Rapid assessment of insect diversity (Ext.), Kalabakan, Sabah

J Razy, B Momin, L Y John and A Y C Chung
Forest Research Centre, Sabah Forestry Department, P.O. Box 1407, 90715 Sandakan, Sabah, Malaysia
* Corresponding author: Razy.Japir@sabah.gov.my

Abstract. The Sungai Tiagau Forest Reserve is a Class 1 Protection Forest Reserve under jurisdiction of Serudong District Forestry Office of Sabah Forestry Department. This reserve is located in south eastern Sabah, covering an area of 7,010 ha. This study was aimed to document the insect fauna of Sg. Tiagau Forest Reserve (Ext.), as well as to investigate the threats affecting insect diversity. Nocturnal insect diversity was assessed through light-trapping from 7:00 p.m. until 9:00 p.m. for three consecutive nights while diurnal insects were documented through sweep nets and forceps. A mean 58 species of nocturnal insects was recorded from a one-square-metre of the light-trapping cloth within three different sites, with an average of 74 individuals. The mean Shannon Index was 3.84 while Simpson Index was 111.26 and Fisher Alpha Index was 178.48. When making a comparison with other forest reserves in Sabah, this reserve shows moderately low in terms of insect diversity but moderate in terms of species richness. Eight Bornean endemic species were recorded during the survey and that will be provide significant information to enhance the conservation of Sg. Tiagau Forest Reserve (Ext.) and serve as a baseline information for future research. From the insects recorded, they can be used to promote nature tourism by highlighting Bornean endemic and interesting species, such as the iconic butterfly, Rajah Brooke Birdwing. There are a few threats and issues that may affect insect diversity, including forest fire, changes in land-use and encroachment. A cooperation between Sabah Forestry Department with relevant agencies could help in addressing the discussed issues. This first-hand information on insects of the reserve can be included in the formulation plan of a sustainable forest management system as stipulated in HCVRN.

Keywords: Rapid assessment; insects; light-trapping; conservation; nature tourism.

1. Introduction
The Sungai Tiagau Forest Reserve (Ext.) is located in the south eastern Sabah (see Figure 1). The Sungai Tiagau Forest Reserve (Ext.) is an extension of the Sungai Tiagau Forest Reserve and has been gazetted as Class I Protection Forest Reserve in 2014. The journey by road to the site was about 3 hours from Tawau town. The forest reserve covers an area of 7,010 ha and it is managed by Sabah Forestry Department under jurisdiction of Serudong District Forestry Office. The insect survey was conducted from 4th to 9th November, 2019 and based at a former police station (N 04°19'53.1", E 117°19'42.8" at 174 m a.s.l.). It took about 9 hours from Sandakan by road. This study aims to calculate insect diversity, document the insect fauna and investigate the potential threats in the forest reserve.

The reserve comprises three forest ecosystems mainly lowland mixed dipterocarp forest and partly upland mixed dipterocarp forest and lowland mixed dipterocarp and kerangas.

In Borneo, most of the species of Dipterocarpaceae are dominating the lowland area [1] and this is highly important for pollinating insects [2]. It is essential to maintain a class of forest reserves in order to maintain the importance of biodiversity. Indirectly, it can also maintain the food chain for animals that live in the reserve.
Through this rapid assessment, the diversity of this forest reserve can be described and the results of the data can help in sustainable forest management and further strengthen the supervision of this forest reserve [3].

Figure 1. Sg Tiagau Forest Reserve (Ext.) location in Sabah. The inset picture shows the three light-trapping sites.

2. Materials and methods

2.1 Light-trapping
Light trap was set up facing the forest reserve to calculate the insect. The trap consists of a vertical white sheet (2 X 2 m) illuminated by a 250W mercury-lithium bulb. It was powered by a portable Yamaha generator. 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) 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).

To evaluate diversity of the sampling area, insect species and individuals (≥ 5 mm) within the 1 X 1 m 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, i.e. Shannon Wiener, Simpson and Fisher Alpha, using the Species Diversity & Richness version IV [4]. This method is simple, fast and can be carried out by non-insect specialist. To avoid compounding human error, the same staff was assigned to count the species and individual numbers throughout the sampling period, and also for other sampling sites.

