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Cover: *Geodorum laxiflorum* Griff.—inflorescence (Orchidaceae) © Ashish Ravindra Bhoyar.

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COMMUNICATION

Butterfly diversity and composition at Chemerong Amenity Forest, Terengganu, Malaysia

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Abstract: A study of butterfly species diversity was conducted in Chemerong Amenity Forest, Terengganu, Malaysia. A total of 939 individuals from 198 butterfly species were obtained using fruit-baited sweep nets and modified VanSomeren-Rydon cylinder traps. The biodiversity of butterflies in the study area was considered high, with a Shannon index (H') of 4.1, Simpson's index ($D_{Simpson}$) of 0.042, and Margalef index ($I_{Margalef}$) of 28.78. Individuals within the community were not evenly distributed among the species (EShannon= 0776). Nymphalidae was found to be the most dominant family (48.5%), and *Lexias dirtea merguia* was the most abundant species recorded with 114 individuals (12%). From the total of eight species protected under Malaysia legislation, one species *Trogonoptera brookiana* was also listed under CITES Appendix II, while only one protected species *Agatasa calydonia calydonia* of the family Nymphalidae (the brush-footed or four-footed) was considered rare. Other rare species found in this study included *Arhopala lucida*, *Curetis saronis sumatrana*, *Miletus nymphis fictus* of the family Lycaenidae (the blues, coppers, & hairstreaks), *Amathusia perakana perakana*, *Bassarona teuta goodrichi*, *Elymnias saueri saueri*, *Elymnias nesaea*, *Mycalesis horsfieldi hermana*, *Mycalesis distanti*, *Ypthima pandocus tahanensis* of the family Nymphalidae (the brush-footed or four-footed), *Celaenorrhinus ladana*, *Erionota sybirita*, *Matapa aria*, *Matapa cresta*, *Matapa druna*, *Pseudokerana fulger*, *Taractrocera ardonia*, *Taractrocera luzonensis*, *Telicota linna*, and *Unkana mytheca mytheca* of the family Hesperiidae (the skippers). The dominance of family Nymphalidae may be due to several factors, including high species diversity, widespread distribution and occurrence, as well as the type of bait used in this study. Besides the Genting Highlands and Taman Negara Johor Endau Rompin, butterfly species at Chemerong Amenity Forest are more diverse than other study sites in Malaysia such as Gunung Serambu, Ulu Gombak Forest Reserve, Setiu Wetlands, Kuala Lompat, Bukit Hampuan Forest Reserve, Sungai Imbak Forest Reserve, Tabin Wildlife Reserve, and Ulu Senagang Substation. Further investigation of aspects such as stratification distribution patterns, host plants and forest dwelling species are recommended for better understanding of butterfly communities in the Chemerong Amenity Forest.

Keywords: Biodiversity indices, butterflies, forest reserve, Lepidoptera, primary forest, tropical rainforest.

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For **Author details** & **Author contributions** see end of this article.

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INTRODUCTION

Studies of butterflies have contributed greatly to the understanding of their ecology, evolution, biogeography, conservation, and usefulness as biodiversity indicators (Sekimura & Nijhout 2019). Knowledge about tropical butterflies is, however, quite limited (Beck 2007; Koh 2007; Bonebrake et al. 2010). In comparison with most temperate ecosystems, tropical forests are characterized by extraordinarily high but poorly- inventoried insect diversity (Bonebrake et al. 2010; Ballesteros-Mejia et al. 2013).

There are 1,182 recorded species of butterfly in Malaysia (Wilson et al. 2015), with 117 being endemic (Tamblyn et al. 2006) and 1,038 species recorded in Peninsular Malaysia (Eliot & Kirton 2000). Continuous monitoring of biodiversity over time is essential to identify changes in species populations. For example, the tradition of recording and monitoring of species occurrences and relative abundance by the Butterfly Monitoring Scheme has provided evidence for declines and losses of some species in the northern temperate zone (Pollard & Yates 1993), while a citizen science project: the 'Peninsular Malaysia Butterfly Count' involved the general public to obtain samples for DNA barcoding of butterflies for monitoring communities in Peninsular Malaysia (Wilson et al. 2015).

Therefore, it is vital to monitor and assess the current status of local biodiversity comprehensively as an action link to the conservation approach and priorities (Green et al. 2003).

Deforestation, together with human population growth increase, have substantial effects on global biodiversity (McKee et al. 2003. Wittmeyer et al. 2008), especially in southeastern Asia. For example, Singapore has recently lost most of its biodiversity due to massive development (Castelletta et al. 2000; Brook et al. 2003; Sodhi et al. 2004; Hau et al. 2005; Sodhi et al. 2010). This concern was also felt in other southeastern Asian countries including Malaysia, which have had high terrestrial degradation in recent years (Sodhi et al. 2010). This is quite worrying as habitat loss is the main cause of butterfly extinction, and diversity is being lost before we can quantify or understand it (Checa et al. 2009).

