Borneo Journal of Resource Science and Technology (2019), 9(2): 119-125
DOI: https:doi.org/10.33736/bjrst.1576.2019

SHORT COMMUNICATION

Species Diversity of Fruit-feeding Butterflies (Lepidoptera: Nymphalidae) in Adis Buan, Bau, Sarawak

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Received: 25 June 2019 Accepted: 21 November 2019 Published: 31 December 2019

ABSTRACT

Species diversity of nymphalid butterflies is one of the most studied topics as the nymphalids are easily sampled and identified. Ten days of field sampling; five continuous days in two sampling periods, were conducted in Adis Buan, Bau. By using 20 baited traps and two aerial nets, 186 individuals representing 36 species of nymphalid butterfly were recorded. The most diverse subfamily was Satyrinae (H': 2.399) and the most abundant species was *Mycalesis anapita fucentia* with a total of 48 individuals. Satyrinae was also recorded with the highest species richness between subfamilies comprising 24 species of total butterfly sampled which could probably due to their unique characteristic as the slow flying butterfly and being attracted to the shady areas. Shannon diversity index revealed that the diversity index of nymphalid butterfly collected in November 2018 was significantly higher than that in January 2019. In this study, documentation on nymphalid butterfly in heath forest was conducted but further documentation would be recommended as there is still lack of previous studies especially in heath forest.

Keywords: aerial net, baited trap, heath forest, nymphalids, species diversity

In modern studies, butterfly is the most common taxonomically studied (Kumar *et al.*, 2017) especially on species diversity. This may be due to their morphology that is varied in colour pattern and their characteristic as a good biological indicator to the ecosystem (Pandit *et al.*, 2018). The previous study conducted by Pawar and Deshpande (2016) concluded that the diversity of butterfly depends on the adaptability of a species to microhabitat and availability of host plant. According to Pandit *et al.* (2018), species diversity of butterfly often influenced by factors such as rainfall, wind speed, temperature and the availability of host plants.

Nymphalid butterfly is one of the most dominant families of butterfly and easily sampled using baited trap and comprises of seven subfamilies which are Danainae, Satyrinae, Nymphalinae, Libytheinae, Amathusiinae, Charaxinae and Apaturinae (Abang, 2006). Nymphalidae is also known as fruit-feeding butterfly because they feed on fruits such as rotten pineapple, banana, honeydew, tree sap and many more. An unique characteristic of Nymphalidae is they have a reduced foreleg and only use two pairs of leg for walking (Wolfe *et al.*, 2011). Other than that, some of the subfamilies of Nymphalidae have distinctive characteristics including distinctive eyespots, ringlets, unpleasant juices to attack enemies and fast fliers (Abang, 2006). According to Ghazanfar *et al.* (2016), lepidopteran especially butterflies have many important values in economy, education and ecosystem functioning. Their role as a pollinating agent in most agricultural areas has contributed to economic values. A complete life cycle of butterflies also gives a proper understanding on the developmental stages in most insects as they undergo a complete metamorphosis starting from the eggs, larvae, and pupa until they become an adult butterfly. Butterfly diversity has also been greatly affected by climate change (Menéndez *et al.*, 2007).

Recent studies on species diversity of butterfly were mainly conducted in mixed dipterocarp forest, and there is still lack of published studies

in heath forest especially in Borneo. Thus, this study was carried out in Adis Buan Bau, Sarawak, which is covered with heath forest and aimed to determine the species abundance and species richness of nymphalid butterfly in Adis Buan, Bau, and to compare the diversity of fruit-feeding butterflies between different sampling trips in November 2018 and January 2019.

The research was carried out in heath forest of Adis Buan, Bau with a coordinate of 1.5421° N, 110.1506° E. Adis Buan, Bau also has a great number of visitors as it is one of the recreational parks in Singai, Bau. The forest is considered to be as disturbed forest due to human activities such as recreational activity and loggings for rubber plantation. The study was conducted in two sampling periods with five continuous days each. The sampling was done for five days in November 2018 (4th November - 8th November 2018) and the following five days in January 2019 (14th January 2019 - 18th January 2019). Two aerial nets were used to collect the nymphalid butterfly. The sampling was carried out along the trails, and the amount of manpower remained the same throughout the sampling period in order to avoid bias. Twenty baited traps were set up along the trails and each baited trap was set about 10 - 15 m apart. The first baited trap was located at 01°32. 615 N, 110°08. 950 E and the last baited trap was located at 01°32. 902 N, 110°09. 202 E. All baited traps were hung 1 m above the ground and checked twice daily, at 11 am and 4 pm. Pineapple was used as bait in this sampling. According to Freitas *et al.* (2014), juicy fruit such as pineapple attracts butterflies more effective than fermented fruits. Rotting pineapples attract more butterflies due to its bright colour, juice and strong smell. Bait was replaced for every 24 to 48 hours to maintain the attractiveness (DeVries & Walla, 2001; Uehara-Prado *et al.*, 2007) as dryness, rain and decomposition can affect the bait (Freitas *et al.*, 2014).

