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SPECIES DIVERSITY AND ABUNDANCE OF BUTTERFLY (LEPIDOPTERA: RHOPALOCERA) AT DIFFERENT ALTITUDES ALONG THE RAUB CORRIDOR TO FRASER'S HILL, PAHANG, MALAYSIA

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ABSTRACT

This study was conducted to record the butterfly fauna along the Raub Corridor to Fraser's Hill, Pahang. A series of field samplings was conducted for three consecutive days in October and December 2014, and again from January till March 2015, at three different altitudes, i.e. at 400 to 500 m (lower altitude), 750 to 850 m (middle altitude), and 1000 to 1250 m (higher altitude) within the study area. The butterflies were randomly collected in the day time between 0900-1700 hours by aerial sweeping using the butterfly net. A total of 716 individuals from 138 species in five families (Papilionidae, Nymphalidae, Pieridae, Lycaenidae and Hesperidae) and 14 subfamilies (Papilioninae, Nymphalinae, Satyrinae, Danainae, Morphinae, Coliadinae, Pierinae, Riodininae, Miletinae, Poritiinae, Lycaeninae, Pyrginae, Hesperiinae and Coeliadinae) were recorded. At the higher altitude, the Shannon Diversity Index was H'= 3.683, evenness index, E’=0.5936 and Margalef's Richness Index, R’= 13.0. At the middle altitude, the Shannon Diversity Index was H'= 3.226, evenness index, E’=0.442 and Margalef's Richness Index, R’= 9.756. At the lower altitude, the Shannon Diversity Index was H'= 3.917, evenness index, E’=0.6128 and Margalef's Richness Index, R’= 14.72, respectively. The highest species diversity, species evenness and also species richness indices were recorded at the lowest altitude i.e. 400 to 500 m above sea level.

Keywords: Butterflies, Fraser’s Hill, elevation, species diversity and abundance

ABSTRAK

Kajian ini dilakukan untuk merekodkan fauna kupu-kupu di sepanjang koridor Raub sehingga ke Bukit Fraser, Pahang. Satu siri persampelan di lapangan telah dilakukan selama tiga hari berturut-turut pada bulan Oktober dan Disember 2014 dan pada bulan Januari sehingga bulan Mac 2015 di tiga altitud berbeza i.e. 400 sehingga 500 m (altitud rendah), 750 sehingga 850 m (altitud pertengahan), dan 1000 sehingga 1250 m (altitud tinggi) . Sampel kupu-kupu dikumpulkan secara rawak pada jam 0900-1700 menggunakan jaring kupu-kupu. Sejumlah 716 individu daripada 138 spesies dalam lima famili (Papilionidae, Nymphalidae, Pieridae, Lycaenidae and Hesperiidae) dan 14 subfamili (Papilioninae, Nymphalinae, Satyrinae, Danainae, Morphinae, Coliadinae, Pierinae, Riodininae, Miletinae, Poritiinae, Lycaeninae, Pyrginae, Hesperiinae and Coeliadinae) telah direkodkan. Nilai indeks kepelbagaian Shannon pada altitud tinggi adalah H'= 3.683, nilai indeks kesamarataan spesies pula adalah E’=0.5936 dan nilai indeks kekayaan spesies Margalef adalah R'= 13.0. Pada altitude pertengahan, nilai indeks kepelbagaian Shannon adalah H'= 3.226, nilai indeks kesamarataan spesies pula adalah E'=0.442 dan nilai indeks kekayaan spesies Margalef adalah R'= 9.756. Nilai indeks kepelbagaian Shannon pada altitud rendah pula adalah H'= 3.917, nilai indeks kesamarataan spesies pula adalah E'=0.6128 dan nilai indeks kekayaan spesies Margalef adalah R'= 14.72. Nilai indeks tertinggi kepelbagaian spesies Shannon, kesamarataan spesies dan nilai indeks kekayaan spesies Margalef adalah pada altitud rendah i.e. 400 sehingga 500 m dari paras laut.

