Journal of Tropical Biology and Conservation 18: 291–303, 2021 ISSN 1823-3902
E-ISSN 2550-1909

Research Article

Documenting Butterflies Diversity (Lepidoptera: Rhopalocera: Nymphalidae) as Potential Nature Tourism Products at Sukau Rainforest Lodge and Sukau Ecotourism Research Centre, Kinabatangan, Sabah

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Abstract

Sukau Rainforest Lodge (SRL) and Sukau Ecotourism Research Centre (SERC) have been recognised as two ecotourism sites in Sabah. However, there were no butterfly tourism products carried out at both sites. As a result, a 5-day survey of butterfly diversity was conducted using fruit-baited traps. Butterfly diversity, richness, and abundance were evaluated using Shannon-Weiner Diversity for both sites. SWOT analysis was also carried out at both sites throughout a 3-week observation. The results showed there were 20 species from 6 subfamilies of Nymphalidae butterflies. A total of 96 individuals of each species were also tabulated, with SRL revealing a higher diversity index compared to SERC due to its large surrounding area. The butterfly specimens were collected for educational purposes as nature tourism products. Lack of research, no butterfly signage, forest fragmentation, and mass tourism activities were identified as weaknesses and threats with their strengths and opportunities as proper guidelines based on SWOT analysis. Hence, it shows that both sites are valuable for nature tourism based on their unique butterfly fauna as butterfly tourism products. This study could also provide baseline data on butterfly diversity and its potential as butterfly tourism products at both sites. Butterfly diversity data and SWOT analysis are compulsory for the creation of butterfly tourism products. Such valuable fauna can be integrated as nature tourism products in conjunction with appropriate decision-making strategies.

Keywords: Sukau Rainforest Lodge, Sukau Ecotourism Research Centre, Shannon-Weiner Diversity, Nymphalidae, SWOT analysis, butterfly tourism products.

Received 19 April 2021
Reviewed 05 June 2021
Accepted 22 June 2021
Published 15 October 2021

Introduction

The Kinabatangan Floodplain of north-eastern Borneo (also known as Sabah, Malaysia) has been named one of the top ecotourism destinations in Malaysia (WWFNM, 1996). Home to several tourist facilities, including the Sukau Rainforest Lodge (SRL) and the Sukau Ecotourism Research Centre (SERC), this is a unique place; one where visitors can see the rare Proboscis monkeys, gibbons, and an Asian elephant munching contentedly along the river's edge of fragmented forests (Teo & Patterson, 2005). In the last 30-40 years, much of the original dipterocarp forest has been cleared or converted for land use along the Kinabatangan River (Goossens et al., 2006; Latip et al., 2013). Oil palm plantations currently dominate the landscape along the river, and the forest is limited to isolated patches. Despite this extensive transformation of the Kinabatangan Floodplain, the forest remnants of the Kinabatangan River still contain a very diverse small mammal community (Brunke et al., 2019).

Nature-based tourism can be broadly defined as an exploration of a natural destination which may be a place for a recreational activity where interaction with animals and plants is incidental, or the object of the visit is to acquire an understanding of the natural history of the place itself (a form of ecotourism) and to interact with the animals and plants (Fennell, 2014; Wolf et al., 2019). Ecotourism is intimately associated with natural features such as scenic beauty, beaches and coastal reserves, flora and fauna, and parks and conservation areas. These prime features could be renowned for their tourist attractions (Goh, 2015). Butterflies are usually large and attractive to most people. Thus, this can provide prioritisation for nature tourism products (Takizawa et al., 2012). They are good indicators of environmental health due to their sensitivity to habitat and climate changes. As an outcome, such intervention in species richness and abundance in specific areas can be influenced by a direct impact on habitat quality and the provision of ecosystem services (Pang et al., 2016; Peters et al., 2016). A manager must have knowledge and insight to make such strategic decisions (Grant, 2008), guiding SRL and SERC management in developing nature tourism products for butterflies.

Borneo is home to 242 butterfly species belonging to the Nymphalidae family (Häuser et al., 1997), an estimated 75% of these adult species feed on rotting fruits (Hill et al., 2001). In Sabah, around 186 Nymphalidae species (76.9%) have been recorded from the Kinabalu Park area, presented in a systematic arrangement by Häuser et al. (1997). The specific purpose of this study is to document the diversity of the butterflies at the SRL and SERC. This study investigates whether the butterfly diversity is sufficient to serve as a nature

tourism product at both sites. This could also provide baseline data on butterfly diversity and its potential as a butterfly tourism product.

