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# DIVERSITY OF LEPIDOPTERA AT R.E.A.C.H BIOD CENTRE, CAMERON HIGHLANDS, MALAYSIA

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## ABSTRACT

Lepidopteran diversity at the16-years old rehabilitated forest that surrounds the R.E.A.C.H BioD Centre was studied from July to August 2016. This forest is currently maintained by the Regional Environmental Awareness Cameron Highlands (R.E.A.C.H), a non-governmental organization (NGO) established by local residents of the Cameron Highlands. The 50 hectares forest with more than 9000 planted trees is located at $4^0$ 31'12.2'' N, $101^0$ 23'40.1''E with elevation of 1781m a.s.l. Order Lepidoptera comprises the day-flying butterflies and night-flying moths. Hence, butterflies were recorded using ten butterfly traps and manual catchment using an aerial net, while moths were recorded using two light traps. A total of 11 butterfly species (four families) and 48 moth species (ten families) were recorded during the 24 days of sampling. Moths were recorded with higher diversity (81.4%; H'=3.22) compared to butterflies (18.6%; H'=2.15). Both butterflies and moths are distributed evenly at the R.E.A.C.H BioD Centre as the Pielou's evenness index (J) is 0.90 and 0.83 respectively. As the forest surrounding the R.E.A.C.H BioD Centre is a rehabilitated forest, the presence of lepidopterans in the forest proves that the rehabilitation effort is achieving its objective. This is in line with previous studies that have proven that lepidopterans are a good bioindicator of healthy forest ecosystem. Due to unavailability of previous data on lepidopterans diversity before the rehabilitation activity, this study is only able to show that the trees planted through the rehabilitation program are successful in attracting lepidopterans species to the forest. The species might be from the nearest forest, probably Gunung Brinchang, as the BioD Centre situated at the edge of Gunung Brinchang. This is proved by data obtained in this study, as most of the collected lepidopterans are forest species. Further diversity studies need to be conducted biannually at the forest to identify changes in lepidopterans diversity and abundance.

**Keywords**: Butterfly, moth, rehabilitated forest, R.E.A.C.H, Cameron Highlands

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## INTRODUCTION

Lepidoptera (butterflies and moths) is one of the most prevalent terrestrial orders, and perform essential ecosystem services such as decomposition, nutrient cycling, pollination and providing prey for passerine birds (Jaroensutasinee *et al.*, 2011). Butterflies and moths are grouped together because they are very closely related. The word Lepidoptera, which means scaly wings, originates from Greek, where *'lepido'* means scale and *'ptera'* means wings. The meaning arises from one of their major features, namely having wings covered in tiny scales. Butterflies are monophyletic groups but moths are paraphyletic groups within the Lepidoptera (Bartlett, 2004).

The distribution of Lepidoptera will decrease when there is disturbance in the environment. Many researchers use Lepidoptera as a model organism to assess the impacts of human and pollution disturbance and management practices of the forest ecosystem (Kristensen *et al.*, 2007; Pyrcz *et al.*, 2009; Elanchezhian *et al.*, 2014). This has led to the recognition of Lepidoptera as a bioindicator for ecosystem health (Patrick, 2007).

The diversity of Lepidoptera depends on the adaptability of a species to a particular habitat as the most significant biological elements of an ecosystem are through the dimension, diversity of species and population size (Kumar, 2013). Factors such as humidity, wind, rainfall and temperature at the area have a great impact on the distribution and population size as well as the rate of development of Lepidoptera, as this community has a great sensitivity to environmental changes (Bartlett, 2004).

Cameron Highlands is one of Malaysia's vast hill station located in Pahang state at 1,829 m above sea level (Tourism Pahang Malaysia, 2017). Cameron Highlands is rich in diversity of fauna, for example 54 species of beetles, 13 species of bats

and five species of non-flying small mammals have been recorded (Shahfiz *et al*., 2008; Abdullah *et al*., 2011). Unfortunately, due to its popularity with tourist and visitors, the forests are facing destruction that has occurred over the years, and the mountain is still reeling from the effects of pollution and over collection of flora and fauna (Abdullah *et al.*, 2011).