In the state of Terengganu, butterfly inventory and monitoring were first carried out by Fleming (1975) and also Corbet & Pendlebury (1992). Since then, there have been few studies of butterfly status in the state of Terengganu, and there are deficient sources and publications on this subject (Tamblyn et al. 2006; Yap et al. 2018). Therefore, the diversity and composition of butterfly at the Chemerong Amenity Forest was investigated. The study site chosen for this study was opportune, as it is proclaimed to be an undisturbed tropical rainforest which houses myriads of flora and fauna species. The results of this study will provide a baseline data on butterflies in the Chemerong Amenity Forest.

MATERIALS AND METHODS

Study Site

The research was conducted at Chemerong Amenity Forest (4.651667, 103.001389) located in the Pasir Raja Forest Reserve, Dungun, Terengganu, Malaysia. It is considered as an undisturbed area with pristine forest. The Chemerong Amenity Forest encompassing of at least 292 ha area and is categorized as a hill dipterocarp forest (Forestry Department of Peninsular Malaysia 2022). This area is blessed with various flora and fauna and is rich with a variety of dicotyledonous plants, namely, Dipterocarpaceae, Rubiaceae, and Euphorbiaceae together with monocotyledonous species such as Zingiberaceae and Palmae (Faridah-Hanum et al. 2006). The amenity forest is well known for the Lata Chemerong waterfall, which is about 305 m in height and the presence of the Malaysia's largest and oldest Cengal tree *Neobalanocarpus heimii* with a height of 65 m, girth of 16.75 m and the estimated age of at least 1,300 years old.

The Chemerong Amenity Forest mainly consists of primary forest. However, due to the status of the area as an amenity forest, the local authority has built several facilities for administration and ecotourism such as an office, cafeteria, toilet, prayer room, camping site, hall, and garden. Various trees and floristic plants were also planted at surrounding areas as decoration. Moreover, a walking trail has also been built in the forest to facilitate tourists to reach the waterfall area.

Data Collection

Sweep sampling method, baits method, and modified VanSomeren-Rydon cylinder trap was utilised to investigate butterfly diversity and composition in Chemerong Amenity Forest from July 2010 to January 2011 (14 days sampling) and August 2011 to January 2012 (10 days sampling). The study was conducted once a month for two days, one-night sampling per effort.

Different collection methods have been used to increase the species diversity of butterflies caught. For instance, some members of subfamily Charaxinae and

Nymphalinae tend to be trapped in the canopy, while Morphinae and Satyrinae in the understory (De Vries 1988). Butterfly collecting was conducted from 0830 h to 1100 h and from 1500 h to 1800 h. Sweep sampling method was conducted by walking in the forest interior, along the trails and garden area at the visitors' complex, and sighted butterflies were captured using sweep net. Baits method on the other hand, was conducted by luring the butterflies using bait that consisted of a mixture of rotten fruits of banana, papaya, apple, orange, and pineapples. The bait was placed on the forest floor at several selected spots such as near the trails, forest fringe and at the forest interior. Lured butterflies were then captured using sweep net.

Butterflies were sampled using modified VanSomeren-Rydon cylinder trap, baited with rotten banana following the method of Rydon (1964). However, the original structure of PVC bait case used by Rydon (1964) was replaced with a plastic plate. To reduce the damage to the trapped samples on a rainy day caused by raindrops, a transparent plastic-sheet was used to cover the top of each trap.

Ten traps were used for each sampling attempts and was positioned about 1 m to 4 m above ground at 10 different selected spots, at the interior of the forest and forest edges. The traps were checked and mixed with fresh baits daily in the morning between 0830 h and 1000 h, and in the evening between 1700 h and 1830 h. The bait was renewed daily by mixing the old bait together with the fresh baits in order to produce the homogenous odour of rotten banana. All butterflies were captured by hand through the zipped part of the trap whilst either resting on the netting or hanging from the cone part of the trap. The butterflies were then killed by using the pinching technique and kept in triangle envelopes. Only butterflies caught using the traps and by sweep net were recorded for this study.

Identification

The samples were identified into species taxon by referring to Otsuka (2001), Corbet & Pendlebury (1992), and Fleming (1975). Revisions were also made by referring to van der Poorten & van der Poorten (2020).

Data Analysis

The diversity, evenness and species richness indices of butterfly communities were assessed and pooled over for two years. Shannon diversity index (*H'*) was applied as a measure of species abundance and richness to quantify diversity of butterfly species. The Shannon diversity index formula is shown below:

$$H' = -\sum_{1}\left(\frac{ni}{N} . ln\left[\frac{ni}{N}\right]\right)$$

where (*ni*) is the number of individuals of one particular species found in the community, (*N*) is the total number of individuals for all species found in the community, (*ln*) is the natural log and (Σ) is the sum of the calculations.

Next, as a tool to measure species dominance, Simpson's index ($D_{Simpson}$) was used while Margalef index ($I_{Margalef}$) was used to determine species richness, evenness and dominance. The equation for Simpson's index is as follows:

$$D = \frac{\Sigma_i\, ni(ni-1)}{N(N-1)}$$

Where (*ni*) is the number of individuals found for particular species in the community, (*N*) is the total number of individuals for all species found in the community and (Σ) is the sum of the calculations.

For Margalef index ($I_{Margalef}$), the equation is as follows:

$$I = \frac{S-1}{\ln N}$$

Where (*S*) is the total number of species and (*N*) is the total number of individuals found for all species.

