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Front cover: The large, charismatic firefly, *Lychnuris opaca* (Photo: Chey Vun Khen)

Sepilok Bulletin 8: 1-8 (2008)

Records of the genus *Citharomantis* Rehn, 1909 from Borneo (Insecta: Mantodea: Hymenopodidae: Acromantinae)

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Abstract. The praying mantis genus *Citharomantis* Rehn, 1909 is a monotypic genus known only from Sumatra and Borneo. The species is easy to recognise but, until a single record was published in 2007, there were no specific locality records for Borneo. It is recorded here from five new localities: two in Sabah, one in Sarawak, one in Peninsular Malaysia, and one in Sumatra. The characteristics of the genus are briefly outlined and illustrations are provided to distinguish it from the related genus *Acromantis* Saussure, 1870. The female of *Citharomantis falcata* Rehn, 1909 is illustrated for the first time.

Keywords: Acromantinae, Borneo, *Citharomantis*, distribution, Hymenopodidae, Mantodea, Peninsular Malaysia, Sumatra

INTRODUCTION

While carrying out research for a book on the praying mantids of Borneo (Bragg, in prep.), I found the Natural History Museum, London (BMNH) contains four specimens of *Citharomantis* Rehn, 1909, from Sabah and one from Sumatra. Initially the genus appeared to be new to Borneo, so the specimens were borrowed for a more detailed examination. Further checks in the literature showed *Citharomantis falcata* Rehn, 1909 had been recorded from Borneo, but that this had been overlooked in Ehrmann's recent (2002) catalogue of world species. This record for Borneo (Giglio-Tos 1915) does not give any information about the locality, apart from "Borneo". In 2007, a second specimen was recorded from Borneo (Helmkampf *et al.* 2007). The species is one of the most recognisable of the smaller mantids in Borneo because of the unusual size and shape of the wings. After this paper was submitted, one of the referees provided photographs and data on three specimens in the Forest Research Institute, Malaysia (FRIM).

THE MANTIS

Citharomantis Rehn, 1909

Citharomantis Rehn, 1909: 184; Giglio-Tos, 1915: 8; Giglio-Tos, 1927: 528; Ehrmann, 2002: 105; Otte & Spearman, 2005: 75. Type species by original designation: *Citharomantis falcata* Rehn, 1909.

The genus *Citharomantis* is very closely related to *Acromantis* Saussure, 1870, but differs by having a triangular lobe on the dorsal surface of the fore femur (Figure 1) and by the shape of the wings at rest: those of *Citharomantis* are clearly emarginate (Figures 4 & 5), those of *Acromantis* are more or less straight (Figures 2 & 3). The shape of the wings at rest is due to the unusual shape of the hind wings: they curve forward at the apex (Figure 6), causing them to project sideways when folded. The genus contains only one species, *Citharomantis falcata* Rehn, 1909, which was described from Sumatra; it was subsequently recorded from Borneo (Giglio-Tos 1915).

Citharomantis falcata Rehn, 1909

Citharomantis falcata Rehn, 1909: 185, figs 8 (♂) & 9 (♂); Giglio-Tos, 1915: 8; Giglio-Tos, 1927: 528; Ehrmann, 2002: 105; Otte & Spearman, 2005: 75; Helmkampf *et al.*, 2007: 13, pl. 2. (♂). Holotype ♂ (ANSP), Sumatra, Bah Soemboe. R. Weber.

Material examined

SUMATRA: ♂ (BMNH, BM 1974-277) South Sumatra, Lampung district, Padangratu, 220ft, C.J.M. Pruett, 14-15.xi.1973; *Citharomantis falcata* Rehn, det. J.A. Marshall, 1979.

SABAH: 2 ♀♀ (BMNH, BM 1979-65) Sandakan district, Ulu Dusun, A. Lamb, 1978. ♀ (BMNH, BM 1974-277) Sandakan district, Rumidi estate, River Labuk, 50-15ft, C.J.M. Pruett, 14-31.ix.1973; heavy forest near plantations.

SARAWAK: ♂ (BMNH, BM 1978-206) Gunung Mulu Nat. Park, RGS Exped. 1977-8; J.D. Holloway *et al.*; Site 16 March, Long Pala (Base) 70m. 324450 Alluv./second.for. MV-on batu-Canopy.

Photographic material examined

SABAH, Danum Valley (N04°58'07" E117°50'7", 340m), ♂ (Christian Schwarz collection) Helmkampf *et al.*, ii-iii.2003.

PENINSULAR MALAYSIA: ♂ (FRIM) F.R. Pasoh, Negeri Sembilan, October 1992. ♀ (FRIM) Pasoh F.R., N. Sembilan, 6.12.'83, Azmi; On Light trap. ♀ (FRIM) Pasoh, N. Sembilan, 5/12/83, Azmi; On Light trap.

DISCUSSION

Giglio-Tos (1915) recorded measurements for the female, and listed Borneo as a locality. However, Ehrmann (2002) overlooked Giglio-Tos's record for Borneo and listed Sumatra as the only locality. Giglio-Tos (1915) does not give any data for the specimens he examined, except to say there is a female from "Borneo" in the Sarawak Museum (SMSM), and a male from Sumatra in Berlin Museum (ZMHB).

Measurements of length for the body, pronotum, and tegmina are given in Table 1 for all the examined specimens. In addition I have included Rehn's measurements for the holotype and Giglio-Tos's measurements of the female in the Sarawak Museum. The body lengths are clearly subject to great variation because of shrinkage when the specimen dries. The lengths of the pronotum and tegmina are a more reliable measurement.

Table 1. Measurements (millimetres) for *Citharomantis falcata*.

Specimen	Body	Pronotum	Tegmina
♂ Holotype – Sumatra	20.5	6.5	16
♂ BMNH – Sumatra	22.1	6.4	15.7
♂ BMNH – Mulu	20.8	6.6	17.8
♀ SMSM – "Borneo"	28	9.5	22
♀ BMNH – Rumidi	30.1	8.8	21.6
♀ BMNH – Ulu Dusun	28.9	9.0	22.9
♀ BMNH – Ulu Dusun	29.3	9.1	22.9

Citharomantis is rare in comparison to the related *Acromantis*: my personal collection of Bornean mantids contains 11 specimens of *Acromantis* but no *Citharomantis*. The data presented here, including the recently published record for Danum Valley (Helmkampf *et al.* 2007), represent the only specific locality records for Borneo. The distribution map (Figure 7) shows the four known localities are all from North-East Borneo (Rumidi Estate plotted at E117°30' N05°45'). The large wings in both sexes suggest good flight capability for females. It is likely that the distribution extends over the whole of Borneo. The specimens in FRIM are the first records for Peninsular Malaysia.

