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Temporal Diversity of the Nymphalids in Kubah National Park, Sarawak, Malaysia

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ABSTRACT.– Unique microhabitats caused temporal-space separation which also indicates that animals are constrained in their flexibility to adapt to the environment. Arthropods was recorded to be temporally patchy within seasons, and in the tropical region, rainfall fluctuations are somewhat varied although only in a considerable range. These minute variations are still however observed to provide unique microhabitats to the insects and thus knowledge on the effects of the rainfall is still much required. To determine any distribution patterns of the nymphalid butterflies, bait-trapping was conducted from May to November 2009 in Kubah National Park, Sarawak. Even though there was a linear relationship between the total rainfall and numbers of nymphalids, there was no significant correlation between the nymphalids and rainfall distribution (p-value > 0.05). Rainfall in the preceded month could increase the overall nymphalids abundance which coincides with the leaf-flushing peak, suitably for the larval stages. In contrast, heavy rainfall during the data collection could also lead to larval mortality. Rainfall parameter and possibly many more environmental variables are important, as the distribution pattern of the nymphalids are strongly related to the environment.

KEY WORDS: diversity, rainfall, Nymphalidae, Kubah, Borneo

INTRODUCTION

Temporal variability has accentuated the numerical fluctuations of a particular population and undoubtedly present, as different communities and resources would have, annual, seasonal, and even diurnal periodicity (Lowman and Wittman, 1996; Saldana et al., 2007). With the high specificity and unique microhabitats, courtship has also involved a temporal-space separation, as different species acquired different time and location of perching (Prieto and Dahners, 2009). This also means that the nymphalids were evolutionary constrained in their flexibility to adapt with the environment. By incorporating both spatial and temporal variables to understand the community structure of nymphalids, accurate comparisons could be produced and subsequently contribute to conservation biology (DeVries et al., 1997). This includes the effects of seasonality to the species abundance of insects which are present yet poorly known (Wolda, 1989; Anu et al., 2007), and thus initiate major interest among ecologists (Thomas, 1991; Molleman et al., 2006).

In the tropical region, the weather is not as distinct as in the temperate, and the temperature fluctuates only in a considerable range (Wolda, 1989; Hill et al., 2003). Borneo, which is in Southeast Asia, is aseasonal, where there is an absence of well-defined wet and dry periods (Hill et al., 2003; Kumagai et al., 2004; Beck et al., 2006). Considerable variations in the distribution patterns and the total amount of rainfall are somewhat evident (Harrison, 2001), and droughts could also happen, which are occasionally associated with the El-Niño Southern Oscillation (ENSO) (Harrison, 2001; Cleary and Mooers, 2004; Kumagai et al., 2004).

The influence of weather has been considered to govern the population cycles of animals, especially in the tropics such as Puerto Rico, and arthropods are temporally patchy within seasons (Stewart and Woolbright, 1996; Royama, 1997). However, detailed information on the temporal variability of forest butterflies is somehow lacking, even though a few studies have been conducted, such as in the Ecuadorian forest and Uganda, as well as in the Borneo, Malaysia (DeVries and Walla, 1997; Barlow et al., 2002; Beck et al., 2006; Molleman et al., 2006). Nevertheless, rainfall has been doubted to be the only factor which contributes to the temporal pattern observed for insects in the tropics (Wolda, 1989; Saldana et al., 2007). Other factors such as predator avoidance, resource availability, parasitoids, drought and even excessive rains are also noted to lead into different temporal patterns (Wolda, 1989).

This study aims to gather more information specifically on the effects of rainfall to the distribution of nymphalids at the Kubah National Park, which is a well-known national park in Sarawak, Malaysia. This protected area is known for its hilly mixed-dipterocarp forest, and its unique offering of different vegetation types, including heath and submontane forests. The National Park's habitat heterogeneity is important, as this characteristic is known to be correlated with species diversity, and thus making this site suitable for study. This study was conducted to determine the temporal diversity of nymphalids in Kubah rainforest throughout six months of sampling. Apart from that, this study also intends to observe any effects of rainfall to the overall species abundance of nymphalids. Findings from this study are hoped to provide distinctive attributes to the overall assemblages of nymphalids in Kubah National Park, Sarawak, Malaysia.

MATERIALS AND METHODS

Study Area.

Kubah National Park (N 1°36'48.43", E 110°11'51.59") is located in the Kuching Division, Sarawak, and is about 20 km from Kuching city (Fig 1). Gazetted in 1989 and opened to the public in 1995, this 2230 ha park consists of mainly undisturbed natural forest with five major vegetation types of namely alluvial forest, lowland mixed dipterocarp forest, heath forest, submontane forest, and secondary forest (Hazebroek and Abang, 2000). The study area mainly consists of mixed dipterocarp forest, heath or 'kerangas' forest as well as secondary forest, all of which are gradually growing after the establishment of this park (Hazebroek and Abang, 2000).

