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Front cover: A Bornean endemic insect, *Mycalesis amoena*, recorded at Kungkular F.R. (Photo: Eyen Khoo)

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New records of insects associated with Red Laran (*Neolamarckia macrophylla*) in Sabah

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Abstract. A total of 9 species of insects associated with Red Laran are discussed here. Seven of them are defoliators, while one is a stem borer and another a sap-sucking bug. Except for bagworms (Lepidoptera: Psychidae), the rest are new records. Information pertaining to the insects, including the life cycle and other ecological data is provided. Control measures are also highlighted.

Keywords: Red Laran, insects, *Neolamarckia macrophylla*

INTRODUCTION

Red Laran or *Neolamarckia macrophylla* (Roxb.) Bosser of the family Rubiaceae is indigenous to Sulawesi, Maluku and possibly Papua (Rismawati 2011 & Setyaji *et al.* 2014). It is a moderate to large tree, about 40-45 m tall, with a straight, columnar bole that is self-pruned up to 80%. This species is found in secondary forests, up to 1000 m in altitude. The young stem and leaf midrib are reddish in colour, hence the name 'Red Laran', 'Red Kelempayan' or 'Red Jabon'. Pereira *et al.* (2016) and Halawane *et al.* (2011) highlighted the morphological differences between *N. macrophylla* and *N. cadamba*. The latter species, known locally as 'Laran', is indigenous to Sabah. It is planted as a fast-growing plantation tree in many Forest Management Units (FMUs), with much emphasis given by the Sabah Forestry Department (Lee *et al.* 2008 & Ajik *et al.* 2008). *N. macrophylla*, however, is lesser known in Sabah and it is only recently that this species was introduced as a plantation tree in two FMUs in the state, namely Sapulut Forest Development and Usahawan Borneo. Some 200 hectares have been planted with Red Laran in the Sapulut Forest Development forest concession in south-central Sabah since October 2013 (Plate 1).

The wood of Red Laran can be used for plywood, furniture, veneer, pulp and paper, and many more. This species is known to have favourable wood properties compared to *Neolamarckia cadamba*, as it preserves well and is a more durable and stronger wood. However, the rotation age for Red Laran is expected to be longer than that of Laran (Pereira *et al.* 2016). Besides timber, Red Laran is also suitable for reforestation in watersheds and eroded areas, and good for windbreaks in agroforestry systems (Halawane *et al.* 2011).

Since this species has only been planted rather recently in Sabah, there is no information on insects causing damage to the tree. Therefore, it is timely and appropriate to conduct surveys and to document insects associated with Red Laran, some of which may be potential pests of the tree. Some research, however, has been conducted on insects associated with Red Laran in Indonesia, e.g. Halawane *et al.* (2011), Setyaji *et al.* (2014) and Rorong (2014). Such information will be useful for practising foresters, planters, researchers as well as the general public.

MATERIALS & METHODS

Assessments were conducted on the saplings at the Sabah Forestry Headquarters within the Heritage Amenity Forest Reserve in Sandakan, Sapulut Forest Development in south-central Sabah and the seedlings at the Forest Research Centre's nursery in Sepilok. Insects that were found damaging Red Laran were collected manually while surveying the study sites. Pictures of the insects were taken and the extent of the damage was recorded. In most cases, the damage was caused by larvae of insects, and thus the larvae were sampled and reared in plastic containers embedded with tissue, to monitor their life cycle at room temperature of about 29°C. When the adult emerged, photographs were taken and the specimens were placed in triangle paper and are kept in the refrigerator. Some were dry-mounted for identification, based on reference materials at the Forest Research Centre, Sepilok. The insect specimens were deposited at the Centre.

RESULTS & DISCUSSION

Insects associated with Red Laran

A total of 9 insect species were recorded from Red Laran in this study (Table 1). Eight of them are new records (except bagworms of the family Psychidae) as they were not listed in Robinson *et al.* (2001) and not documented by Halawane *et al.* (2011), Setyaji *et al.* (2014) and Rorong (2014). A thorough internet search also did not yield any results of the eight insect species being associated with Red Laran.

Halawane *et al.* (2011) provided some details of insects attacking Red Laran in Indonesia, namely moth larvae of *Spodoptera* sp. (Noctuidae), *Thosea asigna* (Limacodidae) and *Achaea* sp. (Noctuidae), sap-sucking bug of the genus *Helopeltis* (Miridae), termite of the genus *Coptotermes* (Termitoidae) and the Javanese grasshopper, *Valanga nigricornis* (Acrididae). Setyaji *et al.* (2014) did not elaborate on the insect species causing damage to Red Laran but a bagworm was featured in one of the photos. Rorong (2014) reported four insect orders, namely Hymenoptera, Coleoptera, Odonata and Hemiptera, associated with 3-month-old seedlings of Red Laran in Manado, Sulawesi. Most of them, however, are not pests except aphids (Aphididae) and mealybugs (Pseudococcidae) of the order Hemiptera.

In this study, the commonest insect encountered was the Gold Dust Weevil, *Hypomeces squamosus* Fabricius (Coleoptera: Curculionidae), feeding from the leaf edge inwards, forming

a semi-circle. This weevil was also recorded feeding on the leaves of Laran (Chung *et al.* 2009a). Other insects that were documented feeding on the foliage of Laran were the Hawk Moth caterpillar, *Daphnis hypothous* Cramer (Lepidoptera: Sphingidae), the Commander Butterfly caterpillar, *Moduza procris agnata* Fruhstorfer (Lepidoptera: Nymphalidae) and various species of bagworms (Lepidoptera: Psychidae). The Stem Borer, *Endoclita* sp., was recorded from Sapulut Forest Development, and the same genus was reported previously attacking Laran. Economically, this is the most serious pest documented in this paper as it causes mortality to the tree. It is interesting to note that the Laran Skeletonizer, *Arthroschista hilaralis* Walker (Lepidoptera: Pyralidae), has not been observed defoliating Red Laran. This is the most serious insect pest of Laran (Chung *et al.* 2009a, Chey 2001 & Nair 2007) which can completely defoliate mature trees.

Table 1: Insects recorded from Red Laran (*Neolamarckia macrophylla*) in this study.

Order	Family	Species	Damage	Occurrence*	Record
Coleoptera	Curculionidae	*Hypomeces squamosus* Fabricius	Leaf	High	New record
Hemiptera	Cicadellidae	*Bothrogonia ferruginea* Fabricius	Leaf and shoot	Moderate	New record
Lepidoptera	Hepialidae	*Endoclita* sp.	Stem	Moderate	New record
Lepidoptera	Limacodidae	*Darna trima ajavana* Holloway	Leaf	Low	New record
Lepidoptera	Lymantriidae	*Calliteara horsfieldii* Saunders	Leaf	Low	New record
Lepidoptera	Lymantriidae	*Clethrogyna turbata* Butler	Leaf	Moderate	New record
Lepidoptera	Nymphalidae	*Moduza procris agnata* Fruhstorfer	Leaf	Low	New record
Lepidoptera	Psychidae	Various species	Leaf	Low	Not possible to identify
Lepidoptera	Sphingidae	*Daphnis hypothous* Cramer	Leaf	Low	New record

* Low = 1-5 specimens recorded during survey
Moderate = 6-20 specimens recorded during survey
High = more than 20 specimens recorded during survey

Some notes on the insects associated with Red Laran

Gold Dust Weevil, *Hypomeces squamosus* Fabricius (Coleoptera: Curculionidae)

This is a polyphagous weevil, about 15 mm in length, feeding on a number of forest trees, agricultural crops and ornamental plants. The adult is active during daytime and can be easily spotted through its conspicuous yellow body (Plate 2). The body is actually covered with shiny yellow scales, with the male generally more striking than the female. The larva feeds on roots of weeds or food plants of the adult weevil but not much is known about the larva as a serious pest.

In this study, this weevil has caused considerable damage to the foliage but it does not kill the tree. If the infestation is severe in the nursery, chemical spraying using contact insecticides, e.g. Cypermethrin or Chlorpyrifos, can be applied. For saplings in the field where spraying is difficult, systemic insecticide, such as Furadan can be used.

Common Red Leafhopper, *Bothrogonia ferruginea* Fabricius (Hemiptera: Cicadellidae)

This insect is a sap-sucking bug (about 10 mm in size) which is often found at the underside of the midrib of leaves as well as young shoots (Plate 3). During the survey, it was often seen individually and did not occur in high abundance. Hence, it did not cause severe dehydration to the plant as a result of excessive removal of plant sap. This red leafhopper has powerful hind legs which enable it to jump from one leaf to another, and also serve as a defence mechanism to escape from intruders.

The attack from the survey sites was not severe. Hence, control measure is not necessary, especially in the field. In the nursery, if the infestation has caused some young shoots and leaves to wither, then systemic insecticide can be applied.

Stem Borer, *Endoclita* sp. (Lepidoptera: Hepialidae)

This stem borer was observed attacking some of the saplings in Sapulut Forest Development in south-central Sabah (Plate 4). Although the attack only occurred in a small number of the saplings, it has caused mortality to a few of them. The tunnel, in some cases, forming a horizontal ring pattern at the bark, has weakened the sapling, and eventually caused the stem to break apart during thunderstorm. The attack often occurs at the basal stem and within two metres from the ground. The larva and mode of attack are similar to that described by Chey (1996). The life cycle of most *Endoclita* spp. takes over a year, and tunnels (1.5 cm in diameter) which were 50 to 60 cm long were reported (Dhanarajan 1976). Larvae of the same genus were reported previously attacking other forest trees, including *Tectona grandis, Gmelina arborea, Eucalyptus deglupta* and *Neolamarckia cadamba* (Chey 1996).

Fresh attack (with wet frass at the entrance hole) can be treated by injecting contact insecticide, e.g. Chorpyrifos, Cypermethrin or Malathion, through the entrance hole using plastic pipette, syringe or a hand-held sprayer with small tube.

Nettle Caterpillar, *Darna trima ajavana* Holloway (Lepidoptera: Limacodidae)

This is a polyphagous species and it is known to cause considerable damage to various plants, including oil palm, coconut, cocoa, coffee and banana. The larva is relatively small, measuring about 12 mm in length (Plate 5). The lateral spines on its body can cause irritation and inflammation to human skin. Like many other nettle caterpillars, the pupa is ball-like. From this study, the pupation was approximately 10 days and the emerged adult moth has a body length of 8 mm with a wing span of 16 mm. More details of this species are provided by Holloway (1986).

From the survey, the occurrence was low and control measure was not necessary. If there is infestation in the future, especially in the nursery, the larvae can be controlled using contact insecticide.

Yellow Tussock Caterpillar, *Calliteara horsfieldii* Saunders (Lepidoptera: Lymantriidae)

As its name suggests, this caterpillar is covered with long yellow hairs and a few dense tufts on its back (Plate 6). It will reveal its dark eye spot towards the anterior part of its body when molested. This is to frighten the intruder. Specimens sampled from the study site grew up to 40 mm in size. Besides Red Laran, this larva is also known to feed on the foliage of a number of forest trees, such as *Acacia, Terminalia, Shorea* and *Parashorea*. Pupation was about 10 days. Male and female moths are different in size and appearance. The female is larger, with a wing span of about 60 mm and appears to be whiter in colour, than the male. Other details of this species are given by Holloway (1999). Control measure is similar to that of the Nettle Caterpillar.

Hairy Caterpillar, *Clethrogyna turbata* Butler (Lepidoptera: Lymantriidae)

This caterpillar can be a serious pest (Plates 7a & b) as it has caused considerable damage to various forest tree seedlings at the Forest Research Centre's nursery in Sepilok (Chung *et al.* 2006 & 2013). The caterpillar can occur in high abundance and completely defoliate the seedlings within a few days. Details of this species are provided by Holloway (1999). Unlike other typical moths, the female of this species is bulky and flightless with vestigial wings, as featured in Chung *et al.* (2009b). While rearing some of the caterpillars in captivity, a few parasitic flies of the dipteran family Tachinidae emerged (Plate 7c).

Regular monitoring at the nursery is important to check any proliferation of the caterpillar's population. If early instar of the caterpillar is detected, it can be terminated through spraying, using contact insecticide.

Commander Butterfly, *Moduza procris agnata* Fruhstorfer (Lepidoptera: Nymphalidae)

This is a very interesting defoliator because the larva and pupa were ingeniously camouflaged, resembling debris or curled dried leaf (Plate 8). It was initially difficult for the survey team members to spot the larva. Specimens were collected and reared in captivity. A mature larva could reach a length of 40 mm. The pupal stage was about 10 days and the emerged adult was identified based on Otsuka (1988 & 2001) and Kirton (2014). It has a wing span of 62 mm. This nymphalid butterfly is a fast and vigorous flyer, hence, the name 'Commander'.

Control measure is not required as this species is not known to have occurred in high abundance.

Bagworms (Lepidoptera: Psychidae)

Bagworms are moth larvae that construct cases of silk and pieces of plant materials in which they live in (Plate 9). The cases are often found hanging at the underside of the leaf. The larva within the case feeds on the foliage of Red Laran with its thoracic legs protruding from the front of the case. It often causes multiple holes on the leaf. The larva may remain in the case for a few months while in some species, the adult females lack wings and hence, cannot be identified accurately. From the survey, the bagworms could be from the genera *Amatissa* and *Eumeta*. Robinson *et al.* (1994) and Chey (1996) provided some information on these two genera.

Bagworms can be hand-picked as the cases do not normally cause irritation to the skin. They can be destroyed by crushing onto the ground or putting the cases in the freezer for an hour. Microbial insecticide, e.g. *Bacillus thuringiensis*, can be used to control bagworms when the infestation is severe. It is recommended because it is specific to insects that feed on the leaves or any surface of the hostplant that have been sprayed with the microbial insecticide.

Jade Hawk Moth, *Daphnis hypothous* Cramer (Lepidotera: Sphingidae)

The larva of this moth is a voracious feeder because of its size which can be up to 90 mm. The fleshy larva is green in colour and can be easily recognized through a reddish 'horn' at the back (Plate 10). At the later instar, the body colour and pattern may change to different shades of brown and yellow. The adult moth has a wing span of 85-110 mm. It is a distinctive moth with hawk-like aerodynamic shape and military-patterned wings. Details of this moth species are provided by Chey (2001) and Holloway (1987).