Methodology

Butterfly surveys were conducted at the SRL and SERC from July 11-15, 2020, to collect butterfly diversity data.

Butterflies were collected using modified Van Someren Rydon's traps (Upton, 1991; Benedick et al., 2007a). The fruit-baited traps were implemented in this study to attract canopy and fruit-feeding butterflies to the ground level. Selected sampling sites for traps were positioned about 1-2 m above the ground and 50-100 m apart. At the SRL, nine traps were set (Figure 1), whereas, at the SERC, four traps were set (Figure 2). The trap placements at both sites were distinct as the sampling area of SRL is larger compared to the SERC. The baits were prepared early in the morning on each sampling day. Each trap was inspected 4 times a day: morning (10:00 – 12:00), afternoon (12:00 – 14:00), evening (14:00 – 16:00), and late evening (16:00 – 18:00) for five consecutive days. Similar butterfly species that were captured were released into the wild.

The list of butterfly species caught and recorded at the SRL and SERC were presented and tabulated by subfamily and species. Recent Otsuka (1988; 2001) classifications and standard reference works for taxonomy and nomenclature were followed. In addition, the butterfly diversity study was considered based on their species richness and abundance at both sites. Hence, the butterfly diversity was calculated using the Shannon-Weiner Index as instructed by Shannon & Weiner (1963), which is described by the following equation:

Species diversity $H'(S) = -\sum_{i=1}^{n} \mathrm{p_i} \log \mathrm{p_i}$

Where:

p_i	=	n_i/N,
n_i	=	Number of individuals of a species i,
N	=	Size of whole community,
S	=	Total number of species.

The butterfly specimens were relaxed, spread, identified, labelled and stored in the SERC collection box for environmental education purpose and for as butterfly tourism products.

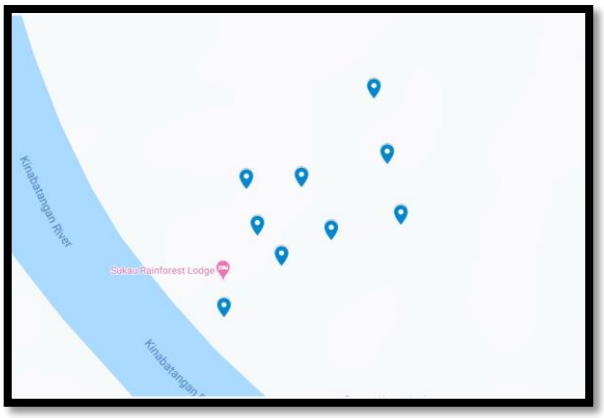

Figure 1. Baited Traps at the SRL (source: www.google.com/maps).

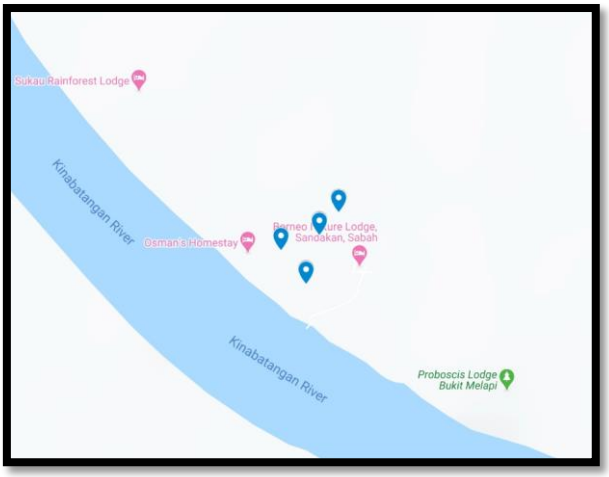

Figure 2. Baited Traps at the SERC (source: www.google.com/maps).