The BMNH specimen collected by Pruett has been mistakenly labelled 14-31.ix.1973; presumably it should read 14-30.ix.1973.

ACKNOWLEDGEMENTS

I thank Dr George Beccaloni (BMNH) for the loan of the specimens of *Citharomantis falcata*, Dr Arthur Chung (Forest Research Centre, Sabah) for providing the latitude and longitude of the Rumidi Estate, and Martin Stiewe for providing some of the literature. Thanks to Dr Laurence Kirton (FRIM), and to Dr Jan Beck (University of Basel) for providing data and photographs.

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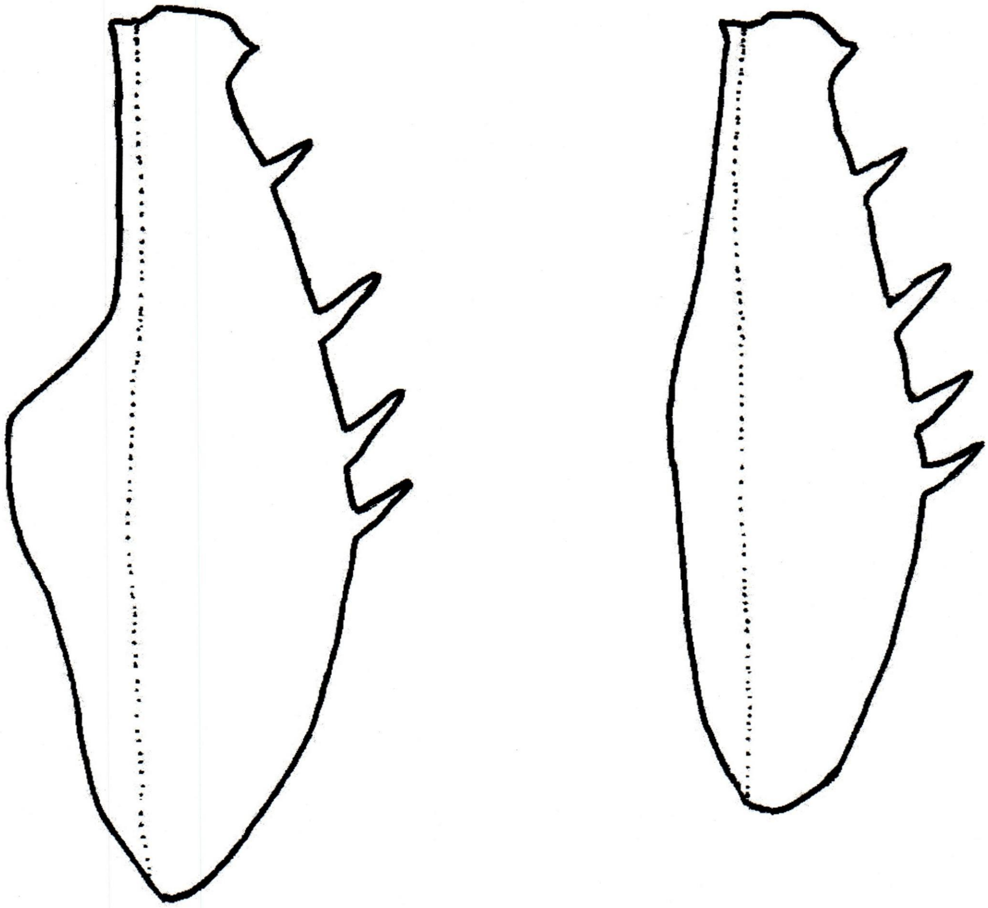

Figure 1. Right fore femur: (left) female *Citharomantis*, (right) female *Acromantis*.

Scale line = 1 cm on Figures 2-6

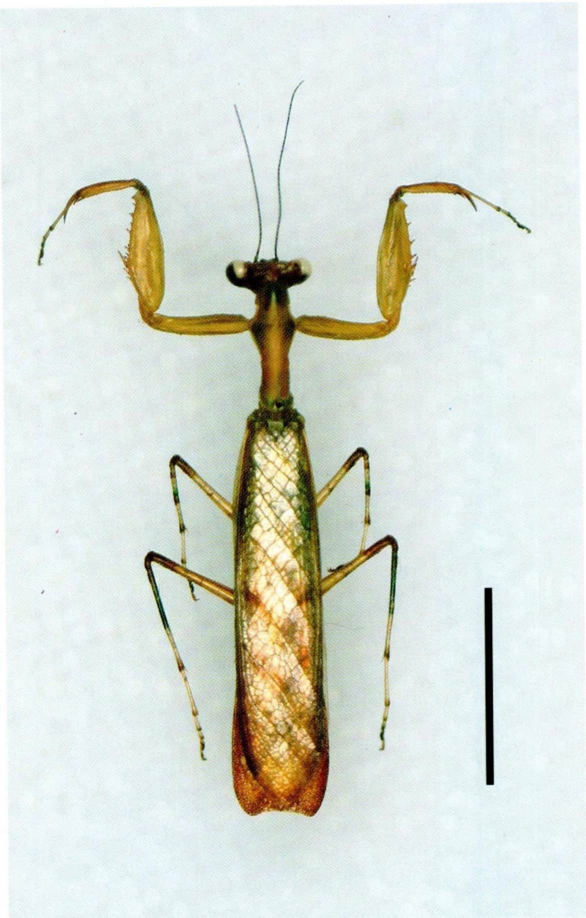

Figure 2. *Acromantis moultoni* Giglio-Tos, 1915. Male.

Figure 3. *Acromantis moultoni* Giglio-Tos, 1915. Female.