Although this species does not generally occur in high abundance, it can cause much defoliation because of its voracious feeding habit. Hence, it can cause complete defoliation, especially for young seedlings in the nursery. Constant monitoring at the nursery is important. The larvae can be removed and destroyed manually. Contact insecticide can be applied if early instar larvae are detected.

Economic importance and management of Red Laran potential insect pests

Rehabilitation, reforestation and planting forest trees are an important and integral aspect of sustainable forest management. These include natural regeneration, enrichment planting in logged over areas and planting in clear-felled areas. As of 2014, more than 230,000 ha in Sabah had been planted with forest plantation species (SFD 2014). At this stage, Red Laran is a lesser known species and it is still on a trial basis in Sabah. Nevertheless, it has the potential as a forest plantation species. Research in Indonesia has indicated that Red Laran is not severely attacked by caterpillars as the leaves and stems are thicker and harder compared to Laran. Wood quality and strength of Red Laran is known to be better than Laran (Pereira *et al.* 2016).

Regular monitoring of insect pests and research on potential insect pests are among the parameters that could contribute indirectly to the understanding of the growth and yield of plantation trees (Chung & Paul 2016), including that of Red Laran. This study shows that most of the insects associated with this tree species occurred in low frequency and abundance, and thus may not pose any threat at present. However, it is important to document and monitor any insects causing damage to Red Laran to understand the ecology of any potential pest species and to prevent future severe infestation. The knowledge gap on pests and the hostplant may affect any decision-making regarding the planting of this species, as happened to some tree species in the past.

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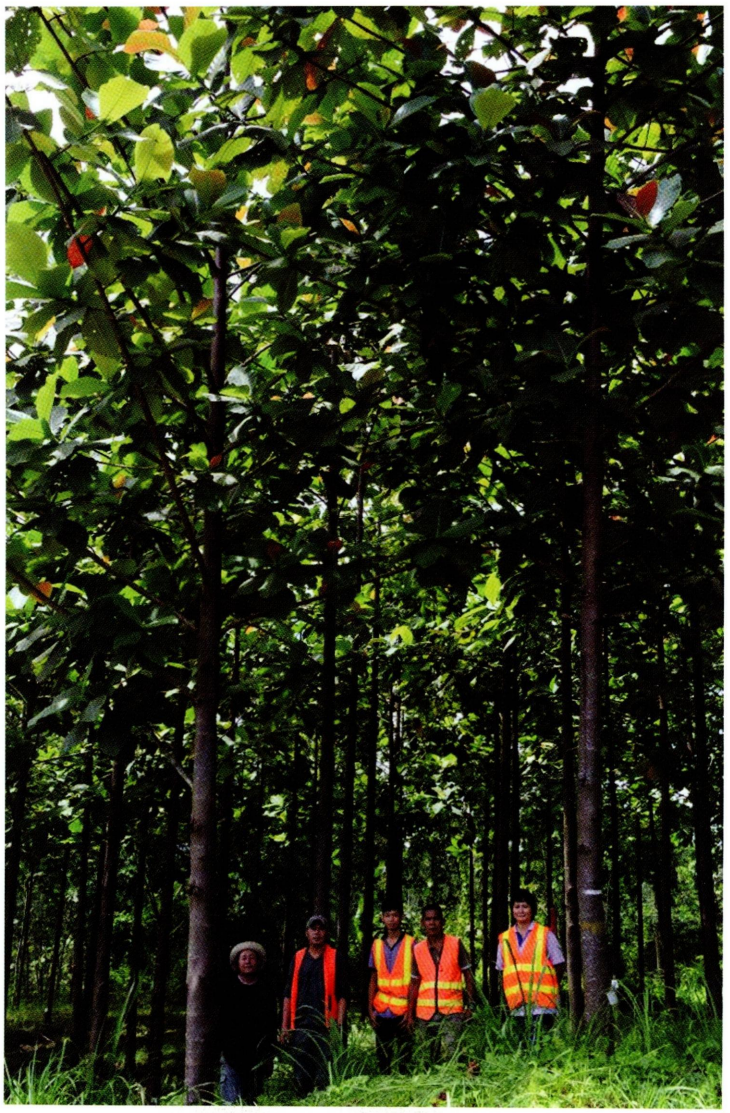

Plate 1. A 3-year-old Red Laran plot in Sapulut Forest Development, with a diameter at breast height (dbh) of up to 30 cm and a height of up to 7 m. No fertilizer was applied.

Plate 2. A mating pair of *Hypomeces squamosus*.

Plate 3. *Bothrogonia ferruginea.*

Plate 4a. A broken sapling stem caused by the stem borer.

Plate 4b. A horizontal ring pattern at the bark of the basal stem of a dead Red Laran.

Plate 4c. Larva of the stem borer, *Endoclita* sp.
(Photo: Sapulut Forest Development)

Plate 5a. Larva of *Darna trima ajavana.*

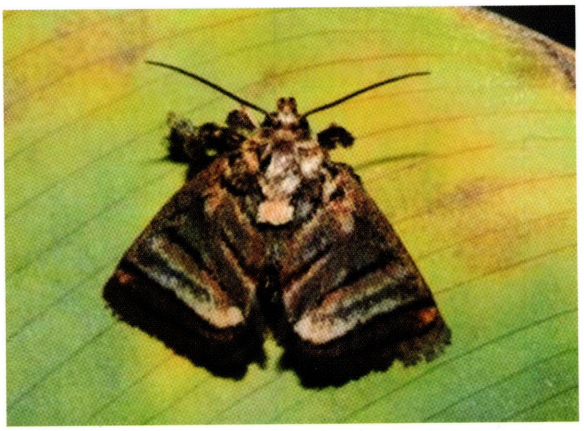

Plate 5b. Adult moth of *Darna trima ajavana.*

Plate 6a. Larva of *Calliteara horsfieldii,* with its black eye spot exposed.

Plate 6b. Adult male moth of *Calliteara horsfieldii.*

Plate 7a. Larva of *Clethrogyna turbata.*

Plate 7b. Pupa of *Clethrogyna turbata*, loosely covered with silky web.

Plate 7c. The parasitic fly (Diptera: Tachinidae) that attacked the larva of *Clethrogyna turbata.*

Plate 8a. The debris-like larva of *Moduza procris agnata.*

Plate 8b. The dried leaf-like pupa of *Moduza procris agnata.*

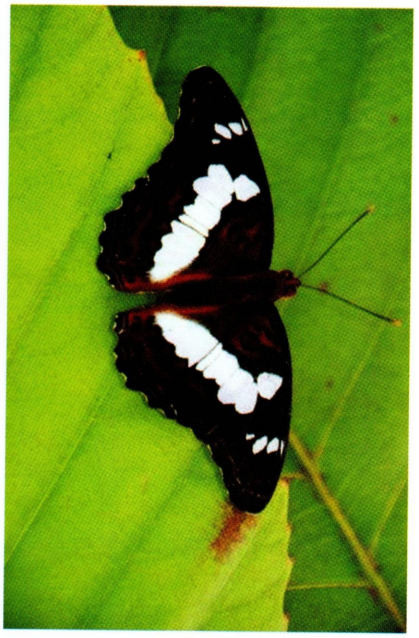

Plate 8c. Adult butterfly of *Moduza procris agnata.*

Plate 9. Bagworms in different cases, constructed from various plant materials. The holes on the leaf are caused by the bagworms.

Plate 10a. Larva of *Daphnis hypothous.*

Plate 10b. Adult moth of *Daphnis hypothous.*

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Ichthyofaunal diversity of a rehabilitated tropical mangrove forest reserve in Sabah

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Abstract. Mangrove ecosystem is one of the most productive coastal ecosystems in the world. The ecological services provided by mangrove ecosystem are significant for both economic development and environmental dynamics. In this study, we set out to answer questions pertaining to replanting programme in restoring the ecological functions of mangrove. Our approach was to assess the ichthyofaunal diversity of a rehabilitated mangrove. The study area is the Sungai Isme rehabilitated mangrove area, Sandakan. The area was replanted in 2012, but our work is the first report on the fishes in the area. Based on a two-day field sampling in Nov 2015, we recorded a total of 37 fish species from 14 families (N=118 individuals). The most diverse and dominant family was Gobiidae (9 species; 22%), followed by Ambassidae (5 species; 16%) and Mugilidae (5 species; 16%). One species, the Orange-spotted Grouper (*Epinephelus coioides*), is listed as a near threatened species in the IUCN Red List Species; whilst another species, Priapiumfish (*Neostethus* spp.) is endemic to Southeast Asia. Eighty one percent of fish caught are juvenile. This suggests that the function of the rehabilitated mangrove ecosystem as nursery ground is gradually being restored. Besides, high scores calculated for Shannon-Weaver diversity (3.33), Margalef richness (17.38) and Pielou equitability (0.92) imply that all species within the area are about equal in population size. On the other hand, the low catch abundance indicates that the fish community is in the process of recovery.

Keywords: fish diversity, rehabilitated mangrove ichthyofauna, Sabah

INTRODUCTION

The mangrove forest which comprises woody halophytes, is among the few ecosystems that has adapted to survive the harsh intertidal zone of the tropics. This coastal marine ecosystem which sits between the transition of the land and sea, where freshwater and seawater mix to form brackish water, is in fact very productive and ecologically functionally important (e.g. Ong & Gong 2013). Significant functions include supporting coastal protection with their hard and complex, yet durable roots which anchor into the soft sediment of mud, thus preventing erosion, as a source of various forest products and by-products; natural mangrove forests have

an abundance of living marine resources, namely fish and crustaceans, providing vital livelihood and food resources to humans.

Another contribution of the mangrove ecosystem is as an important atmospheric carbon sequester (e.g. McLeod *et al.* 2011, Alongi 2014, Quintana-Alcantara 2014). This significant ecological role has been the focus of contemporary mangrove research with the increased global concern about climate change and (fisheries) sustainability (IUCN 2004, Yohe *et al.* 2007).

The mangrove ecosystem is especially important to coastal fisheries as it supports a high fish diversity and biomass. The dependency of many fish species on mangrove ecosystem is recognized worldwide. The linkages between fish and mangrove are well-documented (Sasekumar *et al.* 1992, Blaber 2007, Aburto-Oropeza *et al.* 2008), with resident and diadromous species taking up their niche in the protected shallow waters among the mangrove roots in order to complete, or as a part of, their life cycle. It has also been demonstrated that the complexity of a natural mangrove forest provides a better environment to juvenile fishes seeking refugia here (Islam & Haque 2004, Nyanti *et al.* 2012b). Conservation of mangrove is thus important to ensure sustainable fisheries. However, the negative impacts from exploitation of mangrove forests are regularly reported, especially in the developing countries. In Sabah, many natural mangroves have been converted into other land uses, namely aquaculture pond, oil palm plantation and residential area.

BACKGROUND OF THIS STUDY

Encroachment and illegal exploitation activities in mangrove forest reserves around Sabah's coasts were detected and recorded between 2000 and 2010 by the Sabah Forestry Department (SFD), which is the government body entrusted with protecting the States' natural forest reserves (Tangah *et al.* 2015). The degraded forests, which involved the conversion of natural mangrove forests into various land use purposes for agriculture, aquaculture ponds, oil palm plantations, and residential estates are approximately 1% (3,300 hectares) of the States' total mangrove forest reserves. Sabah's Class V Forest Reserves (Note: Class V Forest Reserves are Mangrove Forest Reserves) are approximately 60% (338,050 hectares) of the total for Malaysia (Tangah *et al.* 2015).

In an effort to counter the continual destruction of mangrove reserves, SFD in 2011 embarked on a programme to systematically rehabilitate the degraded reserves. The programme was achieved through a collaborative project with the International Society for Mangrove Ecosystems (ISME), which adopts a cost-effective rehabilitation method, and with a planting target of 50 hectares per year (Tangah *et al.* 2015). In November 2015, we joined the team of Malaysian and Japanese researchers in the annual monitoring efforts in the SFD-ISME rehabilitated mangrove ecosystems. This is the first report on the fish biodiversity in one of the 14 SFD-ISME mangrove forest rehabilitation project sites in Sabah.

RESEARCH OBJECTIVES

This study was carried out with the primary objective to document and assess the biodiversity of fishes in a rehabilitated mangrove forest. During the field trip, it became apparent that artisanal fisheries by local villagers occurred within the study area; therefore, we also documented such activities and their catches.

STUDY AREA

The study site is a 2-hectare plot of replanted mangroves located within an area known as the Sg. Gum Gum and Sg. Loboh (Class V) Forest Reserve area in Sandakan district, Sabah (Figure 1; Tangah *et al.* 2015). The plot is located along Sg. ISME (hereafter written as 'Sg. Isme'), a 1.5 km left tributary of Sg. Loboh (area within the orange line in Figure 1D), and located near Kg. Padas (Note: 'sungai' or the abbreviated 'Sg.' is Bahasa Malaysia for river; and 'kampung' or 'Kg.' for village).

According to Tangah *et al.* (2015), the area was illegally cleared for oil palm plantation by the land owner adjacent the Reserve (Figure 1D). After intervention, the plot was replanted with 4,200 mangrove propagules and seedlings on 5-7 September 2012. In the following year (2013), it was reported that the seedlings in regularly inundated channels had displayed luxuriant growth.

It is evident that when the area was encroached and cleared for oil palm plantation, a 2 m bund was built around the perimeter, with two small drainage pipes fitted with a valve placed at two locations along the perimeter (light blue bars in Figure 1D). This was followed by clear felling of mangrove trees, and digging of drainage canals (Tangah *et al.* 2015), transforming the ground surface into undulating trenches, and changing the bottom sediment type by covering the surface with coarse sand sourced from elsewhere.

This area was left as it was for the mangrove replanting activity, except that the bund was intentionally breached (light green bars in Figure 1) at two locations before the area was replanted with mangrove propagules and seedlings. This was to facilitate tidal flushing, which is essential for the survival of the mangrove seedlings.