SWOT analysis is an early stage of the strategic planning process that helps planners define strategies and decisions on resource allocation for pursuing those strategies. In this case, determining internal and external factors is critical. This analysis also involves systematic thinking and comprehensive diagnosis of factors relating to a new product, technology, management, or planning. Hence, it provides knowledge regarding the situation and allows the design of procedures that may be deemed necessary for thinking in a strategic way (Shrestha et al., 2004; Lozano & Valles, 2007). The collected butterfly data was analysed using SWOT analysis after three weeks' observation at the SRL and SERC. The result of the SWOT analysis was tabulated in the Internal Factor

Estimate Matrix (IFEM) and External Factor Estimate Matrix (EFEM) tables. Each factor's weight was assigned a value of one.

Results and Discussion

Table 1. List of species caught in baited traps at the SRL and SERC.

No.	Subfamilies	Species	SRL	SERC	Total number of individuals
1.	Charaxinae	*Prothoe franck*	4	0	4
2.	Danainae	*Euploea crameri*	1	0	1
3.		*Euploea phaenareta*	0	1	1
4.		*Ideopsis vulgaris*	0	1	1
5.	Heliconiinae	*Cirrochroa emalea*	1	0	1
6.	Limenitidinae	*Dophla evelina*	1	1	2
7.		*Lexias dirtea*	8	0	8
8.		*Lexias pardalis*	6	1	7
9.		*Parthenos sylvia*	1	0	1
10.		*Tanaecia aruna*	1	1	2
11.		*Tanaecia iapis*	1	0	1
12.	Morphinae	*Amathusia phidippus*	1	0	1
13.		*Zeuxidia amethystus*	0	1	1
14.	Satyrinae	*Elymnias panthera*	1	0	1
15.		*Melanitis leda*	0	1	1
16.		*Mycalesis fusca*	16	13	29
17.		*Mycalesis pitana*	20	8	28
18.		*Neorina lowii*	0	2	2
19.		*Orsotriaena medus*	1	0	1
20.		*Thaumantis noureddin*	1	2	3
		Total	**64**	**32**	**96**

Table 2. Diversity, richness, and abundance of study sites at the SRL and SERC.

Sites	Diversity (Shannon-Weiner)	Richness	Abundance
Sukau Rainforest Lodge	0.8751	15	64
Sukau Ecotourism Research Centre	0.7892	11	32
	Total	**26**	**96**

Based on Table 1, a total of 96 individuals from 20 species (6 subfamilies) were recorded during a sampling period of 5 days. The sampling area around the SERC was small, surrounded by houses and lodges at other villagers. However, *Euploea phaenareta*, *Ideopsis vulgaris*, *Melanitis leda*, *Neorina lowii*, and *Zeuxidia*

amethystus were found at that location. In contrast, *Amathusia phidippus*, *Cirrochroa emalea*, *Elymnias panthera*, *Euploea crameri*, *Lexias dirtea*, *Orsotriaena medus*, *Parthenos sylvia*, *Prothoe franck*, and *Tanaecia iapis* were found at the SRL. Additionally, *Dophla evelina*, *Lexias pardalis*, *Mycalesis fusca*, *Mycalesis pitana*, *Tanaecia aruna*, and *Thaumantis noureddin* were found at both sites. *Mycalesis fusca* and *Mycalesis pitana* had the most individuals caught in baited traps on this expedition, with a total of 29 and 28 individuals, respectively, followed by *Lexias dirtea* (8 individuals), *Lexias pardalis* (7 individuals), *Prothoe franck* (4 individuals), and *Thaumantis noureddin* (3 individuals). *Dophla evelina*, *Neorina lowii*, and *Tanaecia aruna* were all composed of 2 individual species. Meanwhile, all the remaining butterfly species were composed of 1 individual species.

Table 2 shows the determination of the diversity, richness, and abundance of the study sites at the SRL and SERC. Only 15 species with a total of 64 individual species were recorded at the SRL. Meanwhile, only 11 species along with a total of 32 individual species were recorded at the SERC. Apart from this, SRL showed a diversity index of 0.8751, whereas SERC showed a diversity index of 0.7892. Among both sites, SRL showed higher species in terms of diversity, richness, and abundance compared to SERC due to a large area of sampling where nine baited traps were set. Unfortunately, there were no Bornean endemic butterflies (Otsuka, 1988; Maruyama & Otsuka, 1991; Seki et al., 1991; Otsuka, 2001) found at the SRL and SERC as shown in Table 1. Notably, *Prothoe franck* found at the SRL is one of the 11 Nymphalidae species protected under the Wildlife Conservation Act 2010 (Act 716). This species is vulnerable to illegal trade due to its aesthetic appeal (UNEP-WCMC, 2012).

