



INSECT DIVERSITY OF BUKIT HAMPUAN FOREST RESERVE, SABAH, MALAYSIA

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Abstract: An insect diversity survey was carried out at Bukit Hampuan Forest Reserve, adjacent to Kinabalu Park in Sabah, Malaysia. The nocturnal insect diversity was very high, with a mean of 113 species recorded from one square metre of light-trapping cloth. Diurnal insects were sampled using sweep nets and fine forceps. A total of 19 Bornean endemic insect species were recorded, comprising 15 moth and four beetle species. A few of the endemic moths are confined to Sabah, namely *Buzara saikehi*, *Cyana saulia* and *Lyclene mesilaulinea*. Forty-two butterfly species were recorded. Endemic insect species sampled from this survey indicate the significance of protecting and conserving this forest reserve. Such findings provide important data to enhance the need and effort in biodiversity conservation. The recent gazettement of Bukit Hampuan Forest Reserve is appropriate, and it is also recommended that Bukit Hampuan Forest Reserve be connected to the adjacent Kinabalu Park, i.e. to gazette the connecting state land area into a forest reserve. Forest fires, illegal hunting for wild animals and orchids, and agricultural activities are among the threats to Bukit Hampuan Forest Reserve which directly affect its insect diversity. To mitigate these threats, it is important to adopt a multi-disciplinary and participatory approach in a smart partnership involving relevant stakeholders and the local communities in monitoring, enforcement and promoting environmental awareness.

Keywords: Biodiversity conservation, Bukit Hampuan, endemic, Heart of Borneo, Insect diversity.

Bahasa Malaysia Abstract: Satu tinjauan kepelbagaian serangga telah dijalankan di Hutan Simpan Bukit Hampuan, berdekatan dengan Taman Kinabalu di Sabah, Malaysia. Kepelbagaian serangga nokturnal amat tinggi, dengan purata 113 spesies direkodkan dalam satu meter persegi pada kain perangkap lampu. Serangga-serangga diurnal disampel menggunakan jaring sapu dan penyepit halus. Sebanyak 19 spesies serangga yang endemik di Borneo telah direkodkan, merangkumi 15 spesies rama-rama (moth) dan 4 spesies kumbang. Beberapa spesies rama-rama hanya terdapat di Sabah, iaitu *Buzara saikehi*, *Cyana saulia* dan *Lyclene mesilaulinea*. Empat puluh dua (42) spesies kupu-kupu (butterfly) telah direkodkan. Rekod spesies-spesies serangga yang endemik dari tinjauan ini mengesyorkan kepentingan untuk terus melindungi serta memulihara hutan simpan ini. Hasil-hasil kajian ini menyumbang kepada usaha-usaha pemuliharaan kepelbagaian. Perwartaan Hutan Simpan Bukit Hampuan adalah tepat pada masanya. Adalah disyorkan juga hutan simpan ini disambung terus ke Taman Kinabalu, i.e. mewartakan kawasan bukan hutan simpan (stateland) yang menghubungkan hutan simpan berkenaan. Kebakaran hutan, pemburuan haram, pengambilan orkid serta aktiviti-aktiviti pertanian adalah antara ancaman kepada Hutan Simpan Bukit Hampuan, yang secara tidak langsung boleh mempengaruhi kepelbagaian serangga. Untuk mengatasi masalah-masalah ini, adalah penting bagi mengambil pendekatan multi-disiplin serta penyertaan yang melibatkan agensi-agensi yang berkaitan dan penduduk tempatan dalam pengawasan, penguatkuasaan dan juga mempergiatkan kesedaran persekitaran.

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Author Contribution: AYCC, RN & RM participated in this survey. SKFC is an expert on beetles and other montane insects, and he has contributed significantly in identification.

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INTRODUCTION

Malaysia is one of the 12 mega-biodiverse countries in the world, and much attention has been focused on biodiversity conservation (e.g., Yong 2009; CVB 2010). Insects contribute significantly to the high biodiversity of Malaysian rainforests. They are ubiquitous in the environment and play important roles in maintaining the stability of ecosystems by being part of the food chain, mediating decomposition processes and through various ecological interactions such as pollination, predation and herbivory (Cheng & Kirton 2007).

Despite the loss of forest cover in the last 40 years, more than half of the land area in Sabah is still covered with forests (Mannan 2011). The state government, through the Sabah Forestry Department, has been proactive in implementing various programs that contribute to sustainable forest management, such as the Heart of Borneo (HoB) initiative. About 39,000km² of the state's landmass has been set aside for this initiative, mainly comprising important inland and highland forest

ecosystems, with the main objective to protect and conserve the biodiversity of these areas, including insects (Chung et al. 2011). Bukit Hampuan is a recently gazetted forest reserve that lies within the HoB area (Fig. 1).

Under the HoB programme, the purpose of this study was to document the insect fauna of the Bukit Hampuan Forest Reserve (FR) and to investigate the threats affecting insect diversity, as well as to provide recommendations that would contribute towards biodiversity conservation of the study area.

MATERIALS AND METHODS

Bukit Hampuan FR is a Class I Forest Reserve which was only recently gazetted in 2009 (SFD 2010a). It is conserved primarily for environmental protection and biodiversity conservation, protected by law from any form of land conversion or timber exploitation.