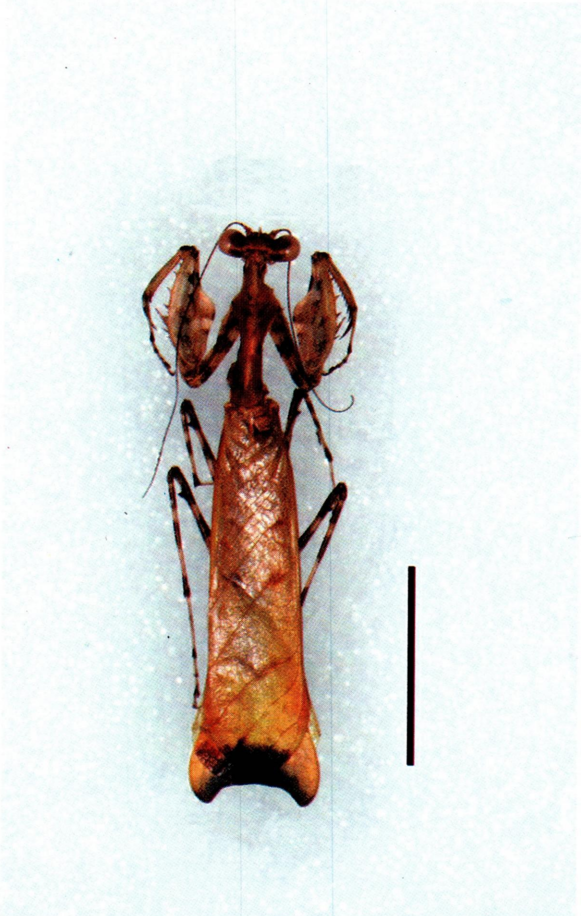

Figure 4. *Citharomantis falcata* Rehn, 1909. Male from Mulu.

Figure 5. *Citharomantis falcata* Rehn, 1909. Female from Rumidi Estate.

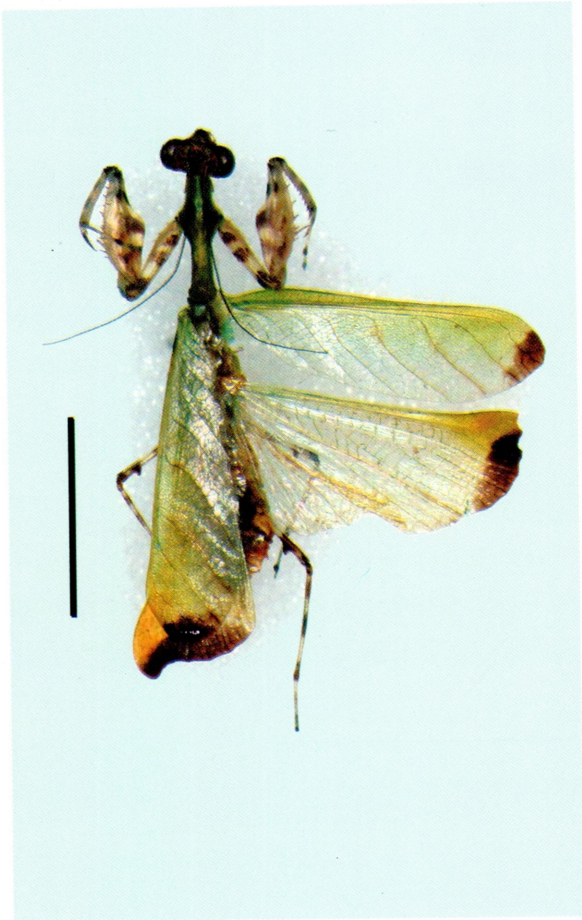

Figure 6. *Citharomantis falcata* Rehn, 1909.
Male from Sumatra.

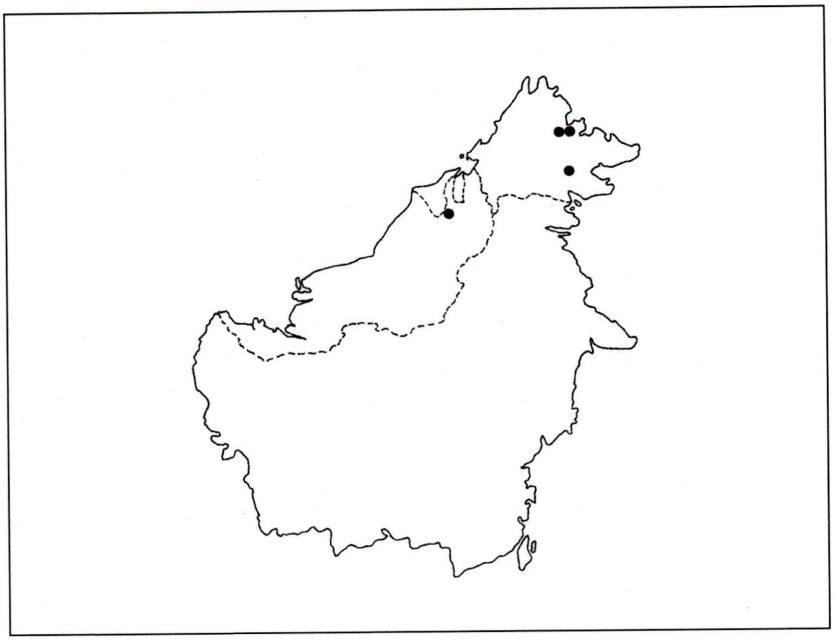

Figure 7. Distribution of *Citharomantis falcata* within Borneo.

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Observation on rooting of Tongkat Ali (*Eurycoma longifolia* Jack) by stem cuttings

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Abstract. An experiment on the rooting of Tongkat Ali through stem cuttings is presented. Wildings about one-year-old from Deramakot Forest Reserve, Tongod district, Sabah, Malaysia were cut and raised in the Ethnobotanic Garden nursery of the Forest Research Centre, Sepilok. It was observed that the percentage of rooting for stem cuttings with apical bud was higher compared to that of cuttings without apical bud. It is recommended that leftover stems while harvesting Tongkat Ali be used as planting material.

Keywords: *Eurycoma longifolia*, rooting, stem cuttings, tropical rain forest

INTRODUCTION

Medicinal plants are very important to humankind especially in developing countries. According to WHO in 1998, the world consumed around 80% of total medicinal plants. In Malaysia, it is estimated that around 1,200 species of medicinal plants are either growing wild or domesticated, and among them is Tongkat Ali.