The study sites include four trails, which are Waterfall Trail, Rayu Trail, Summit Trail and Belian Trail (Fig 2). Swampy areas and small jungle streams were found at the Waterfall Trail, and damp areas were also observed along the Summit Trail. Local fruits were also found at Belian Trail, while wild durian could also be seen at the Waterfall Trail. To be precise, each of these trails represents different forest habitats according to their habitat status, vegetation, as well as locality (Table 1).

Field Sampling.

The six-month field sampling includes both dry and wet periods, which also coincides with the haze period in June and July 2009, and subsequently the rainy period which reached its maximum downpour in September 2009. One ground level baited-trap hung between 1 and 1.5 m above the ground, and the canopy baited-traps were positioned between 21 and 27 m above the ground. This provided a total of ten baited-traps in each habitat type; five canopies, and five ground level, which made up about 40 baited traps. These baited-traps were installed with the

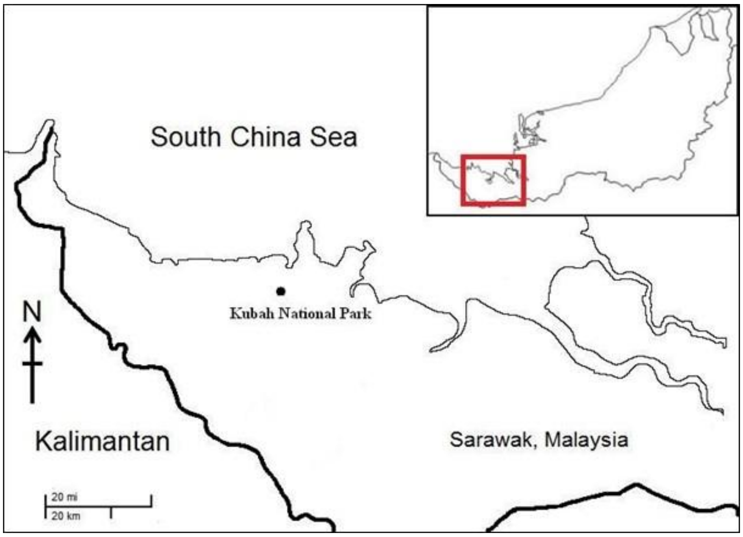

FIGURE 1. Study area, which is located in Kubah National Park, Kuching, Sarawak, in southern part of Malaysian Borneo (Source: Modified after Google Map 2011).

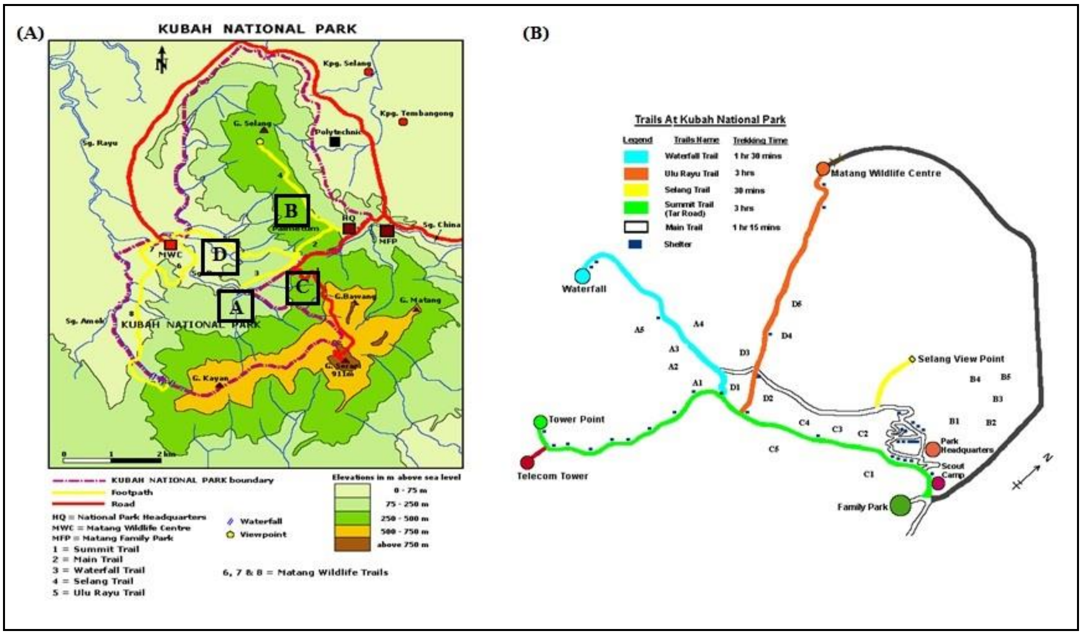

FIGURE 2. (A) Study site in Kubah National Park, Sarawak with four sampling areas; A. Primary Forest, B. Secondary Forest, C. Forest edge, D. Heath Forest; (B) Numbers designate individual replicate sampling units which represents one canopy and one ground level trap (Note: Map is not up to scale) (Source: Hazebroek and Abang (2000)).

Single-Rope Technique, as the traps were suspended from thin nylon ropes run over the branches and adjusted to a considerable height.