In the forest reserve classification, Bukit Hampuan

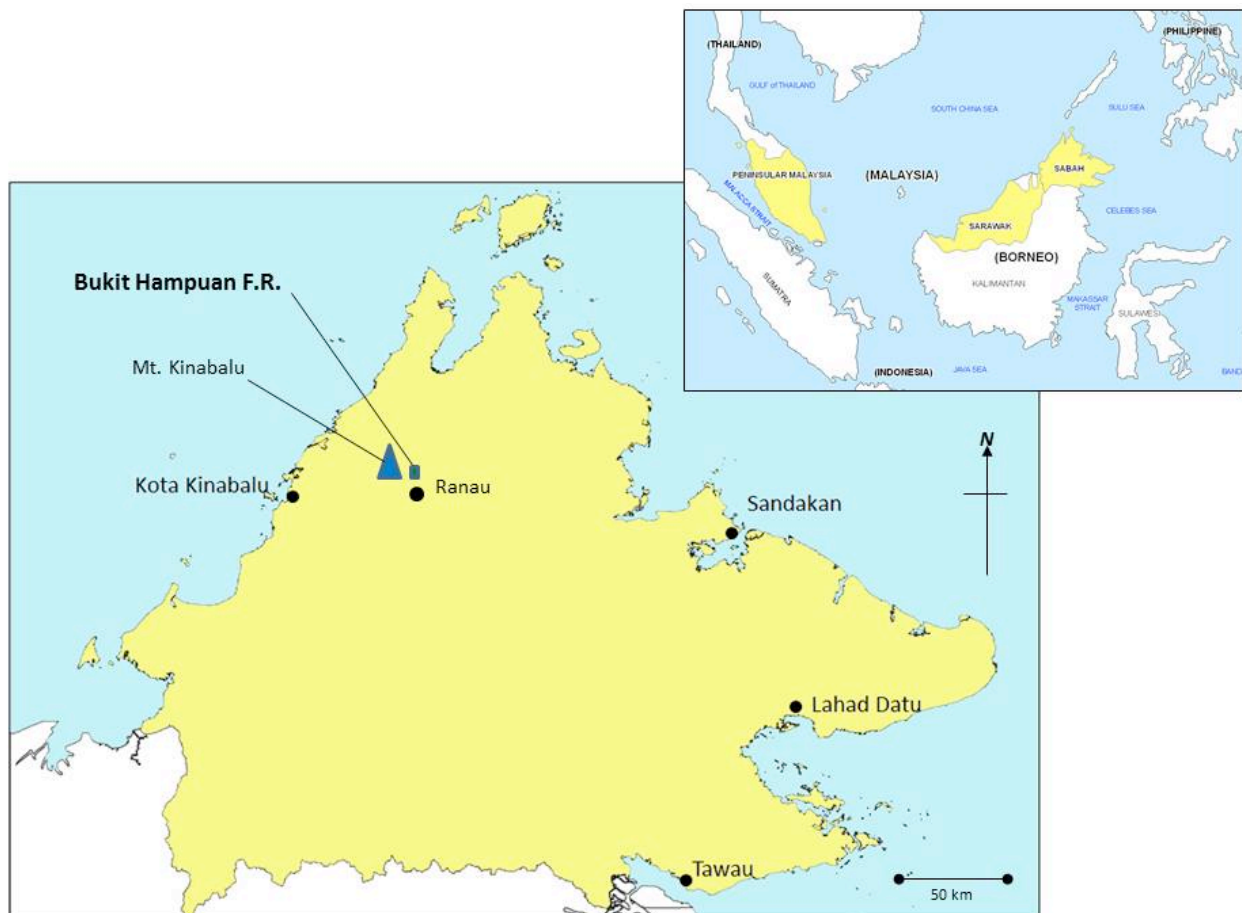


Figure 1. Location of Bukit Hampuan Forest Reserve in Sabah. Inset: Sabah is one of the Malaysian states in Borneo.

FR covers a relatively small area of 1,253ha, under the jurisdiction of the District Forestry Officer of Ranau. The vegetation consists of upland dipterocarp forest to lower montane forest, with the elevation ranging from 670–1,500 m. However, much of the reserve at the lower elevation has been degraded, mainly due to forest fire and human activities in the past. Nilus et al. (2012) provided the details of botanical and forest assessments of this ultramafic forest reserve.

An abandoned massive pit of the former Mamut Copper Mine (MCM) is located at the fringe (northwest) of this reserve. The mine was in operation from 1975–1999. The pit formed a lake at the bottom, with greenish-blue, highly acidic and metal-contaminated water, unsafe for consumption. It is a restricted area under the management of the Federal Department of Minerals and Geoscience.

Bukit Hampuan FR is also situated adjacent to Kinabalu Park, separated by stateland at the north, at a distance of less than 2km. This forest reserve is also significant as a water catchment area for some of the villages, especially Kg. Lohan and Kg. Kilimu. The source of the water is from the streams within the forest reserve, and not originated from the copper mine lake.

The study was conducted as part of the Bukit Hampuan expedition under the Heart of Borneo (HoB) programme of the Sabah Forestry Department from 10 to 14 May, 2010. The base camp was at Kg. Kilimu (05°58'52"N & 116°40'37"E, at 573m elevation), a village located beside the Ranau-Kota Kinabalu highway, south of Bukit Hampuan FR.

Light trap was used to sample nocturnal insects while sweep net and manual collecting (with forceps) were used to sample diurnal insects.

Light trap

The trap consists of a vertical white sheet (2x2 m) illuminated by a 250W mercury-lithium bulb. It was set up in an open area facing the forest reserve, from 19:00–21:00 hr. A GPS (Model: Garmin etrex Vista) was used to determine the coordinates of each sampling site (Table 1). To evaluate diversity of the sampling area, insect species and individuals (≥ 5 mm in length) within the 1x1 m square of the white cloth were enumerated from 20:30–21:00 hr. This is a rapid biodiversity assessment method because by the end of the sampling time, species and individual numbers can be obtained, and the data can be used to calculate diversity indices, i.e. Shannon Wiener, Simpson and Fisher Alpha, using Species Diversity & Richness version IV (SDR 2006). This method is simple, fast and can be carried out by non-

Table 1. Light-trapping sites at Bukit Hampuan Forest Reserve

| Sampling site | Coordinates | Elevation (m) | Sampling date | Remarks |
|---------------|----------------------------------|---------------|---------------|--|
| Hampuan 1 | 06°00'42"N & 116°39'19"E | 1,347 | 11.v.2010 | Cold and misty night, without moonlight |
| Hampuan 2 | 06°01'24.9"N & 116°39'46"E | 1,493 | 12.v.2010 | Raining and heavy mist during sampling, without moonlight. |
| Hampuan 3 | N06°00'49.8" E116°39'19.3" | 1,365 | 13.v.2010 | Windy and drizzling during sampling, without moonlight. |

Table 2. Daytime sampling sites at Bukit Hampuan Forest Reserve

| | Sampling site | Starting point coordinates | Elevation (m) | Sampling distance (km) |
|---|---------------------------------|----------------------------|---------------|------------------------|
| 1 | Mamut Copper Mine graveled road | 06°00'42"N & 116°39'19"E | 1,345–1,495 | 2 |
| 2 | Mamut Copper Mine area | 06°01'59"E & 116°39'14"N | 1,345–1,362 | 2 |
| 3 | Kg. Lohan Bongkud area | 06°00'52"N & 116°41'41"E | 677–775 | 1 |
| 4 | Bukit Hampuan open area | 06°01'06"N & 116°39'51"E | 1,367–1,400 | 1 |

insect specialists. To avoid compounding human error, the same staff was assigned to count the species and individual numbers throughout the sampling period.

Sweep net and manual collection

Sweep nets were used to collect flying insects, such as butterflies and dragonflies while other insects were sampled using fine forceps. Butterflies and dragonflies were put in triangle papers while other specimens were put in vials with 75% ethanol solution. Most of the trails were going up the slope (mostly 20%) heading towards the ridge or peak within the area.

Insect specimens and identification

This survey focussed on certain insect groups, i.e., butterflies, moths, beetles, cicadas and dragonflies. Only insect species of high importance (e.g., those based on Otsuka (1988), Tung (1983), Holloway (1996b) and Orr (2003)) were sampled, as to minimize the workload at the laboratory in preparing the specimens for identification. Common insects were not sampled but photographed for record purposes.

All specimens were dry-mounted and sorted to family and some to the generic and species level. The specimens sampled from this study are deposited at the Forest Research Centre (FRC), Sepilok, Sabah. Dry-mounted specimens were identified based on the FRC Entomology Collection and various reference materials, e.g. Otsuka (1988 & 2001) and Corbet & Pendlebury (1992) for butterflies; Holloway (1983, 1985, 1986, 1988, 1989, 1993, 1996a, 1997, 1998a & b, 1999, 2001, 2003, 2005, 2008 & 2009) and Robinson et al. (1994) for moths; Mizunuma & Nagai (1994), Makihara (1999) and Tung (1983) for beetles; Orr (2003) for dragonflies. Dr. Bakhtiar Effendi Yahya of Universiti Malaysia Sabah assisted in ant identification.