At the time of the present study (November 2015), the mangrove plants had grown into treelets of at least one meter in height (Figure 2A), and the stilt roots of the replanted *Rhizophora* spp. were already well-formed (Figure 2B). Moreover, in addition to the six species of replanted mangroves, many other mangrove plant species were observed to have taken root through natural regeneration (Figure 2C). On the other hand, the adjacent privately-owned land remained degraded, with dead or dying but still standing oil palm trees, and where stagnant water puddles with slimes and rusty coloured iron oxide were also evident (Figure 3). The breaches in the bund had also widened, apparently aided by nature's force (Figure 4).

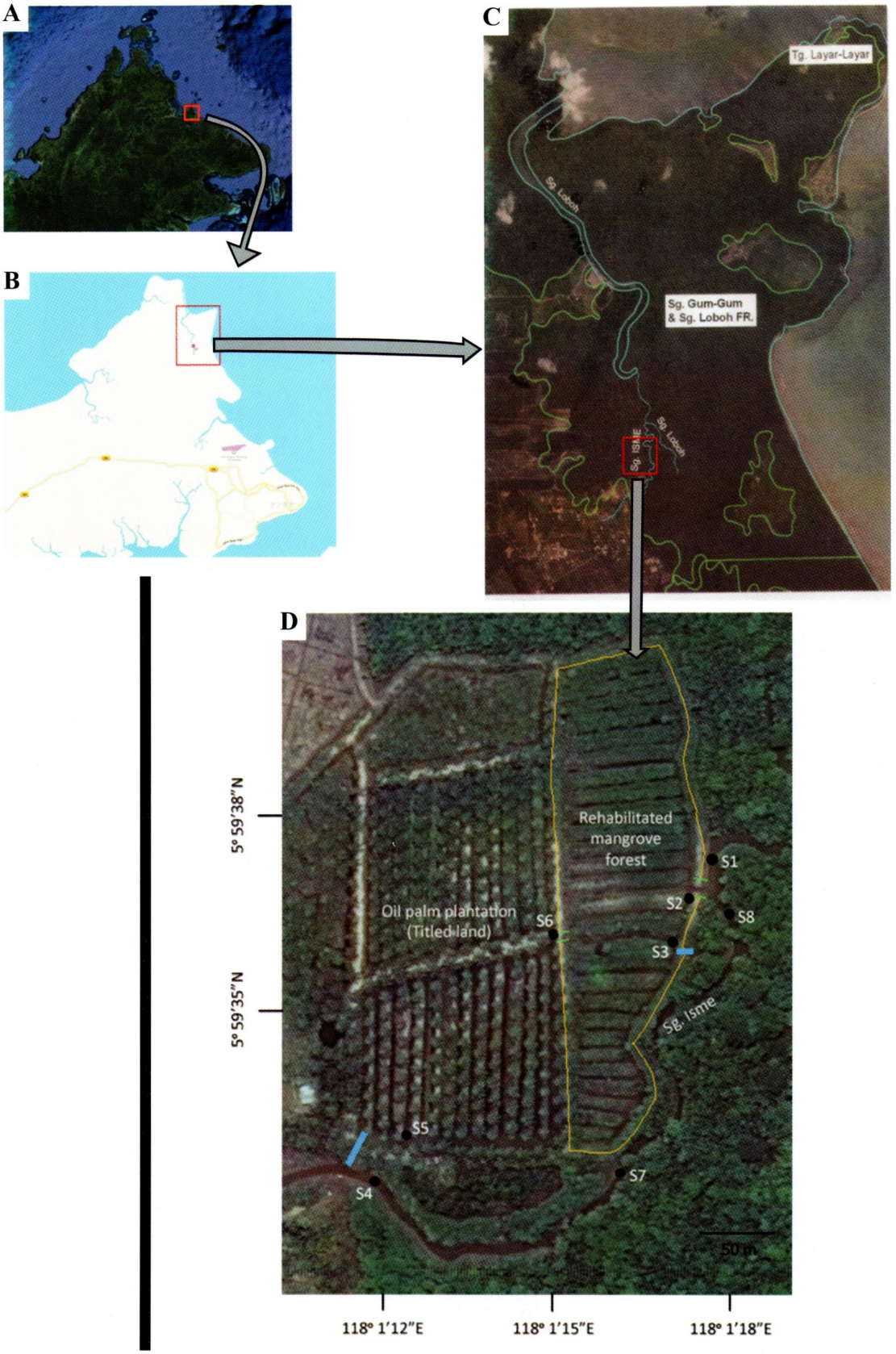


Figure 1. The study site. A- Map of Sabah; B~D- satellite images of the study site (source: A, B & D- Google Earth; C- adapted from Tangah *et al.* 2015).

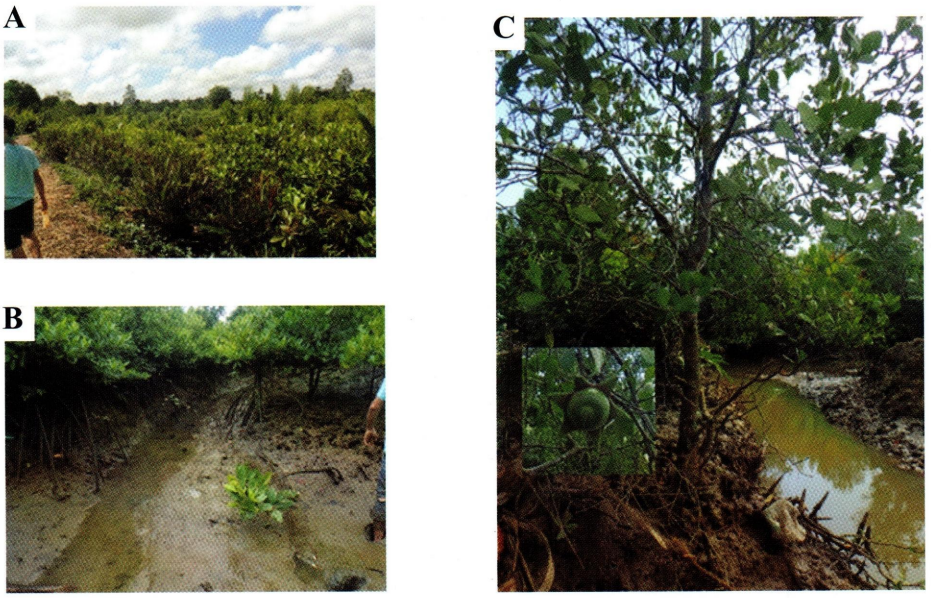


Figure 2. Sg. Isme rehabilitated mangrove forest (November 2015). A- treelets of at least one meter in height; B- the stilt roots of the replanted *Rhizophora* spp.; C- *Sonneratia alba* with fruit (inset), noted to have taken root through natural regeneration.

Figure 3. Dead or dying oil palm stands and slimy water puddles on the adjacent privately-owned land (November 2015).

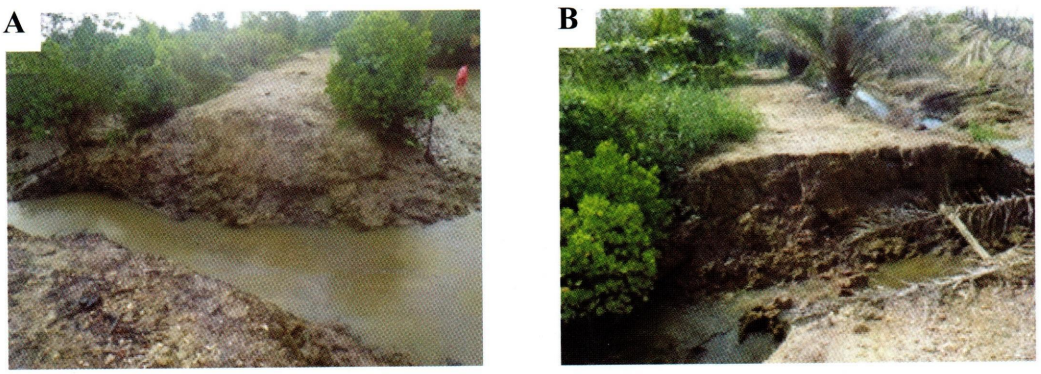


Figure 4. Breaches in the bund had widened, apparently aided by nature's force. A- at S2; B- at S6. Photos taken in November 2015.

MATERIALS & METHODS

Field samplings were carried out on 19 and 20 November 2015, during daylight of both ebb and flood tides. A total of eight sampling stations (S) were selected, two of which are located within the rehabilitated area (S2 and S3 in Figure 1D), two within the degraded area (S5 and S6 in Figure 1D), and four on the main Sg. Isme tributary (S1, S4, S7 and S8 in Figure 1D) (Figure 5).

Fishes were caught using a commercially available trammel net, and monofilament cast nets (mesh sizes 3/8 inches or 1 mm, and 1 inch or 2.5 mm). The trammel net was only used on the main tributary, with soaking time of between 1.5 hours and 5 hours (Table 1). The cast net was casted at least two times in each station. Quinaldine (15-20 ppm) was used to aid the capture of burrowing mudskippers and other fishes in water pools on the mudflats. Water parameters (salinity, conductivity, DO, pH and temperature) were recorded using YSI Professional Plus multiparameter at each station. Other fish habitat conditions, i.e. bottom substrate and mangrove cover were also noted.

All fish specimens obtained were measured for total and standard length (TL, SL) in millimetre (mm) to one decimal point using a vernier calliper, and each species photographed before being fixed in 10% formalin. These were all deposited as vouchers in the Marine Reference Collection of the Borneo Marine Research Institute (IPMB-I). Species with single specimen are given a registration number and individually tagged, while smaller fishes (usually those less than 5 cm TL) are grouped together, given one registration number, and not tagged to any individual specimen.

Fishes were identified to the lowest possible taxonomic level (e.g. Carpenter & Niem 1998a, 1998b, 2001, Froese & Pauly 2009, Kimura *et al.* 2015), is systematically listed following Nelson (2006). Three diversity indices are calculated and used to compare the results with other similar works in the region; these are Shannon-Weaver diversity index (H'), Pielou's equitability index (J), and Margalef richness index (D) (Table 2). Species maturity size was primarily crossed-checked with FishBase data (Froese & Pauly 2009).

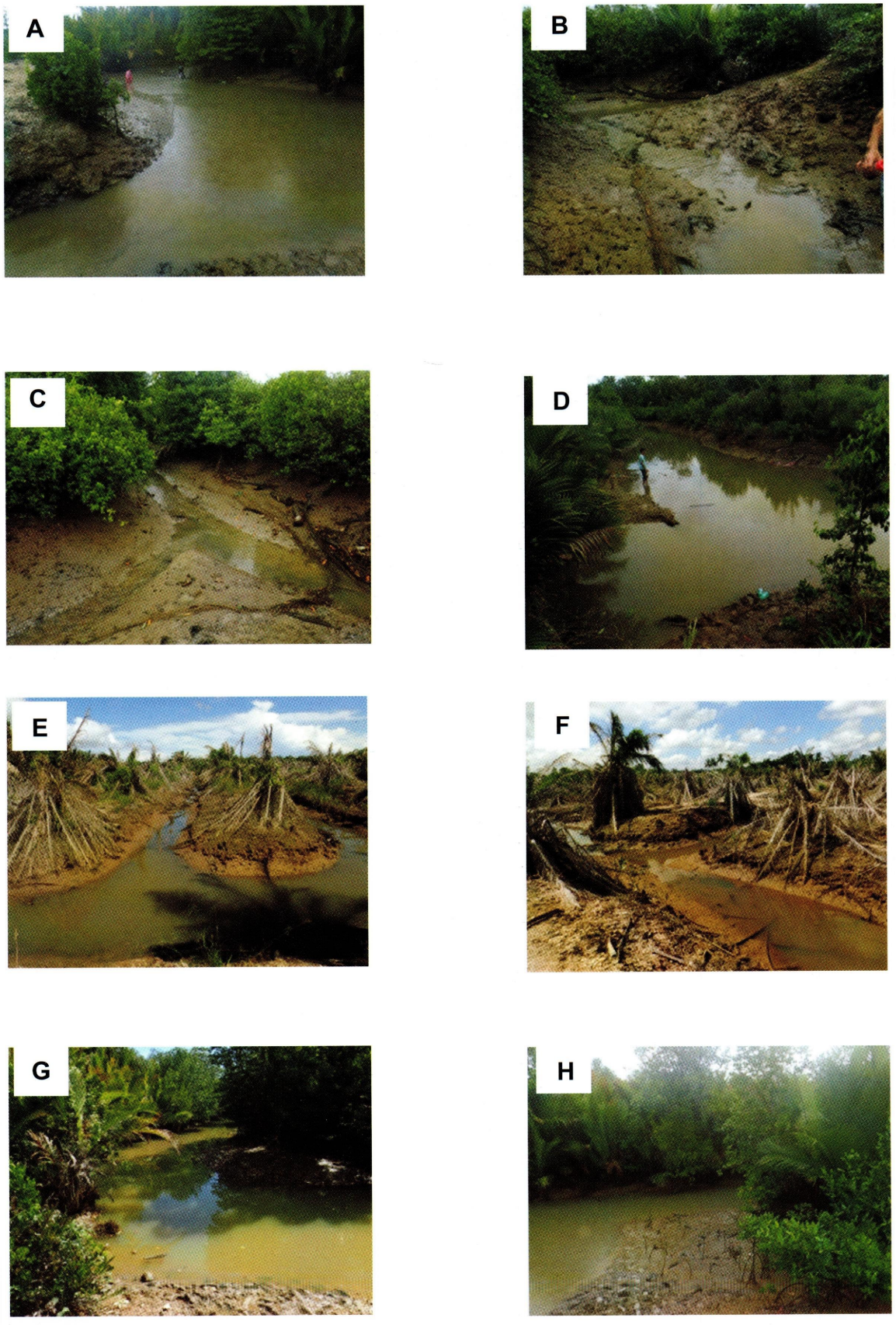


Figure 5. The sampling stations. A- Station 1: S1; B- Station 2: S2; C- Station 3: S3; D- Station 4: S4; E- Station 5: S5; F- Station 6: S6; G- Station 7: S7; H- Station 8: S8.

Table 1. Summary of sampling efforts (19 & 20 November 2015).

