh enam (476) individu tersebar luas di kedua-dua kawasan, dua puluh enam (26) spesis dengan lima puluh satu (51) individu hanya direkodkan di LKBG serta dua puluh Sembilan (29) spesis dengan sembilan puluh tujuh (97) individu hanya didapati KFNC. Hasil kajian juga mendapati kelimpahan kupu-kupu dari famili Pieridae yang paling tinggi (44.2%), diikuti dengan famili Nymphalidae (29.8%), Hesperidae (15.7%), Lycaenidae (6.9%) dan Papilionidae (3.4%). Lima spesis yang paling dominan ialah *Eurema hecabe* (13.6%), *E. lacteola* (8.8%), *E. sari* (7.4%), *Ypthima pandocus* (6.6%) dan *Psolos fuligio* (5.8%).

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LIST OF ABBREVIATIONS

km	Kilometer
sq	Square
m	Meter
etc	Etcetera
CRP	Crocker Range Park
ha	Hectare
LKBG	Lok Kawi Botanical Garden
KFNC	Kawang Forest Nature Centre
sp	Species
E	Evennes Index
H'	Shannon-Weiner Index
a.s.l	Above sea level
e.g	example

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KEY WORDS

Abundance, species composition, diversity

CHAPTER 1

INTRODUCTION

1.1 Biodiversity and Butterflies

Tropical rainforests cover approximately 7% of the earth's surface and contain more than half of the species known in the entire world biota (Wilson, 1988). At the global scale, they play a significant role in the functioning of the atmosphere and biosphere through photosynthesis, evaporespiration, decomposition, succession and other natural processes. The ecological processes and biological diversity of natural forests provide the foundations for stable human communities and opportunities for sustainable development. Natural forests are important as they provide multiple goods, values and environmental services (Connell, 1978).

Diversity is a defining of life and often referred to alpha diversity or to the richness of one or several ecosystem components (Solbrig, 1994; Barthlott and Winiger, 1998). However when people talk about diversity, they are often referring to species biodiversity i.e., the variety of species in an area, which refers to the total number of species in an area, and secondly is species evenness, which refers to the degree of abundance in each species (Shultz *et al.*, 1990).

Diversity can also be a powerful comparative index when used to determine the relative state of a system after human disturbance. According to Alonso (2000), the measurements of the diversity or species richness of such indicator groups also can be used as a representative measure of the species or diversity of other taxa and also as an indicator of the overall diversity of an area.

Replacement of natural forests due to human related activities, such as the process of urbanization generally leads to a decrease in insect diversity (Hill *et al.*, 1995 and Spitzer *et al.*, 1993). Nearly all ecosystems are strongly influenced by human action and this trend is certain to continue due to environmental pollution, habitat disturbance, and loss of vegetation (Miller *et al.*, 2004). According to Otsuka (2001), the changes in geographical distribution and population are indicators of a



healthy or unhealthy ecosystem. This replacement results in the loss, isolation and fragmentation of habitat, as well as changes in the quality of the remaining habitat.

As a consequence of the replacement of natural habitats in recent years, many insect species have disappeared or reduced in abundance (Davis, 1982). Tragically, large numbers of insects across the world are being made extinct as the result of human activities such as rampant deforestation, modern agriculture and widespread pollution and these environmental disturbances is thought to be some of the most important determinants of ecological community diversity and structure (Spitzer *et al.*, 1993).

It has been stated that insects and animals respond more rapidly to disturbance than vertebrates, and therefore have potential as early indicators of environmental change (Kremen, 1992). Insects are not only an important group for studying the patterns of biological diversity but also play a key role in the development of the science of conservation biology (DeVries *et al.*, 1997). Their abundance and diversity in most terrestrial ecosystem and the rapidity of their responses to environmental changes make them attractive model organisms for conservation, research, monitoring, and used as indicators for wider biodiversity (Stewart *et al.*, 2007).

Butterflies are among the best known insects and estimated 90% of the world's species have scientific names. As a consequence, their biology has been extensively investigated and they are perhaps the best group of insects for examining patterns of terrestrial biotic diversity and distribution (Van-Wright and Ackery, 1984). Owen (1971) wrote that butterflies are excellent group for communicating information on science and conservation issue such as diversity. The butterflies and moths, as a well known and highly visible group of insects, are not only fascinating in their own right but also sensitive to global climate change and also the environment (Dennis, 1993). They have also been frequently used as an indicator of the conservation value of tropical habitats (Pullin, 1995 and Miller *et al.*, 2004) including as an indicator taxa for assessing biodiversity and monitoring ecosystem responses to environmental perturbations (Howard *et al.*, 1998).