Kata kunci: Kupu-kupu, Bukit Fraser, ketinggian, kepelbagaian dan kelimpahan spesies

INTRODUCTION

Butterflies belong to Lepidoptera, the second largest insect order after Coleoptera, which comprises moths, butterflies and skippers. Holloway et al. (1987) had described about 17 850 species of butterflies worldwide, and of these, over 1000 species were recorded in Malaysia, with 87% of these being found in East Malaysia (Yong 1983; Corbet et al. 1992). In the Peninsular Malaysia, the distribution of butterfly species is restricted to the certain altitudes and plant associations and they are more or less evenly distributed (Corbet & Pendlebury 1992). The majority of our Malaysian butterflies' dwell in primary forests (Yong 1983).

This paper reports on the butterfly diversity and abundance associated with the altitudes of the Corridor from Raub to Fraser's Hill within a small scale and short-term study period. Butterflies have been identified as one of the good bio-indicators for overall ecosystem health and also in determining the stability of an ecosystem (Holloway et al. 1987). The diversity and abundance of butterflies vary greatly among different forest habitats and along elevation gradients (Lien & Yuan 2003). The abundance and species diversity of butterflies are higher in the tropical region due to their roles as the pollinating agents that contribute to the growth, development, and distribution of the host flora (Bonebrake et al. 2010). In the tropical forests of South-east Asia, studies pertaining to the species diversity of butterflies at different altitudes have not yet been done on a large and long-term scale, although some sporadic studies have been conducted over relatively short periods of 2-3 years and in small areas (Spitzer et al. 1993, 1997; Vu 2009). Studies on different areas and time scales are important because large-scale and long-term research may add more species and reveal more comprehensive results.

The emphasis of this study lies on the collection of primary data for the local butterfly species diversity at selected sites along the Raub Corridor to Fraser's Hill. Signs of impairment to the Fraser's Hill ecosystem can be observed as a result of land use changes such as the construction of roads, golf course, apartments and new private homes. These land use changes have resulted in adverse impacts like landslides, soil erosion and habitat loss. Clark et al. (2007) noted that increase in human activities would result in decreased butterfly species, in which the rich, rare and specialized species were the most affected. Thus, this pioneer study will update us with the most recent and complete list of butterfly species in the study area as the baseline information for monitoring of butterflies in future. All the information is important in the efforts to reduce the total loss of population and to save endangered or vulnerable Lepidopteran species in the future and we hope that this present research will make a useful contribution towards the knowledge of butterflies in this region.

MATERIALS AND METHODS

Study site

This study was carried out along the Raub Corridor to Fraser's Hill, Pahang, which is one of the most popular highland sites in

Peninsular Malaysia for local and foreign tourists. As the vegetation in Fraser's Hill is still relatively undistrubed, the area has become an important ecological site for bird and wildlife diversity. This lower montane ecosystem is a permanently protected nature reserve and has also been gazetted as a wildlife sanctuary (Latiff 2009). Located between latitudes 3° 46' 25" to 3° 47' 50" and longitudes 110° 43' 50" to 110° 45' 15" in the district of Raub, Pahang, east of the Titiwangsa Main Range, the Fraser's Hill covers about 28 km² in area, with altitudes of between 1000 m to 1525 m above sea-level. It is covered mainly by pristine hill dipterocarp and lower montane forests. There are seven peaks with altitudes between 1,220 and 1,524 meters above sea level within the Fraser's Hill spine including Bukit Peninjau (1426 m), Bukit Jeriau (1374 m), Bukit Teras South (1256 m) and Bukit Teras North (1426 m). The daily temperature variation is from 16°C to 25°C (Latiff 2009).

Within this study site, the diversity of butterflies was studied at three altitudes, i.e. 400-500 m (E1), 750-850 m (E2), and 1000-1250 m (E3).