RESULTS AND DISCUSSION

Overall nocturnal insect diversity

Despite the degraded areas within the Bukit Hampuan FR, the nocturnal insect diversity was very high, with a mean of 113 species within a 1m². The high diversity is reflected in various diversity indices in Table 3. A total of 125 insect species were recorded from a 1m² at the first night of light-trapping (Hampuan 1), at

the elevation of 1,347m. However, the diversity indices were comparatively low because of a hymenopteran species with 90 individuals. It was the nuptial flight of this flying ant. Of all the indices, the low diversity value at Hampuan 1 was obvious on the Simpson's Index, which is more sensitive towards dominant species. The species distribution was very even in Hampuan 3 (as each species is represented by 1.1 individuals; see Table 3), followed by Hampuan 2 (one species recorded 13 individuals), compared to Hampuan 1 with a distinct prominent species. The distribution of nocturnal insect species from the three sites is reflected in the species-rank abundance curves in Fig. 2. Although it was raining with heavy mist on day two (Hampuan 2) and drizzling on day three (Hampuan 3) of the light-trapping, insect diversity as indicated by Shannon, Simpson and Fisher Alpha indices were impressively high.

When the nocturnal insect diversity results are compared with other forest reserves in Sabah, Bukit Hampuan FR appears to be impressively high, second to Crocker Range FR as indicated in species richness (Fig. 3a) and Shannon's Index (Fig. 3b). The results also indicate that insect diversity is generally higher in the lower montane forests.

Such high diversity for insects from 670–1500 m

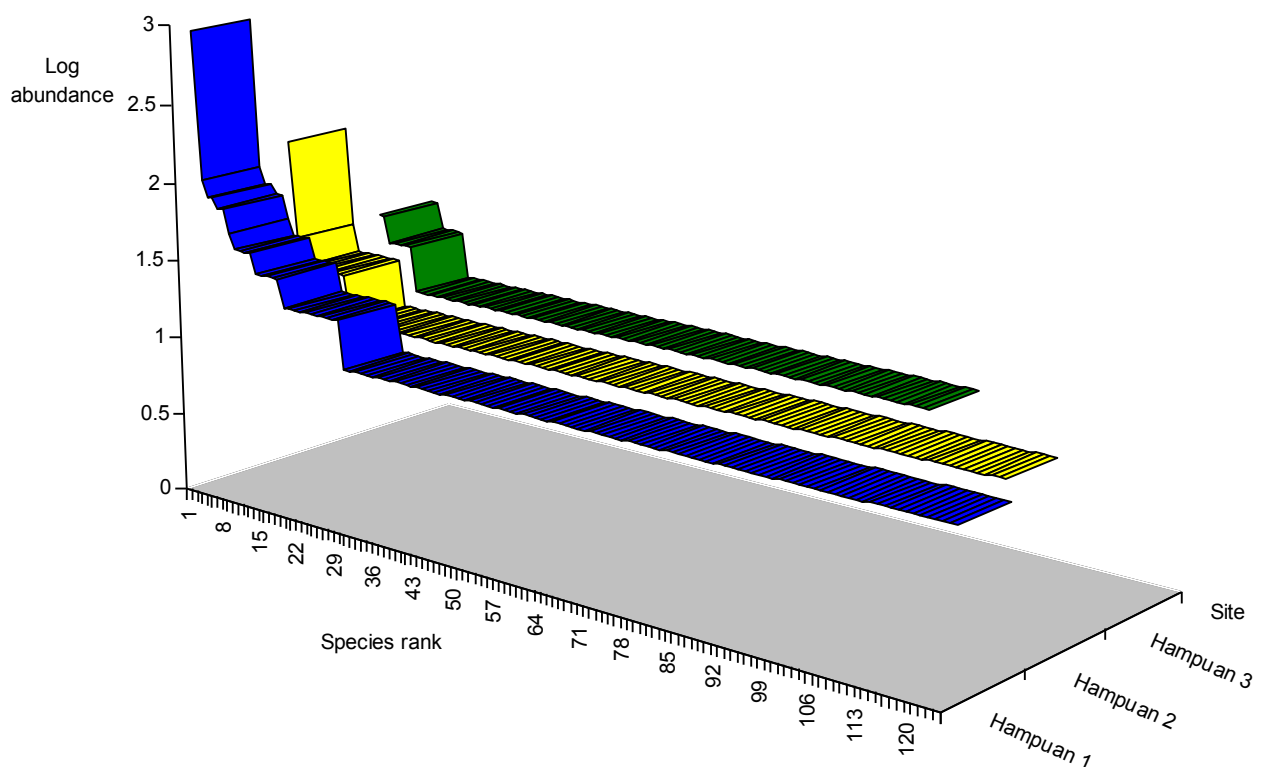


Figure 2. Species-rank abundance curves of the sampling sites at Bukit Hampuan Forest Reserve.

Table 3. Insect diversity within a 1m² as sampled through light-trapping at Bukit Hampuan Forest Reserve

| | Sampling site | Species | Ind. | Shannon | Simpson | Fisher Alpha |
|---|---------------|---------|--------|----------|---------------|---------------|
| 1 | Hampuan 1 | 125 | 286 | 3.73 | 9.69 | 84.64 |
| 2 | Hampuan 2 | 119 | 142 | 4.61 | 111.23 | 346.35 |
| 3 | Hampuan 3 | 96 | 105 | 4.53 | 496.40 | 543.44 |
| | Mean(±SD) | 113±15 | 178±96 | 4.29±0.5 | 205.77±256.76 | 324.81±230.16 |

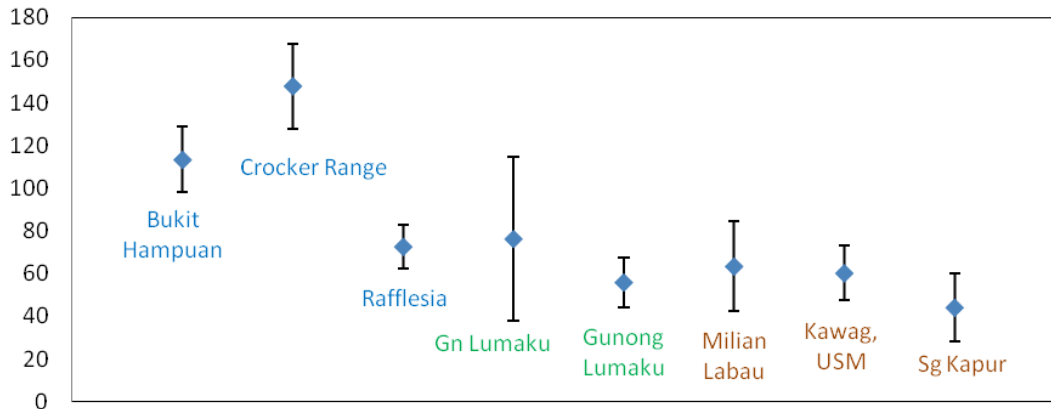


Figure 3a. Species number (±standard deviation) within one square metre as assessed through light-trapping at various forest reserves in Sabah (blue text = lower montane forest, green text = upland dipterocarp forest and brown text = lowland dipterocarp forest).

