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COMPOSITION OF FRUIT-FEEDING BUTTERFLIES (LEPIDOPTERA: NYMPHALIDAE) IN A PEAT SWAMP FOREST, KOTA SAMARAHAN, SARAWAK

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ABSTRACT

A total of 104 individuals of fruit-feeding butterflies representing 24 species and 13 genera were recorded in a 60 continuous days of sampling (26 July to 23 September 2007), in a peat swamp forest in Kota Samarahan, Sarawak. Four subfamilies of Family: Nymphalidae were listed which includes Charaxinae, Morphinae, Nymphalinae and Satyrinae. Ten fruit baited-traps were utilized in this study, and were set-up in both ground and canopy strata by applying Single-Rope Technique in five different individual trees. An average of two individuals per day was recorded with 33.33% of the total samples are represented by Nymphalinae. Known to be strong and rapid fliers, this group of nymphalids is associated with increased light intensity which was observed with the less pronounced canopy at the study area. All recorded nymphalids were also designated with rank in order to assess the rank-abundance distribution of these butterflies. Overall,

nymphalids with wider range of geographical distribution were less abundant and vice versa in the present study. One endemic to Borneo nymphalid species which is *Mycalesis amoena* was sampled in this study.

Keywords: fruit-feeding butterflies, peat swamp forest, species composition, Kota Samarahan

ABSTRAK

Sejumlah 104 individu dari kupu-kupu pemakan buah yang mewakili 24 spesies telah direkodkan selama 60 hari persampelan berterusan, di hutan paya gambut di Kota Samarahan, Sarawak. Empat subfamili daripada famili Nymphalidae telah disenaraikan iaitu Charaxinae, Morphinae, Nymphalinae dan Satyrinae. Sepuluh perangkap umpan buah telah dipasang pada lima pokok individu berbeza di kedua-dua tempat baik permukaan tanah dan beberapa strata kanopi dengan menggunakan Teknik Satu-Tali. Dua individu per hari direkodkan dengan 33.33% daripada keseluruhan sampel diwakili oleh Nymphalinae. Dikenali sebagai serangga penerbang yang kuat dan laju, kumpulan nymphalids berkaitrapat dengan peningkatan intensiti cahaya pada kanopi dikawasan kajian. Semua nymphalids yang direkodkan juga telah ditetapkan berperingkat untuk mengukur peringkat kelimpahan taburan kupu-kupu ini. Secara keseluruhannya nimphalids dengan jarak taburan geografi lebih lebar memiliki kelimpahan lebih sedikit begitu pula sebaliknya. Satu spesies endemik kepada Borneo spesies nymphalid iaitu *Mycalesis amoena* adalah sampel dalam kajian ini.

Kata kunci: kupu-kupu pemakan buah, hutan paya gambut, komposisi spesies, Kota Samarahan

INTRODUCTION

The fruit-feeding butterflies comprise a very large population of species in most terrestrial ecosystem (Schulze *et al*., 2001). Therefore, assessing their distribution in a peat swamp forest will lead to a finding of their faunistic composition as well as the diversity pattern.

Furthermore, the focus on only peat swamp forest will also contribute on species-area relationship, as fruit-feeding butterflies are good indicator tool, and best characterized the particular forest they sustained (Fermon *et al.*, 2000).

Among all nymphalids, Satyrinae and Morphinae are clustered in the same clade, and thus regarded as closely related, whereas Nymphalinae and Charaxinae form a different grouping (Corbet & Pendlebury, 1992). Different characterization on these two groupings has led to specific attributes which defined the traits and behaviour of the fruit-feeding butterflies. For instance, Satyrinae and Morphinae are sensitive to fluctuations in moisture availability as well as humidity; meanwhile Nymphalinae and Charaxinae are rarely sampled in the lower level, if the canopy is higher (Hamer *et al.*, 2003).

Larval resources are one of the important factors that lead to the specialization of butterflies on certain strata (Schulze *et al*., 2001) as well as forest habitats. Most butterflies are host-plant specific, and thus, they would only occur at certain point where the sources are available. With this attributes butterflies serves as good indicator tool which aid in the assessment of forest disturbance (Corbet & Pendlebury, 1992; Fermon *et al.*, 2000; Cleary & Genner, 2004).