TABLE 1. Habitat descriptions for study area in Kubah National Park, Sarawak, based on Hazebroek and Abang (2000) and personal observations.

Forest Trail	Forest Habitat	Elevation (a.s.l in m)	Plant Community
Waterfall	Primary forest	305	*Pandanus* spp., Strangling fig tree, *Alocasia robusta* (Giant Aroid) Large tree crowns which permit only little light penetration and less dense woody undergrowth (seedlings and sapling trees, shrubs, and climbers)
Belian	Secondary forest	120	Farmland over 30 years ago yet replanted mostly with 'Engkabang', and local fruits such as *Artocarpus* spp., *Durio* spp. and *Musa* spp.
Summit	Forest edge	120 – 270	Along the road to the summit of Mt. Serapi, at the ridge of a transition from primary to heath forest
Rayu	Heath forest	274	Bintangor, *Dryobalanops becarii* (Kapur Bukit), *Shorea inappendiculata* (Tekam) Dense herbaceous undergrowth, scarce of buttresses and climbers, and single-dominant communities of trees

Traps were baited with pineapples which are placed at the bottom-side of the traps. Baits were placed on the day prior to the sampling interval and replenished with fresh ones on the subsequent trapping days. Missing baits due to squirrels and heavy rain as well as strong wind were also replaced the next day. The field sampling extended from 13th May 2009 to 17th November 2009 with baited-traps maintained for 14 continuous days every month except October 2009 (Table 2) and resulted to 3360 total sample effort (2 traps x 20 SUs x 84 sampling days). All 40 traps were baited and sampled daily for 14 continuous days monthly, and then collected. Traps were then re-installed and re-baited, and this procedure repeated. All trapped butterflies were collected and identified to species level following Otsuka (1988) and Tsukada (1991), and then preserved. There were no recapture individuals or species.

Statistical analysis.

The conventional biodiversity indices for all monthly replicates were analysed with EstimateS program version 8.2 (Colwell, 2006), which include the Shannon diversity index (H'), Simpson's diversity index (1-D) and Fisher's-Alpha diversity index (α). These daily rainfall distribution data were retrieved from Meteorological Department of Kuching, which was based at the Kuching International Airport (N 1°29', E 110°20' in South Sarawak, 21.7 m a.s.l) and represented a coverage area of approximately 40 km radius

TABLE 2. Summary of all six sampling occasions with study period of each occasion during May to November 2009, in Kubah National Park, Sarawak.

Sampling Occasion	Date
1st	17th – 30th May 2009
2nd	16th – 29th June 2009
3rd	22nd July – 4th August 2009
4th	25th August – 7th Sept 2009
5th	29th Sept – 12th Oct 2009
6th	4th – 17th Nov 2009

(Climate Section, Kuching). All of the analyses were carried out with PAST version 1.96 (Hammer et al., 2001) except and MINITAB Release 13.20 (Minitab Inc., 2000) statistical software.

RESULTS

Overall diversity and abundance of the nymphalids in six monthly replicates.

In total, 665 individuals of 49 nymphalid species were sampled in six consecutive sampling occasions (Table 3). The field sampling revealed greater proportions of both species and individuals during May and June 2009 and decreased gradually until September 2009 (Fig 3). Total abundance ranges from 32 individuals in September 2009 to 230 individuals in June 2009, which mostly comprised of Nymphalinae butterflies (Table 3). Among all the species listed, ten of them were sampled in all six sampling occasions, including a few which were common and dominated the total species listed (*Amathuxidia amythaon*, *Bassarona dunya*, *Bassarona teuta*, *Lexias dirtea*, *Mycalesis mnasicles*, *Mycalesis kina*, *Neorina lowii*, *Prothoe franckii*, *Ragadia makuta,* and *Tanaecia clathrata*) (Fig 4).

Six out of 15 species with more than 20 individuals were significantly more abundant in certain period of the field sampling, mostly during the first two months (Table 4). Singletons (*Charaxes durnfordi*, *Dophla evelina*, *Faunis stomphax*, *Mycalesis amoena*, *Mycalesis horsefieldi*, *Mycalesis mineus*, *Mycalesis patiana*, *Phalanta alcippe*, *Polyura athamas*, *Rhinopalpa polynice*, and *Tanaecia pelea*) were sampled most at the beginning of the field sampling and none was caught in September and November 2009. As many as 33 individuals per sampling occasion were captured for each species such as *B. teuta* (July 2009), and most of these nymphalids sampled were recorded during May and June 2009 (Table 5).

Diversity indices revealed the highest species richness in June 2009 (1-D= 0.9348) whereas the most diverse in May 2009 (H'= 3.027) (Table 6). Overall, butterflies sampled in November 2009 showed the least diverse and richness in species from the overall total butterflies sampled (1-D: 0.8555, H'= 2.369) (Table 6). Monthly diversity indices showed no significant difference between months, except for May-September, May-November, June-August, June-Sept, June-November, July-September, and July-November (Diversity *t*-test, $p < 0.05$).