2.2 Sweep net and manual collection
Sweep nets were used to collect flying insects while other insects were sampled using fine forceps. Butterflies were put in triangle papers while other specimens were put in vials with 75% ethanol.
solution. Sampling was conducted along the trails established for the expedition. Insects that are commonly seen were photographed using a camera while only insects that need to be studied were brought back to the laboratory. Ethical practices in entomology were observed [5,6].

3. Results of analysis

3.1 Diversity assessment through light-trapping

The temperature during light-trapping was 240°C–250°C with humidity between 84% and 85%. Climatic elements such as humidity, temperature and weather condition also are shown in Table 1. Other than that, geolocation with its elevation were recorded at the three light-trapping sites. The diversity indices, namely Shannon Wiener, Simpson and Fisher Alpha were calculated through a diversity analysis software, namely Species Diversity and Richness: Version 2 [7,8,9]. Based on Table 2, Site A shows the lowest Simpson’s Index because of a dominant species which was the honey bee, Apis cerana (Hymenoptera: Apidae). This is also reflected in the higher staggered slope of the species-rank abundance curve of Site A (see Figure 2).

| Site | Geolocation | Elevation (m) | Temp. (°C) | Humidity (%) | Sampling date | Remarks                  |
|------|-------------|---------------|------------|--------------|---------------|--------------------------|
| A    | N 04°36’47.4” E 117°23’54.3” | 110           | 25.3       | 84           | 5 Nov         | Cloudy and half moon     |
| B    | N 04°36’47.1” E 117°23’54.3” | 126           | 25.4       | 85           | 6 Nov         | Cloudy and light-drizzle |
| C    | N 04°36’47.9” E 117°23’54.9” | 83            | 24.1       | 84           | 7 Nov         | Raining                  |

| Site | Species Ind. | Shannon | Simpson | Fisher Alpha |
|------|--------------|---------|---------|--------------|
| A    | 53           | 3.66    | 35.75   | 72.72        |
| B    | 86           | 4.28    | 103.02  | 222.35       |
| C    | 37           | 3.57    | 195.00  | 240.38       |

Mean± standard deviation 58±25 74±32.7 3.84±0.3 111.26±79.94 178.48±92.03

Figure 2. Species-rank abundance curves of the three light-trapping sites. Site A has the highest staggered slope because of a dominant species which was the honeybee. Site B has the most species as reflected in the Shannon’s and Simpson’s diversity values and has the longest tail in the species rank-abundance curve which reflected it has the most species recorded.
Figure 3. Y-axis represents the Shannon Index while X-axis represents the forest reserves in Sabah for the purpose of diversity comparison. Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon index increases as both the richness and the evenness of the community increase. Site C shows the lowest Shannon Index due to the rain that affected the readings. In terms of nocturnal insect diversity as reflected by Shannon Index, it is considered high but moderately low when compared with other forest reserves in Sabah. (1 = Bkt Hampuan, 2 = Crocker Range, 3 = Rafflesia, 4 = Gunong Lumaku, 5 = Milian Labau, 6 = Kawag, USM Office, 7 = Sg. Kapur, 8 = Sg Siliawan, 9 = Nurod Urod, 10 = Punggol & Sansiang, 11 = Gg Tinker, 12 = Sg Imbak 2a&2b, 13 = Tim-Bot, 14 = T. Bohangin, 15 = Sg Imbak 2c&2d, 16 = Kungkular, 17 = Pensiajan, 18 = Nuluhon Trusmadi, 19 = Batu Timbang, 20 = Tambulahan, 21 = Trusan Sugut, 22 = IJM SG, 23 = Ulu Kalang, 24 = Sg Rawog, 25 = Sg Kangkawat, 26 = Lingkabau, 27 = Kungkular, 28 = Sg Pin, 29 = Serudong & 30 = Mensalong).