The collected butterflies were pressed on the thorax before placing them in triangle envelopes, which were then kept in a triangular case. All samples were spread on polystyrene board and pinned with insects' pins. Dates of collection, locality and scientific names were labelled for each individual of butterflies. Species identification was based on the morphological characters described in Otsuka (1988). The collected butterflies were analysed according to their species and number of individuals to obtain the species richness and abundance. Next, Shannon diversity index was used to measure the species diversity, and diversity t-test analysis was used to compare the indices between subfamilies. Mann-Whitney test was used to compare the number of individuals and species between the two sampling periods. All the statistical tests were computed using PAST version 3.17 (Hammer *et al.*, 2001).

Altogether, there were 186 individuals comprising of 36 species from three subfamilies of Nymphalidae recorded over ten days of sampling using 20 baited traps and two aerial nets. These ten days of butterfly samplings had resulted in 84 males and 102 females of Nymphalidae in Adis Buan, Bau (Table 1). The results showed more females were captured than males. Shannon diversity index (H') of overall diversity of the fruit-feeding butterflies was H': 2.78 for the total ten days of sampling in Adis Buan, Bau.

Subfamily Satyrinae dominated the number of individuals sampled with a total of 163 individuals followed by subfamily Nymphalinae and subfamily Danainae (Table 2). The most abundant species was *Mycalesis anapita fucentia* (27 males and 21 females) followed by *M. mnasicles mnasicles* (11 males and 20 females), *Elymnias hypermnestra nigrescens* (ten males and four females), and *Ragadia makuta umbrata* (six males and six females) (Table 1). Meanwhile, subfamily Danainae showed the least abundance among the three subfamilies that were captured. Other than that, subfamily Satyrinae has recorded the highest species richness among the subfamilies (Table 2). Subfamily Danainae recorded the least species richness which represented only 8.33% of the total species captured (Table 2). Nymphalinae stands to be a little higher in percentage of individuals and species (25.0%) than Danainae (8.60%) (Table 2).

Shannon diversity index (H') showed that subfamily Satyrinae represented the highest diversity (H': 2.399) followed by Nymphalinae (H': 1.925), whereas Danainae was the least diverse subfamily (H': 1.079). A t-test analysis ($p<0.05$) shows that there was a significant difference between the diversity of Danainae and Nymphalinae. Meanwhile, there was no significant difference in the diversity between Danainae and Satyrinae, as well as between Satyrinae and Nymphalinae.

Table 1. A list of fruit-feeding butterfly species (Lepidoptera: Nymphalidae) and the number of individuals collected between male and female in Adis Buan, Bau, Sarawak.