Figure 1 Map of Fraser's Hill
Source: Google Earth (2015)

Data collection

Samplings were conducted during the active biological hours of butterflies, i.e. between 09:00 hours and 1700 hours, for three consecutive days at the three different altitudes (400-500 m, 750-850 m and 1000-1250 m) above sea-level. The butterfly specimens were manually collected by using butterfly nets during daytime. Besides that, food-baited traps using overripe pineapple fruits were also used for collecting the butterfly samples. Direct observations (DO) were conducted for the high and fast flying butterflies during the daytime. Each specimen that was successfully collected was killed by gently pressing its thorax between the forefinger and thumb. The specimen was then placed within a triangular folded paper envelope. The envelopes were properly labelled and stored in a plastic container. The voucher specimens were brought back to the UKM laboratory where the specimens were pinned, oven-dried and identified to the species level. Taxonomic identification was accomplished with the aid of standard references such as Corbet et al. (1992).

Data analysis

Species diversity, species richness, and species evenness for the butterflies at different altitudes were analysed with the aid of Past software. Shannon-Weiner index (H') is an estimate of species diversity which incorporates richness and evenness into a single measure. Margalef Index (R') is an estimate of species richness whereas Shannon-Weiner Evenness Index is a measure of species evenness (Magurran 1988).

RESULTS AND DISCUSSIONS

A total of 138 species of butterflies representing five families (Papilionidae, Pieridae, Nymphalidae, Hesperiidae and Lycaenidae) and 14 subfamilies (Papilioninae, Nymphalinae, Satyrinae, Danainae, Morphinae, Coliadinae, Pierinae, Riodininae, Miletinae, Poritiinae, Lycaeninae, Pyrginae, Hesperiinae and Coeliadinae) have been recorded from the three altitudes, 400 m to 500 m (lower altitude), 750 m to 850 m (middle altitude), and 1000 m to 1250 m (higher altitude) in the study area (Table 1).

Table 1 Checklist of butterfly fauna recorded along the Raub Corridor to Fraser's Hill Pahang

No.	Taxa
	PAPILIONIDAE
	Subfamily:Papilioninae
1	*Papilio (Princeps) iswaroides curtisi* Jordan
2	*Graphium sarpedon* (Linnaeus) *luctatius* (Fruhstorfer)
3	*Pachliopta (Pachliopta) aristolochiae asteris* (Rothschild)
4	*Papilio (Princeps) helenus helenus L.*
5	*Papilio (Princeps) iswara iswara* White
6	*Papilio (Princeps) polytes romulus* Cramer
7	*Papilio demolion demolion* Cramer
8	*Papilio nephelus sunatus* Corbet
9	*Parides (Antrophaneura) sycorax egertoni* (Distant)
10	*Pathysa (Pathysa) agetes iponus* (Fruhstorfer)
11	**Troides (Trogonoptera) brookiana trogon* Rothschild
	NYMPHALIDAE
	Subfamily: Nymphalinae
12	*Athyma reta* Moore *moorei* (Fruhstorfer)
13	*Athyma selenophora amharina* (Moore)
14	*Cethosia penthesilea methypsea* Butler
15	*Chersonesia intermedia intermedia* Martin
16	*Cupha erymanthis Drury lotis* (Sulzer)
17	*Euripus nyctelius euploeoides* C.R. Felder
18	*Hypolimnas bolina jacintha* (Drury)
19	*Junonia almana javana* (C.Felder)
20	*Junonia hedonia ida* (Cramer)

21 *Junonia iphita* (Cramer) *horsfieldi* Moore
22 *Moduza procris milonia* (Fruhstorfer)
23 *Neptis clinioides gunongensis* Eliot
24 *Neptis duryodana* Moore *nesia* Fruhstorfer
25 *Neptis hylas* (Linnaeus) *papaja* Moore
26 *Neptis ilira cindia* Eliot
27 *Neptis leucoporos cresina* Fruhstorfer
28 *Symbrenthia lilaea* (Hewitson) *luciana* Fruhstorfer
29 *Tanaecia aruna aruna* (C.R. Felder)
30 *Tanaecia flora* M.R.Butler
31 *Tanaecia iapis puseda* (Moore)
32 *Tanaecia julii bougainvillei* Corbet