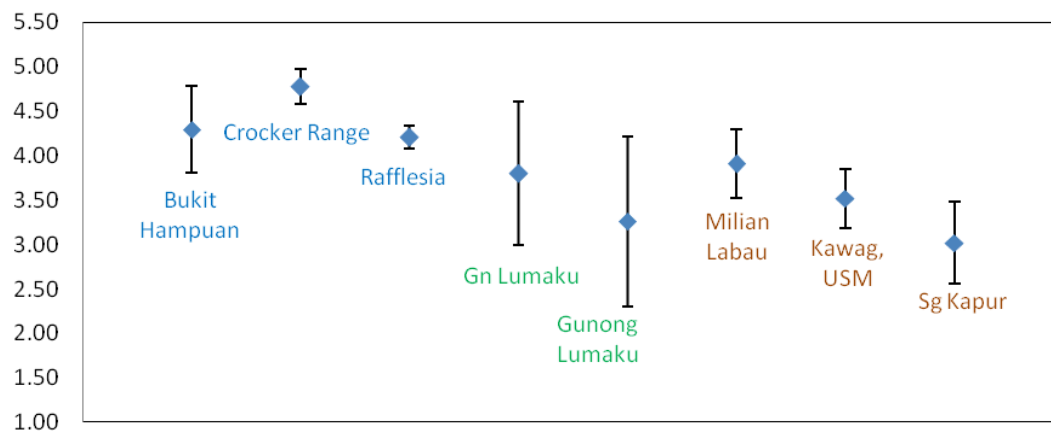


Figure 3b. Shannon's Index (±standard deviation) within one square metre as assessed through light-trapping at various forest reserves in Sabah (blue text = lower montane forest, green text = upland dipterocarp forest and brown text = lowland dipterocarp forest).

could be due to its proximity to the pristine Kinabalu Park. As highlighted by Wong & Phillips (1996) and Holloway (1996b), the insect life of Mount Kinabalu is one of the most enthralling ever known and continues to perplex the most experienced of scientists. It is also incredibly rich in endemic species. A total of 19 Bornean endemic insect species were recorded within a short sampling period (Table 4). In the same survey, 66 Bornean endemic plant species were recorded, including

Microtropis sabahensis (Celastraceae) which is confined to Sabah and *Pittosporum linearifolium* (Pittosporaceae) which is only found at Bukit Hampuan FR (Nilus et al. 2012). Beaman (1996), Meijer (1996) and Corner (1996) noted that the rare and endemic plants within the Mount Kinabalu area are mainly due to its ultramafic geology, cold climate and high elevation.

Table 4. Bornean endemic insect species recorded from Bukit Hampuan Forest Reserve during the survey.

| | Order | Family (Subfamily) | Species | Author |
|----|---------------------|---------------------------|---|------------|
| 1 | Lepidoptera (Moth) | Arctiidae (Arctiinae) | <i>Aethalida borneana</i> | Holloway |
| 2 | Lepidoptera (Moth) | Arctiidae (Arctiinae) | <i>Nyctemera kinibalina</i> | Snellen |
| 3 | Lepidoptera (Moth) | Arctiidae (Arctiinae) | <i>Spilosoma groganae</i> | Holloway |
| 4 | Lepidoptera (Moth) | Arctiidae (Lithosiinae) | <i>Adites hosei</i> | Holloway |
| 5 | Lepidoptera (Moth) | Arctiidae (Lithosiinae) | <i>Barsine euprepia</i> | Hampson |
| 6 | Lepidoptera (Moth) | Arctiidae (Lithosiinae) | <i>Cyana cruentata</i> | Talbot |
| 7 | Lepidoptera (Moth) | Arctiidae (Lithosiinae) | <i>Cyana saulia</i> | Swinhoe |
| 8 | Lepidoptera (Moth) | Arctiidae (Lithosiinae) | <i>Lyclene mesilaulinea</i> | Holloway |
| 9 | Lepidoptera (Moth) | Arctiidae (Lithosiinae) | <i>Lyclene multiramorum</i> | Holloway |
| 10 | Lepidoptera (Moth) | Arctiidae (Syntominiinae) | <i>Auriculoceryx pterodactyliformis</i> | Holloway |
| 11 | Lepidoptera (Moth) | Cossidae | <i>Zeuzera borneana</i> | Roepke |
| 12 | Lepidoptera (Moth) | Geometridae (Geometrinae) | <i>Spaniocentra megaspilaria</i> | Guenee |
| 13 | Lepidoptera (Moth) | Noctuidae (Aganainae) | <i>Asota kinabaluensis</i> | Rothschild |
| 14 | Lepidoptera (Moth) | Noctuidae (Catocalinae) | <i>Buzara saikehi</i> | Holloway |
| 15 | Lepidoptera (Moth) | Thyrididae | <i>Bansia intonsa</i> | Whalley |
| 16 | Coleoptera (Beetle) | Cerambycidae | <i>Neosarmydas costipennis</i> | Fisher |
| 17 | Coleoptera (Beetle) | Lucanidae | <i>Cyclommatus giraffa</i> | Mollenkamp |
| 18 | Coleoptera (Beetle) | Scarabaeidae | <i>Chalcosoma moellenkampii</i> | Kolbe |
| 19 | Coleoptera (Beetle) | Scarabaeidae | <i>Fruhstoferia nigromuliebris</i> | Nagai |

Butterfly (Lepidoptera) diversity

A total of 42 butterfly species were recorded from Bukit Hampuan FR (Appendix 1). Comparatively, the diversity was lower compared to Gn. Lumaku and Imbak Canyon (Table 5). Distribution of species is shown in Fig. 4. Many of the butterflies were sampled between 680–780 m at the fringe of the upland dipterocarp forest at Kg. Lohan Bongkud. Fewer specimens were sampled along the Mamut Copper Mine road but the Kinabalu Bush Orange, *Mycalesis marginata pitan* which is only found in Sumatra and Borneo, was sampled here.

The large and iconic butterfly species recorded from Bukit Hampuan FR were the Rajah Brooke's Birdwing (*Troides brookiana*), the Common Birdwing (*Troides helena*) and the Tree Nymph (*Idea stollii*). A number of Bornean endemic butterflies are found in the Kinabalu region (Otsuka 1988) but unfortunately none of them were sampled during this survey.

Moth (Lepidoptera) diversity

Various moth species were attracted to the light trap set up at three locations facing the forest of Bukit Hampuan between 1,350–1,500 m. A list of the recorded moths is provided in Appendix 2 & 3. Fifteen Bornean endemic moth species were recorded from this survey,

namely 10 species from Arctiidae, one Cossidae, one Geometridae, two Noctuidae and one Thyrididae (Image 1). It is not surprising that many endemics were sighted, as Holloway (1996b) has noted that the Mount Kinabalu area is high in moth endemism, with 112 macro-moth species recorded only from Kinabalu.

Some of the endemic species are only found in Sabah. The noctuid *Buzara saikehi* is a hyper-endemic, as it is only recorded from the Mamut, Ranau and the holotype is in the FRC collection at Sepilok (Holloway 2005). It was named after the late Saikeh Lantoh, a senior research assistant at FRC. In this survey, it was attracted to the light trap at Hampuan 1 (1,347m). Other Sabah endemics sampled were the arctiid *Cyana saulia* and *Lyclene mesilaulinea*. *Cyana saulia* was previously recorded from Paitan at the coast of Sabah while *Lyclene mesilaulinea* was sampled from Mesilau and Mt. Monkobo (Holloway 2001).