To measure equitability or evenness of spread of individuals for each species of butterflies, Shannon evenness index ($E_{Shannon}$) was applied based on the following equation:

$$-\frac{\Sigma_i\left(\frac{ni}{N} . \ln\left(\left[\frac{ni}{N}\right]\right)\right)}{\ln N}$$

Where (*ni*) is the number of individuals found for particular species in the community, (*N*) is the total number of individuals for all species found in the community, (*ln*) is the natural log and (Σ) is the sum of the calculations. If the value obtained in $E_{Shannon}$ approaching zero, the distribution of individuals in each species is considered highly similar or even. However, if the value approaches 1, the community did not have evenly distributed number of individuals for each species.

Whittaker plot or a rank abundance curve (RAC) was also generated by using excel to show the relative species abundance, richness and evenness.

RESULTS

Butterfly composition

We recorded a total of six families, 198 species and 939 individuals (Table 1). The most abundant family (Nymphalidae), included 577 (61.4%) individuals, followed by Hesperidae 161 (17.1%) individuals, Pieridae 131 (14%) individuals, Lycaenidae 46 (4.9%) individuals, Papilionidae 15 (1.6%) individuals, and Riodinidae 9 (1%) individuals (Figure 1). The richest genus was *Mycalesis* (9 species), followed by *Arophala, Neptis,* and *Euremа* (8 species), *Tanaecia* (7 species), *Amathusia* and *Ypthima* (6 species), *Graphium* (5 species), and *Euthalia, Lexias, Charaxes* and *Athyma* (4 species).

Diversity indices analysis

The diversity of butterflies in the Chemerong Amenity Forest recorded a reading of 0.042 for Simpson's index and 4.1 for Shannon-Weiner index with the evenness or equitability of 0.776. These readings indicate that butterfly community in the Chemerong Amenity Forest have very high diversity, yet the equitability of the species can be considered relatively low. However, for the species richness, Margalef index was 28.78 which

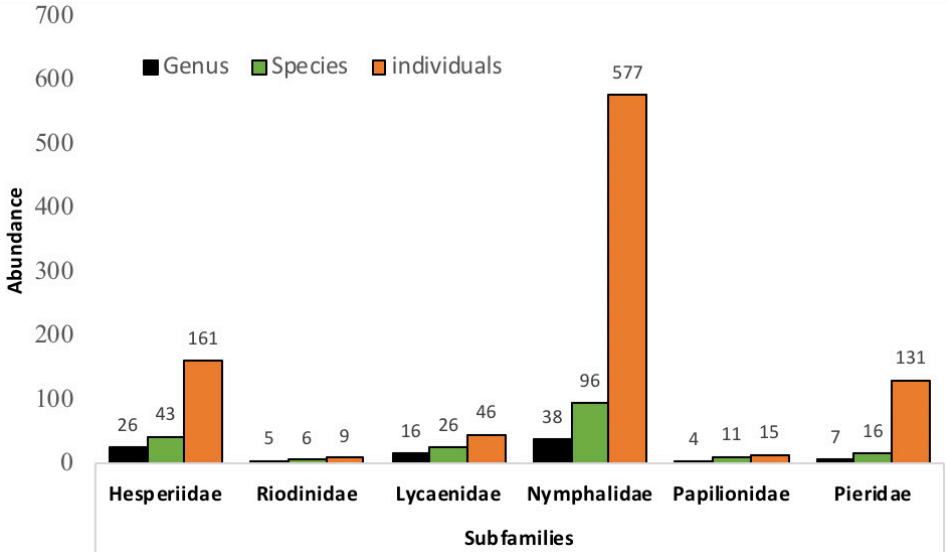

Figure 1. Total number of genus, species, and individuals according to family.

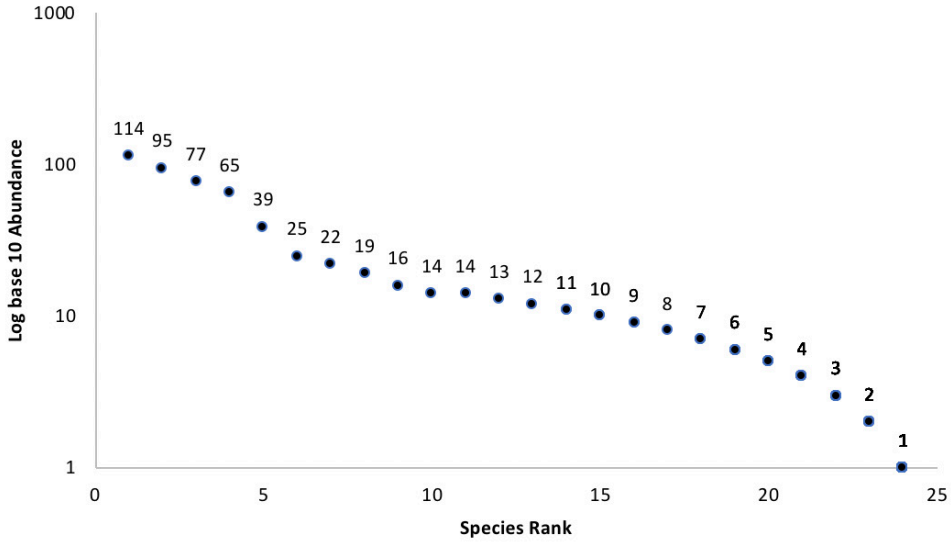

Figure 2. Rank abundance curve of butterfly family's community in Chemerong Amenity Forest.