1.2 Importance of Study

Butterflies are the most suitable insects to use as an indirect measurement of environmental variation because of their high sensitivity to habitat disturbance. Several studies have shown how the patterns of butterfly community structure and diversity changed along a gradient of human disturbance (Leps and Spitzer, 1990). As a result, species of butterflies are now far less abundant or widely distributed than they used to be. Some studies have also shown that habitat disturbance such as habitat loss via land transformation or habitat degradation are one of the main causes of butterflies' decline and loss overall (Collinge, 1996).

Previous studies of butterflies found that many species have declined markedly in abundance or have become extinct due to human activities (Miller *et al.*, 2004). Studies within Borneo have shown that butterfly diversity has been significantly affected by both logging and burning, and responses were dependent upon interspecific morphological, life history and ecological differentiation (Cleary, 2003; Cleary and Genner, 2004).

Therefore, studies of butterfly diversity patterns are urgently needed in order to preserve the communities and their conservation value (Hollaway *et al.*, 1992; DeVries *et al.*, 1997; Spitzer *et al.*, 1997).

The purpose of this study is to investigate the butterfly diversity in two different habitats i.e. altered forest (Lok Kawi Botanical Garden) and natural forest (Kawang Forest Nature Centre). Thus, this study hopes to provide baseline data on butterflies in Lok Kawi Botanical Garden and Kawang Forest Nature Centre for future diversity studies and provide information for effective park management within the two study areas.

1.3 Objectives

The aim of this study is to allow information on aspects of butterfly fauna at Lok Kawi Botanical Garden and Kawang Forest Nature Centre, Papar and considers the following objectives ;

- i. To determine the diversity of butterfly fauna found at Lok Kawi Botanical Garden and Kawang Forest Nature Centre, Papar.
- ii. To compare the diversity of butterfly in Lok Kawi Botanical Garden and Kawang Forest Nature Centre, Papar.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Butterfly (Rhopalocera)

Insects have been around for more than 400 million years and they are the most successful and enduring life form that has ever arisen on this planet. Diverse as well as abundant, insects comprise roughly half of the earth's one and a half million known species (George, 1997). Butterflies are one of the common insects and well known to everyone. They are known as a widespread, recognized group which is conspicuous, easy to observe and also occurs in all parts of the world (Owen, 1971).

The name of the butterfly is derived from the name butter-coloured fly given possibly to the bright-yellow Brimstone butterfly of Northern Europe. Butterflies belong to the class Insecta and order Lepidoptera. Carl von Linne (known as Linnaeus) who first called butterflies (and moths) 'Lepidoptera', derived from the Greek words *lepis* (a scale) and *pteron* (wing), meaning 'scale-wing'.

In general, butterflies are insects belonging to the order of Lepidoptera and Lepidopterans are divided into butterflies and moths. The butterflies and moths, as a well known and highly visible group of insects are not only fascinating in their own right but also visibly attractive and colourful (Dennis, 1993). Butterflies are day fliers whereas moths are generally nocturnal in habit and rest with their wings held in a horizontal or roof-like position. Butterflies rest with their wings closed in an upright position above the body and their antennae are threadlike and gradually thicken to form a club.

Butterflies are divided into the 'true butterflies' and the 'Skipper butterflies'. The Skippers differ from the true butterflies in terms of their antennae that is usually hooked at the tip; they fly with jerky or skipping action and they rest with the forewings usually held closed together over the thorax with the hindwings open and flat (Yong, 1983).