A local NGO named Regional Environmental Awareness Cameron Highlands, generally known as R.E.A.C.H, was started by local residents in 1990. Due to deep concern about forest conservation around Cameron Highlands, a reforestation project was conducted in 2001 with the support of Forestry Department (Melati, 2009). In 2012, R.E.A.C.H set up a biodiversity centre (known as R.E.A.C.H BioD Centre) at the reforestation site on a ridge in Gunung Brinchang, Cameron Highlands for the purpose of research and environmental education. This centre is surrounded by a 50 hectares rehabilitated forest. Previously, this site was cleared for agricultural activities and was reforested by R.E.A.C.H members and a group of volunteers using more than 9000 local tree species such as *Eugania* spp., Gerok, tree fern and *Rhododhendron* spp. (R.E.A.C.H, 2016). The key objective of this centre is to conserve the flora and fauna around the biodiversity centre and provide an opportunity for scientific research while raising public awareness. This study aimed to determine the diversity of the Lepidoptera fauna at the R.E.A.C.H BioD Centre because this order is a good bioindicator for a healthy ecosystem.

## METHODOLOGY

### Study site

Lepidoptera sampling at the R.E.A.C.H BioD Centre, Cameron Highlands (4˚31'12.2"N, 101˚ 23'40.1"E) was conducted from July to August 2016 for 24 days. The surrounded forest is a 16 years old rehabilitated forest located at the ridge of Gunung Brinchang with an elevation of 1781 m above sea level (R.E.A.C.H, 2016). This area was rehabilitated with more than 9000 endemic and local trees such as Gerok, tree ferns, *Eugenia* spp., *Rhododendron* spp., *Nepenthes* spp., *Arundina* spp. and *Baeckea* spp. (R.E.A.C.H, 2016). The study site has two trails, 380 m and 350 m in length respectively from the base camp.

### Butterfly sampling

A 300 m of line transect was set up at each trail of the forest. An aerial net and butterfly traps were used to sample the butterflies. Butterflies were collected along the transect using an aerial net from 0900 hrs to 1700 hrs (Nur Afny &

Amiruddin, 2014; Cheng *et al*., 2015). Butterfly traps were set up along the same transect at 50-m intervals. Traps containing a mixture of anchovies, shrimp paste and banana were hung on tree branches as bait. This bait was chosen due to its strong odor to attract the butterflies. The trapped butterflies were collected every afternoon and evening. Collected butterflies from both the aerial net and butterfly traps were kept in triangle paper for further identification.

**Moth sampling**

As the attraction of light traps decreases with distance and is low at distances exceeding 20 m (Kumar, 2013), two light traps (using white sheets) were set up with 500-m interval at two different locations along the trails of the forest. Moth sampling was conducted at the peak of moth activity, the dusk (Kristensen *et al*., 2007) between 1900 hrs to 2300 hrs. Moths that were attracted to the light trap and perched on the white sheet were collected by hand and kept in triangle paper for further identification.

**Preservation and Identification**

The preservation and identification of specimens was conducted at Universiti Malaysia Kelantan (UMK), Jeli Campus. Both butterflies and moths were dry preserved following the method of Holloway *et al*. (1987). All Lepidoptera specimens were identified using available identification keys such as Barlow *et al.* (1982), Holloway *et al.* (1987) and Carter (1992) for moths and Johnson and Triplehorn (2004), Laurence (2014) and Wijeyeratne (2015) for butterflies. Morphological characteristics such as antennae shape, forelegs, wing patterns and wing shape were observed in detail for the identification. Collected lepidopterans were deposited in the Natural Resource Museum, UMK, Jeli Campus.

**Data analysis**

The collected data were analyzed using a species accumulation curve to determine whether sufficient data had been collected. Diversity indices such as Shannon-Wiener diversity index (H') and Pielou's Evenness index (J) were used to identify the diversity status and evenness of the recorded lepidopterans.