Table 1. List of butterfly species recorded in Chemerong Amenity Forest, Terengganu, Malaysia.

Taxon	Scientific name	No. of individuals	Voucher code
Hesperiidae			
Hesperiinae	*Ancistroides armatus armatus*	1	UMT/8/2012
	Ancistroides gemmifer gemmifer	1	UMT/4/2012
	Ancistroides nigrita maura	4	UMT/34/2012
	Arnetta verones	1	UMT/61/2012
	Astictopterus jama jama	7	UMT/95/2012
	Baoris oceia	1	UMT/113/2012
	Caltoris brunnea caere	1	UMT/120/2012
	Cephrenes acalle niasicus	65	UMT/130/2012
	Erionota acroleuca apicalis	3	UMT/131/2012
	Erionota sybirita	3	UMT/1/2012
	Gangara lebadea lebadea (syn. *glandulosa*)	1	UMT/77/2012
	Gangara thyrsis thyrsis	1	UMT/78/2012
	Hidari doesoena doesoena	1	UMT/157/2012
	Hyarotis microsticta microsticta	1	UMT/158/2012
	Iambrix salsala salsala	4	UMT/2/2012
	Iambrix stellifer	1	UMT/3/2012
	Isma guttulifera kuala	1	UMT/171/2012
	Isma miosticta	6	UMT/172/2012
	Isma umbrosa umbrosa	1	UMT/173/2012
	Koruthaialos rubecula rubecula	5	UMT/24/2012
	Koruthaialos sindu sindu	4	UMT/96/2012
	Matapa aria	1	UMT/18/2012
	Matapa cresta	2	UMT/144/2012
	Matapa druna	1	UMT/156/2012
	Notocrypta clavata clavata (syn. *devadatta*)	1	UMT/183/2012
	Notocrypta curvifascia corinda	1	UMT/184/2012
	Parnara bada bada	1	UMT/35/2012
	Pelopidas agna agna	4	UMT/5/2012
	Pelopidas assamensis	1	UMT/17/2012
	Pelopidas conjunctus	4	UMT/99/2012
	Polytremis lubricans lubricans	4	UMT/146/2012
	Potanthus juno juno	1	UMT/165/2012
	Potanthus omaha omaha (syn. *maesoides*)	3	UMT/10/2012
	Pseudokerana fulgur	1	UMT/32/2012
	Psolos fuligo fuligo	3	UMT/170/2012
	Tagiades lavata	1	UMT/132/2012
	Taractrocera ardonia sumatrensis (syn. *lamia*)	5	UMT/133/2012
	Taractrocera luzonensis zenia	2	UMT/134/2012
	Telicota linna	1	UMT/164/2012
	Telicota besta bina	2	UMT163/2012
	Unkana ambasa batara	6	UMT/193/2012
	Unkana mytheca mytheca (syn. *harmachis*; *standingeri*)	1	UMT59/2012
Pyrginae	*Celaenorrhinus ladana*	2	UMT/9/2012

Taxon	Scientific name	No. of individuals	Voucher code
Riodinidae			
	Abisara saturata kausambioides	3	UMT/98/2012
	Paralaxita telesia lyclene	2	UMT/115/2012
	Stiboges nymphidia nymphidia	1	UMT/159/2012
	Taxila haquinus haquinus	1	UMT/160/2012
	Zemeros emesoides emesoides	1	UMT/114/2012
	Zemeros flegyas albipunctus	1	UMT/175/2012
Lycaenidae			
Theclinae	*Arhopala aedias*	1	UMT/186/2012
	Arhopala antimuta antimuta (syns. *davisonii*; *tana*)	1	UMT/22/2012
	Arhopala lurida	2	UMT/14/2012
	Arhopala major major (syn. *catori*)	1	UMT/15/2012
	Arhopala normani	1	UMT/79/2012
	Arhopala centaurus nakula	1	UMT/80/2012
	Arhopala tropaea	1	UMT/81/2012
	Arhopala wildeyana wildeyana	1	UMT/60/2012
	Drupadia ravindra moorei	1	UMT/30/2012
	Eooxylides tharis distanti	1	UMT/11/2012
	Megisba malaya sikkima (syn. *velina*)	1	UMT/23/2012
	Surendra vivarna amisena	1	UMT/33/2012
Curetinae	*Curetis saronis sumatrana*	1	UMT/162/2012
	Curetis sperthis sperthis	1	UMT/145/2012
Lycaeninae	*Rachana jalindra burbona*	1	UMT/16/2012
Polyommatinae	*Acytolepis puspa* lambi	1	UMT/7/2012
	Catochrysops strabo strabo (syn. *riama)*	1	UMT/57/2012
	Jamides celeno aelianus	2	UMT/58/2012
	Jamides elpis pseudelpis	4	UMT/118/2012
	Jamides zebra lakatti	1	UMT/119/2012
	Prosotas nora superdates	1	UMT/117/2012
	Zizeeria karsandra	5	UMT/161/2012
	Zizina otis lampa	12	UMT/185/2012
Miletinae	*Allotinus horsfieldi permagnus* (syn. *nessus*)	1	UMT/36/2012
	Miletus nymphis fictus	1	UMT/135/2012
Poritiinae	*Simiskina pharyge deolina*	1	UMT/174/2012
Nymphalidae			
Charaxinae	*Agatasa calydonia calydonia*	2	UMT/13/2012
	Charaxes athamas athamas	1	UMT/101/2012
	Charaxes athamas uraeus	1	UMT/21/2012
	Charaxes bernadus crepax	2	UMT/6/2012
	Charaxes echo echo	1	UMT/97/2012
	Doleschallia bisaltide pratipa	1	UMT/102/2012
	Prothoe franck uniformis	11	UMT/191/2012
Amathusiinae	*Amathusia friderici holmanhunti f. utana*	1	UMT/147/2012
	Amathusia ochraceofusca ochraceofusca	6	UMT/148/2012
	Amathusia perakana perakana	1	UMT/12/2012