2.1.1 Morphology of Butterfly

The butterfly body is made up of three parts: head, thorax and abdomen. The head has a pair of antennae or feelers that are usually long and knobbed or clubbed at the ends. The antennae are sensitive to touch and smell, and have a specific number of segments, sometimes used in identification. There is a pair of compound eyes, on either side of the head. The eyes are beveled so that a wide angle of vision is possible. The other main feature on the head is the tongue, or proboscis, used for sucking up liquids. Its structure is like two straws fused together and zipped up (Miller and Miller, 2004).

a. Thorax

The thorax is a muscle box with three segments. The three pairs of joined legs arise from the thorax, one from each of the three segments. In some butterflies the front legs are reduced and non-functional.

b. Abdomen

The abdomen contains the bulk of the digestive system, as well as the excretory system. At the tip of the abdomen are the sexual apparatus, called the genitalia, whose internal characteristics can be useful in identifying different species.

c. Outer body

The outer body or integument of the butterfly is covered with small, sensory hairs. Butterflies also have specialized scales on their wings that contain highly volatile insect hormones, called pheromones. These hormones are released into the air during mating, and affect the behavior of the opposite sex.

d. Head

The head carries a great deal of sensory apparatus for the butterfly. The largest features are the compound eyes that are made up of thousands of individual eyes, each with a tiny lens and a tiny fraction of view. The beveled nature of the compound eye means that the butterfly is aware of its immediate environment through a very large angle. The head is covered with minute bristle and hairs that are sensitive to touch, as are the labial palps and the labrum.

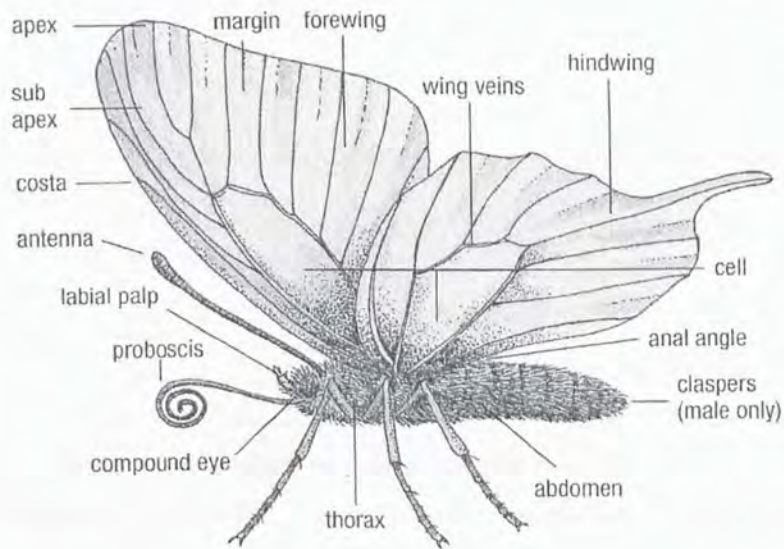


Figure 2.1: Morphology of butterfly (Miller and Miller, 2004)

2.1.2 Classification of Butterfly

Taxonomically all butterflies belong to the class Insecta and order Lepidoptera. Lepidoptera can be divided into two groups, Rhopalocera and Heterochera and all butterflies are grouped under Rhopalocera (Corbet and Pendlebury, 1992). The Rhopalocera can be divided into two major groups or superfamilies; Papilionidea (true butterflies) and Hesperioidea (skippers). They are further subdivided into five families namely Papilionidae, Pieridae, Lycaenidae, Nymphalidae and Hesperidae (Larsen, 1996).

Classification of Rhopalocera is as shown as follows (Corbet and Pendlebury, 1992):

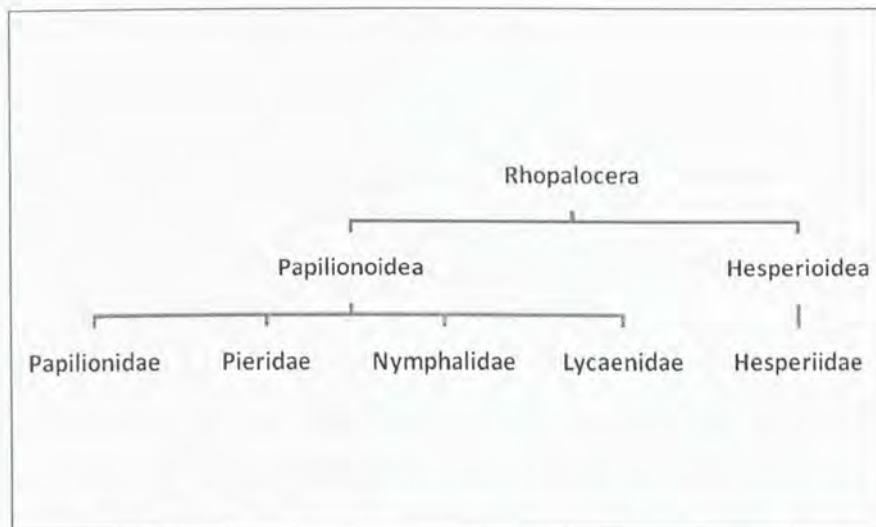


Figure 2.2 : Classification of Rhopalocera (Corbet and Pendlebury, 1992)