Effects of rainfall to the overall diversity and abundance of the nymphalids.

Data on monthly cumulative rainfall distribution as well as overall butterfly species and abundance revealed a linear relationship, which shows decreasing number of butterfly species and individuals with increasing rainfall. These were observed for all forest habitats; primary, secondary and heath forest, as well as forest edge, as the analyses were done separately (Fig 5). Similarly, when tested continuously for each seasonal replicate (monthly), the increasing monthly mean rainfall had also led towards the decrease of species and individuals in all forest habitats (Fig 6). Furthermore, the increase in monthly relative humidity had also caused the same effects on the overall assemblages of butterflies. The species richness and abundance of these nymphalids were however increased with the inclining monthly mean temperature which was clearly observed in June 2009. Monthly mean rainfall as well as relative humidity declined during July 2009, which coincides with the driest period of the year.

When tested to compare between months, the butterfly abundance for July 2009 was proven to be related with the rainfall distribution in the previous month, June 2009 ($F = 2.2603$, $p = 0.049$, regression slope = 0.13879, SE =

TABLE 3. Species richness and abundance of fruit-feeding butterflies (Lepidoptera: Nymphalidae) in Kubah National Park, Sarawak; (a) for each respective sampling occasions, and (b) for every subfamily (upper part refer to species number, whereas the lower part refer to individual number with Fisher's-Alpha in parentheses). Bold values indicate the highest diversity.

(a)

Year	Month	Species Richness	Total Abundance	Fisher's-Alpha (α)
2009	May	31	123	13.330
	June	31	230	9.650
	July	30	165	10.730
	August	27	56	**20.510**
	September	15	32	11.010
	November	18	59	8.827
Total		49	665	

(b)

Year	Month	Subfamily			
		Charaxinae	Morphinae	Nymphalinae	Satyrinae
2009	May	3	5	**11**	12
		9 (1.58)	49 (1.39)	**29 (6.46)**	36 (6.30)
	June	1	6	**13**	11
		8 (0.30)	67 (1.60)	**97 (4.04)**	58 (4.02)
	July	2	5	**12**	11
		9 (0.80)	30 (1.71)	**80 (3.92)**	46 (4.58)
	August	2	4	**10**	11
		2 (0)	5 (9.28)	**32 (4.99)**	17 (13.49)
	September	1	2	**7**	5
		2 (0.80)	3 (2.62)	**20 (3.83)**	7 (7.82)
	November	2	3	**6**	7
		3 (2.62)	6 (2.39)	**29 (2.30)**	21 (3.68)
Total		4	8	**21**	16
		33 (1.19)	160 (1.77)	**287 (5.22)**	185 (4.20)

0.067362, R^2 = 0.25802) and four months previously, March 2009 (F = 2.2603, p = 0.046, regression slope = -0.14095, SE = 0.0671, R^2 = 0.25802). Meanwhile, the numbers of butterflies sampled in September 2009 was observed to be positively related with the rainfall two months before the survey, July 2009 (F = 4.4013, p = 0.000923, regression slope = 0.1193, SE = 0.031916, R^2 = 0.40374). Similar positive relationship was also revealed for butterflies sampled in the early November 2009, which was related to rainfall in September 2009 (F = 2.742, p = 0.013581, regression slope = 0.089711, SE = 0.03388, R^2 = 0.29669). There was no significant difference between all four different habitat types in either the slopes or elevations of the relationship between numbers of nymphalids sampled and rainfall (ANCOVA of butterfly abundance in all forest habitats, with rainfall as covariate, forest habitat x rainfall interaction, p > 0.05).