3.2 The Bornean endemic insects
The tiger beetle, *Calomera crespignyi* was spotted foraging on the riverine area of Sungai Tiagau Forest Reserve (Ext.). These beetles were found in almost all sandy sampling areas. It is not surprising to see many of them gathered as the sandy coarse area is the habitat of the tiger beetles. This species is easily recognized by the ‘T’ pattern on the back of its abdomen (elytra). This tiger beetle has been used as bioindicator. The presence of this tiger beetle is an indication of a good forest and environment [10,11].

For moth, three Bornean endemic species belong to the family, namely *Amata prepuncta*, *Barsine lucibilis* and *Eugoa tesselata* were attracted to the light trap. A Geometrid moth, *Plutodes cyclaria* was recorded attracted to the light trap at second day. A Bornean Hawk Moth, *Eupanacra psaltria* was recorded. This is the only Bornean endemic species of the family Sphingidae [12].

3.3 The insect fauna (non-endemic) of Sungai Tiagau Forest Reserve (Ext.)
The main insect groups that were documented are butterflies, moths, beetles, ants, wasps, dragonflies and other insects (see Appendix). The most recorded group is Lepidopterans. A total of 20 moth species and 18 butterfly species were recorded throughout the survey. Lepidoptera is one of the most important groups as pollinating agents for dipterocarp trees. This has been proven in a study on *Dipterocarpus obtusifolius* [13]. From the data, Lepidoptera is the most widely recorded group in this study which is likely to be the pollinating agent for other dipterocarp species.

A total of 18 butterfly species were recorded. The most interesting species sighted during the expedition was the Malaysian iconic species which is Rajah Brooke, *Trogonoptera brookiana* [14]. This species is protected species under Schedule 2 of Sabah’s Wildlife Conservation Enactment 1997. They were 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 [15]. Other interesting butterflies sighted during the expedition was the Golden Birdwing ( *Troides amphrysus*). The most recorded butterflies were Nymphalid butterflies of different genera, namely *Cirrochroa, Euploea, Idea, Mycalesis, Pantoporia, Parantica, Vindula and Graphium*.
At least 20 moth species from 6 families, namely Erebidae, Geometridae, Lasiocampidae, Limacodidae, Saturniidae and Sphingidae were documented from this expedition. There were two non-endemic Hawk Moths, namely *Cechenena lineosa* and *Theretra suffusa*, attracted to the light trap. They are one of the fastest flying insects. The biggest moth that attracted to the light trap was the Silk Moth, *Antheraea jana* (Saturniidae).

Seven macro beetles, including fungus beetles, *Endomorphus marginatus*, were found underneath of fungus. Three Leaf Beetles, namely *Aulacophora*, *Dercetina* and *Theopea* were recorded during the diurnal survey. There were eight species of Odonata sighted during the survey. Five common dragonflies, which are from family Libellulidae, namely *Orthetrum testaceum*, *Neurothermis terminata*, *Rhodothermis rufa*, *Orthetrum pruinoseum* and *Trithemis festiva*. Three damselflies, from family Calopterygidae, *Euphaeidae* and *Protoneuridae* were recorded during the day 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. Order Odonata is one of the bioindicators for water cleanliness [16]. Dragonflies are more sensitive to indicate clean water than damselflies [17,18].

At least 13 species of other insects were recorded. These include insects from the Order Diptera, Hemiptera, Hymenoptera, and Phasmida. Ants formed most of the insects recorded during the diurnal survey. They can be seen foraging on the forest floor. One of the interesting insects was the Kamikaze Ant, *Colobopsis saundersi* [19]. When they are threatened, they will sacrifice themselves by tearing their body apart to protect the rest of the colony and release yellowish fluid. A female stick insect, namely *Necrosia monticola*, was recorded inside Sungai Tiagau Forest Reserve (Ext.). A number of paper wasps, *Ropalidia* sp. was sighted inside the reserve. According to Chung [20], their nest is made from paper pulp. Many Night Wasps, *Provespa anomala*, were attracted to the light trap.