## RESULTS AND DISCUSSION

### Lepidoptera Assemblage

A total of 11 butterfly and 48 moth species were recorded in this study. The species accumulation curve (Figure 1) indicates that the estimated species richness at the study sites is asymptotic, suggesting that the 24 days of lepidopterans collection at forest surrounded R.E.A.C.H BioD Centre is sufficient to determine the diversity of lepidoptera. Butterflies from four families were recorded, namely Hesperiidae, Lycaenidae, Nymphalidae and Pieridae (Table 1). The collected moths were comprised of 10 families namely, Arctiidae, Bombycidae, Drepanidae, Erebidae, Geometridae, Noctuiidae, Nolidae, Saturniidae, Sphingidae and Uraniidae (Table 2).

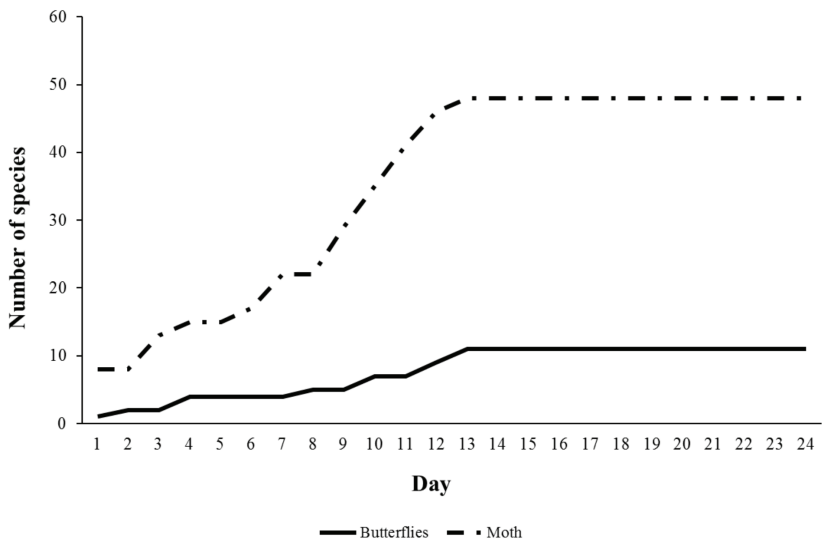


**Figure 1** Species accumulation curve of collected lepidopterans at R.E.A.C.H BioD Centre.

**Table 1** Distribution of butterfly species encountered according to family at R.E.A.C.H BioD Centre.

| Family | Species | No. of individual |
|---|---|---|
| Hesperiidae | *Notocrypta paralysos* | 1 |
| Hesperiidae | *Potanthus omaha* | 1 |
| Lycaenidae | *Heliophorus epicles* | 2 |
| Lycaenidae | *Jamides caeruleus* | 1 |

*cont. Table 1*

| Family | Species | No. of individual |
|---|---|---|
| Lycaenidae | *Udara akasa* | 7 |
| Lycaenidae | *Zizina otis* | 2 |
| Nymphalidae | *Kaniska canace* | 1 |
| Nymphalidae | *Melanocyma faunula* | 5 |
| Nymphalidae | *Parantica sita* | 2 |
| Nymphalidae | *Sumalia daraxa belliatus* | 1 |
| Pieridae | *Eurema hecabe* | 4 |
| **Total=4** | **Total = 11** | **Total = 27** |

**Table 2** Distribution of moth species encountered according to family at R.E.A.C.H BioD Centre.

| **Family** | **Species** | **No. of individual** |
|---|---|---|
| Arctiidae | *Nyctemera adversata* | 1 |
| Arctiidae | *Nyctemera tripunctaria* | 6 |
| Arctiidae | *Vamuna remelana* | 4 |
| Bombycidae | *Comparmustilia semiravida* | 1 |
| Drepanidae | *Callidrepana albiceris* | 1 |
| Erebidae | *Orvasca subnotata* | 2 |
| Erebidae | *Tamba lala* | 1 |
| Geometridae | *Alcis maculata* | 1 |
| Geometridae | *Cleora determinata* | 1 |
| Geometridae | *Cleora pendleburyi* | 2 |
| Geometridae | *Fascellina meligerys* | 1 |
| Geometridae | *Fascellina castanea* | 1 |
| Geometridae | *Hypomecis separata* | 5 |
| Geometridae | *Lassaba acribomena* | 2 |
| Geometridae | *Lomographa luciferata* | 1 |
| Geometridae | *Luxiaria hyalodela* | 2 |
| Geometridae | *Mesotrophe curtisi* | 1 |
| Geometridae | *Myrioblephara simplaria* | 1 |
| Geometridae | *Organopoda acmaea* | 1 |
| Geometridae | *Ornithospila bipunctata* | 2 |
| Geometridae | *Ornithospila succincta* | 1 |
| Geometridae | *Ornithospila sundaensis* | 1 |
| Geometridae | *Orothalassodes hypocrites* | 1 |