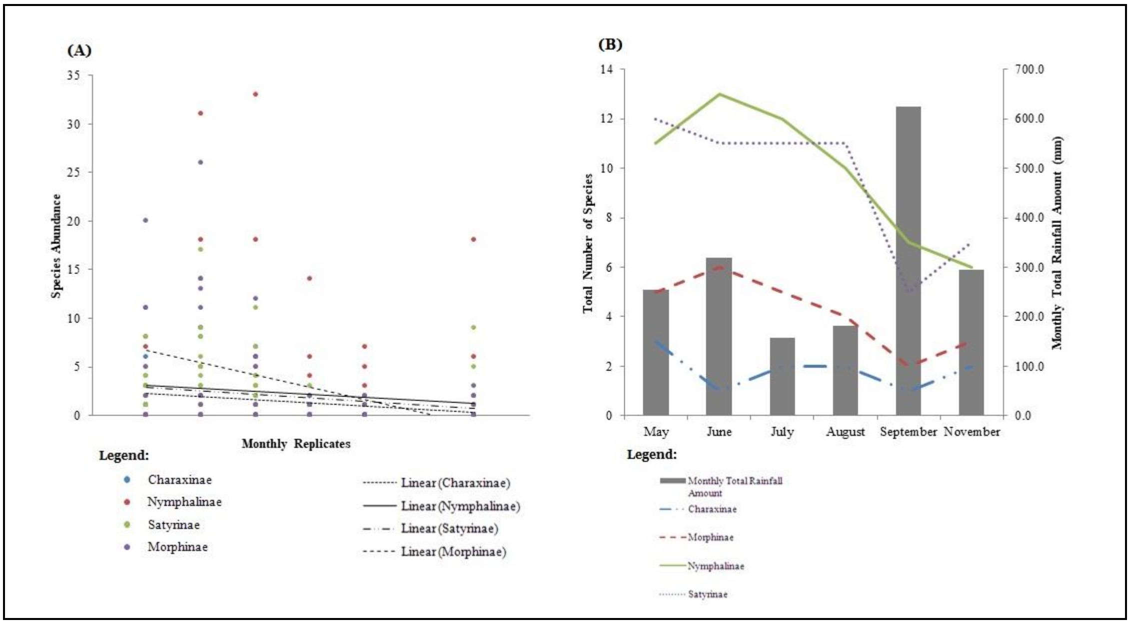

FIGURE 3. Monthly variations for each subfamily (Lepidoptera: Nymphalidae), in Kubah National Park, Sarawak; (A) number of individuals; (B) total number of species.

DISCUSSION

Overall diversity, abundance, and similarity of the nymphalids in relation with the rainfall distribution.

Throughout the six-month period of data collection, the species richness and abundance of the nymphalids in Kubah National Park was observed to be significantly different at different times of the year (Table 3), as also recorded previously in Indonesian Borneo, specifically, Balikpapan-Samarinda, which is the eastern region of Kalimantan (Cleary and Genner, 2004). Population fluctuation is noted to be governed by the interchanging weather (Royama, 1997) as well as microclimatic changes (Anu et al., 2007), and presently, the transition of drier to wetter periods has resulted to the decreasing number of nymphalids, as also noted in India previously (Anu et al., 2007).

Despite the dry weather in July 2009, there was no significant difference between the monthly replicates, except for a few pairs. Nonetheless, the dry weather with the least rainfall in July 2009 has somehow characterised this sampling occasion from the others (rainfall data retrieved from the Climate Section, Meteorological Department of Kuching). Moreover, haze was common at this period of the year, as most farmers in rural Kuching burned and cleared their paddy fields for rice-planting. This haze phenomenon could sometimes extend longer, especially in the Kuching area, with severe haze usually associated with ENSO (Harrison, 2001).

Most of the nymphalid species including singletons were recorded in June and July 2009, which coincides with the dry weather and onset of rainfall. Subsequently, during this period, high larval generations could take place as the production of foliage for larval resources is high with the rain (Hanzen and Gauld, 1997; Fermon et al., 2000). Apart from

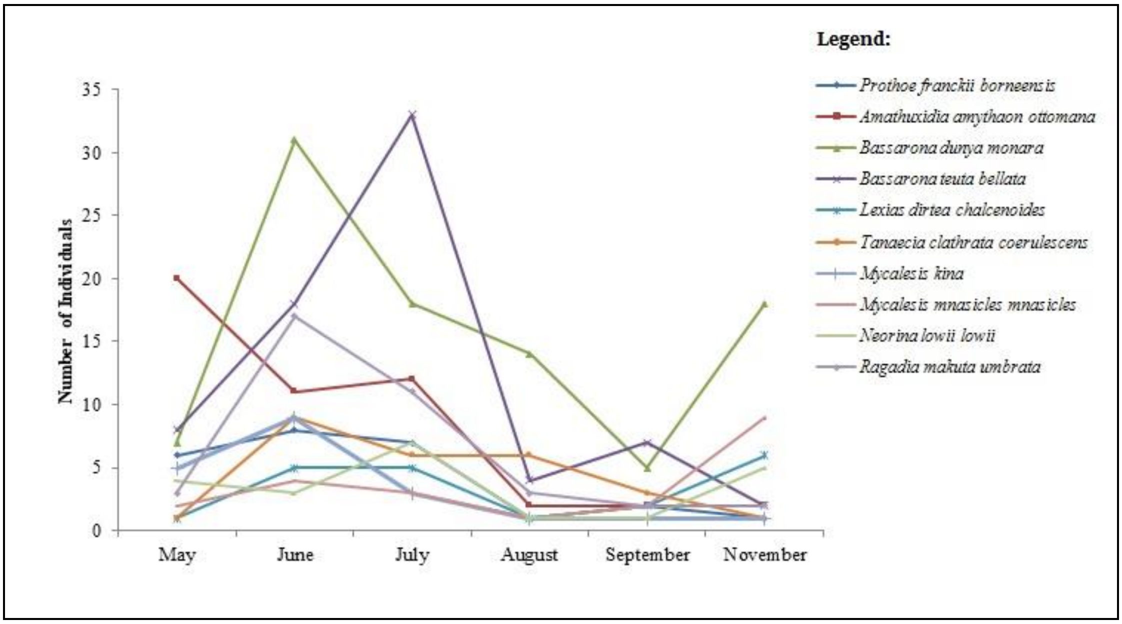

FIGURE 4. Monthly variations of ten fruit-feeding butterfly species (Lepidoptera: Nymphalidae) which were sampled in all six sampling occasions, in Kubah National Park, Sarawak.

that, adult butterflies seldom fly during overcast weather, as they are sun-lovers and are known with gap-exploiting habits (Fermon et al., 2000; Hamer et al., 2003). On the other hand, rainy period during the last 3-month period had resulted to the decrease of both species richness and abundance of the nymphalids sampled. Heavy rainfall has caused felling branches and thus affecting the hanging baited traps, apart from 'soaking' the bait. It is undeniable that the heavy rainfall could possibly affect the study site as well as the sampling method.