Nyctemera kinibalina and *Nyctemera tripunctaria* (both Arctiidae) are day-flying moths and they were sampled with the sweep net at the Mamut Copper Mine road. *Nyctemera muelleri*, however, was attracted to the light trap.

Table 5. Comparison of butterfly diversity between Bukit Hampuan Forest Reserve, Gn. Lumaku Forest Reserve and Imbak Canyon Conservation Area.

| Sampling site | Method | Species | Ind. | Shannon | Simpson | Fisher Alpha |
|------------------------------|-------------------------------------|---------|------|---------|---------|--------------|
| Bukit Hampuan Forest Reserve | Sweep net & observation | 42 | 78 | 3.48 | 31.95 | 37.09 |
| Gg. Lumaku Forest Reserve | Sweep net & observation | 52 | 106 | 3.56 | 29.76 | 40.37 |
| Imbak Canyon* | Fruit bait, sweep net & observation | 72 | 133 | 4.09 | 70.22 | 64.10 |

* Source: Lim-Hasegawa & Chey (2009)

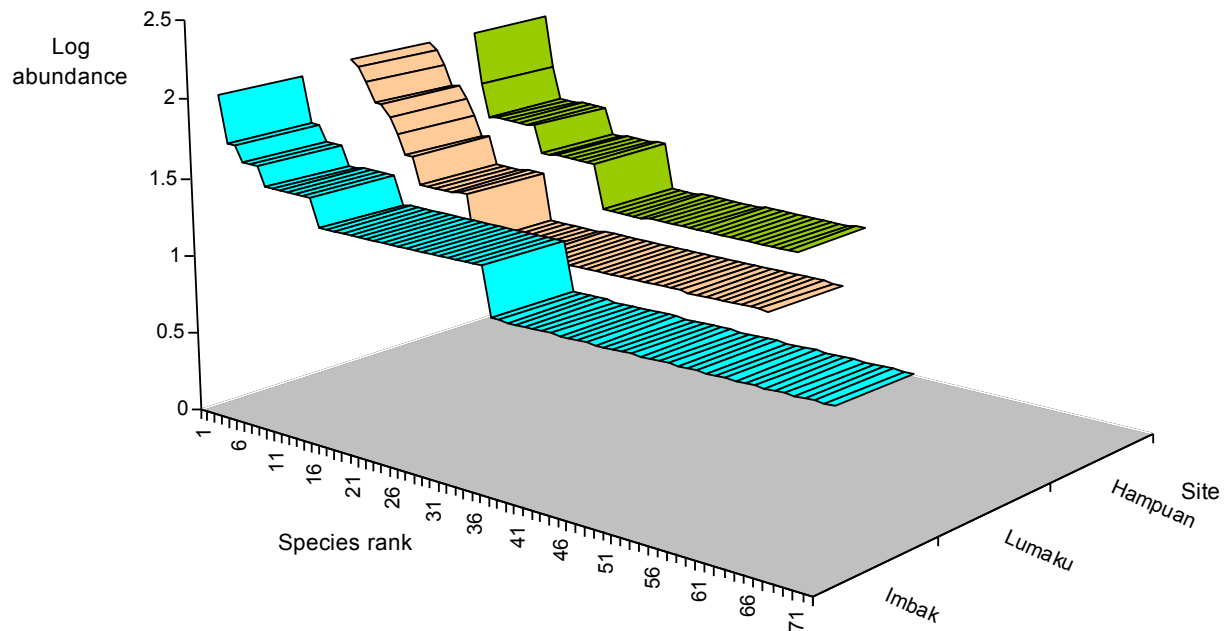


Figure 4. Species-rank abundance curves of butterflies sampled from Imbak Canyon Conservation Area, Gn. Lumaku F.R. and Bukit Hampuan Forest Reserve

Beetle (Coleoptera) diversity

A total of 26 species of macro-beetles were recorded (Appendix 4). Many were sampled through light-trapping. At least four species are endemic to Borneo, namely *Fruhstoferia nigromuliebris*, *Neosarmyds costipennis*, *Cyclommatus giraffa* and *Chalcosoma moellenkampii*. The first two species are rare while *Cyclommatus giraffa* is confined to the montane areas, such as Kinabalu Park and Crocker Range. The Three-horned Beetle *Chalcosoma moellenkampii* is common throughout Sabah although it is only found in Borneo.

Other insects

Unlike butterflies, moths and beetles, no concerted effort was deployed to sample other insect groups. However, a few species of cicadas and dragonflies were sampled, as listed in Appendix 5. Some dragonfly species were sampled along the streams in the forest adjacent to

Kg. Lohan Bongkud, e.g. *Macromia westwoodii* at about 700m while others were collected at the Bukit Hampuan FR open area at 1,370m, e.g. *Pantala flavescens*. *Macromia westwoodii* is a large dragonfly, with its hindwing measuring up to 50mm. It is fairly common on clear fast forest streams from the lowlands to 900m but is extremely inconspicuous and wary. *Pantala flavescens* is the most wide ranging odonate species in the world, being found throughout the tropics and subtropics, from dense primary forest up to at least 3000m (Orr 2003).

A striking Yellow-banded Cicada *Tacua speciosa*, measuring 55mm, was collected at about 1,500m during daytime by the Botany team. It is also known as the ‘Emperor Cicada’. Two species of unidentified Hemiptera, from the family Tomaspidae were also sampled, from about 1,400m.

Myrmecaria ants were frequently encountered feeding on extrafloral nectaries of wild orchids along the

Mamut Copper Mine road. It is likely to be *Myrmecaria subcarinata*, but it could be more than one species (Bakhtiar E. Yahya, pers. comm. June 2010).

Threats and recommendations for insect diversity and conservation at Bukit Hampuan FR

Prior to the recent gazettement of Bukit Hampuan as a Class I Forest Reserve in 2009, the area was under stateland status. About 28% of the area is classified as degraded due to series of forest fires in the past, and 2% was encroached for agricultural activities (Nilus et al. 2012).

The northwestern part of Bukit Hampuan FR was part of the copper mining area, covering about 87ha. This is the area where the overburdens and waste rocks from the mining pit were dumped. The vegetation in this area is poor and sparse. The trees planted by the copper mine management were stunted, e.g., *Falcataria moluccana*. Only certain plant species were found to be growing well. As such, the overall biodiversity within the present Bukit Hampuan FR is not spectacular, compared to the adjacent pristine Kinabalu Park, with the exception of the nocturnal insects sampled from this survey. Insects, such as moths and beetles are very mobile, and they could have traveled from the adjacent pristine forest. Kinabalu Park is less than 2km north of Bukit Hampuan FR nevertheless, the high diversity of nocturnal insects may suggest that Bukit Hampuan FR is still conducive, providing suitable habitats for many of these insects because of the cool environment.