Butterfly abundance was estimated to be higher in peat swamp forest, yet low in terms of species richness, which includes Nymphalidae, Pieridae and some Papilionidae (Abang and Hill, 2006). In the tropical rainforest, Boonvanno *et al.* (2000) found that Nymphalidae and Lycaenidae appear to be the most abundant families captured in baited traps. In contrast to the peat swamp forest, the communities in the tropical forest are characterized with their high number of diversity and low abundance (DeVries and Walla, 2001).

The main objective of this study is to investigate the species composition of fruit-feeding butterflies in a peat swamp forest, which is different from the other types of forest in terms of vegetation and other physical attributes, such as the wet forest floor and less-pronounced canopy. Subsequently, overall diversity of the butterflies sustained in this boggy habitat can be documented for future reference. The second aim is to assess the species rank abundance distribution in order to understand thecommunity structure. Known to be attracted to rotting fruits, this method is best used in order to sample this guild of butterflies.

MATERIALS AND METHODS

Study site

This study was conducted at a peat swamp forest in Universiti Malaysia Sarawak, which is located in Kota Samarahan (01º27', 48''N and 11º27', 30''E). The forest are considered as secondary peat swamp forest and degraded, due to logging activities about 50 years ago (Abang and Hill, 2006; Zainudin, 2006). This is observed with the secondary growth which is denser undergrowth of smaller trees and climbers (Abang and Hill, 2006). A few species of epiphytes can also be observed in this study area, such as *Asplenium nidus*, Polypodiaceae, and Drynaria. The light intensity is relatively high, due to the less dense tree crown. The peat soil is reddish-brown to dark brown in colour, which has been developed in a water-logged condition and high acidity with pH ranging from 3.2 – 4.0 (Ipor, 2006; Tawan 2006). Peat swamp is categorized by the substrate which is damp during the dry season (May to October) and very wet during the rainy season (November to April) (Abang and Hill, 2006). The vegetations are mostly represented by the families Sapotaceae, Euphorbiaceae and Moraceae, such as the *Macaranga* sp. and *Ficus* sp. According to Ipor *et al.* (2006), there are about seven species representing family Sapotaceae that can be observed here, and the *Palaquium* sp. (Sapotaceae) is the most dominant trees. The average diameters of the trees in this site are about 20 to 30 cm and the canopy is defined from 15 to 25 m from the ground, depending on the trees (Page *et al.*, 1999).

Butterfly sampling

Bait trapping was conducted with cylindrical gauze-traps (Schulze *et al*., 2001) installed at two different levels. Trap positions ranged from ground level (1.5 m above ground) to the canopy level (15 – 22m) in order to include the survey of vertical distribution of the fruit-feeding butterflies (documented elsewhere). The cylindrical hanging baited traps consisted of a cloth cylinder made of mosquito netting, while the bottom left is left open as the point of entry (Haber, 2005). Consequently, trapped butterflies will sit motionless on the sides of

the traps until collected (Nakashizuka and Stork, 2002). The traps were installed by using Single Rope Technique which instead of climbing, the traps were tied to the nylon ropes. The ropes are fired up to the branches, by using sling shot and then adjusted to proper heights. Suitable branches were selected, and each individual tree was about 25 m apart. Two traps; ground level (one m above the ground level) and canopy level (15 – 22 m above ground level), for each five individual tree were installed, and these bring up to ten traps in total.

