

INSECT DIVERSITY OF SUNGAI SERUDONG FOREST RESERVE, SABAH, MALAYSIA

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ABSTRACT

Insect diversity of Sungai Serudong Forest Reserve in Sabah was investigated under the Heart of Borneo programme in Sabah. The nocturnal insect diversity was evaluated by using light-trap from 7:00 p.m. until 9:00 p.m. for three consecutive nights. Diurnal insects were sampled using sweep net. A total of nine insect orders were recorded namely Coleoptera, Hemiptera, Hymenoptera, Isoptera, Lepidoptera, Neuroptera, Odonata, and Phasmida. There were four Bornean endemic species recorded during the survey, namely *Chalcosoma moellenkampii* (Coleoptera: Scarabaeidae), *Aethalida borneana* (Lepidoptera: Erebidae), *Amata prepuncta* (Lepidoptera: Erebidae) and *Calvisia sammannani* (Phasmida: Diapheromeridae). The mean Shannon Index was 4.00, Simpson Index was 47.76 and Fisher Alpha Index was 83.64. The diversity is considered high, however moderate when compared to other forest reserves in Sabah, Malaysia. This study was able to identify insect communities inside the reserve. It was also able to identify the potential threats affecting the insect diversity. The documented data can serve as baseline information to be used in forest management plan and other relevant research.

Keywords: Insect diversity, sweep nets, light-trapping, conservation

ABSTRAK

Kepelbagaian serangga Hutan Simpan Serudong di Sabah telah dijalankan di bawah program Heart of Borneo di Sabah. Kepelbagaian serangga nokturnal telah disampel menggunakan perangkap cahaya dari jam 7:00 p.m sehingga 9:00 p.m selama tiga malam berturut-turut. Serangga diurnal disampel dengan menggunakan jaring sauk. Sejumlah sembilan order serangga telah direkodkan antaranya ialah Coleoptera, Hemiptera, Hymenoptera, Isoptera, Lepidoptera, Neuroptera, Odonata dan Phasmida. Terdapat empat spesies endemik kepada Borneo iaitu, *Chalcosoma moellenkampii* (Coleoptera: Scarabaeidae), *Aethalida borneana* (Lepidoptera: Erebidae), *Amata prepuncta* (Lepidoptera: Erebidae) dan *Calvisia sammannani* (Phasmida: Diapheromeridae). Purata Indeks Shannon ialah 4.00, Indeks Simpson ialah 47.76 dan Indeks Fisher Alpha ialah 83.64. Kepelbagaian serangga adalah tinggi, walaupun sederhana apabila dibandingkan dengan hutan simpan yang lain di Sabah. Kajian ini dapat mengenalpasti komuniti serangga di dalam hutan simpan tersebut. Kajian ini juga dapat

mengenalpasti potensi ancaman kepada kepelbagaian serangga. Data yang direkodkan dapat digunakan sebagai maklumat asas untuk digunakan dalam pengurusan hutan mampan dan kajian lain yang berkaitan.

Kata kunci: Kepelebagaian serangga, jaring sauk, perangkap cahaya, pemuliharaan

INTRODUCTION

Insects are the largest group of animals in the world in terms of species richness and abundance. They have to adapt with various habitats to survive (Triplehorn & Johnson 2005), hence, they are also evolved to adapt living with predators such as mimicry, camouflage and chemical defence (Ting et al. 2016). Their life pattern could be learned by studying their behaviours. They play vital roles in providing ecosystem services (Abdullah et al. 2019), such as pollinating flowers and decomposing waste materials. They are good indicators towards environmental changes and sensitive to temperature changes that can affect their population sizes (Schowalter 2020).

Consists of three regions which is Malaysia (Sabah and Sarawak), Brunei and Indonesia, the island is ranked the third largest in the world with an area at about 746000 sq. km (Bosuang et al. 2017). Sungai Serudong Forest Reserve is within the Heart of Borneo area, thus, could enhance conservation and sustainable development in Sabah and set the framework of actions for conserving flora and fauna. In the Heart of Borneo, 123 species of fauna have been discovered just within three years (Greenwood 2010). Sungai Serudong Forest Reserve is a lowland mixed dipterocarp forest. Mixed dipterocarp forests produce the most timber in the world (Ashton et al. 2011). The arthropod of lowland forests in Borneo has been estimated at 3000 species of Hymenoptera, Coleoptera, Diptera and Hemiptera, showing the largest population sizes (World Wildlife Fund 2020).