Subfamily: Satyrinae

33 *Elymnias esaca esaca* (Westwood)
34 *Elymnias hypermnestra* (Linnaeus) *tinctoria* Moore
35 *Elymnias panthera panthera* (Fabricius)
36 *Mycalesis janardana* Moore *sagittigera* Fruhstorfer
37 *Mycalesis orseis nautilus* Butler
38 *Mycalesis perseoides persoides* (Moore)
39 *Mycalesis visala* Moore *phamis* Talbot and Corbet
40 *Neorina lowii* (Doubleday) *neophyta* Fruhstorfer
41 *Orsotriaena medus cinerea* (Butler)
42 *Ragadia makuta siponta* Fruhstorfer
43 *Ypthima baldus* (Fabricius) *newboldi* Distant
44 *Ypthima fasciata* Hewitson *torone* Fruhstorfer
45 *Ypthima horsfieldii* Moore *humei* Elwes & Edwards
46 *Ypthima huebneri* Kirby
47 *Ypthima pandocus* Moore *corticaria* Butler
48 *Ypthima pandocus tahanensis* Pendlebury
49 *Ypthima savara Grose* Smith *tonkiniana* Fruhstorfer

Subfamily: Danainae

50 *Danaus (Salatura) genutia genutia* (Cramer) *f.intermedius* (Moore)

51	*Danaus melanippus hegesippus* (Cramer)
52	*Euploea eunice leocogonis* (Butler)
53	*Euploea mulciber mulciber* (Cramer)
54	*Euploea radamanthus radamanthus* (Fabricius)
55	**Idea hypermnestra linteata* (Butler)
56	**Idea stolli logani* (Moore)
57	*Ideopsis vulgaris* (Butler) *macrina* (Fruhstorfer)
58	*Ideopsis (Ideopsis) gaura peracana* Fruhstorfer
59	*Ideopsis (Radena) similis persimilis* Moore
60	*Parantica aspasia aspasia* (Fabricius)
61	*Parantica melaneus* (Cramer) *sinopion* (Fruhstorfer)
	Subfamily: Morphinae
62	*Taenaris horsfieldii* (Swainson) *birchi* Distant
	PIERIDAE
	Subfamily: Coliadinae
63	*Catopsilia pomona pomona* (Fabricius)
64	*Eurema ada* (Distant & Prayer) *iona* Talbot
65	*Eurema andersonii andersonii* (Moore)
66	*Eurema blanda* (Boisduval) *snelleni* (Moore)
67	*Eurema hecabe* (Linnaeus) *contubernalis* (Moore)
68	*Eurema lacteola lacteola* (Distant)
69	*Eurema sari (Horsfield) sodalis* (Moore)
70	*Eurema simulatrix tecmessa* (de Niceville)
71	*Gandaca harina* (Horsfield) *distanti* Moore
	Subfamily: Pierinae
72	*Appias lyncida* (Cramer) *vasava* Fruhstorfer
73	*Appias cardena perakana (Fruhstorfer)*
74	*Appias indra plana* Butler
75	*Cepora iudith malaya* Fruhstorfer
76	*Cepora nadina* (Lucas) *andersoni (*Distant)
77	*Leptosia nina nina* (Fabricius)
78	*Pareronia valeria* (Cramer) *lutescens* (Butler)

79 *Phrissura aegis cynis* (Hewitson)
80 *Prioneris thestylis malaccana* Fruhstorfer
81 *Saletara liberia distanti* Butler