Tongkat Ali or scientifically known as *Eurycoma longifolia* Jack (Simaroubaceae) is an important medicinal plant species in Malaysia. Its roots are used traditionally as an aphrodisiac, tonic, and also for treating malaria (Guntavid 1992, Kulip 2007). The young leaves are used to treat stomachache (Kulip 1996). Nowadays, large quantities of its roots are collected from the primary forest, processed and sold widely in Malaysia.

Unsustainable wild collection of Tongkat Ali threatens the survival of this species in Malaysia. Measures must be taken to ensure that the species will not go extinct. Among them is cultivation. Due to the difficulty of getting enough seeds or wildings from the forest, alternative steps must be taken to produce planting material such as through cuttings and tissue culture.

In this paper, preliminary results of observation on the rooting and survival of Tongkat Ali plant material through cuttings are presented. The objective of this study is to determine the rooting percentage of Tongkat Ali through cuttings.

MATERIAL & METHODS

Collection and preparation of cuttings

Stem cuttings were made from one-year-old wildings of 98 mother trees of *Eurycoma longifolia* growing in Deramakot Forest Reserve in Tongod district, Sabah, Malaysia. The disease and pest free shoots were cut and divided into two portions (apical and basal parts) at about 2 cm each before planting them in the Ethnobotanic Garden nursery, Forest Research Centre (FRC), Sepilok (Figure 1). The initial total number of stem cuttings without apical bud was 567, while the initial number of stem cuttings with apical bud was 98.

Figure 1. New leaves of Tongkat Ali cuttings.

Rooting powder

The basal ends of cuttings were dipped into containers filled with rooting powder 4-indole-3-methylbutyric acid. The cuttings were then planted into polybags. The planted cuttings were regularly watered. The first readings for rooting percentage, root number and root length (cm) were measured after 5 weeks.

RESULTS

The results with respect to rooting behaviour of basal and apical cuttings are presented below.

Rooting behaviour in nursery

New roots were observed to be formed after 5 months (Figure 2).

Figure 2. New roots formed from the Tongkat Ali cuttings.

(i) Cuttings without apical bud

Table 1 shows the rooting patterns of cuttings without apical bud. Total rooting was 7.94% (45/567). The longest root length recorded was 6.2 cm, the shortest was 0.305 cm and the mean was 1.729 cm long. The maximum number of primary roots formed was 7.

Table 1. Rooting patterns of Tongkat Ali cuttings without apical bud.

Time taken for rooting (months)	Number of rooted cuttings	Rooting (%)
5	17	3.00
7	23	4.06
9	45	7.94

(ii) Cuttings with apical bud

The percentage of rooting for cuttings with apical bud was 13.27% (13/98). The longest root length recorded was 14.89 cm. The maximum number of primary roots formed was 2.

Table 2. Rooting patterns of Tongkat Ali cuttings with apical bud.

Time taken for rooting (months)	Number of rooted cuttings	Rooting (%)
5	13	13.27

Out of the rooted cuttings, 8 died within 7 months and only 5 cuttings survived.

Transplanting in the field

The survived cuttings at the age of 3 years were then transplanted into the field (FRC Ethnobotanic Garden) and subsequently observed for growth. Flowering and fruiting were observed at the age of 4 years (Figures 3 & 4).

DISCUSSION

It was observed that the percentage of rooting for stem cuttings with apical bud was higher compared to that of cuttings without apical bud. Root length formed was also longer for stem cuttings with apical bud compared to stem cuttings without apical bud.

Even though the survival rate was low, the experiment indicates that Tongkat Ali can be propagated vegetatively. So, it is recommended that the leftover apical buds and stems be used for planting material after harvesting of Tongkat Ali rather than just throwing them away. The many small secondary roots formed could also be used as products.

Figure 3. Flowering Tongkat Ali (derived from cutting) at the FRC Ethnobotanic Garden, Sepilok.

Figure 4. Fruiting Tongkat Ali (derived from cutting) at the FRC Ethnobotanic Garden, Sepilok

ACKNOWLEDGEMENTS

I wish to acknowledge the Director of the Sabah Forestry Department and his Deputy (FRC, Sepilok) for endorsing this study. Thanks to the staff of Ethnobotany Section led by RA Mr Lajiman Wasai for taking samples in the forest and collecting monthly data and Mr Ajirin Malius for transplanting the plants in the field. I also like to give my thanks to Dr Doreen K.S. Goh of Innoprise Corporation and Mdm Maria Ajik (tree breeder) for comments on the manuscript. This research was funded by the Sabah State Government under Vot Ethnobotani Perhutanan.

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Sepilok Bulletin 8: 15-22 (2008)

Fireflies of Kionsom

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Abstract. Kionsom, located 19 km from Kota Kinabalu city centre, was found to shelter 7 firefly species in its riverine forest fragment of about 10 ha. Five *Luciola* spp. were sampled, some of which could be new to science. The rare *Pygoluciola wittmeri* Ballantyne, as well as the large, charismatic *Lychnuris opaca* Olivier were also collected. This underlines the importance of conserving forest fragments in city areas, to serve as refuge for wildlife including fireflies.

Keywords: fireflies, forest fragments, Kionsom, *Luciola*, *Lychnuris opaca*, *Pygoluciola wittmeri*, Sabah

INTRODUCTION

Fireflies (Coleoptera: Lampyridae) are of late an ecotourism attraction in Sabah. However, interest is mainly shown on the gregarious species on riverbanks (Mahadimenakbar *et al.* 2003, Chey 2004, Chey 2006), and nothing much has been done on species which are less gregarious or occur singly.

These solitary firefly species are of no less importance as many of them could be new to science, and they are more variable in terms of size and shape.

While I was light-trapping for moths in early 2007 at a forest fragment in Kionsom, about 19 km northeast of Kota Kinabalu city centre, non-gregarious fireflies were seen some distance away on the banks of the Inanam river. Even though few in numbers, their flashes were magical in the dark of the night, and I was attracted to make a study on them.

MATERIALS & METHODS

The study was conducted at Kionsom from February 2007. Sampling of fireflies was done monthly until July 2007, when there appeared to be no additional firefly species.