The study on insect diversity can be used as supporting information in biodiversity management and conservation (Chung et al. 2019; Samways 2018). Various insect diversity studies have been conducted in Sabah. It is to provide input for better conservation management (Chung 2020; Chung et al. 2016; Chung et al. 2020; Japir et al. 2020) and they were used as a tool to monitor conservation status (Chung et al. 2018). From the documented insects, it will provide potential research to be studied by researchers especially for the targeted group of insects such as newly discovered of crickets (Tan et al. 2019a, 2019b, 2020a, 2020b). Therefore, the objective of this study are to determine the diversity of the insect fauna at Sungai Serudong Forest Reserve, Sabah, Malaysia as well as to suggest the management programme towards conservation programme insect diversity.

MATERIALS AND METHODS

Study Site

The Sungai Serudong Forest Reserve is located in the south eastern Sabah (Figure 1). The journey by road to the site is about 3 hours from Tawau town and took about 9 hours from Sandakan by road. The forest reserve covers an area of 7930 ha, and it is managed by Sabah Forestry Department under the jurisdiction of Serudong Forestry District. The insect survey was conducted from 23rd to 26th September, 2019 during scientific expedition under Heart of Borneo programme, organized by Sabah Forestry Department. Light-trapping sites are shown in Table 1. The temperature and humidity are recorded during light-trapping sampling.

Table 1. Light-trapping sites in Sungai Serudong Forest Reserve

Sampling site	Coordinates	Elevation (m)	Temp. (°C)	Humidity (%)	Sampling date	Remarks
A	N 04°19'51.8" E 117°18'49.2"	113	24.7	79	24 Sept	Clear sky with stars
B	N 04°20'10.4" E 117°18'01.9"	114	24.3	81	25 Sept	Clear sky with stars
C	N 04°21'32.9" E 117°19'39.8"	285	24.2	82	26 Sept	Clear sky with stars