LYCAENIDAE

Subfamily: Riodininae

82 *Abisara saturata kausambioides* de Niceville

Subfamily: Miletinae

83 *Taraka hamada mendesia* Fruhstorfer

Subfamily: Poritiinae

84 *Poritia erycinoides phraatica* Hewitson

Subfamily: Lycaeninae

85 *Caleta elna* (Hewitson) *elvira* (Fruhstorfer)
86 *Catochrysops strabo strabo* (Fabricius)
87 *Celastrina lavendularis isabellae* Corbet
88 *Discolampa ethion* (Westwood) *thalimar* (Fruhstorfer)
89 *Ionolyce helicon merguiana* (Moore)
90 *Jamides alecto ageladas (Fruhstorfer)*
91 *Jamides bochus nabonassar* (Fruhstorfer)
92 *Jamides celeno* (Cramer) *aelianus* (Fabricius)
93 *Jamides elpis (Godart) pseudelpis (Butler)*
94 *Jamides malaccanus malaccanus* (Rober)
95 *Jamides philatus subditus*(Moore)
96 *Jamides pura pura* (Moore)
97 *Jamides virgulatus nisanca (Fruhstorfer)*
98 *Lycaenopsis haraldus haraldus* (Fabricius)
99 *Monodantides musina* (Snellen) *candaules* (de Niceville)
100 *Nacaduba angusta kerriana*Distant
101 *Nacaduba hermus swatipa* Corbet
102 *Nacaduba subperusia* Snellen *intricata* Corbet
103 *Nacaduba subperusia* Snellen *lysa* Fruhstorfer
104 *Niphanda cymbia cymbia* de Niceville
105 *Pithecops corvus corvus* Fruhstorfer

106 *Prosotas nora superdates* (Fruhstorfer)
107 *Prosotas pia pia* Toxopeus
108 *Surendra florimel* Doherty
109 *Surendra vivarna amisena* (Hewitson)
110 *Udara (Selmanix) selma tanarata* (Corbet)
111 *Udara (udara) akasa catullus* (Fruhstorfer)
112 *Udara (Udara) dilecta dilecta* Moore
113 *Udara (udara) rona catius* Fruhstorfer
114 *Udara (udara) toxopeusi toxopeusi* (Corbet)
115 *Zeltus amasa maximinianus* Fruhstorfer
116 *Zizeeria karsandra* (Moore)
117 *Zizina otis* (Fabricius) *lampa* (Corbet)
118 *Zizula hylax pygmaea* (Snellen)

HESPERIDAE

Subfamily: Pyrginae

119 *Celaenorrhinus ladana* (Butler)
120 *Koruthaialos sindu sindu* (C.R. Felder)
121 *Tagiades cohaerens cinda* Evans
122 *Tagiades japetus atticus* (Fabricius)

Subfamily: Coeliadinae

123 *Dercas verhuelli herodorus* Fruhstorfer

Subfamily: Hesperiinae

124 *Acerbas anthea anthea* (Hewitson)
125 *Aeromachus jhora creta* Evans
235 *Astictopterus jama jama* C. & R. Felder
127 *Hyarotis microsticta microsticta* (Wood-Mason & de Niceville)
128 *Iambrix salsala salsala* (Moore)
129 *Iambrix stellifer* (Butler)
130 *Notocrypta clavata clavata* (Staudinger)
131 *Notocrypta paralysos varians* (Plotz)
132 *Oriens gola pseudolus* (Mabille)
133 *Polytremis lubricans lubricans* (Heriich-Schaffer)

134	*Potanthus trachala tytleri* Evans
135	*Pothantus chloe (W.H.Edwards)*
136	*Pseudokerana fulgur* (de Niceville)
137	*Psolos fuligo fuligo* (Mabille)
138	*Pyroneura niasana burmana* (Evans)

*Protected species under the Wildlife Conservation Act 2010 (Act 716)

Table 2 Family composition of butterflies showing number of species and individuals recorded from the Raub Corridor to Fraser's Hill during the study period

Family	No. of species	No. of Individuals
Papilionidae	11	21
Nymphalidae	51	403
Pieridae	19	102
Lycaenidae	37	163
Hesperiidae	20	27
TOTAL	138	716

A total of 716 individuals and 138 species of butterflies belonging to five families have been recorded during the study period. Nymphalidae was the most dominant and most abundant family with 51 species and 403 individuals recorded, followed by Lycaenidae (37 species and 163 individuals), Hesperidae (20 species and 27 individuals), Pieridae (19 species and 102 individuals) and lastly, Papilionidae, a small family with the lowest number of species (11 species and 21 individuals) (Table 2). In the tropical rainforest habitat, Lycaenidae, Hesperiidae and Nymphalidae are the families which have the most number of species and with relatively even species distribution. However, compared to the tropical rainforest, temperate rainforests have relatively few nymphalids and lycaenids (Kitching 1999). Fraser's Hill, which is a pristine hill forest ecosystem, is dominated by the family Nymphalidae in terms of number of species and individuals, followed by Lycaenidae and Hesperidae, respectively.