To sustain and improve the biodiversity of Bukit Hampuan FR, it is, thus, highly recommended that the area between the reserve at the northern part and Kinabalu Park be gazetted as a forest reserve. This area which is presently under the stateland status is still in pristine forest condition, but it is subject to any land-use changes and development. By gazettement to a Class I Forest Reserve, the area will be fully protected by law and any encroachment can be penalized. This connectivity will be permanent and it will allow wildlife (especially large animals) to move about from Bukit Hampuan to Kinabalu Park and vice versa. It will also indirectly enhance the diversity of insects in Bukit Hampuan FR.

The State Culture, Tourism and Environment Minister, Datuk Masidi Manjun noted that connectivity and corridors have been overlooked. Even with more than 50% forest cover in Sabah, conservation will not be effective if the fragmented forests are not connected. Lately, the State Government through the Sabah Forestry Department as well as other agencies, has put in much concerted effort in highlighting the importance of forest

connectivity and wildlife corridors, and discussed the way forward in implementation (SFD 2010b).

Forest fire is a common problem in forest reserves during drought. The impact is irreversible, as seen in some degraded areas in Bukit Hampuan FR. To prevent further damage by fire, the forest staff would have to be more alert and work together with the kampung folks on this matter, e.g., via appointment of honorary forest wardens. Environmental awareness and education can be promoted and enhanced among the villagers and their children on the importance of forest and its services. Such awareness will also help to curb illegal hunting for wild animals and orchids, which were common in Bukit Hampuan in the past. For effective implementation, it is important to adopt a multi-disciplinary and participatory approach involving relevant stakeholders, such as Wildlife Department, Environmental Protection Department, Education Department, Fire & Rescue Department, NGOs and the local communities. Funding from local, as well as international agencies would greatly contribute towards the success of the implementation.

Constant monitoring and enforcement by the relevant authorities will minimize encroachment into the forest reserve. Setting up of gates and warning signs at restricted areas would hopefully reduce the number of trespassers. Signage at the forest reserve border will remind the villagers of the boundary and limit of land clearing for agriculture.

CONCLUSION

The nocturnal insect diversity at Bukit Hampuan FR was impressively high despite some degraded areas within the forest reserve. Many endemic insect species sampled from this survey within a short period indicates the significance of protecting and conserving this forest reserve. Such findings provide important data to enhance the need and effort in biodiversity conservation. The recent gazettement of Bukit Hampuan as a Class I Forest Reserve is appropriate and timely. It is also crucial for Bukit Hampuan FR to be connected to Kinabalu Park, i.e., to gazette the connecting stateland area into a Class I Forest Reserve. This connectivity is the prime means of physically linking wildlife habitat and allow some species to move between otherwise isolated area. It can help to replenish isolated populations. Ideally, the connectivity itself also meets some or all of the need for shelter, protection, food and breeding sites. Constant monitoring, enforcement, cooperation with relevant stakeholders and local communities, and

promotion of environmental awareness are among the recommendations to mitigate the threats in Bukit Hampuan FR.

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Appendix 1. Butterflies from Bukit Hampuan Forest Reserve, Sabah (10–14 May 2010).

| | Species | Author | Family | Digital photo no. |
|----|--|----------------|--------------|-------------------|
| 1 | <i>Appias indra plana</i> | Butler | Pieridae | BHP1439 |
| 2 | <i>Catopsilia pomona pomona</i> | Fabricius | Pieridae | BHP1486 |
| 3 | <i>Eurema sari sodalis</i> | Moore | Pieridae | BHP1491 |
| 4 | <i>Leptosia nina malayana</i> | Fruhstorfer | Pieridae | BHP1659 |
| 5 | <i>Pareronia valeria lutescens</i> | Butler | Pieridae | spotted |
| 6 | <i>Graphium agamemnon agamemnon</i> | Linne | Papilionidae | spotted |
| 7 | <i>Graphium antiphates itamputi</i> | Butler | Papilionidae | BHP1665 |
| 8 | <i>Lamproptera curius curius</i> | Fabricius | Papilionidae | BHP1675 |
| 9 | <i>Pachliopta aristolochiae antiphus</i> | Fabricius | Papilionidae | BHP1544 |
| 10 | <i>Papilio helenus enganius</i> | Doherty | Papilionidae | BHP1594 |
| 11 | <i>Papilio memnon memnon</i> | Linne | Papilionidae | BHP1654 |
| 12 | <i>Papilio nephelus albolineatus</i> | Forbes | Papilionidae | BHP1667 |
| 13 | <i>Troides brookiana brookiana</i> | Wallace | Papilionidae | spotted |
| 14 | <i>Troides helena mosychlus</i> | Fruhstorfer | Papilionidae | BHP1580 |
| 15 | <i>Troides</i> sp. | | Papilionidae | spotted |
| 16 | <i>Anosia genutia intensa</i> | Moore | Nymphalidae | BHP1671 |
| 17 | <i>Athyma clerica clerica</i> | Butler | Nymphalidae | BHP1221 |
| 18 | <i>Athyma selenophara amhara</i> | Druce | Nymphalidae | BHP1435 |
| 19 | <i>Cethosia hypsea hypsea</i> | Doubleday | Nymphalidae | BHP1269, 1272 |
| 20 | <i>Euploea leucostictos syra</i> | Fruhstorfer | Nymphalidae | BHP1649 |
| 21 | <i>Euploea diocletianus lowii</i> | Butler | Nymphalidae | BHP1651 |
| 22 | <i>Euploea phaenareta butleri</i> | Moore | Nymphalidae | BHP1278 |
| 23 | <i>Euploea tulliolus aristotelis</i> | Moore | Nymphalidae | BHP1231 |
| 24 | <i>Euripus nyctelius borneensis</i> | Distant | Nymphalidae | BHP1589 |
| 25 | <i>Hypolimnas bolina philippensis</i> | Butler | Nymphalidae | BHP1612 |
| 26 | <i>Idea stollii virgo</i> | Fruhstorfer | Nymphalidae | BHP1660 |
| 27 | <i>Ideopsis vulgaris interposita</i> | Fruhstorfer | Nymphalidae | BHP1494 |
| 28 | <i>Lethe chandica delila</i> | Staudinger | Nymphalidae | spotted |
| 29 | <i>Moduza procris agnata</i> | Fruhstorfer | Nymphalidae | spotted |
| 30 | <i>Mycalesis anapita fucentia</i> | Fruhstorfer | Nymphalidae | BHP1603 |
| 31 | <i>Mycalesis marginata pitan</i> | Staudinger | Nymphalidae | BHP1195 |
| 32 | <i>Neptis leucoporos cresina</i> | Fruhstorfer | Nymphalidae | BHP1591 |
| 33 | <i>Orsotriaena medus medus</i> | Fabricius | Nymphalidae | BHP1682 |
| 34 | <i>Parantica aspasia aspasia</i> | Fabricius | Nymphalidae | BHP1244 |
| 35 | <i>Parantica luzonensis praemacaristus</i> | Fruhstorfer | Nymphalidae | BHP1264 |
| 36 | <i>Parthenos sylvia borneensis</i> | Staudinger | Nymphalidae | spotted |
| 37 | <i>Sumalia daraxa viridans</i> | Fruhstorfer | Nymphalidae | BHP1210 |
| 38 | <i>Symbrenthia lillaea marius</i> | Fruhstorfer | Nymphalidae | BHP1553 |
| 39 | <i>Tirumala septentrionis microsticta</i> | Butler | Nymphalidae | BHP1639 |
| 40 | <i>Ypthima pandocus sertorius</i> | Fruhstorfer | Nymphalidae | BHP1192, 1215 |
| 41 | Lycaenidae sp. 1 | | Lycaenidae | BHP1211 |
| 42 | <i>Koruthaialos sindu sindu</i> | C. & R. Felder | Hesperiidae | spotted |

Appendix 2. Moths of Bukit Hampuan Forest Reserve, Sabah (10–14 May 2010).