Taxon	Scientific name	No. of individuals	Voucher code
	Amathusia phidippus phidippus f. *chersias*	1	UMT/116/2012
	Amathusia phidippus phidippus f. *gunneryi*	2	UMT/129/2012
	Amathusia sp.	4	UMT/100/2012
	Amathuxidia amythaon dilucida	4	UMT/31/2012
	Amathuxidia sp.	1	UMT/37/2012
	Discophora sondaica despoliata	2	UMT/40/2012
	Discophora timora perakensis	2	UMT/128/2012
	Faunis canens arcesilas [syn. *tarakí*]	6	UMT/177/2012
	Faunis gracilis	1	UMT/178/2012
	Faunis kirata	1	UMT/179/2012
	Thaumantis klugius lucipor	1	UMT/48/2012
	Thaumantis noureddin noureddin	2	UMT/192/2012
	Zeuxidia amethystus amethystus	2	UMT149/2012
	Zeuxidia doubledayi doubledayi (syn. *chersonesia*)	4	UMT/150/2012
	Zeuxidia sp.	1	UMT/151/2012
Limenitidinae	*Athyma nefte subrata (*syns. *urvasi*; *nivifera*)	2	UMT/39/2012
	Athyma pravara helma	1	UMT/49/2012
	Athyma reta moorei	1	UMT/167/2012
	Athyma sinope sinope	1	UMT/166/2012
	Bassarona teuta goodrichi (syn. *johorensis*)	1	UMT/76/2012
	Euthalia phemius phemius (syns *ipona*; *corbeti*)	1	UMT/104/2012
	Euthalia kanda marana	2	UMT/190/2012
	Euthalia merta (syn. *simplex*)	2	UMT/137/2012
	Euthalia monina monina (syn. *ramada*; *perakana*)	5	UMT/138/2012
	Lasippa heliodore dorelia	2	UMT/20/2012
	Lasippa tiga camboja	2	UMT/50/2012
	Lebadea martha malayana (syn. *koenigi*)	1	UMT/51/2012
	Lexias canescens pardalina	3	UMT/52/2012
	Lexias cyanipardus sandakana (syn. *johorensis*)	3	UMT/53/2012
	Lexias dirtea merguia (syn. *maga*)	114	UMT/28/2012
	Lexias pardalis dirteana (syn. *erici*)	95	UMT/103/2012
	Neptis cliniodes gunongensis	1	UMT/126/2012
	Neptis duryodana neisa	1	UMT/63/2012
	Neptis hylas papaja (syn. *mamaja*)	1	UMT/125/2012
	Neptis leucoporos cresina	1	UMT/152/2012
	Neptis magadha charon	1	UMT/41/2012
	Neptis nata gononata	1	UMT/42/2012
	Neptis omeroda omeroda	1	UMT/46/2012
	Neptis soma pendleburyi	1	UMT/127/2012
	Tanaecia aruna aruna (syns. *robertsii*, *satapana*)	8	UMT/47/2012
	Tanaecia flora flora (syn. *maclayi*)	1	UMT/71/2012
	Tanaecia godartii picturatus	5	UMT/72/2012
	Tanaecia iapis puseda (syn. *cocyta*)	6	UMT/73/2012
	Tanaecia munda waterstradti	5	UMT/74/2012
	Tanaecia palguna consanguinea	9	UMT/45/2012