3.4 Current issues on insect fauna and conservation at Sungai Tiagau Forest Reserve (Ext.)

The discovery of endemic and interesting insects in the Sungai Tiagau Forest Reserve (Ext.) could generate ideas in the development of ecotourism in the future. Activities such as jungle trekking and insect watching are among the activities that can be carried out in ecotourism. Training or courses in insect watching to the nearby residents can help in the ecotourism sector by attracting tourists and at the same time creating more employment opportunities. Awareness on the value of conservation can be fostered at the local level. A cooperation between multi-agencies could create creativity and innovative ecotourism [21].

The diversity of insects in the forest reserve is modest. Therefore, insect populations should be conserved as they are one of the food sources for wildlife [22]. The importance of insect conservation at the Sungai Tiagau Forest Reserve (Ext.) could help to maintain the nutritional diet of insectivorous animals that live inside the reserve. Indirectly, this can help the ecotourism industry in various tourism activities, such as bird watching, safari and even insect watching in the future.

The main threat to the forest reserve is forest fire. The study site is close to the Luasong-Kalaban road and several surrounding villages. Besides that, the study area is also served as a water catchment area for residents living near the forest reserve. Based on a study [23], forest reserve areas close to roads and village areas are more vulnerable to the risk of forest fires. The distance from nearby Fire and Rescue Department to the forest reserve is quite far from which further complicates fire-fighting operations in the event of a fire. To mitigate this issue, monitoring using drones that have been practiced by Fire and Rescue Department to monitor areas that are potential for forest fire during the dry season [24] can be used to monitor this forest reserve.

Residents living close to the forest reserve mostly live on private land. However, from observation, there are some nearby areas have been converted to oil palm plantations. Changes of land-use are also one of the issues that can affect insect diversity [25]. Altered insect micro-habitats can alter the diversity of certain insects inhabiting those micro-habitats [26]. However, there are also other insects that will inhabit altered land areas such as dung beetles [27]. The dung beetle is one of the best insect engineers that is good in decomposing waste into nutrients that make the soil healthier for plants [28].

Another threat is encroachment as there is a lot of road access to the reserve. This was once reported in Borneo Today in 2016 [29] regarding illegal hunting in Luasong which is just next to this forest
reserve. Therefore, cooperation between Sabah Forestry Department and other agencies, including the villagers in the area should be practiced in order to prevent encroachment in the forest reserve.

4. Conclusion
Research findings from this rapid assessment have revealed that the nocturnal insect diversity (Shannon Index) was moderately low in comparison with 30 other reserves in Sabah. However, there are Bornean endemic and interesting insect species recorded that can enhance the conservation of Sungai Tiagau Forest Reserve (Ext.). The recorded data bring conservation values as stipulated in HCVRN [30].

Continuous monitoring and enforcement within the conservation area is important to minimize the threats and adverse issues. A cooperation between Sabah Forestry Department and relevant agencies such as Wildlife Department, Fire and Rescue Department and even the nearby villagers can also help in addressing the discussed issues.

It is acknowledged that these recorded data do not provide a comprehensive picture of the forest reserve unlike the long-term studies by [31]. Therefore, the recorded data cannot be summarized for conservation purposes because the conservation plan requires a lot of data. However, these data records are basic information that has crucial information on the diversity of insects in the reserve. Therefore, this basic information can be included in the formulation plan of a sustainable forest management system, especially insects that have been recorded including endemic insects as indicator or target species as conservation purposes.