*cont. Table 2*

| | | |
|---|---|---|
| Geometridae | *Ourapteryx claretta* | 2 |
| Geometridae | *Plutodes costatus* | 1 |
| Geometridae | *Pogonopygia nigralbata* | 2 |
| Geometridae | *Pogonopygia pavida xanthura* | 7 |
| Geometridae | *Racotis inconclusa* | 1 |
| Geometridae | *Tristeirometa curvistriga* | 1 |
| Geometridae | *Xenoplia contrasqualida* | 1 |
| Noctuiidae | *Artena dotata* | 1 |
| Noctuiidae | *Callopistria* sp. | 6 |
| Noctuiidae | *Elusa ceneusalis* | 1 |
| Noctuiidae | *Ercheia pulchrivenula* | 1 |
| Noctuiidae | *Erygia* sp. | 1 |
| Noctuiidae | *Lignispalta incertissima* | 1 |
| Noctuiidae | *Ophiusa trapezium* | 1 |
| Noctuiidae | *Parallelia calefaciens* | 1 |
| Noctuiidae | *Sasunaga interrupta* | 2 |
| Noctuiidae | *Spodoptera pecten* | 1 |
| Noctuiidae | *Thyas coronata* | 1 |
| Noctuiidae | *Thyas javanica* | 2 |
| Noctuiidae | *Trachea auriplena* | 1 |
| Nolidae | *Tyana marina* | 1 |
| Saturniidae | *Cricula trifenestrata* | 1 |
| Saturniidae | *Samia cynthia* | 1 |
| Sphingidae | *Cechenena lineosa* | 1 |
| Uraniidae | *Lyssa menoetius* | 2 |
| **Total = 10** | **Total = 48** | **Total = 81** |

Lepidopterans in family Nymphalidae, Lycaenidae, Pieridae, Hesperiidae, Papilionidae, Geometridae and Noctuiidae are commonly found in Peninsular Malaysia (Barlow & Woiwod, 1989; Chey, 2010; Norela *et al*., 2010; Norashikin *et al*., 2014; Nur Afny & Amirrudin, 2014). This study site has been replanted as a reforestation effort. Thus, the lepidopteran species is starting to inhabit the forest as they migrate into the forest and are able to adapt to the new surroundings. The results showed that butterfly families Lycaenidae (4 species) and Nymphalidae (4 species) (butterfly) along with moth families Geometridae (21 species) and Noctuiidae (13 species) (moth) are the most dominant here.

In comparison, Lojing Highlands (Norela *et al*., 2008), which has similar elevation to the R.E.A.C.H BioD Centre recorded a higher number of butterfly species (27 species) and a lower number of moth species (29 species) than the R.E.A.C.H BioD Centre (11 species and 48 species respectively). This difference may be due to the limited duration of the sampling period and area covered in the previous studies compared to the current study. Other than that, the forest surrounding the R.E.A.C.H BioD Centre is only a 16-years old forest sited in land previously cleared for agricultural activities. Thus, this comparison shows that this forest is successful in attracting insect fauna, especially butterflies and moths, and provides a suitable habitat for insect fauna.

**Diversity Analysis of Lepidoptera**

Diversity of lepidoptera can be used as a measure for monitoring the health of forest ecosystems (Patrick, 2007). Studying particular insect species or community in degraded areas can indicate which parts of the ecosystem have been degraded, and the rehabilitation of such parts can be monitored (Holloway, 1984). Identification of species abundance supports this monitoring effort. Species abundance is the number of individuals observed in each encountered species within a community (Iwasaki, 2010; Verberk, 2011). In this study, the abundance was calculated based on the number of individuals sampled for each species.