Taxon	Scientific name	No. of individuals	Voucher code
	Tanaecia pelea pelea (syns. *pulsara*; *supercilia*)	4	UMT/56/2012
Heliconiinae	*Cethosia hypsea hypsina*	2	UMT/153/2012
	Cirrochroa orissa orissa	1	UMT/139/2012
	Vindula erota chersonesia	1	UMT/187/2012
Nymphalinae	*Chersonesia rahria rahria*	1	UMT/38/2012
	Cyrestis themire themire (syn. *periander*)	1	UMT/176/2012
	Dophla evelina compta	9	UMT/136/2012
	Hypolimnas bolina bolina	1	UMT/44/2102
	Hypolimnas anomala anomala	1	UMT/29/2012
	Junonia atlites atlites	1	UMT/55/2012
	Junonia iphita horsfieldi	1	UMT/82/2012
	Junonia orithya wallacei	7	UMT/83/2012
Satyrinae	*Elymnias saueri saueri*	1	UMT/105/2012
	Elymnias hypermnestra tinctoria	3	UMT/106/2012
	Elymnias nesaea lioneli	1	UMT/107/2012
	Melanitis leda leda	2	UMT/108/2012
	Mycalesis fuscum fuscum	3	UMT/109/2012
	Mycalesis horsfieldi hermana	2	UMT/110/2012
	Mycalesis distanti	2	UMT/19/2012
	Mycalesis maianeas maianeas	1	UMT/43/2012
	Mycalesis mineus macromalayana	3	UMT/54/2012
	Mycalesis mnasicles perna	1	UMT/124/2012
	Mycalesis orseis nautilus	1	UMT/140/2012
	Mycalesis perseoides	1	UMT168/2012
	Mycalesis sp.	1	UMT/169/2012
	Neorina lowii neophyte	1	UMT/197/2012
	Ragadia makuta siponta	19	UMT/102/2012
	Xanthotaenia busiris busiris	1	UMT/64/2012
	Ypthima newboldi	77	UMT/65/2012
	Ypthima fasciata torone	4	UMT/66/2012
	Ypthima heubneri	39	UMT/67/2012
	Ypthima horsfieldii humei	2	UMT/68/2012
	Ypthima pandocus corticaria (syn. *emporialis*)	25	UMT/69/2012
	Ypthima pandocus tahanensis	3	UMT/70/2012
Danainae	*Danaus melanippus hegesippus*	1	UMT/90/2012
	Euploea mulciber mulciber	1	UMT/195/2012
	Euploea radamanthus radamanthus (syn. *diocletianus*)	4	UMT/196/2012
	Idea hypermnestra linteata	6	UMT/198/2012
	Ideopsis similis persimilis	1	UMT/154/2012
	Ideopsis vulgaris macrina	1	UMT/155/2012
Apaturinae	*Rohana parisatis siamensis*	1	UMT/189/2012
Papilionidae			
Papilioniae	*Graphium agamemnon agamemnon*	1	UMT/26/2012
	Graphium antiphates alcibiades (syn. *itamputi*)	1	UMT/94/2012
	Graphium eurypylus mecisteus	1	UMT/91/2012

Taxon	Scientific name	No. of individuals	Voucher code
	Graphium evemon eventus (syn. *orthia*)	1	UMT/92/2012
	Graphium sarpedon luctatius	1	UMT/93/2012
	Losaria doubledayi doubledayi	1	UMT/121/2012
	Losaria neptunus neptunus	1	UMT/122/2012
	Papilio demolion demolion	2	UMT/180/2012
	Papilio iswara iswara	2	UMT/182/2012
	Papilio memnon agenor	1	UMT/181/2012
	Graphium antiphates alcibiades (syn. *itamputi*)	1	UMT/94/2012
	Trogonoptera brookiana albescens	3	UMT/188/2012
Pieridae			
Pierinae	*Appias indra plana*	1	UMT/194/2012
	Appias lyncida vasava	7	UMT/142/2012
	Appias paulina distanti	1	UMT/143/2012
	Delias hyparete metarete	3	UMT/27/2012
Coliadinae	*Catopsilia pomona pomona*	2	UMT/141/2012
	Eurema ada iona	22	UMT/87/2012
	Eurema andersonii andersonii	16	UMT/88/2012
	Eurema blanda blanda (syn. *snelleni*)	11	UMT/89/2012
	Eurema hecabe hecabe (syn. *contubernalis*)	2	UMT/86/2012
	Eurema lacteola lacteola	13	UMT/62/2012
	Eurema sari sodalis	14	UMT/84/2012
	Eurema simulatrix tecmessa	10	UMT/85/2012
	Eurema nicevillei nicevillei	14	UMT/112/2012
	Gandaca harina distanti	10	UMT/123/2012
	Parenonia valeria lutescens	3	UMT/111/2012
	Saletara panda distanti	2	UMT/25/2012
Total	Species= 198	939	

indicates high species presence in the study site. Figure 2 summarizes the rank abundance curve for six butterfly families at Chemerong which showed that most of the butterfly species from different families were low ranking species where the number of individuals caught were nearly similar with majority of the butterfly species categorized in low ranking species (106 species or 53.5%) being singletons.

Five species of butterfly were ranked as high-ranking species or dominant species namely *Lexias dirtea merguia* (syn. *maga*), *Lexias pardalis dirteana, Ypthima newboldi, Cephrenes acalle niasicus, Ypthima heubneri, Ypthima pandocus corticaria*, *Eurema ada iona*, and *Ragadia makuta siponta*. These dominant species contributed 48% (456 individuals) of the total individuals caught in this study.

DISCUSSION

The dominancy by the family Nymphalidae may be due to the generally diverse group of butterfly species in this family. The Nymphalidae contains 7,200 species occurring in all habitats and continents except Antarctica (DeVries 1987; Shields 1989), with 281 species recorded in Malaysia (van der Poorten & van der Poorten 2020). In addition, the use of fruit baits as attractants such as rotting banana, papaya, apple, orange and pineapple were found to successfully attract the *Lexias* butterflies which contributed 22.9% of the total individuals caught in this study. This was supported by Owen (1975), who reported that the baits were effective only for certain genera.