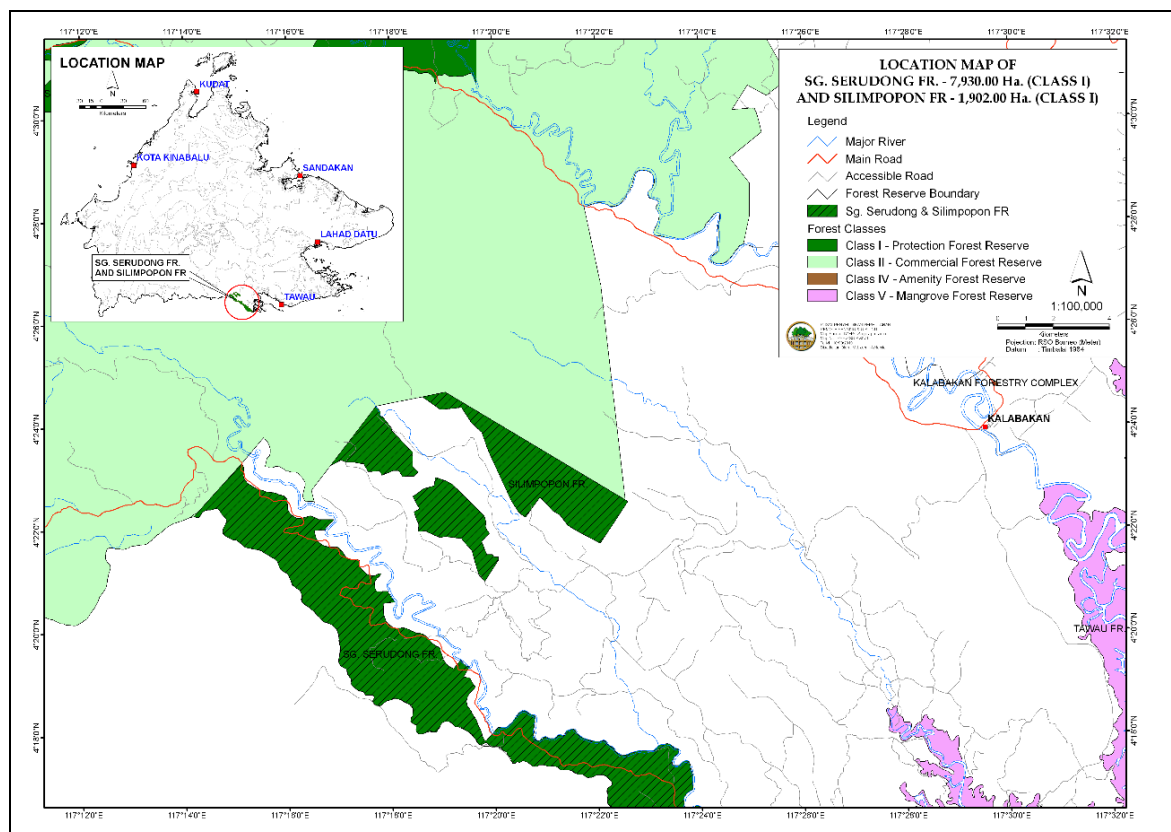


Figure 1. Location of Sungai Serudong Forest Reserve in Sabah

Insect Sampling Methods

In this study, light-trapping, sweep-netting and manual collection were conducted. The light-trap was set-up at night for diversity assessment. During daytime, sweep-netting and manual collection were conducted to record general diurnal insects.

Samplings

Light-trapping

Light trap consisted of a vertical white sheet (2 X 2 m) illuminated by a 250W mercury-lithium bulb. It was powered by a portable Yamaha generator (Model: ET950, China). The trap was set up in an open area facing the forest reserve, from 7:00 to 9:00 p.m. A GPS (Model: Garmin GPSMAP 60CSx, China) was used to determine the coordinates of each sampling site. Temperature and humidity were taken with a digital hygrometer from Extech

Instruments (model no. 445702, China). To evaluate diversity of the sampling area, insect species and individuals (≥ 5 mm) within the 1 X 1 metre square of the white cloth were enumerated from 8:30 to 9:00 pm. 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.

Sweep Net and Manual Collection

Sampling was conducted along the trails established for the expedition. Sweep nets were used to collect flying insects while other insects were sampled using fine forceps. Once captured, butterflies were put in triangle papers while other specimens were put in vials with 75% ethanol solution.

Insect Identification

In this survey, focus was given to certain insect groups, i.e., butterflies, moths, beetles, dragonflies and damselflies. Photographs were taken by using DSLR camera (Model: Nikon D7200, Thailand) were taken to facilitate identification. Selected specimens were dry-mounted and sorted to family and some to the genus and species level. Dry-mounted specimens were identified based on the FRC Entomology Collection and various reference materials, e.g., Otsuka (1988 & 2001) for butterflies; Holloway (1983, 1985, 1986, 1988, 1989, 1993, 1996, 1997, 1998a & b, 1999, 2001, 2003, 2005, 2008, 2009 & 2011) and Robinson et al (1994) for moths; Fujita (2010), Makihara (1999) and Tung (1983) for beetles; Orr (2003) and Tang et al. (2010) for dragonflies and damselflies. Some other insects were identified based on Chung (2014); Hill and Abang (2005); Seow-Choen (2016) and Unno (2016). All the specimens were deposited at the Insect Collection of Forest Research Centre, Sepilok, Sabah.

Statistical Analysis

The diversity indices, namely Shannon Wiener and Simpson were calculated through a diversity analysis namely Species & Richness software by Seaby & Henderson (2007), based on Magurran (2004) and Southwood and Henderson (2000).

RESULTS AND DISCUSSION

Nocturnal Insect Diversity as Assessed through Light-trapping

In total, a mean of 74 species of nocturnal insects were recorded from a one-square-metre of the light trapping cloth, with an average of 109 individuals (Tables 2-3). The distribution of insect species from the light trapping sites is reflected in the species-rank abundance curves (Figure 2). The mean Shannon Index (H') was 4.00 while Simpson Index was 47.76 and Fisher Alpha Index was 83.64. Site A shows the lowest Simpson's Index because of a dominant species which was the Night Wasp, *Provespa anomala* (Hymenoptera: Vespidae). This is also reflected in the higher staggered slope of the species-abundance curve of Site A. Site C has the most species as reflected in the Shannon's and Simpson's diversity values, and the longest tail in the species rank-abundance curve.