Butterflies recorded a total number of 27 individuals while moths had 81 individuals. Among four butterfly families, Lycaenidae recorded the highest abundance with 12 individuals and the lowest was Hesperiidae with 2 individuals (Figure 2). *Udara akasa* from family Lycaenidae dominated the butterfly assemblage with 7 individuals. This is because this is a highland species common in open vegetation (Laurence, 2014). This species is fast-flying and reacts to any movement that disturbs its habitat.

The moth families were dominated by Geometridae with 40 individuals, with the least abundance found in Bombycidae, Drepanidae, Nolidae and Sphingidae with one individual each (Figure 3). The most abundant moth species at this site is *Pogonopygia pavida xanthura* from family Geometridae with 7 individuals. In terms of abundance, diversity of Lepidoptera at this site was found to be low in abundance because most of the species recorded (Table 1 & 2) consist of the least number of individuals. This is because some species of Lepidoptera are apparently restricted to particular forest types correlated with a climatic regime. Some others may be constricted by geographical boundaries and may reflect by the distribution of their host plants (Barlow & Woiwod, 1989).

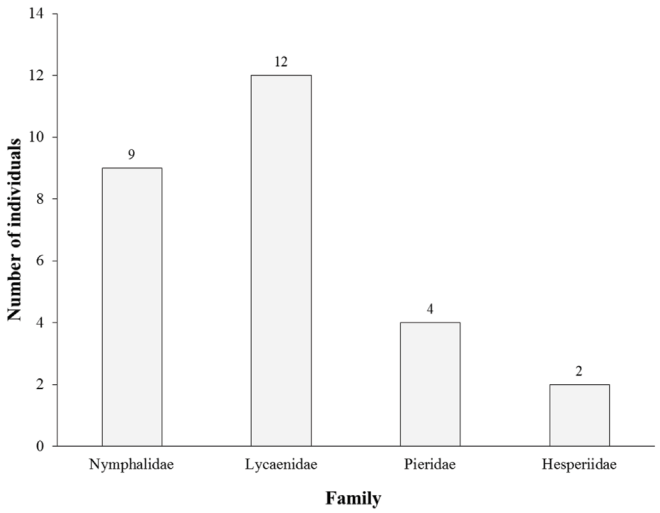


**Figure 2** Number of individuals in each family of the recorded butterflies at R.E.A.C.H. BioD Centre.

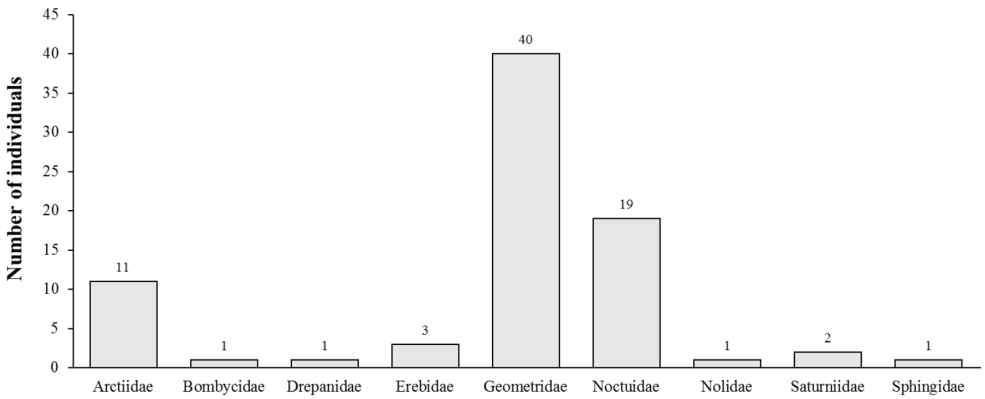


**Figure 3** Number of individuals in each family of the recorded moths at R.E.A.C.H. BioD Centre.

The Shannon-Wiener Diversity Index (H') analysis for butterflies species gives a value of 2.15 ($H'_{max}$ = 2.4). Meanwhile, H' for moths species is 3.22 ($H'_{max}$ = 3.87). On the other hand, the value for Pielou's Evenness Index (J) butterfly and moth are 0.90 and 0.83 respectively with a range of 0 to 1 where the value nearer to 1 shows higher evenness. These analyses indicate that the diversity of Lepidoptera at the forest is high and evenly distributed. The diversity is high due to the availability of food resources in the forest for Lepidopterans that consume

plants in early successional stage (larva) and also adult. The Lepidopterans are evenly distributed as the number of individuals recorded per species shows almost no significant variation, as stated in Table 1 and Table 2.