Furthermore, the usage of rotten fruits especially banana as bait have been practiced by many researchers to trap fruit-feeding butterflies (e.g., Hamer et al. 2006;

Barlow et al. 2007; Bonebrake & Sorto 2009; Sáfián et al. 2010). As the strong odour of fermenting fruits can likely be detected at long distances, and in forest environments, it probably forms a reliable cue for locating a fruit fall by these species (Molleman et al. 2005).

In addition, as Nymphalidae is categorized under the fruit-feeding butterflies' guild, the usage of rotten fruits as bait was felicitous which was manifested through the high number of captured individuals and species. However, although fruit-feeding butterflies are defined as those species attracted to fruit bait, this does not mean that fruits are the main food source for all the species in this guild (Molleman et al. 2005). For instance, most tropical Satyrinae are exclusively fruit-feeders, but Charaxinae and Apaturinae are attracted to both fruit and rotting animal matter and excrement (Fermon et al. 2000). Furthermore, fruit-feeding butterflies (including nymphalids) are among the longest-lived Lepidoptera (Molleman et al. 2008). Therefore, longevity and ability to exploit various food resources may be the reasons why family Nymphalidae was the dominant family in this study.

Besides *Lexias* species, a high number of *Cephrenes acalle niasicus* was also caught in this study. One of the reasons which may have contributed to this might be due to the landscape of the study site where ornamental plants such as the Poison bulb *Crinum asiaticum* and White buttercup *Turnera subulata* were planted at the garden area around the visitor complex. These ornamental plants were some of the plants observed to be frequently visited by many butterfly species and eventually contributed to the ease in capturing *C. accelle* and other fast flyer butterfly species.

Other vegetation structures such as meadows, shrubs, grass and lower ground plants were found to be frequently visited by some butterfly genera, namely: *Ypthima, Eurema, Jamides*, and *Zizeeria*. These butterflies were easily captured at areas close to ground as they obtained protection from winds because of their weaker flight ability. In addition, open areas which offer more light penetration is deemed one of the most visited area by the butterflies to bask under the sun for energy (Van Lien & Yuan 2003). This is proven that, although the developed area and garden area is limited, the occurrence of various surrounding landscape with an array of flora is believed to serve as important habitats for different butterfly species (Asmah et al. 2016; Toivonen 2017).

There were eight species of butterflies categorized as protected under Malaysian legislation, the Wildlife Conservation Act 2010 which were recorded in this study namely *Agatasa calydonia calydonia* (Glorious Begum), *Charaxes athamas athamas* (Common Nawab), *Charaxes athmamas uraeus*, *Charaxes bernadus crepax* (Tawny Rajah), *Charaxes echo echo*, *Idea hypermnestra linteata* (Malayan Tree Nymph), *Prothoe franck uniformis* (Blue Begum), and *Trogonoptera brookiana albescens* (Rajah Brooke).

For *Agatasa calydonia calydonia* (Glorious Begum), it is also considered to be rare in the Malay Peninsula. The two individuals recorded in this study were females and was captured using fruit bait. As for the *Charaxes* recorded, all were singletons except for *C. bernadus crepax* (2 individuals). All individuals were males, and were caught using fruit baits as they are difficult to capture while in flight.

For *Idea hypermnestra linteata* (Malayan Tree Nymph), this species was only seen at some specific trees in the sampling site. Additionally, based on our observation, they are commonly found to be in a group and were caught during mating. Due to their rarity, we speculate that the abundance of this species may depend on its host distribution. Furthermore, the life cycle of this species might also contribute to its rare occurrence as the adults naturally die after laying eggs. Although *I. hypermnestra linteata* has relatively slow flight abilities (Otsuka 2001), it was not an easy task to capture them as they can fly up to very tall trees.

As for *Prothoe franck uniformis* (Blue Begum), 11 individuals of this species were caught during our study with most caught being females (n= 9). Based on our observation, they are strongly attracted to the fruit bait, which is in agreement with Corbet & Pendlebury (1992) whom reported the females to be often seen on fruit bait or on sap from a damaged tree trunk.

The *Trogonoptera brookiana albescens* (Rajah Brooke) population have been reported to be plunging, but the exact status of the population is unknown (Phon & Kirton 2010). The species was rarely observed in this study and only the males were captured. This is since only the males exhibited puddling behaviour by which they tend to aggregate at moist places along forest paths and riverbanks to drink water from which nutrients are obtained (Phon & Kirton 2010). The females by contrast, are forest dwellers and can only be sighted during mating season. This sex disparity is supported by Corbet & Pendlebury (1992). This species is also listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II where the trade in this species is closely regulated.

This study also recorded other rare species such as *Arhopala lucida*, *Curetis saronis sumatrana*,

Miletus nymphis fictus of the family Lycaenidae (the blues, coppers, & hairstreaks), *Amathusia perakana perakana*, *Bassarona teuta goodrichi*, *Elymnias saueri saueri*, *Elymnias nesaea*, *Mycalesis horsfieldi hermana*, *Mycalesis distanti*, *Ypthima pandocus tahanensis* of the family Nymphalidae (the brush-footed or four-footed), *Celaenorrhinus ladana*, *Erionota sybirita*, *Matapa aria*, *Matapa cresta*, *Matapa druna*, *Pseudokerana fulger*, *Taractrocera ardonia*, *Taractrocera luzonensis*, *Telicota linna*, and *Unkana mytheca mytheca* of the family Hesperiidae (the skippers).