Due to the downpour in June 2009, more Satyrinae and Charaxinae butterflies were recorded, whereas Morphinae and Nymphalinae were poorly sampled. Higher rainfall in June 2009 would lead to the leaf flushing peak in the subsequent month, and thus provide more larval resources to the nymphalids (Garrison and Willig, 1996; Harrison, 2001). Therefore, more nymphalids were present in July 2009 as a result from the overcast weather previously. However, this pattern was reversed in September 2009, due to less rainfall in July 2009. Similarly, poor availability of hostplants that could be due to the dry weather can affect the larval survival for these two subfamilies.

Dry period has been known to affect the forest ecology as this would influence the plant resources which are required by pollinators and seed dispersers (Harrison, 2001). This was observed for Nymphalinae and Morphinae butterflies, which were affected by the dry period (Figure 3). Their decrease in species richness with less rainfall in July 2009 was supported as the density of nymphalids was documented to be highest during overcast period (Stewart and Woolbright, 1996; DeVries and Walla, 2001). Moreover, some nymphalid species such as *Bassarona* species were less active and more sedentary during the dry period (Fermon et al., 2000).

TABLE 4. Abundance of fruit-feeding butterflies (Lepidoptera: Nymphalidae) with ≥ 20 individuals, tested against the null hypothesis of homogeneity of distribution between six sampling occasions, in Kubah National Park, Sarawak.

Species		May	June	July	August	September	November	*p*-values
Charaxinae								
	Prothoe franckii borneensis Fruh 1913	6	8	7	1	2	1	ns
Nymphalina								
	Bassarona dunya monara Fruh 1913	7	31	18	14	5	18	< 0.05
	Bassarona teuta bellata Distant 1886	8	18	33	4	7	2	< 0.05
	Lexias dirtea chalcenoides Fruh 1913	1	5	5	1	2	6	ns
	Lexias pardalis dirteana Corbet 1941	0	14	6	2	1	1	< 0.05
	Tanaecia clathrata coerulescens Vollenhoeven 1862	1	9	6	6	3	1	ns
Morphinae								
	Amathuxidia amythaon ottomana Butler 1869	20	11	12	2	2	2	< 0.05
	Zeuxidia amethystus wallacei C & R Felder 1867	11	26	6	1	1	0	< 0.05
	Zeuxidia aurelius euthycrite Fruh 1911	5	13	6	1	0	0	ns
	Zeuxidia doubledayi horsefieldii C & R Felder 1867	11	14	5	0	0	1	< 0.05
Satyrinae								
	Melanitis leda leda Linnaeus 1758	8	6	6	2	0	0	ns
	Mycalesis kina Staudinger 1892	5	9	3	1	1	1	ns
	Mycalesis mnasicles mnasicles Hewitson 1864	2	4	3	1	2	9	ns
	Neorina lowii lowii Doubleday 1849	4	3	7	1	1	5	ns
	Ragadia makuta umbrata Fruh 1911	3	17	11	3	2	2	ns

Due to the heavy rainfall in September 2009, total species richness for all subfamilies was increased in November 2009, except for Nymphalinae. This subfamily was probably subjected to the predatory effects of parasitoids, which are noted to be abundant during the wet period (Harrison, 2001). Consequently, the abundance of the profuse parasitoid could affect the Nymphalinae butterflies. On top of that, high rainfall might also affect the larval survival as well as host-plant quality, and hence disrupt the population cycle of the nymphalids (Hamer et al., 2003). Furthermore, with the strong wind and heavy rainfall, fruits could fall to the ground and thus cause the traps to be less effective (Fermon et al., 2000; Schulze et al., 2001).

Regardless of the influence of rainfall distribution, ten nymphalid species were listed during all six sampling occasions. Undeniably, this revealed that some nymphalid species are not affected by the interchanging weather and adaptations could take place (Fig. 4). Accordingly, a few of them were abundantly sampled and dominated the overall nymphalids recorded. One of them was *B. teuta*, which was sampled up to 33 individuals in July 2009, the driest month in this study. Furthermore, single common endemic to Borneo species, *M. kina*, was recorded in every sampling occasion yet the least during the overcast weather with only a single individual for each month (Figure 4). This showed that the effects of rainfall

TABLE 5. Total number of species sampled every month during the field sampling, with species representation (%) from the overall total species sampled.