a. Papilionidae

Papilionidae usually characterized by their tailed hind wings, some are tailless and commonly known as Swallowtails. The family includes many large, active and they are generally large and colourful. They often fly high and are normally found in open space and forest areas.

b. Pieridae

The butterflies in this family are moderate to fairly small in size. Pieridae tend to be easy to identify by their bright colours. The butterflies are never tailed and often congregate on the road or at puddles. Most species in this family of worldwide occurrence are white or yellow in colour and common names known as White, Yellow and Sulphur butterflies. White are a large and widespread group, while the sulfurs include many of the clouded yellow.

c. Nymphalidae

The Nymphalidae are a very large family of butterflies with a great variety of shape, bright colours and markings. The family includes many large, strong fliers and many species are attracted and found in open and also sunny areas. However, there are a number of species which are restricted to the forests.

d. Lycaenidae

The Lycaenidae is a large family of small butterflies, many of which have tailed hind wings. This family contains three main groups of butterflies, the hairstreaks, coppers and blues, each identified by various external characteristics. Metallic colours are the most common.

e. Hesperidae

The Hesperidae are distinguished from all other butterflies by their short, wide bodies and relatively short wings; they look more like moths than butterflies. The clubbed or hooked antennae are set wide apart on the head. Most are grey or brown with lighter markings, although some are more colorful.

2.1.3 The Roles of Butterfly

All butterflies formed easily recognizable biotic component of the ecosystem, as they are visibly attractive and strikingly colourful. They are notable for their unusual life cycles which undergo complete metamorphosis in which they go through four different life stages. The butterfly plays an important role in ecosystems, acting as a pollinator, a food source, as an indicator of the ecosystem's well being and also appreciated for their aesthetic value (Kremen, 1992).

a. Herbivores

Most butterflies are oligophagous, feeding on plants from one or only a few plant families, with apparent evolutionary trends in the host ranges throughout the family (Heinz and Feeny, 2005). Butterflies are also highly dependent on particular host plants during the larval stage, most species are day-flying and regularly attract attention and are also sensitive to changes in temperature and light levels (Kirton, 1991 and Warren, 2001).

b. Pollinator

Butterflies play a big role as pollinators even though not as efficient as bees and their often wide geographical ranges (Thomas and Mallorie, 1985). They play a big role in pollinating flowers that open during the day and tend to favour big, colorful flowers that have a landing platform (labellum) to gather pollen on their long, thin legs as they sip nectar from a flower.

c. Indicator

Butterflies have annual life cycles (transforming from egg to adult in a year), requiring that the same conditions be present every year for new eggs to mature. That makes butterflies especially sensitive to climate change, such as pollution and habitat loss, and causes them to be more responsive than birds, plants and other species with longer life cycles. Therefore, diversity and relative abundance of butterflies usually indicates a healthier ecosystem due to their sensitivity (Spitzer *et al.*, 1993).

Like other insects, butterflies are dependent on environmental conditions for growth, development and survival. Butterflies have been suggested as a good environmental indicator due to their common dependence on particular food plants, their sensitivity to microenvironment variations and also useful in assessing habitat (Pollard, 1995).

c. Restoration

Butterflies contribute to ecosystem restoration because they supply pollination and a source of food. Increased butterfly populations may indicate an increase in plant diversity and other pollinator groups within restored areas (Warren, 2001).

2.1.4 Habitat of butterfly

Butterflies can be found almost anywhere from an urban area to a forest and as high as mountain area. In Sabah, an outstanding 625 species of butterflies were recorded in Mount Kinabalu and within its boundaries making it one of the most highly diverse areas on butterflies' richness. The number recorded there are higher than the whole of Europe whose species numbers at only 365 species. Habitats of butterfly can be divided into (Akinori *et al.*, 2004):

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