Although both *Arhopala lucida* and *Bassarona teuta goodrichi* are common in Langkawi but they are considered to be rare in the Malay Peninsula (van der Poorten & van der Poorten 2020). Similarly, the two *Mycalesis* species are listed as rare, being uncommon to other parts of the Malay Peninsula although *M. horsfieldi hermana* is found in the Tioman group of islands and along the east coast of Johor while *M. distanti* is more common in Kedawi. *Telicota linna* is another species listed as not common to the Malay Peninsula.

For montane species, *Miletus nymphis cresta* is recorded as a rare montane species while *Ypthima pandocus tahanensis* was recorded from Gunung Tahan at elevation of 1650m (van der Poorten & van der Poorten 2020). *Pseudokerana fulgur* restricted to Neomalaya, is another very rare species which is usually observed in the hills.

As for *Amathusia perakana perakana*, it is a rare species that is only found in primary forest while *Erionata sybirita* and *Unkana mytheca mytheca* are very rare species that are confined in lowland forest. For both *Elymnias saueri saueri* and *Elymnias nesaea*, these are rare species that are restricted to heavy forest as their habitat (van der Poorten & van der Poorten 2020).

For the *Matapa* species, *M. aria* (Common Redeye) is listed by van der Poorten & van der Poorten (2020) as being not common in the Malay Peninsula, occurring in lowland primary and secondary forests, while *M. cresta* and *M. druna* are rare in the Malay Peninsula lowlands.

As for the other rare species, according to van der Poorten & van der Poorten (2020), *Curetis saronis sumatrana* has only been recorded on the edges of mangrove swamps in Singapore, while *Celaenorrhinus ladana* is very rare with its recorded range being only the Malay Peninsula and Borneo. Both *Taractrocera ardonia* and *T. luzonensis* are also rarely recorded in the Malay Peninsula.

Two major factors are believed to impose great pressure on butterfly populations, namely, habitat loss and an extraordinarily high demand for butterflies by collectors and commercial dealers (Phon & Kirton 2010), especially for *T. brookiana albescens*. Habitat loss due to timber industries and conversion of extensive area of natural forest for agricultural activities and urbanization, shrink the habitat as well as diminish the host and nectar-plants of this and many other butterfly species.

Comparison of the Shannon-Weiner index results for this study with Kuala Lompat which consists of primary forest located in the Krau Wildlife Reserve, Pahang showed that the diversity of butterfly species in Chemerong Amenity Forest (*H'*= 4.1) was higher than Kuala Lompat (*H'*= 3.87) (Nur Afny Syazwany & Amirrudin, 2014) (*H'*= 3.37) and (*H'*= 3.37) (Zaidi & Abin 1991). Furthermore, the results of butterfly diversity recorded in the Chemerong Amenity Forest (939 individuals from 198 species) were also highest as compared to other study sites in Malaysia namely Gunung Serambu, Sarawak (377 individuals from 97 species) (Pang et al. 2016), Ulu Gombak Forest Reserve, Selangor (194 individuals from 28 species) (Min 2014), Setiu Wetlands, Terengganu (350 individuals from 45 species) (Tamblyn et al. 2006), Kuala Lompat, Pahang (302 individuals from 90 species) (Nur Afny Syazwany & Amirrudin 2014), Bukit Hampuan Forest Reserve, Sabah (42 species) (Chung et al. 2013), Sungai Imbak Forest Reserve, Sabah (174 species) (Jalil et al. 2008), Tabin Wildlife Reserve (136 species) (Akinori et al. 2001) and Ulu Senagang Substation (147 species) (Haruo et al. 2012) yet lower than what was recorded from Genting Highlands, Pahang (2,876 individuals from 214 species) (Min 2014) and Taman Negara Johor Endau Rompin (349 species).

Based on the comparison with other studies, the Chemerong Amenity Forest environment can accommodate more diverse species of butterflies. This can be proven if the sampling period was extended and the study site not only focuses on the lowlands (not more than 200 m above sea level) but includes different elevations (more than 200m above sea level). Nevertheless, Chemerong can be considered as pristine forest and the introduction of certain ornamental plants in the garden area plays an important role as attractant for the various species of butterflies such as *Papilio memnon agenor*, *Catopsilia pomona pomona*, and many Hesperiidae butterflies.

Conclusion and Recommendations

In general, short-term sampling with limited manpower and equipment was considered satisfactory, although it only provides a snapshot of the butterfly community present in the Chemerong Amenity Forest. The presence of endangered butterfly species which are

protected under the Malaysian Wildlife Conservation Act 2010 increases the conservation value of the Chemerong Amenity Forest as a forest reserve in Malaysia. A much longer term sampling is strongly recommended to further observe and examine butterfly species at different elevations, across different seasonality and years, as well as further exploration of forest canopy to reveal more species in that stratum. The rapid loss of primary forest habitats and the growth of oil palm plantations in many areas of Malaysia as well as in the state of Terengganu underline the urgency with which this work needs to be undertaken.

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