This study shows planted trees species have successfully attracted the lepidopteran species to R.E.A.C.H BioD Centre. The species might be attracted from the nearest forest, Gunung Brinchang, as most of the collected lepidopterans are forest species. It can be explained that the diversity of lepidoptera found at the disturbed sites might be due to the role of immigrating species from adjacent intact forest and the suitability of secondary forest remnants as habitats (Chey *et al*., 1997).

The composition and diversity of Lepidoptera can be determined through floral diversity at the disturbed sites because their larvae often shows a great specificity to host plants even though their adults can use many kind of flowers as sources of nutrition (Pogue, 2009). For example, most geometrid and noctuid moths are flower feeders that mainly feed on young broadleaf plants (Coley & Barone, 1996). Varied vegetation in the R.E.A.C.H BioD Centre resulted in a more diversified lepidoptera fauna as the plants provide food and space for lepidopterans to inhabit this area.

The vegetation community plays an important role in lepidopteran diversity, abundance and evenness. Changes in vegetation structure and lower plant diversity at higher elevation can cause decline in the number of lepidopterans (Brehm & Fiedler, 1999; Cavieres *et al*., 2000; Pyrcz *et al.*, 2009). In the study area, fruit trees and flowering plants were observed during the sampling. This contributed to the presence of the White hedge blue butterfly (*Udara akasa*) at the BioD Centre. This species was spotted flying and perched on rocks or plants. The Pallid faun butterfly (*Melanocyma faunula*) had five individuals recorded in the study area. These species can be found flying around forest edge habitats or sunny glades. They also have a slow wing beat, but fly rapidly when disturbed (Hoskins, 2012). The third highest species recorded was the Common grass yellow butterfly (*Eurema hecabe*) with four individuals. The Common grass yellow inhabits almost every habitat at all elevations (Laurence, 2014). Mostly, it flutters more closely to the ground. During the middle of the day they tend to avoid the heat of the sun. It flies away quickly when disturbed (Choudhary, 2017).

It is known that collection using a light trap for moths is best conducted during moderate temperatures and not the rainy season as this can affect the moth composition directly or indirectly (Choi, 2008; Okyar *et al*., 2009). During the sampling periods in this study, the irregular rainfall caused the temperature to

drop slightly (17˚C to 15˚C) at night. This caused the light traps less attractive in this study due to the low temperatures. Most of the moth families were recorded with one or two individuals. However, there are certain families of moth, such as Geometridae and Noctuiidae, which can adapt to low temperatures at high altitudes due to their dense scales. They are able to survive at high altitudes (>2000m) with a temperature variation from 15$^{o}$ C to 20$^{o}$ C (Holloway, 1984; Chen *et al*., 2009). Hence, these families showed a high number of individuals in this study.

## CONCLUSION

As the forest surrounding R.E.A.C.H BioD Centre is a rehabilitated forest, the presence of 11 butterfly species and 48 moth species in the forest proved that the rehabilitation effort is achieving its objective. The trees planted in the forest have succeeded in attracting common forest lepidopteran species. The success of the rehabilitation effort is also supported by previous studies that have proven the presence of lepidopterans as bioindicator of a healthy forest ecosystem. However, the unavailability of previous scientific data on lepidopteran diversity before the rehabilitation activity means that a comparison of the species diversity pre and post rehabilitation could not be carried out in this study. The success rate of the rehabilitation programme is also unable to be decided. This study is only able to conclude that the planted trees are successful in attracting butterfly and moth species to the forest. Hence, it is recommended that further diversity studies should be conducted at the R.E.A.C.H. BioD Centre biannualy to identify the changes in lepidopteran diversity and abundance.

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