Sampling of fireflies was done after 7 pm by using a sweep-net, and specimens were put into labelled glass vials, and subsequently photographed. Two nights of sampling were done per month except April, when logistics did not permit.

Kionsom is better known for its waterfall. Its water drains into the clear, rocky Inanam river, which is fringed by forest vegetation within a fragment of about 10 ha. Altitude is around 180 m. Specimens of vegetation where the fireflies were captured were taken for identification.

RESULTS & DISCUSSION

Table 1 shows the firefly species sampled in the study. Altogether 7 species were captured consisting of 3 genera.

Table 1. Firefly species sampled at Kionsom in 2007. Number of individuals in brackets.

February	March	May	June	July
Lychnuris opaca Olivier (1) *Luciola* sp. 1 (6) *Luciola* sp. 2 (4) *Luciola* sp. 3 (1)	*Lychnuris opaca* Olivier (2) *Luciola* sp. 1 (10) *Luciola* sp. 2 (1) *Luciola* sp. 4 (3)	*Lychnuris opaca* Olivier (2) *Pygoluciola wittmeri* Ballantyne (4) *Luciola* sp. 4 (1) *Luciola* sp. 5 (11)	*Lychnuris opaca* Olivier (4) *Luciola* sp. 1 (3) *Luciola* sp. 4 (2)	*Lychnuris opaca* Olivier (1) *Luciola* sp. 1 (2) *Luciola* sp. 4 (2) *Luciola* sp. 5 (21)

A large charismatic firefly, *Lychnuris opaca* Olivier, about 18 mm long, was consistently found in Kionsom (Figure 1). It seemed to fly higher and its light did not flash that often. Some workers think the species should be placed under the genus *Pyrocoelia*. The female adult is large and flightless (Wong 2001).

A very rare species, *Pygoluciola wittmeri* Ballantyne, about 9 mm long, was collected in May (Figure 2). The male of the species has a lower heart-shaped light organ, and is distinguished by the following characters: apex of its median posterior projection of abdominal tergite 7 deeply emarginate, laterally ensheathing the downturned apex of tergite 8 and projecting laterally beside it (Ballantyne & Lambkin 2006).

Five species of *Luciola* were collected. According to Thancharoen *et al.* (2007), *Luciola* is a large genus of about 268 species restricted to the Old World, with an enormous amount of morphological variation. In my samples, *Luciola* sp. 4, body length about 14 mm, looks very different from the other *Luciola* spp. (body length 4-8 mm). It is interesting to note that none of these *Luciola* spp. could be identified to the species level (Figures 3-7), and some of them could even be new species.

Most of the smaller fireflies were caught while flying either on the river or its vegetation on the riverbank. A species list of the vegetation where the fireflies were sampled is given in Table 2. The fireflies showed no plant species preference. The bigger fireflies were caught mostly on the wing higher up.

Table 2. Species list of the riverside vegetation where the fireflies were sampled.

Family	Species
Araceae	*Homalomena* sp.
Aspleniaceae	*Diplazium riparium*
Cecropiaceae	*Poikilospermum suaveolens*
Compositae	*Eupatorium odoratum*
Cyatheaceae	*Cyathea* cf. *latebrosa*
Davalliaceae	*Nephrolepis biserrata*
Euphorbiaceae	*Macaranga gigantea* *Macaranga pearsonii*
Gramineae	*Dinochloa* sp.
Leguminosae	*Derris heptaphylla* *Mimosa pudica* *Spatholobus oblongifolius*
Malvaceae	*Urena lobata*
Moraceae	*Artocarpus elasticus*
Palmae	*Arenga undulatifolia*
Rhamnaceae	*Ziziphus* sp.
Rubiaceae	*Neolamarckia cadamba*
Schizaeaceae	*Lygodium circinnatum*
Urticaceae	*Oreocnide trinervis*

This study indicates the importance of conserving forest fragments (such as the riverine one in Kionsom) in city areas to serve as refuge for our wildlife including fireflies. Kionsom also provides shelter to creatures such as butterflies and moths, dragonflies and damselflies, frogs and crabs, among others (Chey 2007).

ACKNOWLEDGEMENTS

I am grateful to Dr Lesley Ballantyne of Charles Sturt University, Australia, who identified the fireflies. My colleagues En Mathius Allai, En Richard Ansis, En Willibrord Jimin, En Malih Antiu and En Masuari Bagrit helped to collect the fireflies. Some information was provided by En Osman Jaludin, head of Kionsom village. The plant specimens were identified by staff of the Sepilok Herbarium.

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Figure 1. The large, charismatic *Lychnuris opaca* Olivier, body length 18 mm, showing light organ towards abdominal end. Male.

Figure 2. The rare *Pygoluciola wittmeri* Ballantyne. Body length 9 mm, with its lower light organ heart-shaped. Male.

Figure 3. *Luciola* sp. 4. Body length 14 mm. Male.

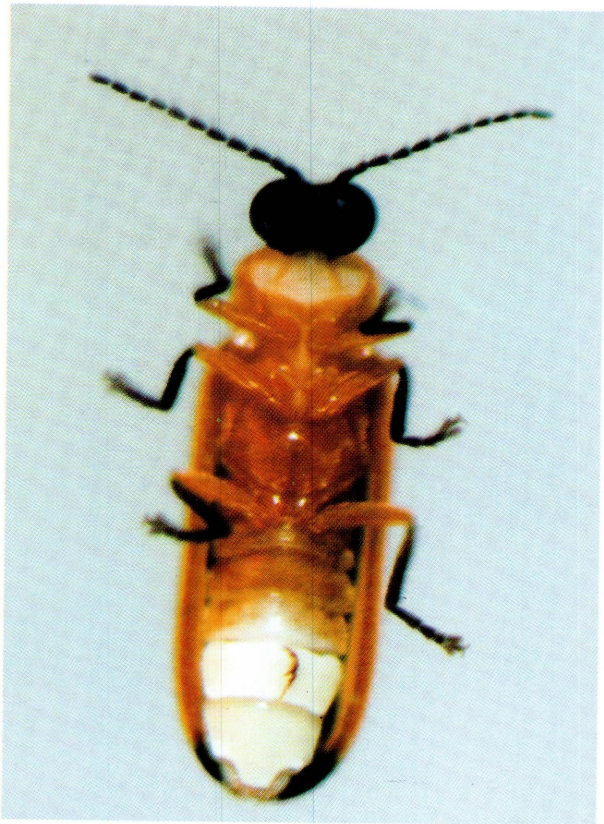

Figure 4. *Luciola* sp. 1.
Body length 6 mm.
Male.