Fruit-feeding butterflies were lured with either rotting bananas or pineapples alternately between individual trees. The effectiveness of the use of rotting fruits or any soft fruits because of the odour, are proven by previous studies (Beck and Schulze, 2000; De Vries and Walla, 2001; Fermon *et al.*, 2000; Dumbrell and Hill, 2005; Haber, 2005). According to DeVries and Walla (2000), fruit-feeding butterflies are easily sampled either in spatial or temporal dimensions, by using bait trapping with rotting fruits. The bananas were first mashed, mixed and fermented for about 48 hours whereas the pineapples were kept for a week, prior to be used (DeVries and Walla, 2001). Bait trapping were conducted for 60 continuous days, from 26 July to 23 September 2007. Traps were baited prior to the next sampling day and checked in the early afternoon (between 1400 and 1500). The effect of time is literally large; with studies done before that the butterflies are at their activestage in the afternoon (Pollard and Yates, 1993). Collection date, number of individuals, weather condition and levels above the ground were recorded.

Mounting and preserving

The specimens were pinned, labeled with data on collection date and level above the ground, and kept in the insect box. Any hard specimens were first relaxed inside the relaxing jar, and left overnight during the process. The relaxed specimens were properly spread for the identification purposes. The specimens were spread on the spreading board with the rear margins of the front wings straight across, at right angles to the body, and the hind wing far forward (Abang and Karim, 2005).

Identification and taxonomy
Specimens were identified until species level by referring to Otsuka (1988) and the UNIMAS Museum's voucher specimens. The numbers of individuals for each subfamily were recorded and all specimens were deposited at the UNIMAS Insect Reference Collections.

Geographical and Rank Distribution
All species sampled were ranked according to their geographical distribution based on Hamer *et al.* (2003), whom had conducted a study on the ecology of butterflies in the Northern Borneo. Most widespread species which are distributed in the Oriental (Asia South of the Palaearctic region). African and Australasian regions have the lowest rank (rank= 61), whereas species ranked from 2 – 22 have distributions within Sundaland (Borneo, Sumatra, Java, West Malaysia and Palawan). Species ranked lower than 22 were distributed in other parts of the Oriental and/or Australasian regions.

Species Diversity
Species diversity was measured with Shannon diversity index, performed with PAST version 1.96 (Hammer *et al.*, 2001)

RESULTS

Overall Species Diversity
A total of 104 individuals of fruit-feeding nymphalidsrepresenting 24 species and 13 genera from four subfamilies, were trapped along a vertical gradient from the ground (one m) and canopy (15 – 22m) levels of a peat swamp forest, in Kota Samarahan (Table 1). An average of two individuals was recorded per day throughout the study, and a few abundant species were also listed. Several of them were *Prothoe franck* (12 individuals), *Mycalesis anapita* (11 individuals), and *Zeuxidia amethystus* (11 individuals) which were sampled exclusively at the ground level. Species diversity measures as indicated by Shannon index reveals that the ground level sustained higher species richness compared with the canopy level (H'= 1.17466) (Figure 1).

Table 1. A list of fruit-feeding butterfly species (Lepidoptera: Nymphalidae) and the number of individuals collected by using baited traps at two different heights above ground level, in a peat swamp forest, Kota Samarahan.

Species	Number of Individuals at Different Trap Heights		Total
	Ground	Canopy	
Satyrinae			
Elymnias nesaea hypereides Fruhstorfer 1902	0	1	1
Elymnias panther labuana Staudinger 1889	0	2	2
Mycalesis amoena Druce 1873	1	0	1
Mycalesis anapitafucentia Fruhstorfer 1911	11	0	11
Mycalesis fusca adustata Fruhstorfer 1906	3	0	3
Mycalesis mineus macromalayana Fruhstorfer 1911	1	0	1
Mycalesis patiana patiana Eliot 1969	4	0	4
Morphinae			
Amuthuxidia amythaon ottoman Butler 1869	2	0	2
Discophora necho cheops Felder 1867	5	1	6
Zeuxidia amethystus wallacei Felder 1867	11	0	11
Zeuxidia doubledayi horsfieldii Felder 1867	8	1	9