Table 2. Insect diversity within a one-square-metre, as sampled through light-trapping in Sungai Serudong Forest Reserve

No.	Sampling site	No of Species	No of Ind.	Shannon (H')	Simpson	Fisher Alpha
1.	A	62	105	3.73	30.85	63.39
2.	B	69	95	4.04	53.10	140.76
3.	C	92	128	4.24	59.33	146.56
	Mean	74±15.7	109±16.9	4.00±0.3	47.76±14.9	83.64±46.3

Table 3 List of insect species collected from Sungai Serudong Forest Reserve

Order	Family	Species	Remarks	
Coleoptera	Cicindelidae	<i>Cosmodela aurulenta</i>		
	Elateridae	<i>Cryptalaus superbus</i>		
	Passalidae	<i>Leptaulax bicolor</i>		
	Scarabaeidae	<i>Chalcosoma moellenkampi</i>	Endemic to Borneo	
		<i>Lepidiota stigma</i>		
Hemiptera	Alydidae	<i>Leptocorisa</i> sp.		
	Cicadidae	<i>Dundubia vaginata</i>		
		<i>Megapomponia merula</i>		
	Tessaratomidae	<i>Pycanum rubens</i> (Nymph)		
	Formicidae	<i>Dinomyrmex gigas</i>		
Hymenoptera		<i>Polyrhachis dives</i>		
	Ichneumonidae	<i>Xanthopimpla</i> sp.		
	Vespidae	<i>Provespa anomala</i>		
Isoptera	Nasutitermididae	<i>Nasutitermes</i> sp.		
		<i>Xyleutes mineus</i>		
		<i>Daddala</i> sp.		
		<i>Aethalida borneana</i>	Endemic to Borneo	
		<i>Amata prepuncta</i>	Endemic to Borneo	
		<i>Asota heliconia</i>		
		<i>Barsine crustata</i>		
		<i>Barsine roseororatus</i>		
		Erebidae	<i>Barsine rubricostata</i>	
			<i>Cyana conclusa</i>	
			<i>Cyana determinata</i>	
			<i>Cyana malayensis</i>	
			<i>Cyana perornata</i>	
			<i>Cyana selangorica</i>	
			<i>Eugoa aequalis</i>	
			<i>Oenistis altica</i>	
			<i>Comibaena attenuata</i>	
			<i>Hipochrosis binexata</i>	
		Lepidoptera	Geometridae	<i>Mustilia dierli</i>
<i>Takanea diehli</i>				
<i>Dudusa vethi</i>				
	Notodondidae			

		<i>Moduza procris agnata</i>	
	Nymphalidae	<i>Parthenos sylvia borneensis</i>	
		<i>Vindula dejone dejone</i>	
		<i>Ypthima pandocus sertorius</i>	
		<i>Graphium sarpedon sarpedon</i>	
		<i>Graphium</i> sp.	
		<i>Papilio memnon memnon</i>	
	Papilionidae	<i>Papilio nephelus albolineatus</i>	
		<i>Trogonoptera brookiana brookiana</i>	
		<i>Troides amphrysus flaviscollis</i>	
	Pieridae	<i>Eurema alitha gradiens</i>	
		<i>Daphnusa ocellaris</i>	
	Sphingidae	<i>Rhagastis rubetra</i>	
	Uraniidae	<i>Lyssa menoetius</i>	
Neuroptera	Mantispidae	<i>Tuberontha</i> sp.	
Odonata	Calopterygidae	<i>Vestalis</i> sp.	
	Chlorocyphidae	<i>Libellago semiopaca</i>	
	Coenagrionidae	<i>Ceriagrion cerinorubellum</i>	
	Libellulidae	<i>Neurothemis fluctuans</i>	
		<i>Orthetrum testaceum</i>	
	Platycnemididae	<i>Prodasineura verticalis</i>	
Phasmida	Diapheromeridae	<i>Calvisia sammannani</i>	Endemic to Borneo