Months	May	June	July	August	September	November
Total Species Richness (S)	31	31	30	27	15	18
Species Representation (%)	63.3	63.3	61.2	55.1	30.6	36.7

TABLE 6. Diversity indices for fruit-feeding butterflies (Lepidoptera: Nymphalidae), in six continuous months, sampled in Kubah National Park, Sarawak.

Year	2009					
Month	**May**	**June**	**July**	**August**	**September**	**November**
Shannon (H')	3.027	2.988	2.960	2.867	2.469	2.369
Simpson's (1-D)	0.933	0.935	0.923	0.905	0.893	0.856
Fisher's-Alpha (α)	13.330	9.651	10.730	20.510	11.010	8.827

distribution were practically evident for even the endemic species, which suggests the influence of this environmental parameter to their presence.

Effects of temperature to the temporal distribution of the nymphalids.

Apart from the rainfall fluctuations, the presence of variations in temperature and relative humidity could also affect the temporal distribution of the forest butterflies (Figure 6). Different peak abundance at certain times of the day is observed, as temperature is also known as the best predictor for aerial insect abundance including butterflies (Kwok and Corlett, 2002; Whited and Harris, 2004). Moreover, being one of the limiting environmental factors, temperature can potentially affect the forest ecology (Haukioja and Honkanen, 1997).

In the present study, the increasing temperature for the first three months also coincides with the increase of species abundance, whereas it started to decrease at the last three months with the declining temperature (Figure 6). Prieto and Dahners (2009) with their survey at Colombia have stated that forest flying insects are determined by the fluctuation of temperature, in terms of thermoregulation and flight capability. By acquiring an optimal range of temperature, the nymphalids community was temporally distributed as courtship as well as oviposition can only take place during these particular optimal flight temperatures. This explained the species abundance of nymphalids in Kubah National Park, which correlated with the temperature.

Forest gaps and edges which permit light penetration could also affect the occurrence of nymphalids. Some of the forest butterflies depend on the light availability in the forest for flight, as being diurnals, presence of solar radiation is required to elevate their body temperature (ectothermic) (Prieto and Dahners, 2009). Alternatively, rainy days which are associated with lower temperature would not totally affect the overall nymphalids abundance if there is light availability.

Collectively, as the variation in temperature are less significant, the rainfall changes are thus the most essential influence on the butterflies' abundance, especially in the tropics such as in Hong Kong, China, and Sabah, Malaysia (Kwok and Corlett, 2002; Hill et al., 2003). Dry periods which are usually slight yet frequent have demonstrably influenced the forest ecology in Borneo and potentially caused fluctuations in the

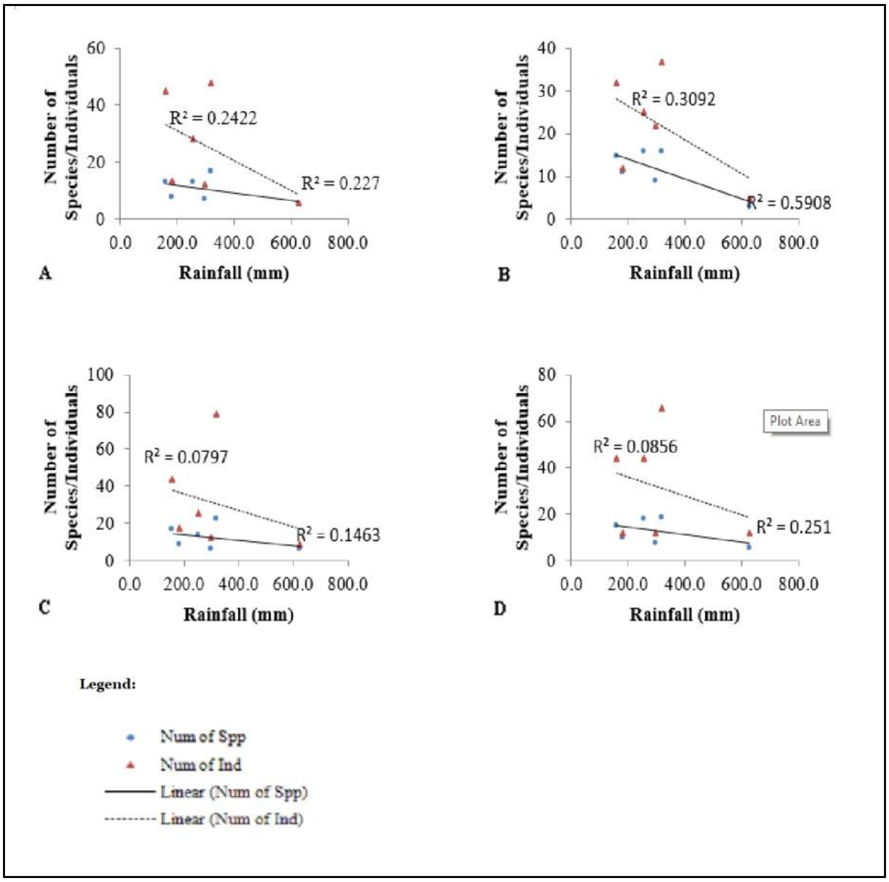

FIGURE 5. Number of species and individuals of fruit-feeding butterflies (Lepidoptera: Nymphalidae) sampled, with the accumulated rainfall data, in Kubah National Park, Sarawak (A. Primary Forest, B. Secondary Forest, C. Forest Edge, D. Heath Forest).