In the recent past, studies by Norela et al. (2010) at the Fraser's Hill revealed that Nymphalidae was the most predominant family in terms of number of species. Elsewhere in the country too, Nymphalidae was always dominant in terms of diversity and abundance based on the studies of butterflies by Norela et al. (2002); Teoh (2004), Zaidi et al. (2002); and Majumder et al. (2012). According to Holloway et al., (1987), most of the Nymphalidae species are always dominant in the tropical region because they are polyphagous in nature, which enable them to live in all kinds of the habitats. They are also capable of finding food resources within large areas due to the fact that they are strong and active fliers (Raut & Pendharkar 2010). Nymphalidae is also one of the largest families of butterflies in the world, comprising over 7000 species under 16 subfamilies.

Ypthima pandocus Moore *corticaria* Butler (Nymphalidae) was recorded as the most common species in this study, which was found in highest abundance at every altitude and for every sampling month. This species is dubbed as the poor Cinderella of butterflies because it is so common and not many experts have taken the trouble study its life history in great details. According to Corbet and Pendlebury (1992), *Ypthima pandocus* Moore *corticaria* Butler (Nymphalidae) is one of the larger and most common *Yapthima* butterflies in Malaysia, where it occurs at all altitudes such as in the forests, in secondary growths and even in the gardens. Larvae of this species feed on various species of Graminae while the adults feed on a variety of fruits and nectar. Thus, the presence of the Graminae species such as rushes and bamboo along the roadsides in this study area together with other food resources might be among the reasons for the higher abundance of *Ypthima pandocus* Moore *corticaria* Butler (Nymphalidae) in our results.

Eurema hecabe contubernalis (Moore) was stated to be the most common butterfly in the eastern tropics, however, in this study, this species was not commonly found. This might be due to the lack of suitable host plants and food resources in the study area for this species. The usual food plants for the larva of *Eurema hecabe contubernalis* (Moore) are the species of *Pithcellobium*, and other legumes such as *Cassia*, *Moullava*, *Acacia*, *Caesalpinia*, *Albizia* and *Sesbania sp.* (Corbet & Pendlebury 1992).

Species under Lycaenidae were found in higher abundance in this study site probably because they belong to the second largest family after Nymphalidae, and over one-third of the butterfly fauna in Malaysia belong to this family. As compared to the other butterfly families, Papilionidae was recorded with the lowest number of individuals and species in this study area, probably because this family only has one subfamily and the number of Papilionidae species recorded from Peninsular Malaysia is also very low at about 45 species (Holloway et al. 2001).

Table 3 Percentage contribution of butterfly species at different altitudes recorded in the study area

Altitude	Total number of species	Percentage (%) of species
E1	82	59.4
E2	57	41.3
E3	67	48.6

The number of species recorded spatially varied between altitudes (Table 3), most likely due to the heterogeneity of the habitats associated with the availability of sunshine and abundance of host and food plants for the butterflies (Beccaloni 1997). Previous studies by Sparrow et al. (1994), Price (1997) and Van Lien & Yuan (2003) indicated that the diversity of butterflies and other insects decreased with increase in latitudes and altitudes. Higher altitudes receive more rainfall and rainy days than lower altitudes, and some butterfly species such as members of Nymphalidae and Lycaenidae do not favour the cold and moist conditions prevalent in the higher altitudes.