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## Appendix

| Order            | Family       | Species                             | Remarks                     |
|------------------|--------------|-------------------------------------|-----------------------------|
| Coleoptera       | Chrysomelida | *Aulacophora* sp.                   |                             |
|                  | Cicindelida  | *Dercetina* sp.                     |                             |
|                  |              | *Theopea* sp.                       |                             |
|                  | Endomychidae | *Calomera crespignyi*               | Endemic to Borneo           |
|                  | Scarabaeida  | *Endomorphus marginatus*            |                             |
|                  |              | *Ontophagus semiaureus*             |                             |
|                  |              | *Ontophagus* sp.                    |                             |
| Lepidoptera      | Lycaenidae   | *Curetis tagalica* jopa             |                             |
| (Butterflies)    |              | *Zizina otis* otis                  |                             |
|                  | Nymphalidae  | *Cirrochroa satellita satellita*    |                             |
|                  |              | *Euploea crameri crameri*           |                             |
|                  |              | *Euploea algea zonata*              |                             |
|                  |              | *Euploea diocletianus lowii*        |                             |
|                  |              | *Idea leuconoe virgo*               |                             |
|                  |              | *Mycalesis horsfieldi hermana*      |                             |
|                  |              | *Mycalesis patiana patiana*         |                             |
|                  |              | *Pantoporia aurelia aurelia*        |                             |
|                  |              | *Parantica aspasia aspasia*         |                             |
|                  |              | *Vindula dejone dejone*             |                             |
|                  | Papilionidae | *Graphium antiphates itamputi*      |                             |
|                  |              | *Papilio demolion demolion*         |                             |
|                  |              | *Trogonoptera brookiana brookiana*  |                             |
|                  |              | *Troides amphrysus flaviscolis*     |                             |
|                  | Riodinidae   | *Paralaxita orphna orphna*          |                             |
| Lepidoptera      | Erebidae     | *Amata prepuncta*                   | Endemic to Borneo           |
| (Moths)          |              | *Barsine cruciata*                  |                             |
|                  |              | *Barsine lucibilis*                 | Endemic to Borneo           |
|                  |              | *Eugoa aequalis*                    |                             |
|                  |              | *Eugoa tesselata*                   | Endemic to Borneo           |
|                  | Geometridae  | *Astygisa stueningi*                |                             |
|                  |              | *Cleora inoffensa*                  |                             |
|                  |              | *Comibaena nr attenuata*            |                             |
|                  |              | *Eucyclodes albisparsa*             |                             |
|                  |              | *Eucyclodes semialba*               |                             |
|                  |              | *Heterostegane subtesselata*        |                             |
|                  |              | *Plutodes cyclaria*                 | Endemic to Borneo           |
|                  | Lasiocampidae| *Tanaorhinus rafflesii*             |                             |
|                  | Limacodidae  | *Mustilia dierli*                   |                             |
|                  |              | *Paralabeda lucifuga*               |                             |
|                  | Saturniidae  | *Birthana congrea*                  |                             |
|                  | Sphingidae   | *Antheraea jana*                    |                             |
|                  |              | *Cechenena lineosa*                 |                             |
| **Odonata** | **Caloptrygidae** | *Eupanacra psaltria*  
*Endemic to Borneo*  
*Theretra suffusa*  
*Neurobasis longipes*  
*Vestalis sp.*  
*Chlorocyphidae*  
*Helicypha biseriata*  
*Libellago semiopaca*  
*Euphaeidae*  
*Euphaea sp.*  
*Libellulidae*  
*Diapcodes nebolusa female*  
*Neurothemis fluctuans*  
*Orthetrum chrysis*  
*Orthetrum glaucum*  
*Orthetrum pruinosem*  
*Orthetrum testaceum*  
*Trithemis aurora*  
*Trithemis festiva*  
*Coeliccia nemoricola*  
*Vestalis* sp.  
*Eupanacra psaltria*  
*Endemic to Borneo* |
| **Diptera** | **Calliphoridae** | *Calliphora sp.* |
| **Hemiptera** | **Tessaratomidae** | *Unidentified* |
| **Hymenoptera** | **Formicidae** | *Camponotus sp.*  
*Colobopsis saunders*  
*Diacamma nr rugosum*  
*Leptogenys sp.*  
*Odontoponera transversa*  
*Polyrhachis armata*  
*Polyrhachis dives*  
*Mutillidae*  
*Mutilla sp.*  
*Vespidae*  
*Provespa anomala*  
*Ropalidia sp.*  
| **Phasmda** |  
*Necrosia monticola* |