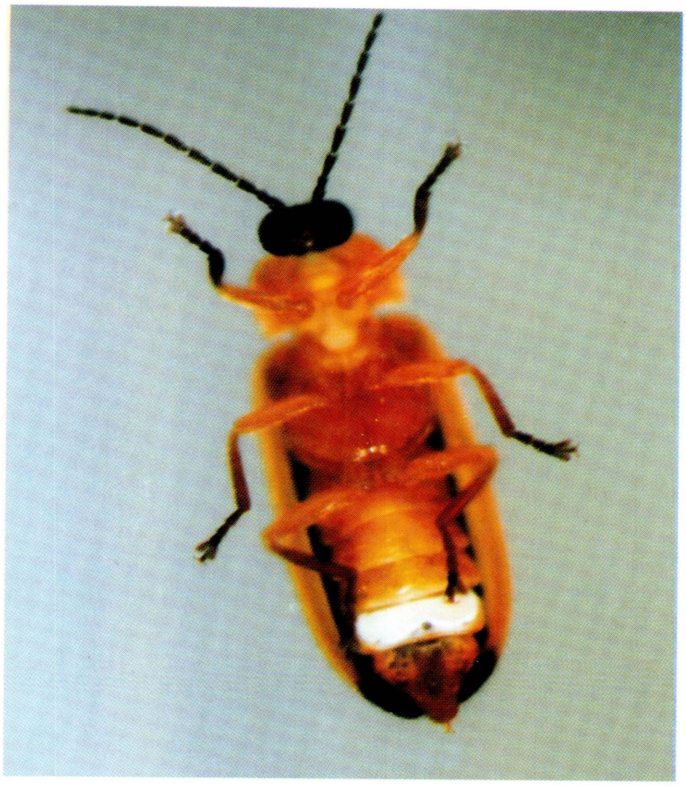

Figure 5. *Luciola* sp. 2.
Body length 8 mm, bigger than *Luciola* sp. 1 (above).
Female. Light organ on only one abdominal segment.

Figure 6. *Luciola* sp. 3. Body length 6 mm. Male. Dark. Rather similar to *Luciola* sp. 5 (below) but bigger.

Figure 7. *Luciola* sp. 5. Body length 4.5 mm. Male. The smallest species collected and the only one to show some gregariousness on the river.

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Insect fauna of Lake Linumunsut

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Abstract. As part of the Lake Linumunsut Scientific Expedition in October 2001, a survey was conducted on the insect fauna of the area for the first time. The survey focused on Lepidoptera (moths and butterflies), Odonata (dragonflies and damselflies), and Isoptera (termites). The biodiversity of the area, as indicated by moths, was representative of lowland rain forest in Borneo. The area harboured numerous rare and sought-after insect species, as well as endemics. Its unpolluted water ecosystem was found to be rich in dragonflies and damselflies, with about a-tenth of the Bornean species sampled.

Keywords: biodiversity, insects, Isoptera, Lake Linumunsut, Lepidoptera, Maliau Basin, Odonata

INTRODUCTION

Lake Linumunsut, about 12 ha of water area, lies 400 m above sea level (a.s.l.) in the northern tip of the Maliau Basin Conservation Area of 58,840 ha (Phillipps 2002). As part of the Lake Linumunsut Scientific Expedition in October 2001, a survey on the insect fauna of the area was conducted. The survey was done mainly at the vegetation surrounding the lake, as well as the nearby primary rain forest in an area of about 500 ha.

Hitherto, there is only one published report on the insect fauna (butterflies) of Maliau (Maryati *et al.* 1998), based on work conducted at the southern rim of the basin. This report represents the first insect survey conducted at the northern part of Maliau.

The present two-week expedition did not allow extensive sampling, and only a few groups were investigated, focusing on the Lepidoptera (moths and butterflies), Odonata (damselflies and dragonflies), and Isoptera (termites). Moths were chosen as they are more speciose, easily sampled, better known taxonomically, and their caterpillars being mainly herbivores make them useful indicators of biodiversity. Butterflies and dragonflies/damselflies are the most attractive of insects, which make them flagships in most conservation projects. Termites are important recyclers, by breaking down organic matter in the forest and returning the nutrients into the soil.

MATERIALS & METHODS

Light-trap

A light-trap was employed to sample the moth fauna. It was made up of a vertical white sheet (3 m^2) illuminated by a 250W mercury-lithium bulb. The trap was run on the floor in a clearing next to the helipad by the lakeside, from 6.30 pm until 10 pm which are the peak hours of moth activity, weather permitting. The trap served to pull down the moth fauna from the forest fringing the lake. Moths attracted to the light were collected using killing bottles charged with ethyl acetate, and papered.

Fruit-baited trap

Fruit-baited trap was used to sample fruit-feeding butterflies. The trap was a cylindrical tube of whitish semi-transparent cloth 1 m in length, with a plate at its lower end where a couple of bananas were placed. Butterflies attracted to the bananas entered through the gap above the plate and were trapped. Six traps were placed in a transect that ran from the base camp (Trap 1), through the forest trail towards Sungai Nematoi (Traps 2, 3), to the ridge above Sungai Nematoi (Traps 4, 5, 6). Each trap was placed hanging from a tree branch about 1 m above the floor, and about 50 m apart from the other. Butterflies were collected from the traps before sunset every evening.

Hand-net

Standard butterfly nets were used in the day to hand-net butterflies, dragonflies/damselflies at the sampling sites namely Lake Linumunsut and its surrounding habitats, as well as the nearby Sungai Nematoi, a river cut off from the lake.

Termite plots

A transect of 5 circular plots (each 5 m radius) was made on the forest trail towards Sungai Nematoi. The plots were 10 m apart from each other. Termites within the plots were collected and kept in labelled vials with 70% alcohol.