Nymphalinae			
Dophla evelina magama Fruhstorfer 1913	3	1	4
Euthalia iapis ambalika Moore 1858	1	0	1
Euthalia merta apicalis Vollenhoeven 1862	0	1	1
Euthalia monina bipunctata Vollenhoeven 1862	1	2	3
Lexias cyanipardus sandakana Fruhstorfer1896	5	0	5
Lexias pardalis dirteana Corbet 1941	5	0	5
hinopalpa polynice helionice Fruhstorfer 1896	1	0	1
Tanaecia aruna aparasa Vollenhoeven 1862	5	1	6
Tanaecia clathrata coerulescens Vollenhoeven 1862	1	0	1
Tanaecia munda munda Fruhstorfer 1899	4	5	9
Charaxinae			
Agatasa calydonia mahasthama Fruhstorfer 1913	1	1	2
Charaxes bernadus repititus Butler 1869	1	2	3
Prothoe franck borneensis Fruhstorfer 1913	12	0	12
TOTAL (24 species)	**86**	**18**	**104**

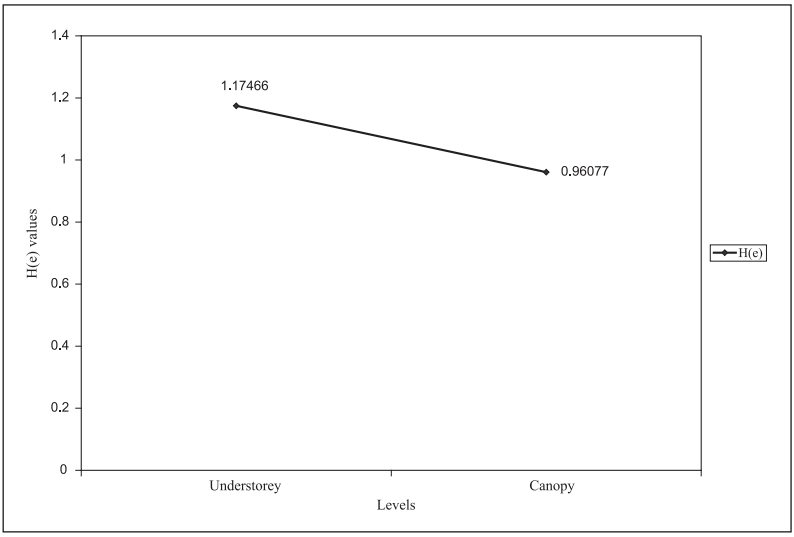

Figure 1. Shannon-Weiner diversity index (H) (e) of fruit-feeding butterflies at the ground and canopy levels in a peat swamp forest, Kota Samarahan, Sarawak.

Nymphalinae stands to be the most diverse and abundant subfamily, which represents 41.67% of the total nymphalid species recorded, and 33.33% from the total individuals caught (Figure 2). *Tanaecia munda* was the most abundant species for Nymphalinae, with nine individuals sampled (Table 1). On the other hand, Charaxinae was the least diverse and abundant subfamily sampled in this study (Figure 3). Overall species abundance distribution (Figure 3) ranged from seven species representing single individual to one species with 12 individuals which was *P. franck* (11.54%).

Species Rank-Abundance Distribution

The nymphalid species were ranked based on the rank-abundance distribution of Hamer *et al.* (2003), which had carried out a study on the ecology of butterflies in natural and selectively logged forests of northern Borneo. Overall results of the present study revealed that the fruit-feeding butterfly species with wider range of geographical distribution tend to be low in abundance. In other words, a widely distributed species was lessin number (Figure 4).