Accessing a canopy can be partially solved by using fruit-baited traps to lure canopy and fruit-feeding butterflies to the ground level as suggested by Tangah et al. (2004). However, fruit-baited traps only catch a specific butterfly guild that is attracted to rotting fruits. Consequently, most canopy butterflies cannot be studied in their entirety. There is also limited information about butterflies and any other species attracted to that traps, making it difficult to determine a trap sampling area. The advantage of using these traps is that it reduces field identification problems because all individuals can be spotted and easily identified. Besides that, this is an easy way to conduct a canopy study without the need to access the canopy (Barker & Sutton, 1997).

Table 3. IFEM for potential butterfly tourism products at the SRL and SERC.

No.	Internal Factors	Weight	Effectiveness Score	Final Score
	Strengths (S)			
1.	Trails along the SRL and SERC are easily accessible and many open-field butterfly species can be seen.	0.30	4	1.20
2.	Unique scenery that features the real ecosystem of secondary forests.	0.20	4	0.80
3.	Available rare species of butterfly (i.e., *Prothoe franck*).	0.20	3	0.60
	Weaknesses (W)			
1.	No population study and impact assessment on the butterflies. Carrying capacity is unknown.	0.25	4	1.00
2.	No signage about butterfly information that includes potential sighting.	0.05	3	0.15
	Total	**1**	**18**	**3.75**

Across the world, there are plenty of butterfly tours that have been mainstreamed. However, Sabah lacks butterfly tours. Few attempts have been made to use butterflies for environmental education (Takizawa et al., 2012; Chung, 2019). Total score values for IFEM were 3.75 as shown in Table 3. Based on the result, each factor's weight ranged from 0.05 to 0.30, and the effectiveness score ranged from 3 to 4 only. Three factors had been identified as strengths for butterfly tourism products based on three weeks' observation at both sites. The highest weight given to trails along the SRL and SERC as these were easily accessible and many open-field butterflies can be seen with a total of 1.20 as the final score, followed by unique scenery that features the secondary forest and available rare butterfly species with a total of 0.80 and 0.60, respectively. Two factors were highlighted as weaknesses. Signage about butterfly information was lower (0.15) compared with population study and impact assessment on the butterflies (1.00).

Along the boardwalk and trails at the SRL and SERC, many open-field and common butterfly species can be spotted like *Lexias pardalis*, *Lexias dirtea*, *Thaumantis noureddin*, *Mycalesis fusca*, and *Mycalesis pitana*. Rare species like *Prothoe franck* were seen during the expedition. Furthermore, because SRL and SERC were built around the secondary forest (Tropical Rainforest) that houses flora and fauna, all guests who stay at the SRL and SERC are able to enjoy this scenery. These benefits can provide an ecosystem balance in terms of the prevalence of butterflies' species and their dependability on the state of the environment (Ivinskis & Rimšaitė, 2004).

No population studies and impact assessments have been carried out at the SRL and SERC for butterfly studies recently. As a result, the carrying capacity of butterflies is still unknown and must be thoroughly investigated through scientific research. These could potentially have a direct impact on butterfly misinformation at the SRL and SERC. As an outcome, the butterfly information provided by the signage will be rejected.

Table 4. EFEM for potential butterfly tourism products at the SRL and SERC.

No.	External Factors	Weight	Effectiveness Score	Final Score
	Opportunities (O)			
1.	An opportunity for the scientific study of butterflies to determine their population and carrying capacity.	0.20	4	0.80
2.	Increasing flowering plants along the boardwalk and trails for butterfly attraction.	0.10	3	0.30
3.	Butterfly specimens that have been preserved will be displayed in the SERC building.	0.30	4	1.20
4.	Providing pamphlets and brochures about butterfly information for tourists.	0.25	4	1.00
	Threats (T)			
1.	Threat to butterfly species through forest fragmentation due to oil palm plantations near the SRL and SERC.	0.10	2	0.20
2.	Mass tourism activities that could cause habitat disturbance and noise pollution.	0.05	2	0.10
	Total	**1**	**19**	**3.60**

Total score values for EFEM were 3.60 as shown in Table 4. Hence, each factor's weight ranged from 0.05 to 0.30, whereas the effectiveness score ranged from 2 to 4. There were four factors related to opportunities. Butterfly specimens that have been preserved received the highest score (1.20), followed by providing pamphlets and brochures for tourists (1.00), butterfly scientific study (0.80), and increasing flowering plants along the boardwalk and trails to attract butterflies (0.30). There were two factors related to threats. Threat to butterfly species due to oil palm plantations received a score of 0.20, while mass tourism activities received a score of 0.10 as the final score.