	Day 1					Day 2		
Station (S)	S1	S2	S3	S4	S5	S6	S7	S8
Fishing Net Gear type	Trammel	Cast	Cast	Trammel	Cast	Cast	Trammel	Cast
Time in (hour)	0730	-	-	0930	-	-	0730	-
Time out (hour)	1230			1130			0900	
Soak time (hours)	≈ 5	-	-	≈ 2	-	-	≈ 1.5	-
Depth (meter)	0.3-0.5	0.5	0.1	~0.6	~0.55	~0.6	0.6-0.8	0.4
Tide (E: ebb tide; F: flood tide)	E, F	F	F	E	E	E	E	E
Cloud cover	Light rain	Cloudy	Overcast	Clear	Clear	Clear	Clear	Clear

Table 2. Diversity indices.

1) *Shannon-Weaver diversity index, H'* (Shannon & Weaver 1963)

$$H = -\sum_{i=1}^{s} p_i \ln p_i$$

where:

s = total number of species;
p_i = proportion of individuals of a particular species.

2) *Pielou's equitability index, J* (Pielou 1966)

$$E_H = \frac{H}{In\, s}$$

where:

H = Shannon-Weaver diversity index;
s = total number of species

3) *Margalef richness index, D* (Margalef 1968)

$$D = \frac{(S-1)}{\log_{10} n}$$

where:

S = total number of species;
n = total individuals

RESULTS & DISCUSSION

Physical Water Quality

The values of the water parameters in the study area were within normal range, albeit on the lower end of the range (Table 3).

Table 3. Physical water parameters of this study, compared with values from other studies in a mangrove ecosystem.

Station	S1	S2	S3	S4	S5	S6	S7	S8	Aris *et al.* 2014	Juen *et al.* 2014	Manjaji-Matsumoto *et al.* In prep.
Salinity (ppt)	15.81	17.75	13.14	18.43	19.37	18.22	17.98	11.91	34.18±0.16	25.49±3.66	22.99±6.73
Cond (mS/cm)	27.38	31.78	23.60	30.99	32.64	30.79	30.48	21.50	31.00±23.00	39.70±5.08	39.70±11.13
DO (mg/L)	2.39	2.68	3.14	1.87	1.84	2.04	1.88	2.03	5.05±1.24	5.54±1.09	3.09±1.06
DO (%)	33.1	40.0	44.0	25.8	26.0	28.4	27.0	27.7	NA	NA	45.41±14.11
pH	6.96	7.05	6.85	7.09	6.90	6.95	7.03	6.65	7.23±18.69	7.21±0.92	7.20±0.26
Temp (°C)	28.1	29.9	28.9	27.2	27.4	27.2	27.4	27.9	28.78±14.62	31.62±2.30	29.53±0.88

Note: Cond = conductivity, DO = dissolved oxygen, Temp = temperature.

As the quality of water in an aquatic environment has a direct effect on its faunal inhabitants, it is worthwhile to evaluate water quality in the rehabilitated mangrove forest. Estuarine fishes, especially larvae and juveniles are more susceptible to ammonia poisoning in waters of high salinity, low pH and high ammonia loading (Eddy 2005), whereas a high acidic condition is detrimental to both the fish food organisms and fish (Alongi 2002). Moreover, the fluctuations of (especially) water temperature and salinity have been shown to adversely impact fish distribution and production (FAO 2010), leading to fish kills or disease. In this (brackish) water ecosystem, the acid sulphate soils may develop extreme acidity upon drainage and drying (Poernomo & Singh 1982; Singh & Poernomo 1984), more so when the soil is disturbed and exposed to oxygen (Dinesh *et al.* 2004).

Diversity of species

Species Composition

Thirty-seven fish species belonging to 24 genera, 14 families and 6 orders (N=118) were recorded from the area. These include 7 species identified up to family level, one species (Giant Mudskipper, *Periophthalmodon schlosseri*) which was observed but no specimen obtained, and one grouper species caught downstream of Sg. Isme by a local fisherman (Table 4).

The most speciose family is Gobiidae (9 species, including 4 unidentified species), while 8 families are represented by only one species. Gobiidae (gobies and mudskippers) and Leiognathidae (ponyfishes) are the two top families with the most number of individuals per species caught (N=10; 8.5% each of the total number).

The notably interesting priapiumfish, family Phallostethidae is a new record for the northeast coast of Borneo. Members of the family are small and slender (known maximum size not exceeding 40 mm TL), transparent to opaque, and thus are easily missed or mistaken as fish larvae (Roberts 1971). The males have a pair of bilaterally asymmetric spiny thoracic structure termed the priapium, an intromittent organ for internal fertilization. Although the family is ubiquitous throughout the brackish water environments of Southeast Asia, two new species were only described in the last two years, both from this region, while two other species are thought to be endemic to northwestern Borneo (Brunei) (Shibukawa *et al.* 2012, Parenti 2014, Suksri *et al.* 2015). At the time of this report writing, however, we were only able to identify specimens up to genus level (*Neostethus* sp.).

Some of the species recorded are shown in Figure 6.

Table 4. List of fish species found in Sg. Isme rehabilitated mangrove. The last column indicates their respective conservation status (IUCN Red List 2015). *Note: NE=Not Evaluated, LC=Least Concern, DD=Data Deficient, NT=Near Threatened. *=of commercial fisheries interest*

Order	Family	Scientific name	Common name	IUCN Red List status
Batrachoidiformes	Batrachoididae	*Allenbatrachus grunniens*	Grunting Toadfish	NE
Mugiliformes	Mugilidae	*Chelon macrolepis*	Largescale Mullet	LC*
		Chelon subviridis	Greenback Mullet	NE*
		Mugil broussonnetii	Broussonnet's Mullet	NE*
		Mugil cephalus	Flathead Grey Mullet	LC*
		Paramugil parmatus	Broad-mouthed Mullet	NE*
Atheriniformes	Phallostethidae	*Neostethus* sp.	Priapiumfish	NE
Beloniformes	Hemiramphidae	*Zenarchopterus* sp.	Halfbeaks	NE
Perciformes	Ambassidae	*Ambassis jacksoniensis*	Port Jackson Perchlet	NE
		Ambassis kopsii	Freckled Hawkfish	NE
		Ambassis macracanthus	Estuarine Glass Perchlet	DD
		Ambassis nalua	Scalloped Perchlet	NE
		Ambassis vachellii	Vachelli's Glass Perchlet	NE
Perciformes	Serranidae	*Epinephelus coioides*	Orange-spotted Grouper	NT*
Perciformes	Leiognathidae	*Equulites leuciscus*	Whipfin Ponyfish	NE
		Eubleekeria splendens	Splendid Ponyfish	LC*
		Leiognathus sp.	Ponyfish	-
		Photopectoralis bindus	Orangefin Ponyfish	NE

Table 4. Continued.

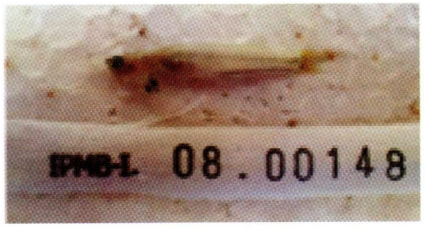
Order	Family	Scientific name	Common name	IUCN Red List status
Perciformes	Gerreidae	*Gerres cinereus*	Yellowfin Mojarra	NE*
		Unidentified sp. 1	Mojarra	-
		Unidentified sp. 2	Mojarra	-
Perciformes	Toxotidae	*Toxotes jaculatrix*	Banded Archerfish	LC
Perciformes	Eleotridae	*Butis butis*	Duckbill Sleeper	LC*
		Ophiocara porocephala	Northern Mud Gudgeon	LC*
Perciformes	Gobiidae	*Acentrogobius viridipunctatus*	Spotted Green Goby	NE
		Bathygobius ostreicola	Gudgeon	DD
		Glossogobius giuris	Tank Goby	LC
		Periophthalmodon schlosseri	Giant Mudskipper	NE
		Periophthalmus variabilis	Dusky Gilled Mudskipper	NE
		Unidentified sp. 1	Goby	-
		Unidentified sp. 2	Goby	-
		Unidentified sp. 3	Goby	-
		Unidentified sp. 4	Goby	-
Perciformes	Scatophagidae	*Scatophagus argus*	Spotted Scat	LC
Perciformes	Siganidae	*Siganus guttatus*	Goldlined Spinefoot	NE*
Tetraodontiformes	Tetraodontidae	*Tetraodon nigroviridis*	Spotted Green Pufferfish	NE

Allenbatrachus grunniens (56.5 mm SL)

Chelon subviridis (57.1 mm SL)

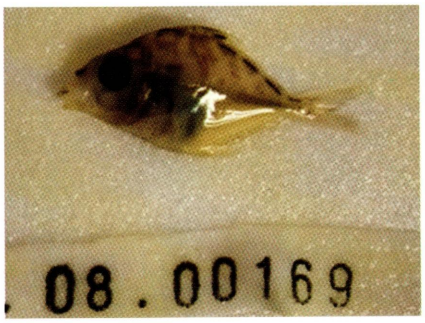
Mugil broussonnetii (109.7 mm SL)

Paramugil parmatus (44.8 mm SL)



Neostethus sp. (21.9 mm SL)

Ambassis macracanthus (43.1 mm SL)



Leiognathus sp. (23.1 mm SL)

Photopectoralis bindus (25.1 mm SL)

Acentrogobius viridipunctatus (64.9 mm SL)

Periophthalmus variabilis (59.2 mm SL)

Figure 6. Some of the fish species recorded in this study.

Characteristics & conservation status of the ichthyofauna

All of the fish species recorded are euryhaline species, a few are being anadromous as well. As samplings were carried out during low water levels (ebb and flood tides; Table 1), this would explain the small body size (averaging 60 mm TL) of the specimens obtained. Moreover, based on the body size (TL and SL) of the specimens obtained, 81% are immature. For most fishes, the longest stage in its life is to reach sexual maturity (Shulman & Love 1999). Hence it is important for juveniles of a species to get shelter and protection from predators, and survive to mature stage.

Most of the fishes were caught from Stations 1, 2, 3, 4, 7 and 8. Within the degraded area (S5 and S6), the only specimens caught were mudskippers. In fact, the Giant Mudskippers were observed both at the degraded and rehabilitated parts of the study area. They stayed entirely out of the water, and were quite motionless on the mudflat, until approached, where they took a few small but quick leaps to distance themselves, and at times leaping into a burrow to hide.

On the species conservation status, only one species, the Orange-spotted Grouper *Epinephelus coiodes,* is listed as Near Threatened; the rest are listed as LC (Least Concern; 18 species), DD (Data Deficient; 2), with the majority NE (Not Evaluated; 17) (Table 4). Several of the recorded species are commercially important species (marked with an asterisk in Table 4), with minor interest in aquaculture or aquarium trade.

A few local fishermen were encountered at separate times in vicinity of the study area during the sampling. Of the two who were on foot, one was using baited cast net (to catch prawns), while the other dug for *Lukan* (Mangrove Clam, *Polymesoda* sp.; Figure 7). Three others (including a young boy), from whom we obtained the grouper specimen, were seen in a small boat on Sg. Isme in the afternoon of the Day 2. They had been fishing at the estuary of Sg. Loboh (since dawn the same day), and were on their way back home (in nearby Kg. Padas). Thus, Sg. Isme also serves as an important access to the sea by villagers who apparently routinely use the tributary as a source of their livelihood.

Figure 7. *Lukan* (Mangrove Clam, *Polymesoda* sp.). The bagful of large-sized clams was collected from the Sg. Isme area by a local fisherman in a matter of a few hours in the morning.

Diversity Comparison

The result of the present study is compared with similar studies in regional mangrove ecosystems (Table 5). A relatively higher number of fish species recorded is noted for mangrove forests that are relatively intact (Sasekumar *et al.* 1992; Ikejima *et al.* 2003; Nyanti *et al.* 2005), and vice versa for areas that are impacted by anthropogenic factors (Nyanti *et al.* 2012a, 2012b, present study). In the latter areas, the mangrove forests are fragmented and take several years to regenerate to its natural complex state, enough to support more diverse fish communities and perhaps higher population.

Table 5. Comparison of similar studies on fish species diversity in various regional mangrove ecosystems. [Note: H': Shannon-Weaver diversity index; D: Margalef richness index; J: Pielou's equitability index]

Authors	Area	Number of species recorded	Dominant groups	H'	D	J
Sasekumar *et al.* 1992	Klang Straits & Angsa Bank, Johor	119	Ambassidae (31%)	NA	NA	NA
Ikejima *et al.* 2003	Sikao Creek, Thailand	89	Engraulidae (28%)	NA	9.50	NA
Nyanti *et al.* 2005	Paloh mangrove, Sarawak	70	NA	NA	NA	NA
Nyanti *et al.* 2012b	Semariang mangroves, Sarawak	37	Mugilidae (16%), Leiognathidae (16%)	0.81	8.02	0.81
Nyanti *et al.* 2012a	Lutong River, Sarawak	33	Ambassidae (39%)	0.98	9.84	0.34
Hoque *et al.* 2015	Sibuti River, Sarawak	55	Engraulidae (15%)	3.08	14.71	0.78
Present study	Sg. Isme, Sandakan, Sabah	37	Gobiidae (8.5%), Leiognathidae (8.5%)	3.33	17.38	0.92

Potential Threats Observed

Ghost Net Fishing

Not one, but *several* abandoned fishing gears, namely *pukat* (monofilament gill net) were found within the rehabilitated mangrove area itself (Figure 8). This discovery is perhaps not really surprising, as mentioned earlier, the locals are accessing and using the area for artisanal fishing activities, as well as for other ecosystem services offered by the mangrove ecosystem.

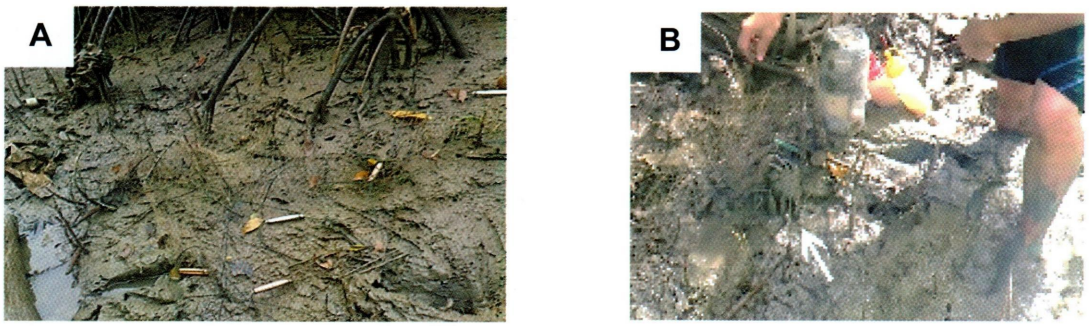


Figure 8. A– an abandoned gill net in the rehabilitated mangrove area. **B**– a large mangrove crab was found entangled in one of these nets at S2.