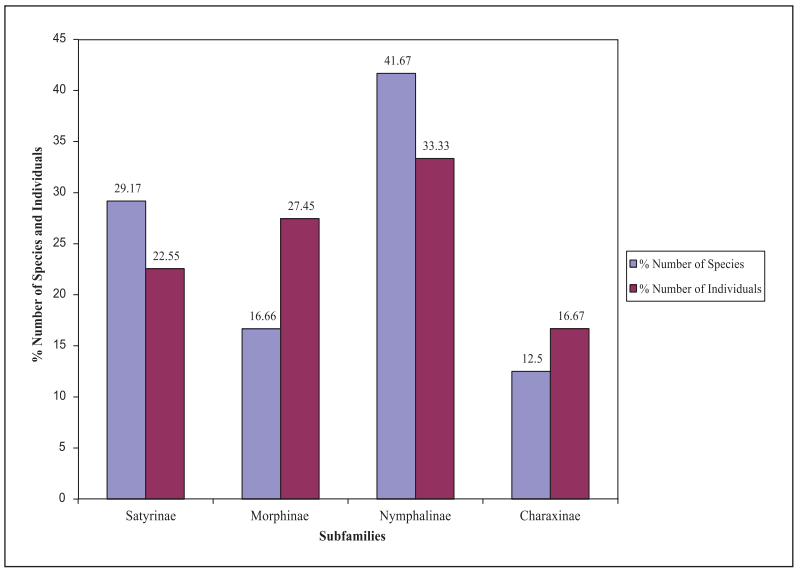

Figure 2. Percentage representation of species and individuals of the fruit-feeding butterflies (Lepidoptera: Nymphalidae), in a peat swamp forest, Kota Samarahan, Sarawak.

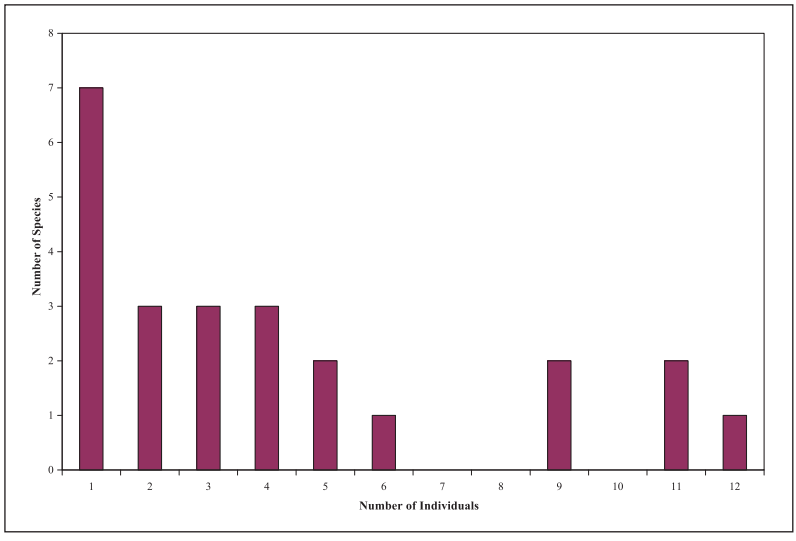

Figure 3. Relative abundance of fruit-feeding butterflies captured in baited traps, in a peat swamp forest, Kota Samarahan, Sarawak.

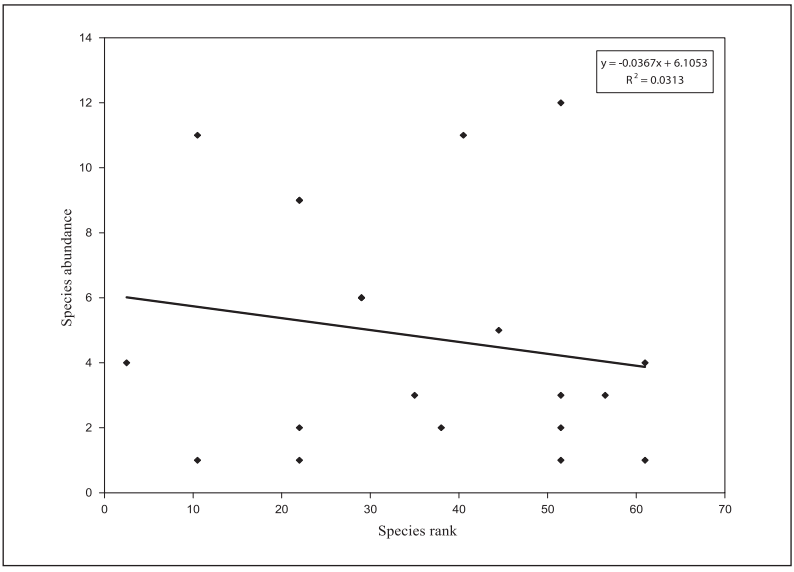

Figure 4. Rank-abundance distribution for the total sample of fruit-feeding butterflies in a peat swamp forest, Kota Samarahan, Sarawak.