Subfamily	Species	Number of individuals	
		Male	Female
Danainae	*Euploea crameri crameri* (Lucas, 1853)	2	1
	Ideopsis vulgaris interposita (Fruhstorfer, 1910)	0	2
	Parantica aspasia aspasia (Fabricius, 1787)	1	1
Satyrinae	*Amathusia phidippus phidippus* (Linnaeus, 1763)	0	2
	Coelites euptychoides euptychoides (C. & R. Felder, 1867)	0	2
	Discophora sondaica symphronia (Fruhstorfer, 1911)	0	1
	Elymnias esaca borneensis (Wallace, 1869)	0	1
	Elymnias hypermnestra nigrescens (Butler, 1871)	10	4
	Elymnias nesaea hypereides (Fruhstorfer, 1902)	1	0
	Elymnias panthera labuana (Staudinger, 1889)	2	2
	Lethe mekara sumati (Fruhstorfer, 1911)	1	0
	Melanitis leda leda (Linnaeus, 1758)	0	1
	Melanitis zitenius rufinus (Fruhstorfer, 1908)	0	2
	Mycalesis anapita fucentia (Fruhstorfer, 1911)	27	21
	Mycalesis fusca adustata (Fruhstorfer, 1906)	6	4
	Mycalesis horsfieldi hermana (Fruhstorfer, 1911)	1	3
	Mycalesis mineus macromalayana (Fruhstorfer, 1911)	1	2
	Mycalesis mnasicles mnasicles (Hewitson, 1864)	11	20
	Mycalesis orseis borneensis (Fruhstorfer, 1906)	1	3
	Mycalesis patiana patiana (Eliot, 1969)	0	1
	Neorina lowii lowii (Doubleday, 1849)	2	6
	Orsotriaena medus medus (Fabricius, 1775)	1	1
	Ragadia makuta umbrata (Fruhstorfer, 1911)	6	6
	Ypthima baldus selinuntius (Fruhstorfer, 1911)	1	0
	Ypthima fasciata fasciata (Hewitson, 1865)	1	4
	Ypthima pandocus sertorius (Fruhstorfer, 1911)	1	2
	Zeuxidia amethystus wallacei (C. & R. Felder, 1867)	0	1
Nymphalinae	*Cethosia hypsea hypsea* (Doubleday, 1847)	1	0
	Cupha erymanthis erymanthis (Drury, 1773)	0	1
	Dophla evelina magama (Fruhstorfer, 1913)	1	1
	Euthalia monina bipunctata (Vollenhoeven, 1862)	1	2
	Junonia atlites atlites (Linnaeus, 1763)	4	2
	Kalima limborgi boxtoni (Moore, 1879)	0	1
	Lexias canescens canescens (Butler, 1868)	0	1
	Tanaecia aruna aparasa (Vollenhoeven, 1862)	0	1
	Terinos terpander terpander (Hewitson, 1862)	1	0
Total		84	102
Total individuals		186	
Total species		36	

Table 2. Composition of fruit-feeding butterfly fauna captured in Adis Buan, Bau, Sarawak.

Subfamily	No. of species	Percentage (%)	No. of individuals	Percentage (%)
Danainae	3	8.33	7	3.76
Satyrinae	24	66.67	163	87.63
Nymphalinae	9	25.00	16	8.60

Most numbers of individuals and species were captured during the first trip which was in November 2018 for all three subfamilies (Table 3). Sampling trips in November 2018 harboured 61.30% total individuals and 80% total species which recorded higher than in January 2019 (Table 3). The difference in the total number of individuals caught in November 2018 and January 2019 was 36.84%, and 72.22% difference in total number of species. Subfamily Satyrinae dominated the number of individuals and species in both November 2018 and January 2019 sampling trips (Figures 1 and 2). Meanwhile, subfamily Danainae recorded the least number of both individuals and species in November 2018 and January 2019 (Figures 1 and 2).

Table 3. Total number of individuals and species of the fruit-feeding butterflies (Lepidoptera: Nymphalidae) recorded for two sampling trips in Adis Buan, Bau, Sarawak.

Sampling trips	Total no. of species	Percentage (%)	Total no. of individuals	Percentage (%)
November 2018	72	80.00%	114	61.30%
January 2019	20	21.74%	72	38.71%

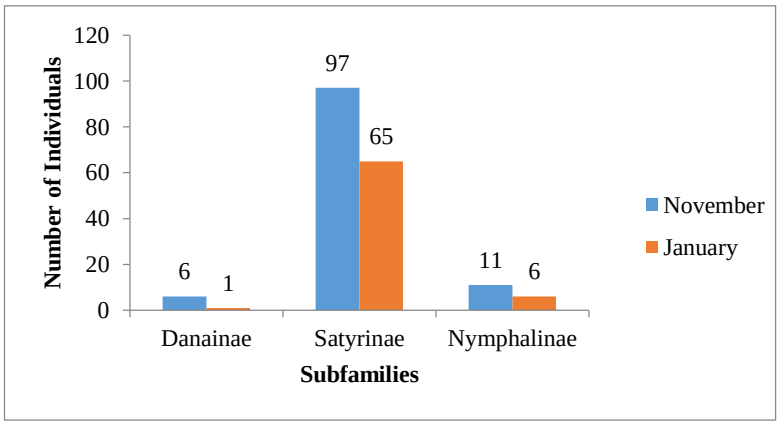

Figure 1. Number of individuals of the fruit-feeding butterflies (Lepidoptera: Nymphalidae) between November 2018 and January 2019.