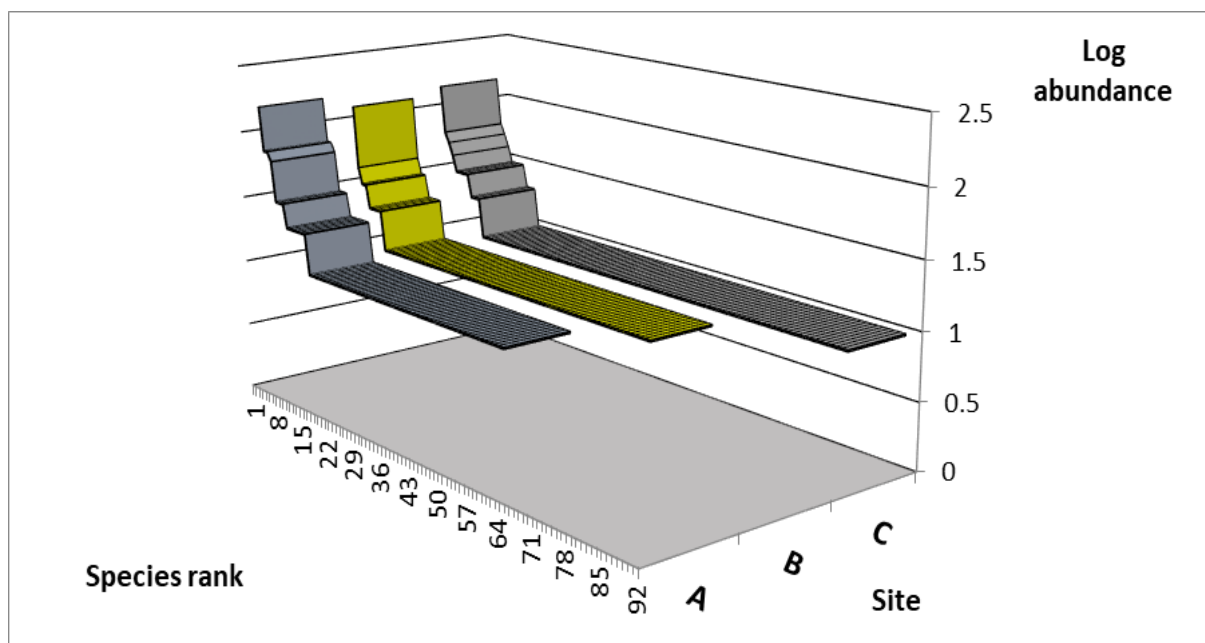


Figure 2. Species-rank abundance curves of the light-trapping in Sungai Serudong Forest Reserve

When the nocturnal insect species richness and diversity is compared with 28 other forest reserves in Sabah, they are moderate as shown in Figure 3a and Figure 3b.