Identification

All specimens were brought back to the insect museum of the Forest Research Centre in Sepilok, Sandakan for identification purposes, where they were subsequently kept.

Moths were mainly identified using monographs by Barlow (1982), Holloway (1983, 1985, 1986, 1987, 1988, 1989, 1993, 1996, 1997, 1998, 1999, 2001, 2003, 2005) and Kobes (1985, 1989, 1994). Only the macromoths were sorted. Butterflies were identified by referring to Otsuka (1988), Seki *et al.* (1991), Maruyama (1991), as well as Corbet & Pendlebury (1992). Dragonflies/damselflies were identified using Pinratana *et al.* (1988), Lieftinck (1954) and Orr (2003). Termites were identified by referring to Thapa (1981).

Analysis of diversity

Moths were used to indicate the biodiversity of the area. Williams Alpha diversity index (log series) based on the numbers of individuals and species sampled was measured. This diversity index is commonly used for light-trapped moth samples, and it is independent of sample size (Fisher *et al.* 1943). Higher value of the index means higher diversity.

RESULTS & DISCUSSION

Moths (Order: Lepidoptera)

In total, 130 individuals from 91 species of moths were obtained from 3 sampling nights. Rain interrupted the light-trapping, as it rained almost every night during the sampling, which explained the relatively low catch.

The pooled samples yielded a Williams Alpha diversity index of 134.72 ± 48.69 (Table 1), comparable to values of similar sampling done in Lanjak-Entimau, Sarawak (Chey 2000). The result implies that the biodiversity of the area, at about 400 m a.s.l., was typical of lowland rain forest habitat in Borneo. Higher diversity was obtained at hill dipterocarp forest (700 m a.s.l.) in Lanjak-Entimau, which shows an overlap of both lowland and montane elements (Figure 1).

Table 1. Diversity index (Alpha) based on moths sampled at the lowland rain forest of Lake Linumunsut, with number of individuals (N) and species (S), compared with samples from Lanjak-Entimau (LE), Sarawak.

Forest	m a.s.l.	N	S	Alpha ± 95% confidence range
Lake Linumunsut	400	130	91	134.72 ± 48.69
Alluvial (LE)	150	268	139	116.28 ± 24.42
Lowland Dipterocarp (LE)	325	437	201	144.20 ± 22.88
Secondary (LE)	335	646	230	127.64 ± 16.01
Hill Dipterocarp (LE)	700	461	228	178.89 ± 28.20

Table 2 shows the break-down of the samples into the various moth groups. It can be seen that the biggest groups are Geometridae: Ennominae (34 individuals, 17 species), and Noctuidae (24 individuals, 20 species), which are of similar proportions to other light-trapped moth samples in Borneo (Chey 2000, Chey 2001).

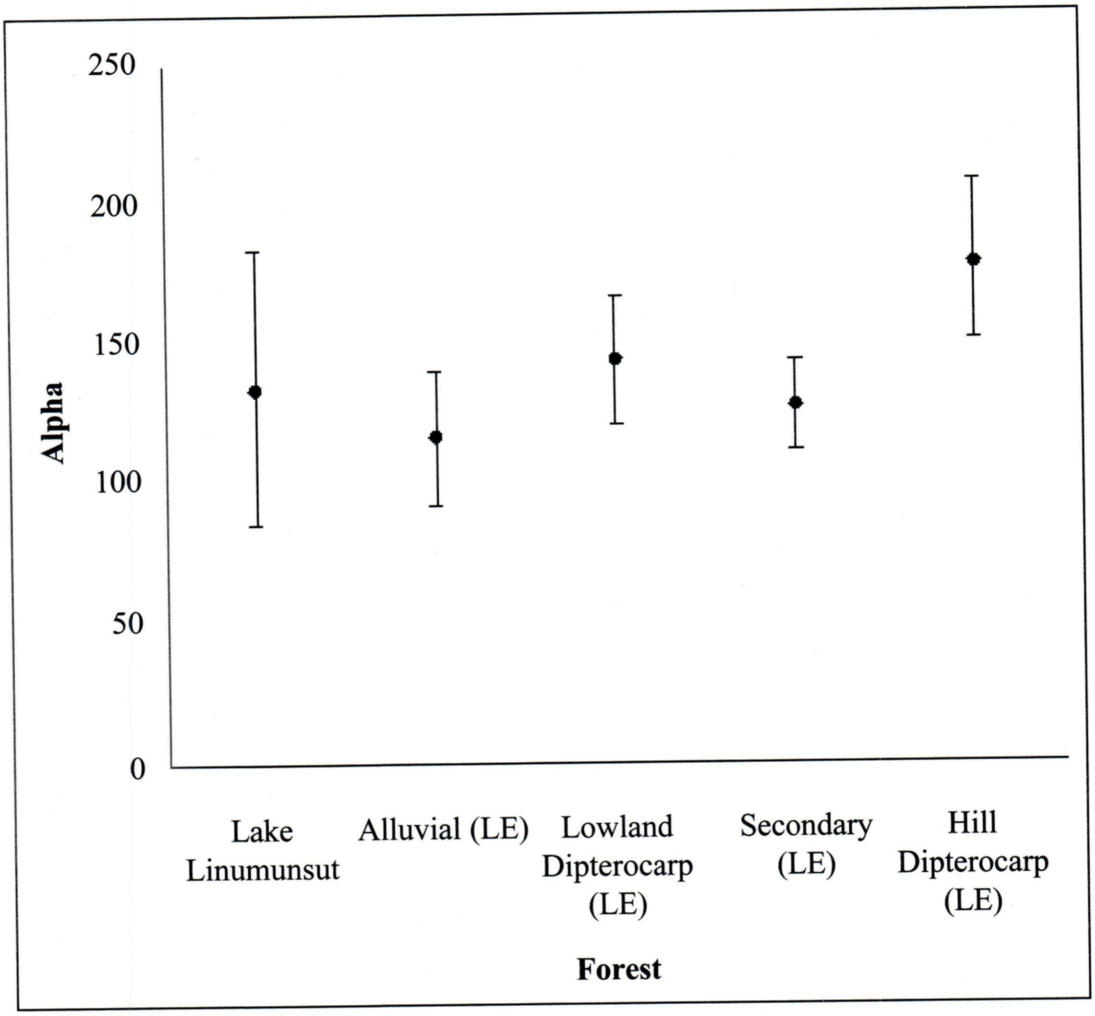

Figure 1. Diversity index (Alpha) based on moths of Lake Linumunsut compared with those of Lanjak-Entimau (LE).