Bottom sediment type

The bottom sediment type in Sg. Isme rehabilitated mangrove forest was observed to contain a considerable amount of coarse sand, albeit unevenly distributed, other than the muddy substrates. Such composition is different from other, relatively intact mangrove forests such as in the Marudu Bay (pers. obsvn., second author in Oct 2015). The addition of foreign sandy material is a part of the agronomic management technique of oil palms (Mutert *et al.* 1999). Such foreign material may remain in the rehabilitated mangrove area for a significant period of time, due to the slow discharge ability of a mangrove ecosystem. A change in bottom sediment type can cause catastrophic impacts to the estuarine fish communities, especially species that use the soft bottom sediment for burrowing, foraging or simply to avoid predators (Sasekumar *et al.* 1992, Snelgrove 1999).

CONCLUSION

The ichthyofaunal diversity of the Sg. Isme rehabilitated mangrove ecosystem is relatively high (37 species), although the catch abundance was low (N=118). The low catch abundance is partly attributed to sampling efficiency, and that with increased efforts (sampling time), the species record might be increased by about 10% (to 40-41 species, or about 50% of recorded species from intact mangrove forests). As pointed out earlier, the ichthyofaunae are more vulnerable and less tolerant to extreme conditions; thus although the mangrove plants have displayed luxuriant growth in the area, the ichthyofaunal community seem to have only partially recovered from the destruction of their estuarine habitat, and from continued fishing pressure (observed during this study). Nevertheless, the presence of large juvenile fish assemblages, is a good indicator that the rehabilitated mangrove ecosystem is in the process of restoring to a high level of habitability. For a mangrove ecosystem to serve as a nursery, its complex structure is vital for increasing chances of juvenile survivorship (Nyanti *et al.* 2012b). The benefit of a complex root system of the mangrove forest, is manifested in the accumulated muddy substrates, and turbidity which provides juveniles the ideal environment to forage food, and to escape from predators (Sasekumar *et al.* 1992, Islam & Haque 2004).

It is disheartening to discover abandoned fishing gears in the rehabilitated mangrove area, and to know that this reflects the lack of conscience rather than ignorance on the part of the users. Despite such potential threats to the ichthyofauna and the mangrove ecosystem, we are optimistic that the rehabilitated mangrove ecosystem will gradually be fully restored, provided no significant anthropogenic disturbances are introduced in the area.

ACKNOWLEDGEMENTS

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An insect survey in Kungkular Forest Reserve, Tenom, Sabah

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Abstract. An insect survey was carried out from 14th to 17th of March, 2016 in Kungkular Forest Reserve, Tenom, Sabah. An average of 108 individuals from 81 nocturnal insect species were recorded from a one-metre-square area of the light-trapping cloth. The mean Shannon Index was 4.18 while Simpson Index was 81.92 and Fisher Alpha Index was 145.15. Some Bornean endemic species were recorded during the survey, namely *Chalcosoma moellenkampi* (beetle), *Mycalesis amoena* (butterfly), *Amata prepuncta, Auriculoceryx pterodactyliformis, Barsine lucibilis, Lygniodes schoenbergi* and *"Pidorus" hilaris* (all moths), and *Pyrops sultana* (lantern bug). These data will serve as baseline information for other research work in future, as no insect survey was conducted in the past. The data will further strengthen the management of this forest reserve as a Class I Forest Reserve (Protection). Efforts have to be taken to safeguard and maintain the forest quality in order to increase its biodiversity, with cooperation from the local communities and other relevant agencies.

Keywords: insects, diversity, Kungkular Forest Reserve, conservation, Heart of Borneo

INTRODUCTION

Kungkular Forest Reserve

Kungkular Forest Reserve is located in the south western part of Sabah, comprising an area of 1,260 ha. (Figure 1). The management of the reserve is directly under the jurisdiction of the Tenom District Forestry Office (DFO) of the Sabah Forestry Department. The reserve is previously classified as a stateland. It was gazetted as a Class I Forest Reserve (Protection) in 2012 (SFD 2015), due to its function as a water catchment area for the adjacent villages, namely Kg. Kungkular, Kg. Nanturan and Kg. Lohot.

The vegetation is mainly upland mixed dipterocarp forest, with a small patch (5.10 ha) of lower montane forest at the south western part of the reserve. However, much of the lower part of the reserve is disturbed due to its status as a stateland previously. Much of the adjacent area has been planted with rubber trees, bananas and other agricultural crops. The lowest point in the area is about 600 m a.s.l., while the highest point is about 1,100 m.

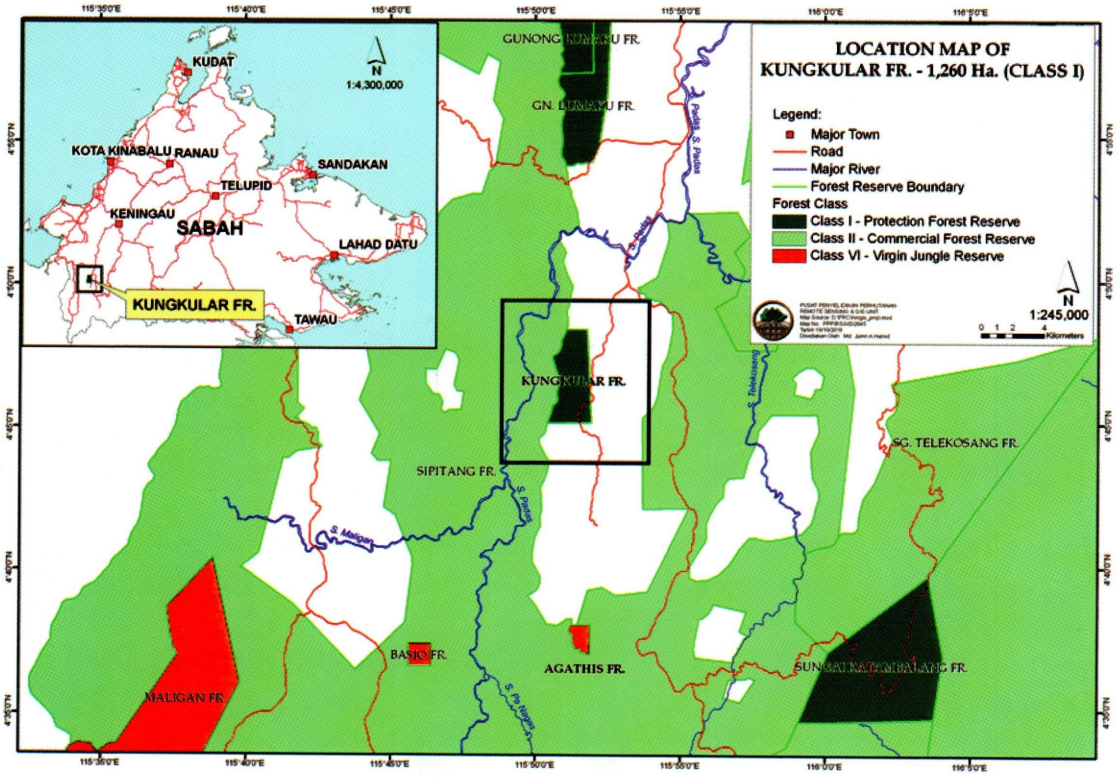

Figure 1. Kungkular F.R. (dark green in box) and its location (inset) in Sabah.

Purpose of the survey

This survey was conducted from 14th to 17th of March, 2016, with the expedition base camp at the DFO Tenom staff quarters in Tenom town, about an hour drive to the reserve. The objectives of this study were to document the insect fauna of Kungkular F.R. as part of the Heart of Borneo (HoB) programme, 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 & METHODS

Light trap

Light trap was used to sample nocturnal insects. The trap consists of a vertical white sheet (2 X 2 m) illuminated by a 250W mercury-lithium bulb, powered by a 12V 100 AH battery set. The trap was set up in an open area facing the forest reserve from 7:00 to 8:30 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 8:00 to 8:30 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 (SDR 2006). This method is simple, fast and can be carried out by a non-insect specialist. To avoid compounding human error, the same staff was assigned to count the species and individual numbers throughout the sampling period at different sites. Light-trapping sites are shown in Table 1.

Table 1. Light-trapping sites in Kungkular F.R.

Sampling site	Coordinates	Elevation (m)	Temp. (°C)	Humidity (%)	Sampling date	Remarks
A	N 04°48'19.5" E 115°51'02.1"	912	22.1	82	15 March	Fine weather with stars and half moon.
B	N 04°48'20.9" E 115°51'06.5"	931	21.3	86	16 March	Fine weather with stars and half moon.

Sweep net and manual collection

Sweep nets were used to collect day-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 by the villagers and also old skid trails. Details of the daytime sampling sites are listed in Table 2.

Table 2. Daytime sampling sites in Kungkular F.R.

Sampling site	Starting point coordinates	Elevation (m)
1	N 04°48'19.8" E 115°51'03.0"	905-929
2	N 04°48'20.20" E 115°51'03.3"	932-946

Insect specimens and identification

In this survey, focus was given to certain insect groups, i.e., butterflies, moths and beetles. Only interesting and potential indicator insect species were sampled. Photographs were taken with DSLR Nikon D800E and Nikon Coolpix cameras to facilitate identification.

Selected specimens were dry-mounted and sorted to family and some to the genus and species level. The specimens sampled from this survey were deposited at the Forest Research Centre, Sepilok, Sabah. Dry-mounted specimens were identified based on the FRC Entomology Collection and various reference materials, e.g. Otsuka (1988 & 2001) and Kirton (2014) for butterflies; Holloway (1983, 1985, 1986, 1988, 1989, 1993, 1996, 1997, 1998a & b, 1999, 2001, 2003, 2005, 2008, 2009 & 2011), Robinson *et al.* (1994) and Sutton *et al.* (2015) for moths; Fujita (2010), Makihara (1999) and Tung (1983) for beetles. Some other insects were

identified based on Hill and Abang (2005). Insect expert, i.e. Dr Steven Bosuang, assisted in the identification of beetles and lantern bug. Unidentified specimens were morphotyped.

RESULTS & DISCUSSION

Overall insect diversity

The nocturnal insect diversity was high, as shown in Table 3. The mean Shannon Index was 4.18. The Shannon index increases as both the richness and the evenness of the community increase. Typical values are generally between 1.5 and 3.5 in most ecological studies (Magurran 2004). Hence, the value of over 4 is high. The value for Simpson Index was 81.92 while Fisher Alpha Index was 145.15. During light-trapping, the temperature was low, between 21°C and 22°C with relatively high humidity, between 82% and 86% (Table 1). The distribution of insect species from the light-trapping sites is reflected in the species-rank abundance curves in Figure 2. Site B recorded more species, hence, the longer horizontal line of the graph. This site also recorded a few dominant species which are reflected in the higher and steeper curve. Nine wild honeybee individuals, *Apis dorsata* and seven green cicadas, *Dundubia vaginata*, were recorded in Site B. There could be a wild honeybee nest nearby while for the green cicadas, it could be their breeding period.

Table 3. Insect diversity within a one-metre-square area, as sampled through light-trapping in Kungkular F.R.

No.	Sampling site	Species	Ind.	Shannon	Simpson	Fisher Alpha
1.	A	68	92	4.02	74.75	117.9
2.	B	94	125	4.33	89.08	172.4
	Mean	81±18	108±23	4.18±0.22	81.92±10.13	145.15±38.54

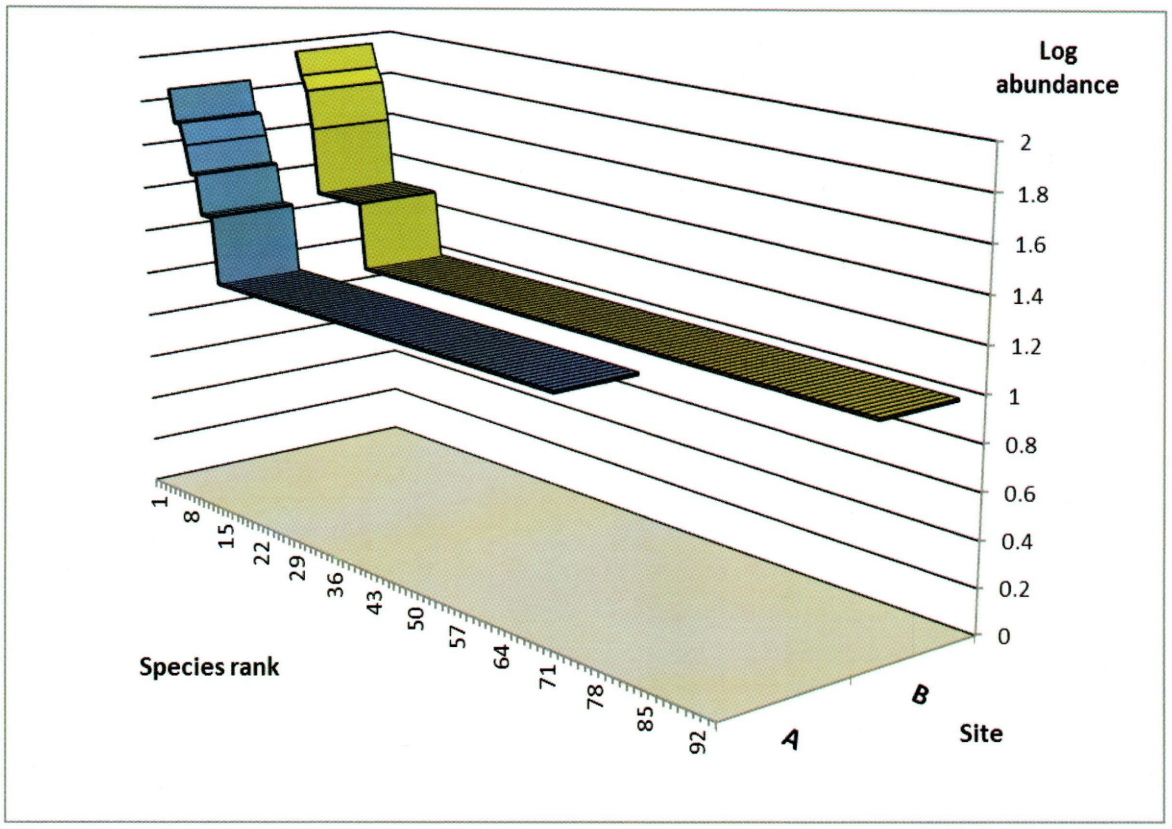

Figure 2. Species-rank abundance curves of the light-trapping sites in Kungkular F.R.