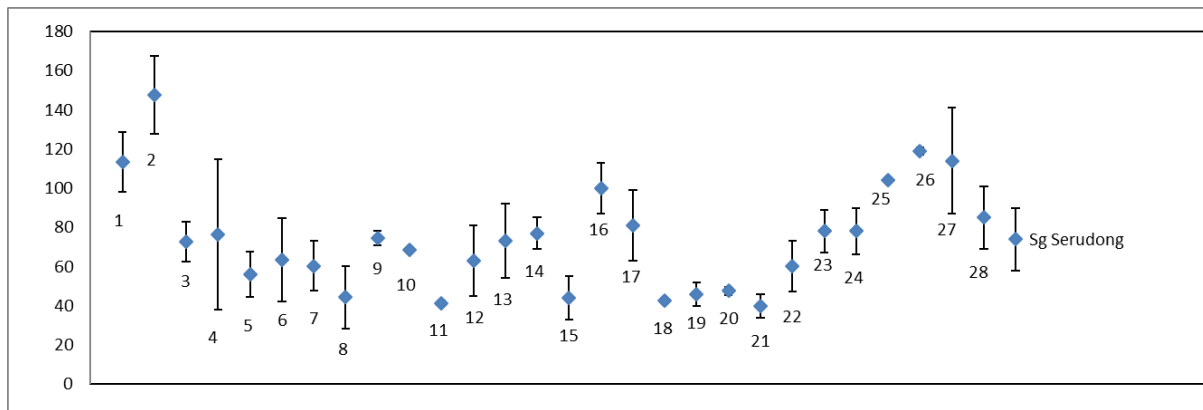


Figure 3a. Species number (\pm standard deviation) within one square metre as assessed through light-trapping in various forest reserves in Sabah (1 = Bkt Hampuan, 2 = Crocker Range, 3 = Rafflesia, 4 = Gn. Lumaku, 5 = Gunong Lumaku, 6 = Milian Labau, 7 = Kawag, USM Office, 8 = Sg. Kapur, 9 = Sg. Siliawan, 10 = Nurod Urod, 11 = Punggol & Sansiang, 12 = Gg Tinkar, 13 = Sg Imbak 2a&2b, 14 = Tim-Bot, 15 = T. Bohangin, 16 = Sg Imbak 2c&2d, 17 = Kungkular, 18 = Pensiangan, 19 = Nuluhon Trusmadi, 20 = Batu Timbang, 21 = Tambulanan, 22 = Trusan Sugut, 23 = IJM SG, 24 = Ulu Kalang, 25 = Sg Rawog, 26 = Sg Kangkawat, 27 = Lingkabau & 28 = Sg Pin)

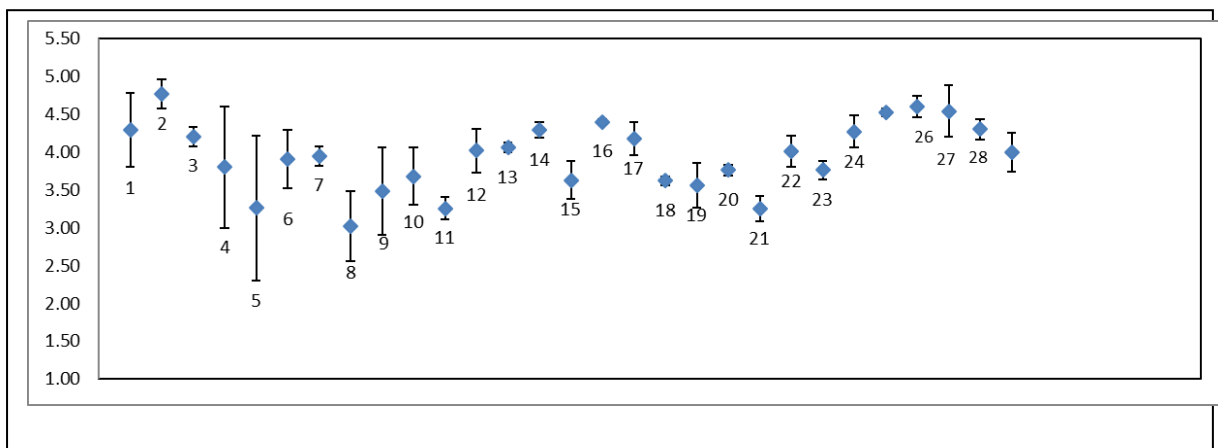


Figure 3b. Shannon Index (\pm standard deviation) within one square metre as assessed through light-trapping in various forest reserves in Sabah (For sites 1-28, refer to details in Figure 3a)

Bornean Endemic Insect Species from the Survey

A total of four Bornean endemic species were recorded during the survey, as listed in Table 4 and photographed in Figure 4. This information provides input towards recommendations on high conservation values (HCV) of the area, based on HCV 1 as stipulated in HCVRN (2013).

Table 4. Bornean endemic insect species recorded from Sungai Serudong Forest Reserve

No.	Species	Author	Order	Family
1	<i>Chalcosoma moellenkampi</i>	Kolbe	Coleoptera	Scarabaeidae
2	<i>Aethalida borneana</i>	Holloway	Lepidoptera	Erebidae
3	<i>Amata prepuncta</i>	Holloway	Lepidoptera	Erebidae
4	<i>Calvisia sammannani</i>	Seow-Choen	Phasmidae	Diapheromeridae

Two Bornean endemic moth species were recorded in this expedition which belong to family Erebidae. For beetles, there was a Three-horned Rhinoceros Beetle, *Chalcosoma moellenkampi* attracted to the light trap. It is not surprise to see this species because the forest reserve is surrounded by the oil palm plantation since this beetle is one of the serious pests for the palm. A stick insect, *Calvisia sammannani*, was found during the daytime sampling. The species was named after the former Chief Conservator of Forests, Sabah, Datuk Sam Mannan. All the Bornean endemic species were identified based on various resources, for moths: Hollloway (2001), for beetle: Bosuang et al. 2017 and for stick insect Seow-Choen (2016) and through pers. comm. with Prof. Dr. Francis Seow-Choen.