According to Hamer *et al*. (2003), the high rank (2.5) indicates the narrow geographical distribution, whereas the low rank (61) was the most widespread. However, a few of the nymphalid species documented in this study were unable to be ranked as there was no record reported in Hamer *et al*. (2003). The assumption of this species-rank abundance distribution is somehow only applied to certain species because some of the fruit-feeding butterflies were abundant regardless of their lower ranking and also less abundant even though they were high-ranked. The distribution of the nymphalid species were also included, based on Otsuka (1988).

Five species were recorded as widely distributed namely *Mycalesis mineus*, *Amathuxidia amythaon*, *Euthalia monina*, *Rhinopalpa polynice*, *Charaxes bernadus*, *Dophla evelina* and *P. franck*. All of these species were sampled with less than five individuals respectively with the exception of the *P. franck*, which was the most abundant species (12 individuals). Only one individual of *Mycalesis amoena* (endemic to Borneo) was recorded in this study (Table 1).

DISCUSSION

Overall Species Diversity

The total record of 104 individuals from 24 species over 60 continuous trapping days with an average of two individuals per day is relatively low compared to previous study carried out in Poring hill dipterocarp forest, Sabah (Schulze *et al.* (2001). In this study, an average of ten individuals was sampled per day, with a total of 485 individuals from 53 species in 51 days (two consecutive sampling periods). High species richness and abundance recorded in Poring was possibly due to the dense and rich vegetation, which are remarkably pronounced compared with the peat swamp forest. A peat swamp forest is therefore observed to be lower in species diversity particularly for nymphalids butterfly.

As observed, in the present study nearly half of the total species sampled were Nymphalinae. These sun-loving fruit-feeding butterflies are known to be strong and rapid fliers, and thus easily escape from predators as well as migrate if there are any chances of habitat degradation (Corbet and Pendlebury, 1992). Encountered mostly in open areas, Nymphalinae as well as the other subfamilies are associated with increased light intensity, which accordingly increased in species diversity (Hamer *et al.*, 2003).

Species Rank-Abundance Distribution

Geographical range of any particular microfauna has been a very good indicator as well as explicit traits in order to characterize them. According to Beck and Chey (2006), by plotting and analyzing the rank-abundance distributions, species assemblages in the particular habitat can be characterized, as different types of habitats tend to acquire different models of distributions. Furthermore, it is also stated that the average of rank-abundance distributions in the disturbed habitat will be different compared with in the primary forest (Beck and Schulze, 2000).

Attributes in terms of their habitat specificity, migration and adaptation are among the aspects that could be elaborated more in order to describe and study them. In this study, fruit-feeding nymphalids were ranked so that better understanding on their occurrence and stratification could ease the data interpretations regarding their

distributions. As a result, the rank-abundance distributions of the nymphalids follow a similar trend, which are few abundant and many rare species, which correlates well with Beck and Schulze (2000).

According to Fermon *et al.* (2000), forest disturbance which may occur from logging or any human encroachment activities may lead to the disruption of the insect fauna, particularly the stratification fruit-feeding butterflies. Apart from that, changes in the ecological processes due to the habitat alteration will also affect the rank-abundance distributions (Beck and Chey, 2006). In this context, species with narrow geographical range (higher rank) are more likely to be affected (Fermon *et al.*, 2000) especially Satyrinae and Morphinae (Hamer *et al.*, 2003). Furthermore, habitat specificity of the high-ranked fruit-feeding butterflies tends to be higher, which means this category of nymphalids is confined only at certain microhabitats (Fermon *et al.,* 2000). Typically, this category of nymphalids possesses higher shade preference, and thus was encountered most beneath the canopy in the dense forest (Hamer *et al.*, 2003).