When the nocturnal insect richness is compared with other forest reserves sampled in the past using similar method, Kungkular F.R. appeared to be moderate as shown in Figure 3a. In terms of nocturnal insect diversity, it is high, as indicated in Figure 3b.

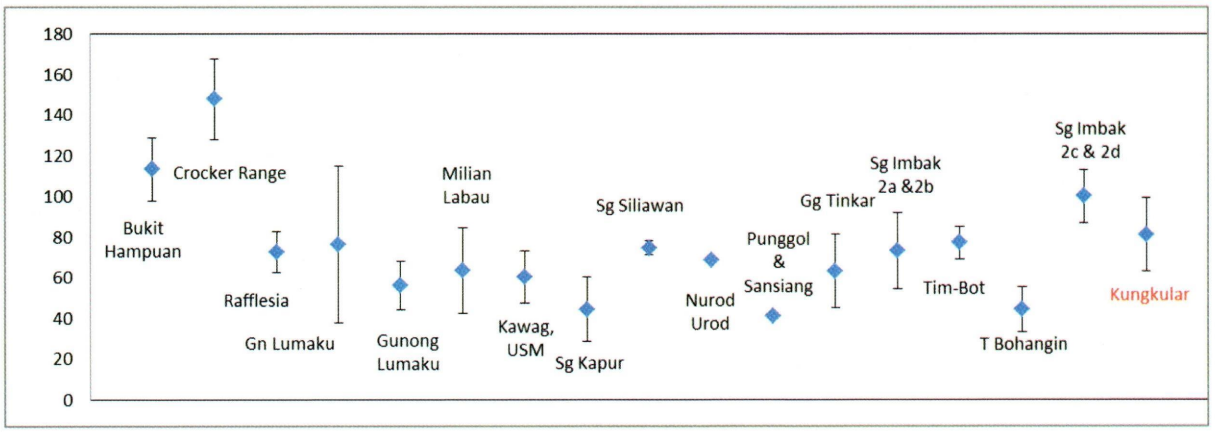

Figure 3a. Species number (±standard deviation) within a one-metre-square area, as assessed through light-trapping in various forest reserves in Sabah.

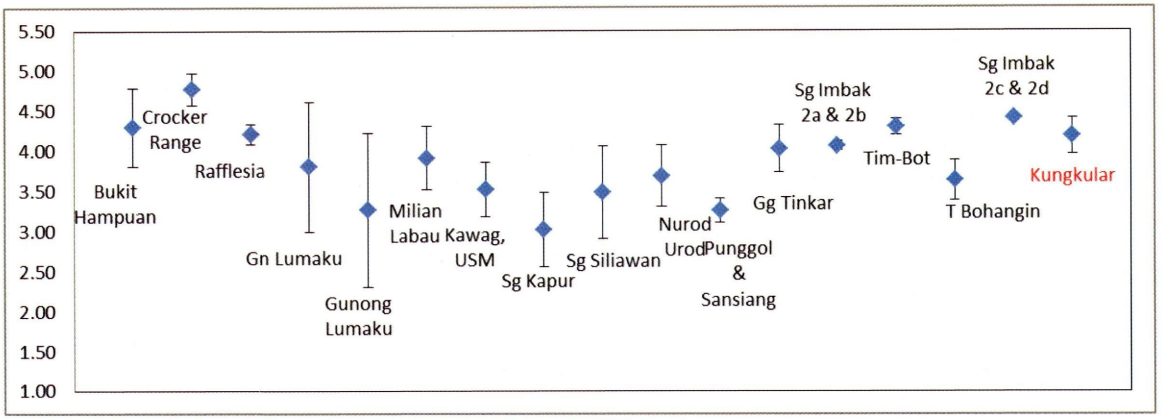

Figure 3b. Shannon Index (±standard deviation) within a one-metre-square area, as assessed through light-trapping in various forest reserves in Sabah.

Some Bornean endemic species were recorded from Kungkular F.R. during the survey, as listed in Table 4. The endemics included one beetle species, one butterfly species, one bug species and five moth species. Some of the endemics are shown in Plate 1. This information is useful for providing recommendations on High Conservation Value Forest (HCVF) of the area, namely HCV 1.3 (WWF-Malaysia 2009).

Table 4. Bornean endemic insect species from Kungkular F.R. during the survey.

No.	Species	Author	Order	Family
1	*Chalcosoma moellenkampi*	Kolbe	Coleoptera	Scarabaeidae
2	*Mycalesis amoena*	Druce	Lepidoptera	Nymphalidae
3	*Amata prepuncta*	Holloway	Lepidoptera	Arctiidae
4	*Auriculoceryx pterodactyliformis*	Holloway	Lepidoptera	Arctiidae
5	*Barsine lucibilis*	Swinhoe	Lepidoptera	Arctiidae
6	*Lygniodes schoenbergi*	Pagenstecher	Lepidoptera	Noctuidae
7	*"Pidorus" hilaris*	Jordan	Lepidoptera	Zygaenidae
8	*Pyrops sultana*	Adams	Hemiptera	Fulgoridae

Butterflies (Lepidoptera)

At least 13 butterfly species were sampled during this brief survey (Chung 2016). One endemic species was recorded, namely *Mycalesis amoena*, which is from the Nymphalidae family. It is predominantly a brown butterfly with some ocelli, measuring 25-30 mm in size. The Harlequin Butterfly of the family Lycaenidae, *Paralaxita telesia ines*, was sighted a number of times inside the understory of the forest.

Moths (Lepidoptera)

Some 48 moth species were recorded from this study (Chung 2016). Five of these are endemic to Borneo; three from the family Arctiidae, one each from Noctuidae and Zygaenidae. Both *Amata prepuncta* and *Auriculoceryx pterodactyliformis* are wasp-mimicking moths and they are quite commonly encountered and are endemic to Borneo. *Barsine lucibilis* is a frequent lowland forest species, occurring also in disturbed habitats and at elevations up to 1000 m a.s.l. *Lygniodes schoenbergi* is found in the lowland as well as montane forests. The male is predominantly black in colour with the hindwing dorsum extensively yellow. Zygaenidae moths are predominantly day flying but *"Pidorus" hilaris* was attracted to the light at night.

Beetles (Coleoptera)

A total of 19 species of macro-beetles were recorded (Chung 2016). The Three-horned Beetle, *Chalcosoma moellenkampi*, is a Bornean endemic beetle recorded in this survey. Although endemic, it is a locally common beetle found in various types of forests and oil palm plantations in Sabah.

Other insects

At least 33 species of other insects were recorded during the survey (Chung 2016). There was no concerted effort in sampling other insects. They were recorded while sampling the core insect groups during this survey. A Lantern Bug endemic to Borneo, *Pyrops sultana,* was recorded during the daytime sampling in Site 1 at about 910 m a.s.l. Some of the other insects are shown in Plate 2.

Current issues on the insect fauna and conservation in Kungkular F.R.

From observation and discussion with relevant people during the survey, the main issues that affect the insect fauna and conservation in this reserve are similar to that of other forest reserves, and should be viewed holistically. 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 Kungkular F.R. are the adjacent land-use changes, forest fire and encroachment (wildlife hunting). Many of the surrounding areas of this reserve are planted with agricultural crops, especially rubber and banana. This would indirectly affect species that have low tolerance towards environmental changes. In addition to this, much of the lower part of the reserve has been disturbed, infested with climbers, bamboos and rattans. This is not surprising because prior to the gazettement of this area as a forest reserve, it was a stateland. Many big trees were felled previously and skid trails from logging activities were seen at the fringe of the forest.

Forest fire is a serious threat to all the forest reserves. The El Nino effect had caused prolonged dry and hot weather throughout Sabah since March 2016. During that period, the temperature in the afternoon (11:00 am to 2:00 pm) reached 37°C and this would adversely affect not just the health of all living organisms but also pose a potential fire risk. Hence, the

risk of forest fire in this reserve is quite high. Forest fire will severely affect the flora and fauna in the forest, including insects. Although Kungkular F.R. is not affected yet, many of the forests along the roads in Tenom, Keningau and Sook were razed by forest fire.

It is believed that wildlife hunting is rampant in this forest as animal carcasses and bullet shells were found during the survey. Such activity is common among the villagers as wildlife is their main source of food. Wildlife hunting has been part of the livelihood and culture of the local people in the interior and also in other parts of Sabah, as pointed out by Wong *et al.* (2012). It is also part of their social activity. It is quite a daunting task to eliminate wildlife hunting. However, since the area is now gazetted as a forest reserve, it is illegal to take its resources without permission from the Director of the Sabah Forestry Department. The District Forestry Officer and his staff should inform the villagers about the changes in the land status and the regulation under the Forest Enactment. The fire set up by the hunters at their temporary shed as well as cigarette butts could also lead to forest fire.

At present, forest fragmentation in Kungkular F.R. may not be a serious issue as this forest is connected to the bigger Sipitang F.R. It is important for the commercial Sipitang F.R. to have buffer zones as well as riparian reserves for wildlife connectivity.

Sabah is moving in the right direction in sustainable forest management under the HoB initiative (SFD 2013). This is in line with the Policy Statement of the National Policy on Biodiversity (2016-2025), in which Malaysia is committed to conserve its biological diversity, promote its sustainable use and ensure fair and equitable sharing of the benefits arising out of the utilisation of biological resources. Scientific expeditions on biodiversity documentation in protected areas are part of the HoB initiative (Nilus *et al.* 2014). The exploration in Kungkular F.R. provides salient up-to-date information for conservation of this area. The data will be used for the formulation of a forest management plan and also in enhancing biodiversity conservation of Kungkular F.R. as well as connectivity with other areas. The adjacent villagers have also put up sign boards at some parts of the reserve, indicating the forest as their water catchment area.

Evaluation and monitoring, as well as enforcement in Kungkular F.R. on a regular basis are important in ensuring that this reserve is protected and conserved according to its status as a Class I Forest Reserve.

CONCLUSION

The results of this survey shows that the nocturnal insect diversity in Kungkular F.R. was high compared to other forest reserves surveyed earlier. A few endemic species were recorded. This data will serve as baseline information for other research work in future. The endemic and interesting insect species recorded during the survey provide salient information to enhance the conservation of this forest reserve as well as to provide input for better management of the reserve. The information will further strengthen the protection of this forest reserve as a Class I (Protection) Forest Reserve which was gazetted in 2012. Efforts have to be taken to safeguard and maintain the forest quality in order to increase its biodiversity. The villagers would have to be well-informed of the status of the forest reserve. It is important for them to work hand-in-hand with the department to protect this forest as their water catchment area.

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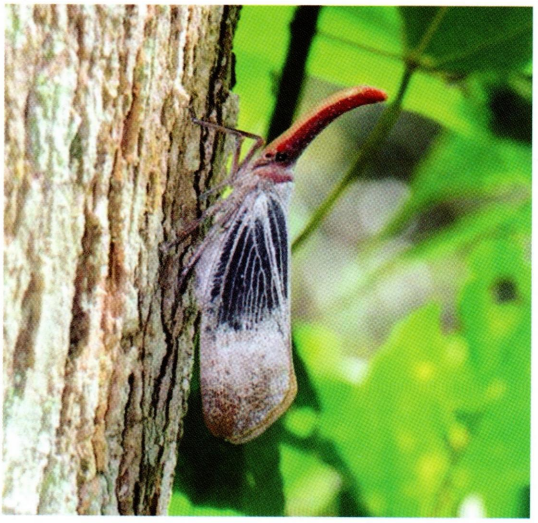
1a. *Mycalesis amoena* (Photo: Eyen Khoo).

1b. *Amata prepuncta*

1c. *Auriculoceryx pterodactyliformis*

1d. *Barsine lucibilis*

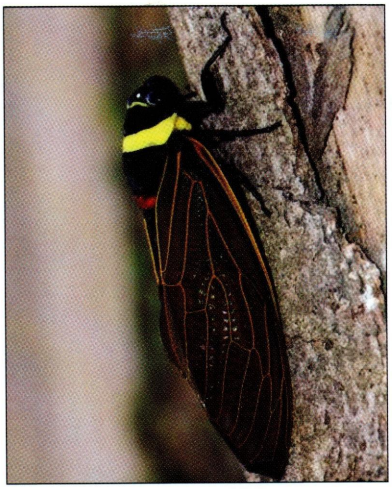
1e. *Chalcosoma moellenkampi*



1f. *Pyrops sultana*

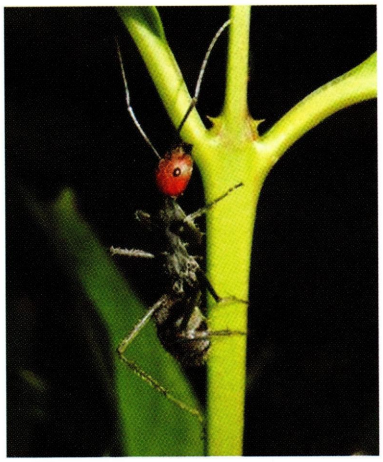
Plate 1. Some of the Bornean endemic insects recorded from Kungkular F.R.