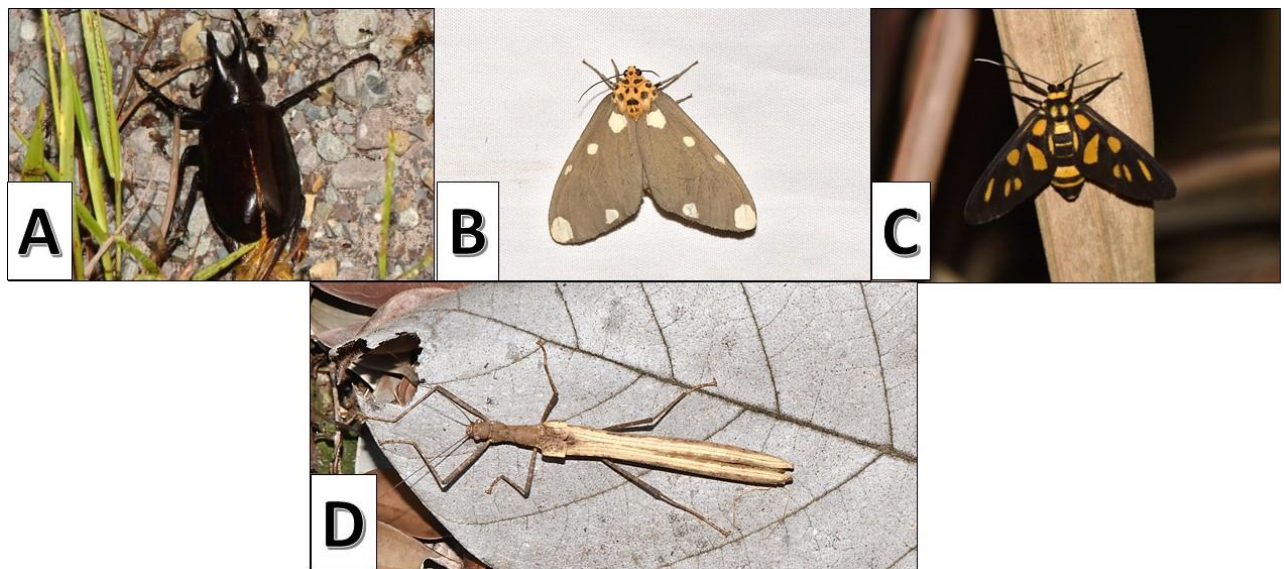


Figure 4. Some Bornean endemic insects recorded during the survey. A) *Chalcosoma moellenkampi*; B) *Aethalida borneana*; C) *Amata prepuncta* and D) *Calvisia sammannani*

Butterflies

A total of 11 butterfly species were recorded. The most interesting species sighted during the expedition was the Malaysian iconic species, Rajah Brooke birdwing, *Trogonoptera brookiana* (Parry 2020). It is often sighted feeding on the nectar of ornamental tree species, *Mussaenda* nr *phillippenensis*, which belongs to the family Rubiaceae, based on the expert, John Baptist Sugau (pers. comm). Other interesting butterflies sighted during the expedition was the Golden Birdwing (*Troides amphrysus*) which is often featured in Sabah's nature tourism promotion (Anonymous 2014; Japir et al. 2020). Both are protected species under Schedule 2 of Sabah's Wildlife Conservation Enactment 1997. The River Cruiser Butterfly, *Vindula dejone* was sighted puddling at the riverbank of Sungai Serudong.

Moths

A total of 24 moth species were documented from this expedition. Quite a number of Tiger Moths of the genus *Cyana* were recorded from light-trapping. Two Geometrid moths attracted to the light trapping were *Comibaena attenuata* and *Hipochrosis binexata*. Other interesting species recorded was the Durian Hawk Moth, *Daphnusa ocellaris*. This species is well-known as Durian Hawk Moth as the larvae feed on *Nephelium* and *Durio* species (Otsuka 1987; Rao & Arora 1997; Robinson et al. 1994). Other large moth species included the Hawk Moth (Sphingidae), *Rhagastis rubetra* and the Black and White Swallowtail Moth, *Lyssa menoetius* (Uraniidae).