It is necessary to pay for the existence of butterflies in terms of maintaining and improving the village environment. Scientific studies of butterflies should be utilised to determine their current population and carrying capacity (Curtis et al., 2015), therefore, ensuring that butterfly diversity can be safeguarded. Increasing flowering plants along the boardwalk and trails can attract some

butterflies, adding to the scenery, a plus for tourists. When choosing flowers to attract butterflies, low lantana and hibiscus could be a few choices as recommended by Takezawa et al. (2012). It is suggested that orchards should be planted at open areas around the SRL's boardwalk and trail, as well as at the surrounding of the SERC area's trail, for butterfly observation and to keep bare wet spots for butterflies to absorb moisture. Bringing tourists to SERC to see an actual butterfly specimen could be proposed as part of environmental education, thus addressing butterfly conservation awareness. Such small tours are beneficial and appealing to SRL guests within the context of nature tourism products. Above all, the provision of signage, appropriate pamphlets and training guides are vital to attracting tourists. Such activities should serve as a key task for the Information Centre.

Butterflies on Borneo are diverse with many rare, endemic and restricted-range species that are dependent on the canopy forest and do not occur in oil palm or other crops (Otsuka, 1988; Maruyama & Otsuka, 1991; Seki et al., 1991; Otsuka, 2001; Benedick et al., 2006). However, the fragmentation of tropical rainforests could threaten butterflies at the SRL and SERC because both sites have been surrounded by oil palm plantations (Brunke et al., 2019). In support of this notion, there was some evidence of a reduction in genetic diversity of *Mycalesis orseis* following forest fragmentation in Sabah as reported by Benedick et al. (2007b). Environmental education about butterfly conservation awareness such as exhibitions and talk sessions are suggested to prevent such tragic deforestation. Moreover, it is possible for tourists to take small-scale butterfly tours at the SRL and SERC to reduce habitat disturbance and noise pollution.

Conclusion

The present study has identified about 20 butterfly species of Nymphalidae from 6 subfamilies with 96 individual species at the SRL and SERC. SRL had a higher diversity index compared to SERC based on Shannon-Wiener Diversity. There is an opportunity for butterfly tourism products to be carried out at both sites based on a SWOT analysis. Butterfly diversity and potential for butterfly tourism products at both sites acted as the baseline data as no research had been conducted previously. Continuous studies on butterfly species are needed as some butterflies have not been caught and listed due to time and resource limitations at both sites.

The main issues at the SRL and SERC affecting the diversity of butterflies as potential nature tourism products have been addressed. Such weaknesses and

threats such as lack of research, no butterfly signage, forest fragmentation, and mass tourism activities have been given proper guidelines and action plans in the SWOT analysis for strengths and opportunities. These findings could help decision-makers and stakeholders develop butterfly tourism products at the SRL and SERC.

Both findings of butterfly diversity and SWOT analysis are compulsory for development of butterfly tourism products. Such valuable fauna, together with appropriate decision-making strategies, can be correlated with nature tourism products. As a long-term prospect, this will ensure a preserved heritage.

Acknowledgements

The authors wish to express their thanks to the staff of SRL and SERC, in particular, Mr Fernando D Rulloda and Mr Jamil Amad, Assistant General Manager and Field Supervisor, respectively, for their assistance with this research. This study was carried out as part of an internship and was funded by the Borneo Ecotourism Solutions and Technologies (BEST) Society and Universiti Malaysia Sabah (UMS).

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Appendix. (A) *Amathusia phidippus*, (B) *Cirrochroa emalea*, (C) *Dophla evelina*, (D) *Parthenos sylvia*, (E) *Prothoe franck*, and the protected species under Wildlife Conservation Act 2010 [716]; (F) Set of butterfly specimen collection for environmental education purpose.