The vegetation at lower altitudes is more diverse than at the higher altitudes. The preference of butterflies for particular habitats and also their growth rate are associated with the availability of larval host plants and adult nectar plants (Slansky Jr 1992). Changes in vegetation structure and composition associated with altitudes and climatic factors such as temperature, humidity, rainfall and sunshine might also affect the distribution and diversity of butterflies and other invertebrates. The higher counts of butterfly species recorded at E1 and E3 compared to other sites were probably due to the presence of a small stream and waterfall at both altitudes, where many butterflies were observed to congregate near these water bodies. Many lepidopteran species are attracted to animal waste like faeces and urine left behind along forest roads and on sand banks beside rivers and streams (Yong 1983). Butterflies also like to congregate near salt licks and waterfalls to replenish their supply of water and salts (Goodden 1976).

The total number of species recorded also varied between the sampling months. Climatic factors such as drought and heavy rain might affect the butterfly species abundance (Braby 1995), where in the tropical region with distinct wet and dry seasons, many insect species attained their maximum adult abundance during the wet season (Didham & Springate 2003; Tiple & Khurad 2009). Samplings were carried out at the end of the year, during the monsoon season (October and December) and the drought season (February and March). Heavy rainfall reduced the butterfly abundance and increased mortality of adults (Ehrlich and Raven, 1964) due to depletion of the host plants and nectar sources, while extreme heat in the drought season might restrict the flight activities of some species and reduced the larval host-plant quality. Since butterfly species are directly dependent on plant species composition for larval and adult food resources, the depletion of the latter will directly affect species abundance.

Table 4 Shannon-Weiner Diversity Index (H'), Shannon-Weiner Evenness Index (E'), Margalef's Richness Index (R') for butterflies at three different altitudes

No.	Altitude (m)	No. of species	H’	E’	R’
1	E1	82	3.917	0.613	14.720
2	E2	57	3.226	0.442	9.756
3	E3	67	3.683	0.594	13.000

Table 4 shows that the highest values of Shannon Diversity Index (H'), Margalef's Richness Index (R') and Shannon Evenness Index (E') are recorded at E1, as compared with the other two altitudes, E2 and E3. T-test (α=0.05) analysis shows that there are no significant differences between H’ of E1 and E2, between E2 and E3 and between E1 and E3. Higher variations and heterogeneity in vegetation cover will affect butterfly presence and diversity (Tews et al. 2004) and our results indicated that there were no significant differences for H’, E’ and R’ between the altitudes ($p>0.05$, α=0.05). This could mean that there were no significantly diverse variations and heterogeneity in vegetation cover between the altitudes due to the relatively small area covered in this study, where each altitude was only 100 m to 250 m apart from one another. The proximate distant between the altitudes also enabled the butterfly species to move freely through the existing corridor (Forman 1995).

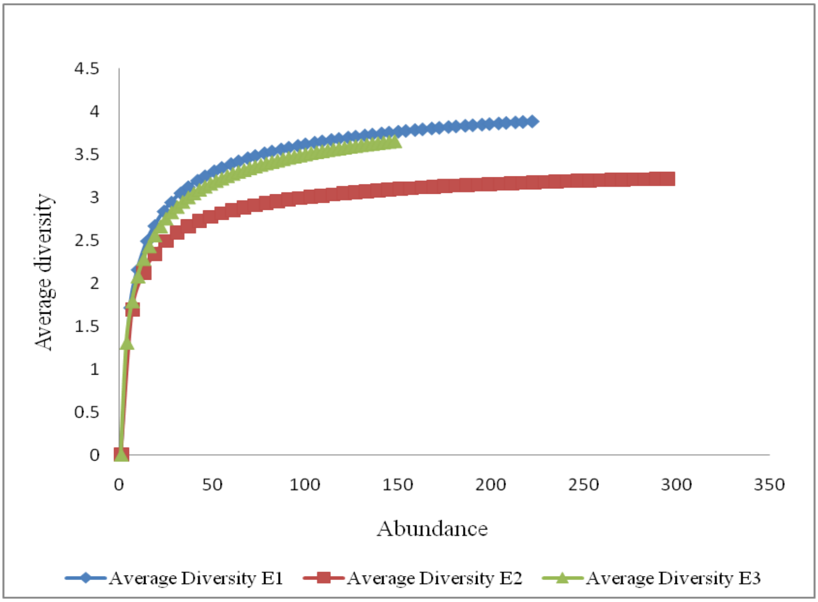

Figure 2 Species accumulation curves (SAC) for average diversities at three different altitudes, E1, E2, and E3