2a. *Cryptotympana aquila*
(Hemiptera: Cicadidae)



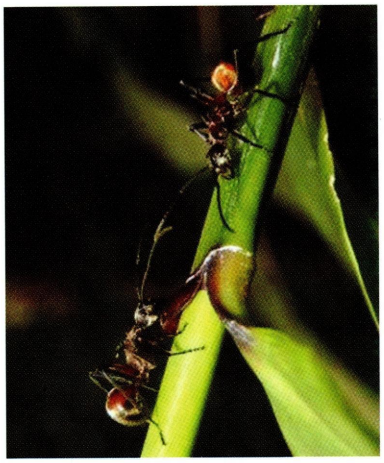
2b. *Tacua speciosa*
(Hemiptera: Cicadidae)

2c. *Exopholis hypoleuca*
(Coleoptera: Scarabaeidae)



2d. *Camponotus singularis*
(Hymenoptera: Formicidae)*

2e. *Leptogenys* nr *diminuta*
(Hymenoptera: Formicidae)



2f. *Polyrhachis ypsilon*
(Hymenoptera: Formicidae)*

2g. *Nevromus* sp.
(Neuroptera: Corydalidae)

2h. *Titulcia rufimargo*
(Lepidoptera: Nolidae)

2i. *Siglophora bella*
(Lepidoptera: Nolidae)

Plate 2. Some non-endemic insects recorded from Kungkular F.R.
*Photo by John L. Yukang.

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A note on the growth and resin production of Gaharu in the Sook Forest Reserve, Sabah

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Gaharu (also known as agarwood) is considered to be an important non-timber forest produce. Historical records show that this valuable resinous wood has been traded for over 2000 years, from as far as the Middle East to East Asia (Hou 1960). It is valued in many cultures for its unique fragrance, and is used mainly in rituals and perfumeries. One of the most common genera that produce Gaharu is *Aquilaria* of the Thymelaeaceae family, which is naturally distributed in Sabah (Soerianegara & Lemmens 2001).

Driven by the high demand for this valuable resinous wood, wild Gaharu has been exploited extensively (Barden *et al.* 2000). This has led to the depletion of the species in the wild significantly, thus threatening the survival of the species. As a result, the genus *Aquilaria* (along with *Gyrinops* and *Gonystylus*) has been listed in Appendix II of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Effective 2nd January 2004, the Sabah Forestry Department has classified all Gaharu species as "prohibited species" to be retained inside forest reserves (Sch C; Clause 1(31) in the Standard Sustainable Forest Management Licence Agreement – s 15(1) Forest Enactment 1968). In addition, Sabah's Wildlife Conservation Enactment 1997 requires a permit for harvesting a plant of a species specified in Appendix I or II of CITES. The interest in Gaharu has risen in tandem with the demand and by as early as the 2000s, many Gaharu plantations have been established, with the hope of producing the valuable resin on a commercial scale.

Sook Forest Reserve is located 36 km, southeast from Keningau town with an elevation of 350 m above sea level. This area is easily accessible through the Keningau-Nabawan road. The soil in Sook is mostly alluvium which comprises river deposit in the form of both fine-textured and course-textured mineral (Bower *et al.* 1975). The weather throughout the year is hot with a temperature in the range of 23°C to 28°C. The area has an average humidity of 63-75% with a rainfall in the range of 1500 – 2000 mm. Table 1 provides the details of three *A. malaccensis* trial plots established in Sook, Keningau.

Table 1. *A. malaccensis* trial plots in Sook Forest Reserve.

Location	Plot no.	Number of trees	Spacing (m x m)	Year of planting
Sook	KPT2000	200	3 x 4	2000
Sook	98A	280	3 x 3	1998
Sook	90A	154	3 x 4	1990

Table 2 shows the growth performance of these three plots since establishment. The total height and diameter at breast height (DBH) of each individual tree were measured and recorded annually. The survival percentage and the mean growth rate and mean annual increment (MAI) were derived. The 13-year-old *A. malaccensis* has a MAI DBH of 1.47 cm/year, and a MAI total height of 0.90 m/year. The 24-year-old *A. malaccensis* has a MAI DBH of 1.26 cm/year, and MAI total height of 0.84 m/year. The 15-year old *A. malaccensis* has a MAI DBH of 1.12 cm / year, and a MAI total height of 0.90 m/year. Both plots, KPT2000 and 98A have a survival percentage of 84.0% while plot 90A, which is the oldest among the trial plots, has a survival percentage of 20.0%.

Table 2. Growth performance of *A. malaccensis* in Sook Forest Reserve.

Location	Plot no.	Age (Years)	Survival Percentage (%)	Mean Ht (m)	MAI Ht (m/year)	Mean DBH (cm)	MAI DBH (cm/year)
Sook	KPT2000	13	84.0	11.74	0.90	19.10	1.47
Sook	98A	15	84.0	13.57	0.90	16.80	1.12
Sook	90A	24	20.0	20.15	0.84	30.18	1.26

La Frankie (1994) reported that the average diameter growth rate of *A. malacensis* in native forests in Malaysia is 0.33 cm/year, but the fast-growing larger specimens are reported to grow at 0.8 – 1 cm/year. From this study, the growth rate of the trial plots in Sook looks promising with a DBH growth rate of 1.12 – 1.47 cm/year. Based on another study by Lok and Zuhaidi (1996), *A. malaccensis* plantation in Peninsular Malaysia established in 1928 has an original population density of 833/ha but has decreased to 31/ha by 1995 (a survival percentage of 3.72%).

In 2007, a joint study was initiated by Sabah Forestry Department, Forest Research Institute Malaysia, Malaysia Institute of Nuclear Technology and University of Minnesota on the inducement of Gaharu resin production in planted Gaharu using a technique developed by Blanchette and van Beek (2005). Six selected *A. malaccensis* trees with DBH above 10 cm in Sook were treated. Three of the trees were harvested 20 months after the treatment for Gaharu resin quantitative assessment. The resinous wood was separated from the sapwood and later categorized, based on the resin content and quality.

Table 3. Resin content of trees treated in Sabah.

Category	Weight (g)			
	Tree#1	Tree#135	Tree#157	Average
1	286 (1.1%)	325 (0.9%)	175 (1.0%)	262 (1.0%)
2a	770 (2.9%)	330 (0.9%)	253 (1.5%)	451 (1.7%)
2b	7,785 (29.5%)	12,240 (33.1%)	6,060 (34.9%)	8,695 (32.3%)
3	15,385 (58.3%)	22,560 (61.0%)	9,203 (53.0%)	15,716 (58.4%)
4	2,143 (8.1%)	1,500 (4.1%)	1,675 (9.6%)	1,773 (6.6%)
Total	**26,369**	**36,955**	**17,366**	**26,897**

Category 1 – Resinous wood
Category 2a – Wood with dark coloration
Category 2b – Wood with light/visible resin
Category 3 – Non resinous wood
Category 4 – Rotten wood in the central column

The wood from each of the 3 respective trees were dried and separated into 5 categories based on the coloration and resin content. Table 3 shows the breakdown of the weight of each tree, based on the 5 categories. The non-resinous wood Category 3, made up the majority of the bulk with an average of 15,716 g or 58.4% of the tree. The marketable wood consists of Category 1 and 2a which had an average weight of 262 g (1.0%) and 451 g (1.7%) respectively. The remaining wood from Category 2b with an average weight of 8,695 g or 32.3% of the wood can only be used for oil extraction. Resin analysis using the United States Pharmacopeia Standard Method XXII was conducted on wood sample taken from tree #135 and the result shows the percentage of resin content at an average of 11.83%. As a comparison, the resin content of a sample of good quality Gaharu from a natural forest was recorded at 24.54% (Blanchette & Jurgens 2009).

The data from the trial plots yield promising results in the growth of DBH and height of *Aquilaria malaccensis*. The MAI DBH (1.12 – 1.47 cm/year) would enable the Gaharu tree to reach a DBH of 10 cm in 7 - 9 years for the resin inducement treatment to be carried out. Evaluations made from the Gaharu harvested from the resin inducement study indicated that Gaharu resin had begun to form in the trees after 20 months. Although an average of about 9 kg of Gaharu were harvested from the treated trees, the resin content on the Gaharu was low. Further studies need to be conducted to identify the optimum and effective technique for Gaharu resin inducement to determine the viability of Gaharu for commercial cultivation.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. Blanchette of University of Minnesota and Dr. Robert C. Ong of Forest Research Centre (FRC) for their support and guidance throughout this project. Involvement of fellow researchers from the Forest Institute Malaysia (FRIM) and Malaysia Institute of Nuclear Technology (MINT) in the Gaharu inducement study is also acknowledged. Thanks are also due to the staff of FRC who have helped tremendously in the data collection.

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Sepilok Bulletin 23 & 24: 55-60 (2016)

The diversity of herbaceous plants in moist flat and dry hillside areas of the Sandakan Rainforest Park, Sabah

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Herbs are usually non-woody, small and soft-leaved plants (Soepadmo 1998). Although herbs are not known as woody plants, some of these plants gained wood characteristic due to the long life nature in the tropical forests. Herbs grow well in moist soil (Bonar 1994).

The study was conducted in Sandakan Rainforest Park. The coordinates of the study area are (5°50'45"N and 118°3'10"E). The park has a coverage of 148.6 hectares, located about 9 km from Sandakan town, and is largely used by the local community for fitness activities such as strolling and jogging. The Sandakan Rainforest Park was gazetted as an Amenity Forest Reserve (Class IV) in August 2009.

Two sample plots with a size of 20 m x 50 m were established, one in a moist flat area (Figure 1), and the other covering a dry hillside area (Figure 2), with slope of 45°. Each plot is divided into two small subplots of 10 m x 50 m and each subplot is further divided into five subsections measuring 10 m x 10 m to get more systematic data (Mojiol & Lo 2009). All herbaceous plants within the plot were counted and marked. Each herb species was assigned codes from H001, H002, H003 and, so on, to facilitate the identification. A Canon-DSLR camera was used to take photos of the herb species for further identification. Each herb found in the plot was identified to species level with the assistance of staff from the Herbarium at Forest Research Centre, Sepilok, Sandakan.

The data collected from the sampling were analyzed using PAST software (Paleontological Statistics Software Package for Education and Data Analysis) to determine the abundance and diversity of herbs in each plot. Similarity Analysis (E) and analysis of Shannon-Wiener (H') index were used. The data were presented in tabular form, which include the species and family names, and quantity abundance percentage.

Altogether 19 species were identified in both study areas. The total number of herbs recorded in the moist flat area was 324 (Table 1). A total of 17 species were identified and the most abundant species in the plot was *Melastoma malabathricum* (23.5%). *Costus speciosus* was the second most abundant herb found in the moist flat area (18.8%). Meanwhile, *Nephenthes gracilis* had the lowest percentage in number of individuals with only 0.3%.

Figure 1. Moist flat area.

Figure 2. Dry hillside area.

Table 1. Abundance of herbs in the moist flat area.

No.	Scientific Name	Family Name	Quantity	(%)
1	*Melastoma malabathricum**	Melastomaceae	76	23.5
2	*Costus speciosus**	Costaceae	61	18.8
3	*Clidemia hirta**	Melastomaceae	28	8.6
4	*Lygodium flexuosum*	Schizaeaceae	28	8.6
5	*Smilax officinalis*	Smilacaceae	25	7.8
6	*Dillenia suffruticosa*	Dilleniaceae	23	7.1
7	*Curculigo latifolia*	Hypoxidaceae	22	6.8
8	*Blechnum orientale**	Blechnaceae	17	5.3
9	*Stenochlaena palustris*	Polypodiaceae	11	3.4
10	*Imperata cylindrica*	Gramineae	9	2.8
11	*Phyllanthus niruri*	Phyllanthaceae	9	2.8
12	*Mimosa pudica*	Fabaceae	5	1.5
13	*Murraya koenigii*	Rutaceae	3	0.9
14	*Eupatorium odoratum*	Asteraceae	2	0.6
15	*Leucas zeylanica*	Lamiaceae	2	0.6
16	*Polygala panniculata*	Polygalaceae	2	0.6
17	*Nepenthes gracilis*	Nepenthaceae	1	0.3
		Total	**324**	**100.0**

*See Plate 1 – 4.

Based on Table 2, the total number of herbs recorded on the dry hillside area was 221. A total of 15 species were identified and as in moist flat area, the most abundant species was *Melastoma malabathricum* (16.7%). *Costus speciosus* was the second most abundant herb found on the dry hillside (14.5%). Meanwhile, *Musa* sp. had the lowest percentage in number of individuals found, with only 0.5%.

Table 2. Abundance of herbs on the dry hillside area.

No.	Scientific Name	Family Name	Quantity	(%)
1	*Melastoma malabathricum**	Melastomaceae	37	16.7
2	*Costus speciosus**	Costaceae	32	14.5
3	*Dillenia suffruticosa*	Dilleniaceae	31	14.0
4	*Lygodium flexuosum*	Schizaeaceae	30	13.6
5	*Curculigo latifolia*	Hypoxidaceae	27	12.2
6	*Clidemia hirta**	Melastomaceae	23	10.4
7	*Blechnum orientale**	Blechnaceae	8	3.6
8	*Stenochlaena palustris*	Polypodiaceae	8	3.6
9	*Eupathorium odoratum*	Asteraceae	7	3.1
10	*Imperata cylindrica*	Gramineae	5	2.3
11	*Smilax officinalis*	Smilacaceae	5	2.3
12	*Mimosa pudica*	Fabaceae	4	1.8
13	*Piper porphyrophyllum*	Piperaceae	2	0.9
14	*Murraya koenigii*	Rutaceae	1	0.5
15	*Musa* sp.	Musaceae	1	0.5
		Total	**221**	**100.0**

*See Plate 1 – 4.

Shannon-Wiener Index Analysis

Magurran (2004) stated that diversity increases if the Shannon-Wiener index (H') value increases. The value obtained from empirical data usually falls between 1.5 and 3.5 and rarely surpasses 4. In this study, as presented in Table 3, the value of H' of either site of the Sandakan Rainforest Park was in moderate range as suggested by Magurran (2004).

Table 3. Index diversity of herbs in moist flat and dry hillside areas.

Diversity	Moist flat area	Dry hillside area
H'	2.33	2.30
Hmax	2.83	2.71
E (%)	82	85

The value of H' index in the moist flat area was 2.33 while on the dry hillside, it was 2.30. The maximum diversity (Hmax) in the moist flat area was 2.83 while on the dry hillside, it was 2.71. The values also do not differ much from each other. In term of Evenness (E), the value in the moist flat area and on the dry hillside was 82% and 85% respectively. The value was nearly similar to each other.