Beetles

Five macro beetle species were recorded during the survey. Many Passalid beetles, *Leptaulax bicolor*, were found inside a dead log. According to Bosuang et al. (2017), they are living in small groups in decaying wood and the mature beetles will feed their young at all stages. Another interesting beetle recorded was the Click beetle, *Cryptalaus superbus*, which is the largest white-coloured Click Beetle in Borneo. Cockchafer Beetle, *Lepidiota stigma*, was attracted to the light trap. This species is easily recognized by its shape that looks like an egg and covered with whitish scales.

Dragonflies and damselflies

There were eight species of Odonata sighted during the survey. There were two dragonflies, which is from family Libellulidae, and six damselflies, from the families Calopterygidae, Chlorocyphidae, Coenagrionidae and Platycnemididae recorded during the daytime sampling. One of the interesting dragonflies was the green damselfly, namely *Vestalis* sp. This genus is easy to recognize as by its green metallic body (Choong 2011; Tang et al. 2010; Orr 2003). Orange-tailed Marsh Dart, *Ceriagrion cerinorubellum* (Coenagrionidae), was spotted at the riverbank of Sungai Serudong Forest Reserve.

Other insects

A total of 11 species of other insects were recorded. These include insects from the order Hemiptera, Hymenoptera, and Neuroptera. One of the most interesting groups recorded were the cicadas. Two cicadas were attracted to the light trap, namely *Megapomponia merula* and the Green Cicada, *Dundubia vaginata*. *Megapomponia merula* is the biggest Cicada recorded in Sabah, measuring up to 70 mm of body length and a wing span of 190 mm (Chung 2019). Many Night Wasps, *Provespa anomala*, were attracted to the light trap. The Giant Forest Ant, *Dinomyrmex gigas*, could be seen on the forest floor. They are also a good indicator for a healthy forest. A parasitoid wasp, *Xanthopimpla* sp., was sighted resting on a leaf. A mantidfly, *Tuberontha* sp. (Neuroptera), was recorded attracted to the light trap. It is one of the predatory insects that is often nocturnal (Chung et al. 2014; Japir et al. 2021; Kral 2013).

Contribution of Insect Diversity Assessment in Forest Management

This rapid assessment on insect diversity in Sungai Serudong Forest Reserve has provided some baseline information that is fundamentally important and can contribute towards conservation and protection of this area as a Class I Forest Reserve. It is acknowledged that such brief results may not give a comprehensive picture of the overall diversity of insects in the whole forest reserve unlike long-term studies, such as Ting et al. (2016). Therefore, the findings cannot be used to interpret and provide conclusive recommendations for conservation. We acknowledge that conservation planning requires a large scale of data on insect diversity. Nevertheless, the findings from this study are first-hand information that are crucial to provide an indication of the diversity of insects in that area. Research has never

been carried out in the past because of logistics problems and accessibility issues. Hence, results gathered from this brief survey can be incorporated in the formulation of forest management plan, especially insects that have been documented, and the endemic insects which are important indicators or target species for conservation purposes.

The threats and issues that are affecting insect diversity are similar to those with many other forests in Sabah, as highlighted by Chung & Lee (2009), Chung et al. (2018), Japir et al. (2020) and Nilus et al. (2014). They should be viewed in a holistic approach. Conserving the forest would mean protecting its flora and fauna as well. Hence, any threats or issues that are affecting the ecosystem would indirectly have an impact on insect fauna as well. The threats that are affecting the fauna and flora of Sungai Serudong Forest Reserve are forest fire and encroachment. There is a risk of forest fire during drought at certain time of the year and also indiscriminate burning and throwing of cigarette butts from poachers that encroach into the forest. The reserve is located close to the border of Sabah (Malaysia) and Kalimantan (Indonesia). Hence, encroachment and poaching are potential threats that might affect the reserve.

In order to minimise the threats and issues on insect diversity as well as other resources in the forest, the relevant agencies, such as the Forestry Department, Wildlife Department and the armed forces would have to work together in safe-guarding the reserve. Enforcement through patrolling has to be conducted regularly to ensure that sustainable forest management is being practised accordingly. It is also important to have more signages to warn trespassers.

CONCLUSION

Research findings from this rapid assessment have revealed that the nocturnal insect diversity was moderate, in comparison with 28 other reserve forests in Sabah. The data on insect fauna and endemic species are important in contributing towards the formulation of the forest management plan of this reserve. In order to maintain the insect diversity, minimize the threats and adverse issues, continuous monitoring and enforcement at strategic locations within the forest reserve should be conducted.

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