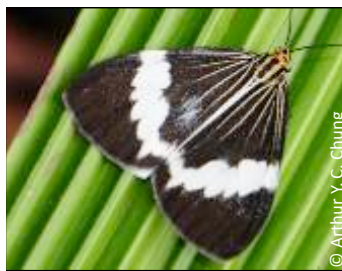
| | Species | Author | Family | Subfamily | Digital photo no. |
|----|---|------------------|--------------|---------------|-------------------|
| 1 | <i>Aethalida borneana</i> | Holloway | Arctiidae | Arctiinae | BHP1363, 1710 |
| 2 | <i>Amerila astreus</i> | Drury | Arctiidae | Arctiinae | BHP1344, 1348 |
| 3 | <i>Nyctemera kinibalina</i> | Snellen | Arctiidae | Arctiinae | BHP1233 |
| 4 | <i>Nyctemera muelleri</i> | Vollenhoven | Arctiidae | Arctiinae | BHP1312 |
| 5 | <i>Nyctemera tripunctaria</i> | Linnaeus | Arctiidae | Arctiinae | BHP1219 |
| 6 | <i>Spilosoma groganae</i> | Holloway | Arctiidae | Arctiinae | BHP1512 |
| 7 | <i>Adites hosei</i> | Holloway | Arctiidae | Lithosiinae | BHP1366 |
| 8 | <i>Adites</i> sp. | | Arctiidae | Lithosiinae | BHP1727 |
| 9 | <i>Barsine euprepia</i> | Hampson | Arctiidae | Lithosiinae | BHP1347 |
| 10 | <i>Barsine roseororatus</i> | Butler | Arctiidae | Lithosiinae | BHP1333 |
| 11 | <i>Cyana cruentata</i> | Talbot | Arctiidae | Lithosiinae | BHP1313, 1724 |
| 12 | <i>Cyana horsfieldii</i> | Roepke | Arctiidae | Lithosiinae | BHP1770 |
| 13 | <i>Cyana malayensis</i> | Hampson | Arctiidae | Lithosiinae | BHP1741 |
| 14 | <i>Cyana saulia</i> | Swinhoe | Arctiidae | Lithosiinae | BHP1729 |
| 15 | <i>Cyana</i> sp. | | Arctiidae | Lithosiinae | BHP1751 |
| 16 | <i>Eugoa trifascia</i> | Walker | Arctiidae | Lithosiinae | BHP1749 |
| 17 | <i>Lyclene circumdata</i> | Walker | Arctiidae | Lithosiinae | BHP1695 |
| 18 | <i>Lyclene mesilaulinea</i> | Holloway | Arctiidae | Lithosiinae | BHP1736 |
| 19 | <i>Lyclene multiramorum</i> | Holloway | Arctiidae | Lithosiinae | BHP1760 |
| 20 | <i>Lyclene</i> sp. | | Arctiidae | Lithosiinae | BHP1707 |
| 21 | <i>Monosyntaxis</i> sp. | | Arctiidae | Lithosiinae | BHP1747 |
| 22 | <i>Padenia obliquifascia</i> | Rothschild | Arctiidae | Lithosiinae | BHP1761 |
| 23 | <i>Teulisna</i> sp. | | Arctiidae | Lithosiinae | BHP1730 |
| 24 | <i>Auriculoceryx pterodactyliformis</i> | Holloway | Arctiidae | Syntominiinae | BHP1768 |
| 25 | <i>Mustilia dierli</i> | Holloway | Bombycidae | | BHP1735 |
| 26 | <i>Zeuzera borneana</i> | Roepke | Cossidae | | BHP1532 |
| 27 | <i>Zeuzera indica</i> | Herrich-Schaffer | Cossidae | | BHP1737 |
| 28 | <i>Canucha specularis</i> | Moore | Drepanidae | | BHP1523 |
| 29 | <i>Tridrepana flava</i> | Moore | Drepanidae | | BHP1365 |
| 30 | <i>Amblychia infoveata</i> | Prout | Geometridae | Ennominae | BHP1310 |
| 31 | <i>Bracca georgiata</i> | Guenee | Geometridae | Ennominae | BHP1731 |
| 32 | <i>Dilophodes elegans</i> | Butler | Geometridae | Ennominae | BHP1342 |
| 33 | <i>Krananda semihyalina</i> | Moore | Geometridae | Ennominae | BHP1531 |
| 34 | <i>Milionia basalis</i> | Walker | Geometridae | Ennominae | BHP1535 |
| 35 | <i>Ourapteryx claretta</i> | Holloway | Geometridae | Ennominae | BHP1352 |
| 36 | <i>Plutodes argentilauta</i> | Prout | Geometridae | Ennominae | BHP1370 |
| 37 | <i>Pogonopygia nigralbata</i> | Warren | Geometridae | Ennominae | BHP1518 |
| 38 | <i>Agathia laetata</i> | Fabricius | Geometridae | Geometrinae | BHP1517 |
| 39 | <i>Spaniocentra megaspilaria</i> | Guenee | Geometridae | Geometrinae | BHP1740 |
| 40 | <i>Tanaorhinus rafflesii</i> | Moore | Geometridae | Geometrinae | BHP1530 |
| 41 | <i>Calliteara cox</i> | Schintlmeister | Lymantriidae | | BHP1756 |
| 42 | <i>Calliteara diplozona</i> | Collenette | Lymantriidae | | BHP1757 |
| 43 | <i>Asota albiformis</i> | Swinhoe | Noctuidae | Aganainae | BHP1773 |
| 44 | <i>Asota kinabaluensis</i> | Rothschild | Noctuidae | Aganainae | BHP1511, 1521 |
| 45 | <i>Asota producta</i> | Butler | Noctuidae | Aganainae | BHP1510 |
| 46 | <i>Clethrora pilcheri</i> | Hampson | Noctuidae | Amphipyriinae | BHP1284 |
| 47 | <i>Avatha bubo</i> | Geyer | Noctuidae | Catocalinae | BHP1297 |
| 48 | <i>Buzara saikehi</i> | Holloway | Noctuidae | Catocalinae | BHP1283 |
| 49 | <i>Hamodes propitia</i> | Guerin-Meneville | Noctuidae | Catocalinae | BHP1529 |
| 50 | <i>Hypopyra</i> sp. | | Noctuidae | Catocalinae | BHP1748 |
| 51 | <i>Thyas javanica</i> | Gaede | Noctuidae | Catocalinae | BHP1744 |
| 52 | <i>Tiracola aureata</i> | Holloway | Noctuidae | Hadeninae | BHP1507 |
| 53 | <i>Blenina</i> sp. | | Nolidae | | BHP1305 |
| 54 | <i>Dichocrocis zebralis</i> | Moore | Pyrilidae | Crambinae | BHP1766 |
| 55 | <i>Pachynea purpuralis</i> | Walker | Pyrilidae | Crambinae | BHP1304 |
| 56 | <i>Botyodes asialis</i> | Guenee | Pyrilidae | Pyraustinae | BHP1361 |