The most abundant herb species in both areas was *Melastoma malabathricum* with 76 individuals or 23.5% in the moist flat area and 37 individuals or 16.7% on the dry hillside area. The least common species found in the moist flat area was the pitcher plant, *Nephenthes gracilis*. Although the pitcher plant thrives in moist soil and shady forests, only one pitcher plant was found within the plot in the moist flat area. This is because the moist flat area is an open area and is not suitable for the growth of the pitcher plant. The least common species found on the dry hillside area is *Murraya koenigii* or curry leaf plant.

The analysis of Evenness (E) value in the moist flat area and the dry hillside area was 0.82% and 0.85% respectively. The range of Evenness value should be between 0 and 1 and cannot be equal to 0 as indicated by Weaver & Shannon (1949). This study shows that species in the moist flat area were not uniformly distributed and were uneven due to the high number of species found in the plots. On the dry hillside area, the composition of herb species was also similar as in the moist flat area although the number of species was less, likely due to drier soil.

The overall number of herbs found in both the moist flat and the dry hillside areas (with slope of 45°) were 19 species. The Shannon-Wiener diversity index (H') of herb species in the moist flat and the dry hillside do not differ much from one another with H' = 2.33 and H'= 2.30 respectively. The most abundant species in both areas was *Melastoma malabathricum* and the least was *Nephenthes gracilis* in the moist flat area and *Murraya koenigii* on the dry hillside.

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The authors would like to express their appreciation to the Sabah Forestry Department, Sandakan for permission to conduct the study.

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Plate 1. *Melastoma malabathricum*

Plate 2. *Blechnum orientale*

Plate 3. *Costus speciosus*

Plate 4. *Clidemia hirta*

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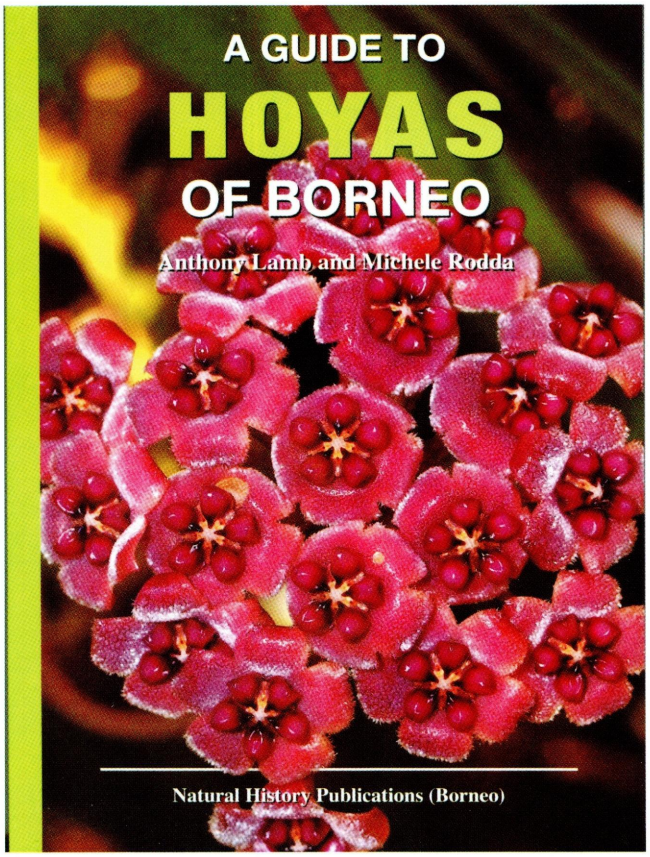
BOOK REVIEWS



A guide to Hoyas of Borneo by Anthony Lamb & Michele Rodda. Published by Natural History Publications (Borneo), Kota Kinabalu, 2016. Pp. 210. ISBN 978-983-812-170-5.

Reviewed by E. Khoo

In the world of plants, one can never ever cease to be amazed by the myriad of varieties and structural designs one encounters, the hoya is a good example. This can be observed from the leaf morphology, which can be of all shapes and sizes, from that of elliptic to those of thin linear; or be of 1cm in length to that of 45 cm; leaf venation can range from palmate, pinnate to invisible. To many, the most distinguishing feature of this genus would be its flower that seems to have a shiny waxy appearance. Hence, it is also given the common name, such as the wax plant or porcelain flower. The latter is due to the inflorescence that may contain few to multiple flowers and when in bloom, its structure and colouration are akin to that of a fine cluster of porcelain flowers put on display.

The genus Hoya was established by botanist Robert Brown in 1811. It was named in honour of his friend, Thomas Hoy, the gardener in the Duke of Northumberland at Syon House in Middlesex, whom Brown described as having "*merit as an intelligent and successful cultivator that has been long known to the botanists of this country*", that is, in the United Kingdom.

To date, the interest in cultivating this genus as an ornamental plant has not waned with time, as can be noticed by the number of Hoya societies established across the globe in Australia, USA, Europe or any of the South East Asia countries. Although there is growing interest in this genus, there remains a knowledge gap in terms of the number of species available and their population density, especially those in Borneo.

The publication of the book is timely as it presents the first checklist and identification key for the 72 hoya species that have been recorded in Borneo, providing information, such as species description, distribution range, habitat, and special features for a selected number of species. As with any special group publications, the book also contains an introductory chapter with brief but detailed descriptions of hoya, covering various aspects, such as plant systematics, environment and habitats (various forest types), conservation needs and its cultivation. Although the book seems to be biased towards being more of a botanical reference, hence a must have for any keen botanist or naturalist, with its impressive photographs, it is a good book for the layman or one's library collection, for the purpose of understanding more of the exquisite natural beauties we have on the island or to inspire the love for nature.

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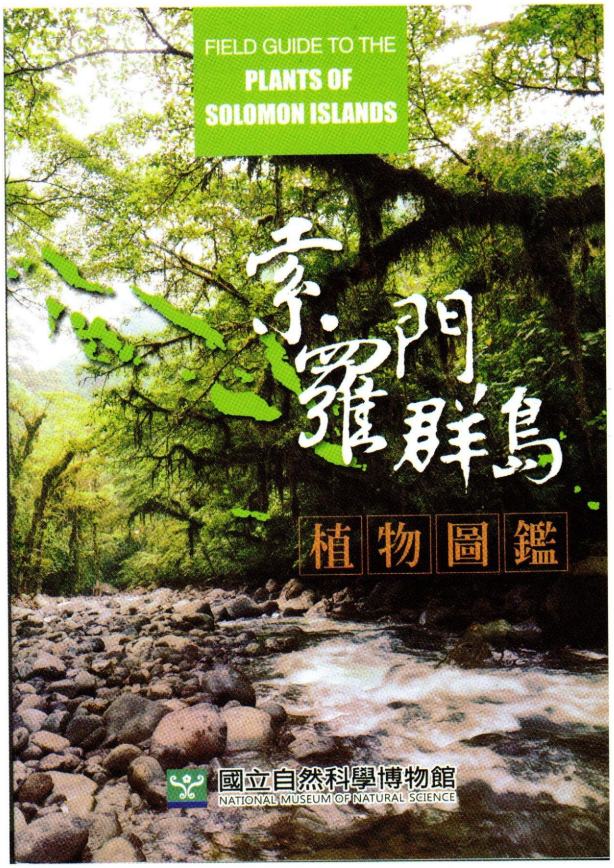


Field Guide to the Plants of Solomon Islands. Supervised by Wei Hsin Sun. Edited by Wen Liang Chiou, Jer Ming hu, Chih Hui Chen, Chien Fan Chen, Hsiu Chun Huang & Tsung Yue Yang Aleck. Published by National Museum of Natural Science, Taiwan, 2016. Pp. 334. ISBN 978-986-04-9038-1.

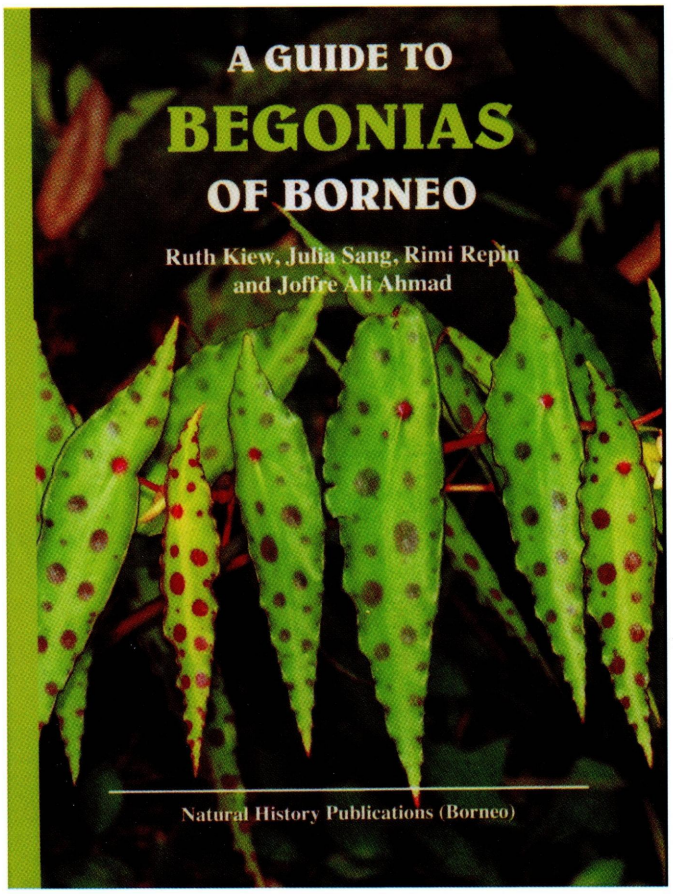
Reviewed by E. Khoo

The mention of Solomon Islands will prompt the readers to think whether the naming of the island is in relation to King Solomon. In fact, when the islands were discovered in the 15th century, assumptions were made that it contains great wealth like that of King Solomon, hence the Spanish navigator, Álvaro de Mendaña, gave the islands their name. Made up of over 1000 islands covering an area of 28,400 square kilometres in Oceania, east of Papua New Guinea, the islands' wealth comes from its natural resources both on land and sea; mineral deposits, such as gold, copper, nickel and bauxite. Such wealth results in challenges as well, recent mining operations, mineral prospecting and timber harvesting have put much of the islands' natural resources in jeopardy, raising concerns at both national and international level.

Therefore, in 2012, the Taiwan National Museum of Science, Japan Makino Botanical Garden and the Solomon Islands Ministry of Forestry and Research decided to collaborate to conduct an assessment and botanical collection of the plant resources in the Solomon Islands. The initiative did not come about because of the recent developments on the islands but also because it has been a dream and plan of Professor Dr. Tetsuo Koyama, Director of the Kochi Prefectural Makino Botanical Garden (previously the former senior curator and director of Asian botany at the New York Botanical Garden), to conduct botanical work in the area. The work was carried out with generous funding from Taiwan International Cooperation and Development Fund (Taiwan ICDF) and it involves researchers and personnel from different organizations and institutes from the three countries.

This publication is a compilation of the 3-year survey work on the plant families and the respective genera that are found within the islands in the Central, Choiseul, Guadalcanal, Isabel, Makira, Malaita, Renbel and Western Provinces. Even though many more islands are yet to be assessed, this publication gives the readers a glimpse of the wealth of plant families and genera that are found within the islands.

In total 153 genera are listed and described in detail and in certain cases, the number of species and locality found are provided. It is noted that the work is far from complete and the publication is considered as just a simple compilation of plants down to the genus level only. Even though there is still much to work on, this is a first step towards an attempt to come up with a comprehensive documentation of the plants of the Solomon Islands. It is hoped that future publications will provide a comprehensive species list of the plants that are found on the islands.



A guide to Begonias of Borneo by Ruth Kiew, Julia Sang, Rimi Repin & Joffre Ali Ahmad. Published by Natural History Publications (Borneo), Kota Kinabalu, 2015. Pp 293. ISBN 978-983-812-161-3 (Hardcover).

Reviewed by M. Ajik

It is estimated that there are over 1500 species of *Begonia* worldwide with the number of *Begonia* hybrids in horticulture even greater, exceeding 10,000. The forests of Borneo are hot spots for begonias. The exact number of species, however, remains unknown as during the course of preparing this Guide, new species were published and a lot more were waiting to be scientifically described as mentioned in the Foreword.

Begonias are known for their attractive foliage in that there are very few, if any other genera can compare with them for their variety of leaf shape, size, colour, pattern and texture. Variegation and the remarkable asymmetric leaves are the hallmark of the Begonia. However until now, it is difficult to identify Bornean begonias which are all endemics. The identification of species is much easier as the Guide provides numerous illustrations, a brief description and information on the distribution, habitat and uses. It is hoped that with the Guide in place, further interest in the begonias can be stimulated.

A total of 134 species out of the 194 begonias known from Borneo are beautifully illustrated and described in this Guide. The photographs are strikingly attractive to see. One will be utterly amazed at the beauty and variety of native begonias described.

Board Director of Gardens By The Bay, Singapore, Tan Jiew Hoe, PBM, whose ardent interest and support for Begonia research has inspired the publication of this Guide. This Guide is a must-have book for horticulturists and begonia enthusiasts.

GUIDE TO CONTRIBUTORS

Sepilok Bulletin is a biannual peer-reviewed journal published by the Forest Research Centre of the Sabah Forestry Department. The Bulletin publishes manuscripts addressing subjects related to tropical forestry, in Borneo and elsewhere. Manuscripts may be in the form of original research papers, short communications, review articles, monographs, book reviews, and announcements.

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In the list of references, the papers should be arranged alphabetically by authors' names, and chronologically per author, and conform to the following format. All citations in the text should be listed, and all papers listed should have been cited.

Burgess, P.F. (1966). *Timbers of Sabah*. Sabah Forest Record No. 6. Sabah Forest Department, Sandakan. 501 pp.

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REPRINTS

On publication, 25 reprints will be supplied free to the author(s).

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Front cover: A Bornean endemic insect, *Mycalesis amoena*, recorded at Kungkular F.R. (Photo: Eyen Khoo)