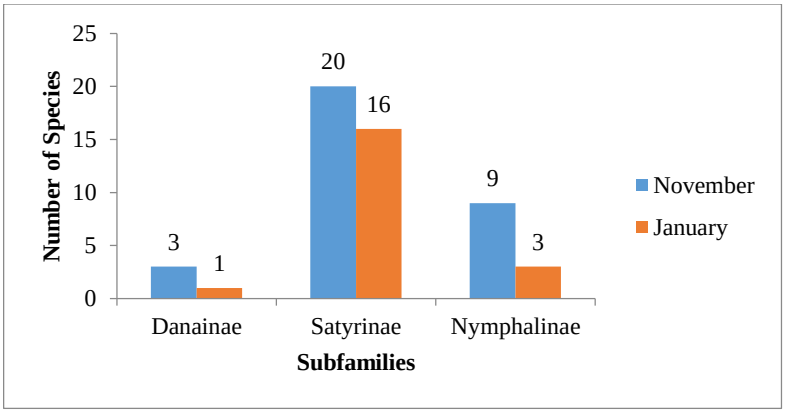

Figure 2. Number of species of the fruit-feeding butterflies (Lepidoptera: Nymphalidae) between November 2018 and January 2019.

Furthermore, subfamily Satyrinae was the highest in the relative abundance of individuals in both November 2018 and January 2019. The relative species abundance of subfamily Satyrinae has increased from 62.5% to 80.0% between November 2018 and January 2019. On the other hand, subfamily Danainae decreased in relative species abundance from 9.38% to 5.26%. Similarly, the relative species abundance of Nymphalinae decreased from 28.13% to 15.00% (Figures 3 and 4).

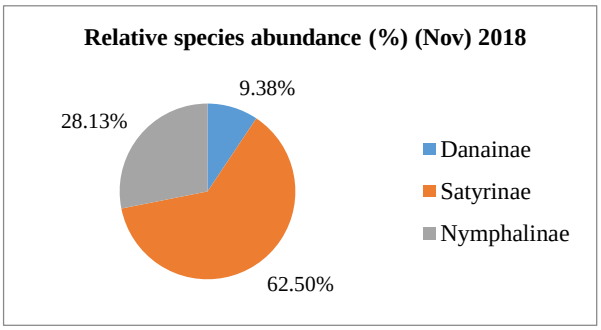

Figure 3. Relative species abundance (%) of the fruit-feeding butterflies (Lepidoptera: Nymphalidae) in November 2018.

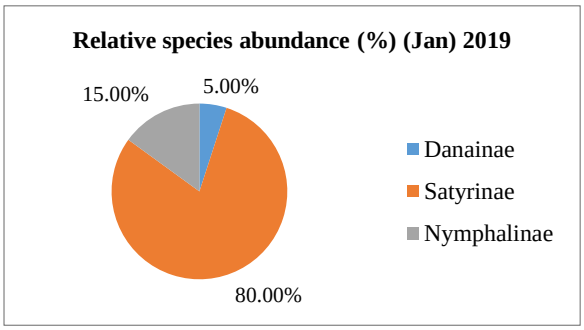

Figure 4. Relative species abundance (%) of the fruit-feeding butterflies (Lepidoptera: Nymphalidae) in January 2019.

Table 4 shows the analysis of species diversity indices for nymphalid butterfly collected between two sampling trips in Adis Buan, Bau. Shannon diversity index revealed that the diversity index of nymphalid butterfly collected in November 2018 was significantly higher than that in January 2019 (t-test; p-value<0.05) (Table 4). Meanwhile, Mann-Whitney test ($p<0.05$) showed that there was no significant difference in the number of species between all the three subfamilies in November 2018 and January 2019. Overall, there was no significant difference in terms of total nymphalid individuals captured between November 2018 and January 2019.

Table 4. Analysis of species diversity indices using Shannon diversity index (H') of the fruit-feeding butterflies between sampling trips in Adis Buan, Bau.

Sampling trips	Shannon diversity index (H')
November 2018	2.769
January 2019	2.459

Overall diversity and abundance of nymphalid butterflies in this study were dominated by subfamily Satyrinae which recorded the most species and individuals of the total butterfly sampled. According to Pang *et al.* (2016), the high abundance of subfamily Satyrinae was due to their characteristic as 'shade lovers'. Satyrinae also prefer forest floor which makes them easily caught using baited traps and aerial nets other than their preferences to fermenting fruits (Pang *et al.*, 2016). Besides that, the abundance of Satyrinae has a positive effect on the increase of disturbance (Fermon *et al.*, 2005), which correlated to Adis Buan, Bau as a recreational area.