| | Species | Author | Family | Subfamily | Digital photo no. |
|----|----------------------------|-----------|------------|-------------|-------------------|
| 57 | <i>Nevrina procopia</i> | Cramer | Pyralidae | Pyraustinae | BHP1514 |
| 58 | <i>Parotis laceritalis</i> | Kenrick | Pyralidae | Pyraustinae | BHP1373 |
| 59 | <i>Syllepte fabiusalis</i> | Walker | Pyralidae | Pyraustinae | BHP1513 |
| 60 | <i>Acherontia lachesis</i> | Fabricius | Sphingidae | | BHP1339 |
| 61 | <i>Acosmeryx shervilli</i> | Boisduval | Sphingidae | | BHP1354 |
| 62 | <i>Eurypteryx bhaga</i> | Moore | Sphingidae | | BHP1704 |
| 63 | <i>Banisia intonsa</i> | Whalley | Thyrididae | | BHP1728 |
| 64 | <i>Telchines vialis</i> | Moore | Thyrididae | | BHP1754 |
| 65 | <i>Lyssa menoetius</i> | Hopffer | Uraniidae | | BHP1746 |
| 66 | <i>Lyssa zampa</i> | Butler | Uraniidae | | BHP1318 |

Appendix 3. Bornean endemic moth species recorded from Bukit Hampuan Forest Reserve.



Aethalida borneana Arctiidae (Arctiinae)



Nyctemera kinibalina Arctiidae (Arctiinae)



Spilosoma groganae Arctiidae (Arctiinae)



Adites hosei Arctiidae (Lithosiinae)



Barsine euprepia Arctiidae (Lithosiinae)



Cyana cruentata Arctiidae (Lithosiinae)



Cyana saulia Arctiidae (Lithosiinae)



Lyclene mesilaulinea Arctiidae (Lithosiinae)



Lyclene multiramorum Arctiidae (Lithosiinae)



Auriculoceryx pterodactyliformis Arctiidae (Syntomiinae)



Zeuzera borneana Cossidae



Spaniocentra megaspilaria Geometridae (Geometrinae)



Buzara saikehi Noctuidae (Catocalinae)



Asota kinabaluensis Noctuidae (Aganainae)



Banisia intonsa Thyrididae

Appendix 4. Beetles from Bukit Hampuan Forest Reserve, Sabah (10–14 May 2010).

| | Species | Author | Family | Digital photo no. |
|----|------------------------------------|-------------|------------------------------|-------------------|
| 1 | <i>Glenea elegans</i> | Oliver | Cerambycidae | BHP1840 |
| 2 | <i>Macrotoma (Bandar) pascoei</i> | Lansberge | Cerambycidae | BHP1383 |
| 3 | <i>Macrotoma (Bandar) ?fisheri</i> | Waterhouse | Cerambycidae | BHP1394 |
| 4 | <i>Megopis marginalis</i> | (Fabricius) | Cerambycidae | BHP1829 |
| 5 | <i>Neosarmyds costipennis</i> | Fisher | Cerambycidae | BHP1567 |
| 6 | <i>Rhytidodera</i> sp. | | Cerambycidae | BHP1831 |
| 7 | <i>Epilachna</i> sp. | | Coccinellidae | BHP1598 |
| 8 | <i>Monochilus</i> sp. | | Coccinellidae | BHP1240 |
| 9 | Curculionidae sp. 1 | | Curculionidae | BHP1447 |
| 10 | Curculionidae sp. 2 | | Curculionidae | BHP1835, 1833 |
| 11 | Elateridae sp. 1 | | Elateridae | BHP1421 |
| 12 | Elateridae sp. 2 | | Elateridae | BHP1427 |
| 13 | Elateridae sp. 3 | | Elateridae | BHP1430 |
| 14 | ? <i>Eulichas</i> sp. | | Eulichadidae | BHP1415 |
| 15 | <i>Cyclommatus giraffa</i> | Mollenkamp | Lucanidae | BHP1720, 1717 |
| 16 | <i>Dorcus thoracicus</i> | Mollenkamp | Lucanidae | BHP1425 |
| 17 | <i>Odontolabis castelnaudi</i> | Parryi | Lucanidae | BHP1408 |
| 18 | <i>Aceraius</i> sp. | | Passalidae | BHP1431 |
| 19 | <i>Chalcosoma moellenkampi</i> | Kolbe | Scarabaeidae (Dynastinae) | BHP1236, 2020 |
| 20 | Scarabaeidae sp. 1 | | Scarabaeidae (Dynastinae) | BHP1825 |
| 21 | <i>Hoplia</i> sp. | | Scarabaeidae (Melolonthinae) | BHP1698 |
| 22 | Scarabaeidae sp. 2 | | Scarabaeidae (Melolonthinae) | BHP1565 |
| 23 | <i>Anomala</i> sp. | | Scarabaeidae (Rutelinae) | BHP1819 |
| 24 | <i>Fruhstoferia nigromuliebris</i> | Nagai | Scarabaeidae (Rutelinae) | BHP1413 |
| 25 | Scarabaeidae sp. 3 | | Scarabaeidae (Rutelinae) | BHP1558 |
| 26 | <i>Setenis</i> sp. | | Tenebrionidae | BHP1571 |

Appendix 5. Other insects from Bukit Hampuan Forest Reserve, Sabah (10–14 May 2010).

| | Species | Author | Family | Digital photo no. |
|--------------------|----------------------------------|-------------|--------------|-------------------|
| Dragonflies | | | | |
| 1 | <i>Macromia westwoodii</i> | Selys | Corduliidae | BHP1617 |
| 2 | <i>Pantala flavescens</i> | (Fabricius) | Libellulidae | BHP1806 |
| 3 | <i>Neurothemis ramburii</i> | Brauer | Libellulidae | BHP1239 |
| 4 | <i>Crocothemis</i> sp. | | Libellulidae | BHP1268 |
| 5 | <i>Orthetrum glaucum</i> | Brauer | Libellulidae | BHP1225 |
| 6 | Libellulidae sp. 1 | | Libellulidae | BHP1798 |
| 7 | Libellulidae sp. 2 | | Libellulidae | BHP1185 |
| Cicadas | | | | |
| 1 | <i>Tacua speciosa</i> | Illiger | Cicadidae | BHP1387 |
| 2 | <i>Platylomia viridimaculata</i> | Distant | Cicadidae | BHP1576, 1574 |
| 3 | <i>Dundubia vaginata</i> | Fabricius | Cicadidae | BHP1774 |
| 4 | <i>Dundubia rufivena</i> | Walker | Cicadidae | |
| 5 | Tomaspididae sp. 1 | | Tomaspididae | BHP1196 |
| 6 | Tomaspididae sp. 2 | | Tomaspididae | BHP1263 |
| Ant | | | | |
| 1 | <i>Mymicaria? subcarinata</i> | | Myrmicinae | BHP1453 |