Hamer *et al.* (2003) also stated that widely distributed fruit-feeding butterflies such as Charaxinae (*C. bernadus*) and Nymphalinae (*E. monina*, *R. polynice, D. evelina*) are susceptible to the effects of logging activities. The isolated remnant of peat swamp forest in the study site was heavily logged 50 years ago (Abang and Hill, 2006) and recently cleared for development purposes, leaving only a small portion at about 0.1 ha. It is hypothesized that this explains the record of only a few widely distributed species in the present study. Furthermore, according to Benedick *et al.* (2006), small isolated remnants show least resemblance to intact forest, and species poor.

Similarly, habitat fragmentations also affected *E. panthera*, which was noted to have narrow geographical distribution, as well as a few of the Morphinae species (Hamer *et al.*, 2003). Nevertheless, a number of the satyrine butterflies such as *M. anapita* and *Mycalesis patiana* were richly sampled despite of known to be restricted only to certain places. Essentially, smaller species tend to be more abundant in the small fragments, than the larger one (Benedick *et al.*, 2006). Hence the high record of the restricted satyrine butterflies in the peat swamp forest.

Geographical distributions of the fruit-feeding butterflies are also stated to be correlated with the larval host-plant specificity (Benedick

et al., 2006). The wider the distribution of the particular species, the more specific the host plants are. Species with only one host-plant family were less abundant in small fragments, compared with those which have two or more host-plant families (Benedick *et al.*, 2006). This explained the occurrence of only a few individuals of the lower ranked fruit-feeding butterflies such as *M. mineus*, *A. amythaon*, *D. evelina*, *E. monina*, *R. polynice*, and *C. bernadus*.

CONCLUSIONS

Overall diversity and abundance of the fruit-feeding butterflies in the peat swamp forest Kota Samarahan, shows a declining pattern with increasing trap heights in all subfamilies. Results from this study also indicate a high proportion of Nymphalinae in this forest remnant, in terms of species richness and abundance in both strata.One endemic species was recorded (*M. amoena*) which appears to be endemic in Borneo.

Problems such as damaged traps and missing baits are mostly encountered in this study. Traps could be damaged by heavy rainfall and strong wind as well as by monkeys and squirrels. Longer period of sampling time is also recommended to get more precise data, in order to produce a better conclusion for the species fluctuation on this study area. Small sample sizes and inadequate information on spatial and temporal distribution of the fruit-feeding butterflies are also some of the limitations that need to be addressed, in order to evaluate community patterns, as well as comparing diversities between different areas (DeVries and Walla, 2001). Furthermore, a good differentiation of rank-abundance distributions in order to compare between habitats, also require bigger sample size or species-rich assemblages (Beck and Chey, 2006).

Nevertheless, the study of the fruit-feeding butterflies has indeed contributed in the assessment of the forest disturbance, as the baited butterflies provide as a good indicator tool. The abundance of the species of concern which are the restricted range species, appeared to be more indicative in value, and immediately bring the whole picture of the management impact.

REFERENCES

Abang, F. and Hill, D.S. 2006. The Invertebrate Fauna. In Abang, F. and Das, I. (Eds.), *The Biodiversity of a Peat Swamp Forest in Sarawak*, (pp 87 – 98). Kota Samarahan. Universiti Malaysia Sarawak.

Abang, F. and Karim, C. 2005. Diversity of Macromoths (Lepidoptera: Heterocera) in the Poring Hill Dipterocarp Forest, Sabah, Borneo. *Journal Asia-Pasific Entomology*, 8(1): 69 – 79.

Beck, J. and Chey, V.K. 2006. Are Rank-Abundance Distributions a Useful Tool of Assemblage Discrimination in Tropical Moth? *Acta Zoologica Sinica*, 52(6): 1148 – 1154.

Beck, J. and Schulze, C.H. 2000. Diversity of Fruit-feeding Butterflies (Nymphalidae) Along a Gradient of Tropical Rainforest Succesion in Borneo with Some Remarks on the Problem of "Pseudoreplicates". *Trans. Lepid. Soc. Japan.,* 51(2): 89 – 98.

Benedick, S., Hill, J.K., Mustaffa, N., Chey, V.K., Maryati, M., Searle, J.B., Schilthuizen, M., and Hamer, K.C. 2006. Impacts of Rain Forest Fragmentation on Butterflies in Northern Borneo: Species Richness, Turnover and the Value of Small Fragments. *Journal of Applied Ecology*, 43: 967 – 977.