The abundance of genus *Mycalesis* in this study, can be related to their characteristic, which is low-flying butterflies that prefer undergrowth forest (Hamer *et al.*, 2003). In this study, *M. mnasicles* and *R. makuta* were effectively caught using the aerial net due to their slow and low flying characteristics (Pang *et al.*, 2016). Meanwhile, Danainae was recorded with the least species richness and abundance probably due to the absence of family Asclepiadaceae, as a host-plant (Brower, 2009) at the sampling site and would prefer shady forest understorey.

Satyrinae was the most diverse subfamilies and this might be due to the unique characteristic of satyrine butterflies which is slow fliers and attracted to shady areas (Hamer *et al.*, 2003) that enable them to feed on the rotting fruit that were found scattered on the forest floor. According to Christharina and Abang (2014), Satyrinae has better flight activity which allows them to maneuver better than the other two subfamilies and it is highly sampled due to the availability of bamboos as host-plants. Based on the t-test analysis ($p<0.05$), there was a significant difference between the diversity of Danainae and Nymphalinae. This could be probably due to the Nymphalinae having diverse larval host plant (Schulze *et al.*, 2001) than Danainae. Widhiono (2015) stated that abundance of Nymphalinae and Satyrinae can be correlated with the availability of host plants, on top of the abundance of adult food resources and microclimate conditions.

Most of the nymphalid species were sampled in November 2018 and less in January 2019. This might be due to the rainy season in November 2018. According to Subba Reddi *et al.* (2003), rainfall can greatly affect the abundance of butterfly distribution, as the butterflies tend to avoid dry and mostly prefer moist season (Rajagopal *et al.*, 2011). During the dry season,

the areas become too hot. Thus, individuals will tend to find cooler areas (Nobre, 2012). According to Fermon *et al.* (2000), satyrines would migrate to damp areas with high cover of larval host-plants areas during dry seasons. Diversity of species also has a positive relation towards warmer days, high rainfall and high relative humidity (Bhusal & Khanal, 2008). Pereira *et al.* (2017) stated that food availability is also high during the rainy season which explains the higher number of butterflies in November 2018 than January 2019. Conversely, during the dry seasons, the abundance of butterfly decline due to the plant defoliation and decreasing in fruit availability (Nobre *et al.*, 2012).

Satyrinae was recorded as the highest in number of individual percentage in both November 2018 and January 2019. Arun (2008) reported that butterflies are peak in abundance during the month of November and more rainfalls help flourish diverse vegetation which is vital for food sources (Patel & Pandya, 2014). Besides that, related factors such as wind speed, rainfall and temperature also affect the butterfly assemblages (Pandit *et al.*, 2018). Meanwhile, Danainae and Nymphalinae were low in the percentage number of species. In this study, most Danainae and Nymphalinae butterflies were mainly caught with aerial nets, and could be biased as it was an active method which depends on the collector.

Overall, nymphalid butterfly collected in November 2018 was more diverse than in January 2019. In January 2019, the low number of individuals and species sampled may correlate with the dry season, which could cause defoliation and less fruit availability (Nobre *et al.*, 2012). According to Pang *et al.* (2016), the difference in the numbers of butterfly captured between sampling trips could be due to the different flowering times for different host plant species. There was no significant difference between the total number of individuals captured between November 2018 and January 2019 which might be due to the small sample sizes.

Overall, the diversity of nymphalid butterflies was observed in this study. Subfamilies Satyrinae, Nymphalinae and Danainae were found and Satyrinae was recorded as the most diverse and abundant subfamilies in terms of both individuals and species probably due to their characteristics as shade lovers. Meanwhile, the low abundance of Danainae might be due to the low numbers of family Asclepiadaceae as a host-plant. Different periods of the year have greatly affected the abundance of nymphalids; most butterflies were sampled in November 2018 were due to the high rainfall and high relative humidity level which helped to flourish diverse vegetation. In this study, a documentation on the diversity of nymphalid butterfly in heath forest was conducted but further documentation on ecological and resting behaviour, courtships and vertical distribution would be recommended for more accurate data of this butterfly family in heath forest.

ACKNOWLEDGEMENTS

The authors would like to thank Universiti Malaysia Sarawak, Sarawak Forestry Department, Adis Buan Bau Resort owner for the permissions to conduct this research. Also thanks to Solomon Laja Anak Jimbai and Elsiey Ercy Jomes Joseph who have assisted in this project.

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