Figure 2 shows the accumulative curves for average diversities at three altitudes, 400-500 m (E1), 750-850 m (E2) and 1000-1250 m (E3). Species accumulation curves (SAC) in Figure 2 indicated a rapid increase in the initial number of species caught and the curves increased almost at the same range for all the altitudes, rising steeply and overlapping at the initial slopes of the curves. SAC for E2 was the longest and showed direction towards the asymptote due to the highest number of species present there compared to the other altitudes. Sampling efforts for E2 might be greater and better than the rest of the study sites, thus the resulting curve approached towards the asymptote. It has been suggested that continual and extensive sampling efforts are needed to determine the actual species diversity in a large study area. Nevertheless, SAC is perhaps not a suitable indicator in reflecting the species diversity of an area with very diverse assemblages, where there may be thousands of species present and thus, an asymptote is not reached even after extensive samplings (Didham et al. 1998; Willottf 1999).

Table 5 Comparative number and percentage of butterfly species and families in the study area and in Peninsular Malaysia

Family	No. of species in each family of this study	No. of species in each family in Peninsular Malaysia	Percentage of species compared to Peninsular Malaysia (%)
Papilionidae	11	45	24.4
Nymphalidae	51	275	18.5
Pieridae	19	45	42.2
Lycaenidae	37	411	9
Hesperiidae	20	255	7.8
Total	138	1031	13.9

A total of 1031 butterfly species has been recorded for the Malay Peninsula (Corbet & Pendlebury 1992). Results from this study recorded a total of 138 species from the Raub Corridor to Fraser's Hill, Pahang, which represented only 13.9% of the total species known in Peninsular Malaysia (Table 5). However, the Shannon species diversity index (H'=4.024), evenness index (E'=0.4053), and Margalef species richness (R'=20.84) indicate that study area can support a relatively rich diversity of butterflies. The list of species recorded for the study is not exhaustive and the actual species diversity remained unknown compared with the list of species recorded by Corbet and Pendlebury for Peninsular Malaysia (1992). This might be due to the relatively short sampling period and small study area covered during our field study. Samplings were feasible only along the roads at different altitudes because many places could not be accessed due to steep terrain, landslides, heavy rains and the presence of wild animals. No new species was recorded in this study either. Thus, a more comprehensive butterfly study is still needed to compile a more updated and complete list of butterflies in the study area.

CONCLUSION

A total of 716 individuals comprising 138 species of butterflies belonging to five families (Papilionidae, Nymphalidae, Pieridae, Lycaenidae and Hesperidae) has been recorded from the three altitudes (400-500 m, 750-850 m, and 1000-1250 m) along the Raub Corridor to Fraser's Hill. Among the families, Nymphalidae was the most abundant in terms of the number of individuals and species recorded (51 species and 403 individuals) due to their polyphagous nature.

The study site exhibited a somewhat rich diversity of butterflies relative to the altitudes covered during the study period, i.e. about 400 m to 1250 m above sea level. A relatively high number of butterfly species and individuals had been successfully recorded despite facing some difficulties in catching and observing them because there were some places in the study area which were inaccessible due to landslides and also bad weather. Nevertheless, the results from this study alone are not enough to determine the actual species richness and diversity of butterflies in the study area.

Overall, the information obtained from this study has contributed to a better knowledge of the butterflies and also provided a more recent and complete list of butterfly species from the area. However, further studies should be conducted with detailed physical and biological parameters, more locations and altitudes to get better information for effective conservation efforts to protect the endangered species such as Rajah Brooke's Birdwing (*Troides (Trogonoptera) brookiana trogon* Rothschild), the tree Nymph *Idea stolli logani* (Moore) and *Idea hypermnestra linteata* (Butler) that have been listed as a protected species under the Wildlife Conservation Act 2010 (Act 716).

Conservation is necessary to keep these endangered and rare species from being pushed to extinction.

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