abundance of forest butterflies yet less evident (Garrison and Willig, 1996; Harrison, 2001). High amount of rainfall in the preceded month could affect the larval stages and the quality of hostplants (Hill et al., 2003; Anu et al., 2007; Barlow et al., 2007). Furthermore, the high precipitation during the rainy period has increased larval mortality, due to fungus infection (Beck et al., 2006). In contrast, the dry weather was also expected to have a substantial influence on the population of nymphalids as the plant's phenology are also affected (Harrison, 2001; Beck et al., 2006).

CONCLUSION

The influence of rainfall distribution has highlighted the nymphalids occurrence pattern in different monthly replicates. The fluctuation of rainfall amount was observed to determine the total number of species as well as individuals in a few periods, as the downpour is noted to affect this guild of butterflies directly and indirectly. Rainfall in the preceding month could increase the overall abundance of nymphalids, which coincides with the leaf-flushing peak, suitably for the larval stages. However, heavy rainfall

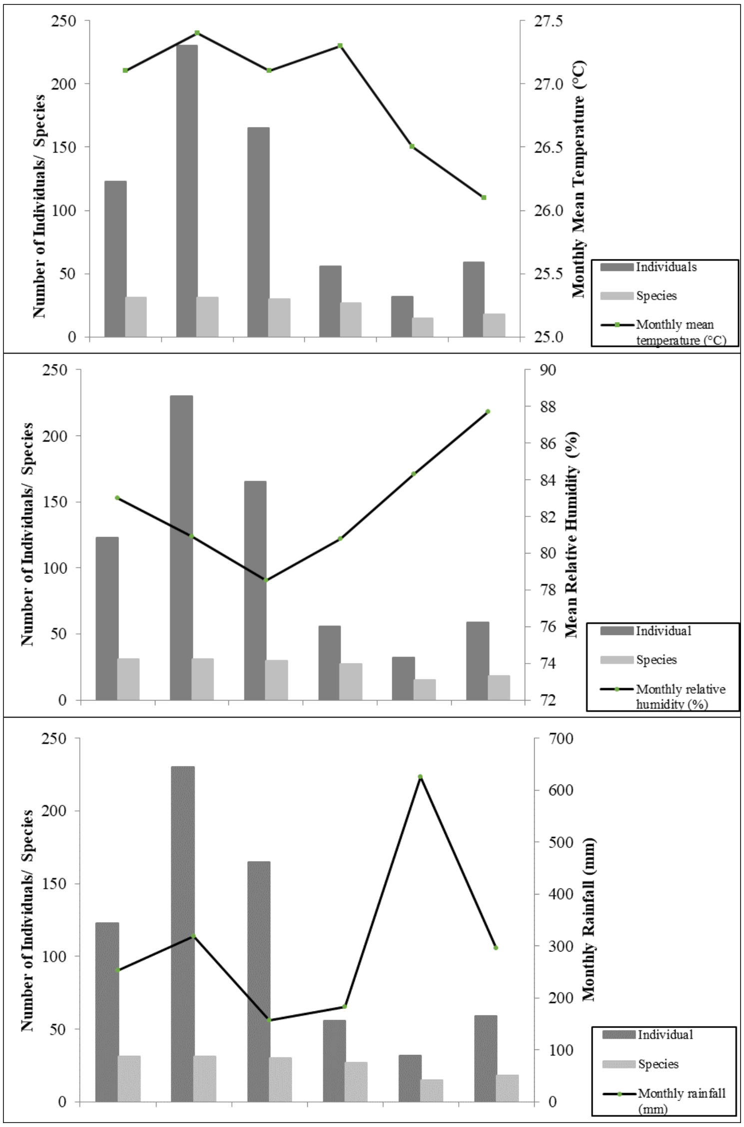

FIGURE 6. Number of species and individuals of fruit-feeding butterflies (Lepidoptera: Nymphalidae) with monthly mean temperature (°C), monthly mean relative humidity (%), and monthly rainfall (mm) for six months (May to Nov 2009) in Kubah National Park, Sarawak.

during data collection could also lead to larval mortality, possibly due to fungus infection. In contrast, some of the nymphalid species are sun-lovers, while some are also known to be less active during the drier period.

Overall, this inter-changing weather has consequently led to a distinctive assemblage of nymphalids, separating the first drier period with the later wet period. The significance of incorporating the rainfall parameter and possibly other environmental variables are undeniable, as temporal patterns of the butterflies are strongly related with the environment. Nevertheless, heavy rainfall during survey could cause more fallen fruits on the ground, and thus disrupting the utilisation of baited traps, and consequently affecting the data. Perhaps by conducting more observations instead of just manipulating their feeding behavior, more detailed data could be achieved.

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