Butler, T. 2005. Studying the Rainforest Canopy, Learning About the Richest Region of the Forests. *Crane's Eye View.* Online Article: http://news.mongabay.com/2005/0331tina_butler.html Accessed Date: 11 July 2007

Corbet, S. and Pendlebury, H.M. 1992. *The Butterflies of the Malay Peninsular.* Kuala Lumpur, Malaysia. Malayan Nature Society.

DeVries, P.J. and Walla, T.R. 2001. Species Diversity and Community Structure in Neotropical Fruit-feeding Butterflies. *Biological Journal of the Linnean Society*, 74: 1 – 15.

Dumbrell, A.J. and Hill, J.K. 2005. Impacts of Selective Logging on Canopy and Ground Assemblages of Tropical Forest Butterflies: Implications for Sampling. *Biological Conservation*, 125(1): 123 – 131.

Fermon, H., Waltert, M., Larsen, T.B., Dall'Asta, U., and Muhlenberg, M. 2000. Effects of Forest Management on Diversity and Abundance of Fruit-feeding Nymphalid Butterflies in South-eastern Cote d'Ivoire. *Journal of Insect Conservation*, 4: 173 – 189.

Haber, E. 2005. Baseline Assessment of Butterfly Biodiversity and Community Composition at the Firestone Center for Restoration Ecology, Costa Rica. *Research Reports of the Firestone Center for Restoration Ecology,* (1).

Hamer, K.C., Hills, J.K., Benedick, S., Mustaffa, N., Sherratt, T.N., Maryati, M., and Chey, V.K. 2003. Ecology of Butterflies in Natural and Selectively Logged Forests of Northern Borneo: The Importance of Habitat Heterogeneity. *Journal of Applied Ecology*, 40: 150 – 162.

Ipor, I. 2006. Review of Peat Swamp Forests in Sarawak. In Abang, F. and Das, I. (Eds.), *The Biodiversity of a Peat Swamp Forest in Sarawak*, (pp. 1 – 18). Kota Samarahan. Universiti Malaysia Sarawak.

Ipor, I., Tawan, C.S., and Mustafa, H.S. 2006. Floristic Structure and Tree Species Composition. In Abang, F. and Das, I. (Eds.), *The Biodiversity of a Peat Swamp Forest in Sarawak,* (pp. 61 – 86). Kota Samarahan. Universiti Malaysia Sarawak.

Nakashizuka, T. and Stork, N. 2002. *Biodiversity Research Methods, IBOY in Western Pacific & Asia.* Kyodai Kaikan. Kyoto University Press.

Otsuka, K. 1988. *Butterflies of Borneo.* Tobishima Kensetsu K.K. Tokyo.

Page, S.E., Rieley, J.O., Shotyk, O.W. and Weiss, D. 1999. Interdependence of Peat and Vegetation in a Tropical Peat Swamp Forest. *Phil. Trans. Soc. Lond*., 354: 1885 – 1897.

Pollard, E. and Yates, T.J. 1993. *Monitoring Butterflies for Ecology and Conservation.* London. Chapman & Hall.

Schulze, C.H., Linsenmair, K.E. and Fiedler, K. 2001. Understorey versus Canopy- Patterns of Vertical Stratification and Diversity among Lepidoptera in a Bornean Rainforest. *Plant Ecology,* 153: 133 – 152.

Tawan, C.S. 2006. Plant Diversity and Commercial Timbers. In Abang, F. and Das, I. (Eds.), *The Biodiversity of a Peat Swamp Forest in Sarawak,* (pp. 29 – 60). Kota Samarahan. Universiti Malaysia Sarawak.

Zainudin, R., 2006. The Amphibian Fauna. In Abang, F. and Das, I. (Eds.), *The Biodiversity of a Peat Swamp Forest in Sarawak,* (pp. 107 – 114). Kota Samarahan. Universiti Malaysia Sarawak.