However, the samples were also marked by a relatively big proportion of Bombycoidea (Sphingidae, Lasiocampidae, Saturniidae). The group, particularly the sphingids (hawkmoths), are mainly robust fliers, and the more open nature of the light-trapping site (by the lakeside) was able to draw more members of the group towards the light. A big, splendid female Moon Moth (*Actias maenas* Doubleday, Saturniidae), was in fact the first specimen obtained in the sampling. The species is getting increasingly scarce in the Bornean rain forest, and it was heartening to find this elegant moth in the forest of Lake Linumunsut.

Despite the small samples, there were also several unidentifiable species which could be new to science.

The full moth list is given in Appendix 1. The most abundant species sampled being *Hypochrosis binexata* Walker (Ennominae), indicative of lowland rain forest ecosystem.

Table 2. Number of individuals (N) and species (S) according to moth groups sampled at Lake Linumunsut.

Moth Group		N	S
Geometridae		**44**	**25**
	Ennominae	34	17
	Geometrinae	7	5
	Sterrhinae	2	2
	Larentiinae	1	1
Drepanidae		**1**	**1**
Uraniidae		**2**	**1**
Noctuidae		**24**	**20**
	Ophiderinae	2	2
	Catocalinae	15	11
	Amphipyrinae	2	2
	Herminiinae	1	1
	Hypeninae	3	3
	Aganainae	1	1
Nolidae		**2**	**2**
Arctiidae		**14**	**9**
Lymantriidae		**14**	**11**
Notodontidae		**1**	**1**
Lasiocampidae		**9**	**6**
Saturniidae		**1**	**1**
Sphingidae		**9**	**6**
Limacodidae		**4**	**3**
Cossidae		**5**	**5**
TOTAL		**130**	**91**

Butterflies (Order: Lepidoptera)

The full list of butterflies sampled by hand-net in 10 days is given in Appendix 2, with 54 species and 91 individuals, some of which were observed but not captured. It includes the beautiful Rajah Brooke's Birdwing (*Troides brookiana brookiana* Wallace), a much sought-after butterfly, which is protected by law in Sabah. The Green Dragontail (*Lamproptera meges meges* Zinken), rather rare these days, was sampled at Sungai Nematoi. Many of the butterflies sampled were singletons. The most common was the Bush Brown (*Mycalesis anapita fucentia* Fruhstorfer), a lowland forest species.

The fruit-baited traps set up for 8 days attracted as many as 14 species of butterflies with 28 individuals (Appendix 3). The number of species trapped was relatively high compared to work done at Danum by Tangah (2000) who trapped 40 species in a year on a tree platform of varying heights, and Benedick (2001) who sampled 63 species using a more intensive protocol for a year at both logged and unlogged forests. The more abundant species were the Malayan Owl (*Neorina lowii lowii* Doubleday), the Bush Browns (*Mycalesis* spp.), and *Bassarona dunya monara* Fruhstorfer, all of which are members of the family Nymphalidae, as expected. However, the Striped Ringlet (*Ragadia makuta umbrata* Fruhstorfer), reported as abundant in fruit-baited traps by Tangah (2000) and Benedick (2001), was absent in our traps but hand-netted (Appendix 2). It should be noted that Trap 1 placed in the base camp did not attract a single butterfly as there was too much human activity at the site.

The combined samples from hand-nets and fruit-traps yielded a total of 63 butterfly species with 4 endemics, out of 930 species with 88 endemics in Borneo.

Dragonflies/Damselflies (Order: Odonata)

Lake Linumunsut with its marshland was found to be rich in dragonflies and damselflies. Apart from that, Sungai Nematoi with its riverine ecosystem was also found to harbour numerous species which favour undisturbed habitat. Appendix 4 shows the full list of Odonata sampled in 10 days, yielding 20 species and 76 individuals. With 275 species of Odonata documented in Borneo (Orr 2003), the survey yielded about a-tenth of the species.

The most abundant dragonfly sampled was *Trithemis aurora* Burmeister, which was commonly seen on the lake. The pretty damselfly *Euphaea subcostalis* Selys with iridescent blue-green hindwings was also commonly seen in the unpolluted running water of Sungai Nematoi.

The abundance and diversity of Odonata observed could be attributed to the relatively clean water ecosystem in the area. The nymphs of Odonata are aquatic, and many cannot tolerate water contamination.

Termites (Order: Isoptera)

The transect of 5 small circular plots yielded 7 termite species (Appendix 5), including one of the biggest termites *Macrotermes malaccensis* Haviland, its major soldier (with a head length reaching 5 mm) can induce a most painful bite.

The number of termite species was comparable to that of the similarly sampled lowland dipterocarp forest in Lanjak-Entimau, Sarawak, which gave 10 species (Chey 1998). Previous sampling by Chey (1989) using a transect of similar circular plots produced 17 species at Danum and 16 species at Sepilok. But those two transects were done with the plots 50 m apart from one another instead of the present 10 m. This implies that sampling over a longer transect with similar sized plots would result in higher species number as it is likely that more niches would be covered.

It should also be noted that all the termites collected in the present survey were from dead organic matter and none was found attacking living trees. In simplified tree monocultures, several termite species can become serious pests (Chey 1996). But in the diverse primary rain forest, most termite species are beneficial by breaking down dead organic matter and returning the nutrients into the soil.

Management implication

Some insect species are widespread generalists, and include those which are tolerant of disturbance. There are also those stenotopic or specialist species which can only thrive in undisturbed environments with very limited ecological tolerance (Chey *et al.* 1997), and they are the ones which are most vulnerable when forest is logged or degraded (Hill 1999). The forest around Lake Linumunsut and its water system being undisturbed are home to numerous specialists, and forest managers can do well to keep the area from any form of degradation.

CONCLUSION

The survey indicates that the insect fauna of Lake Linumunsut was representative of that of lowland rain forest in Borneo. The place was also shown to harbour numerous rare and sought-after species as well as endemics which, with the depletion of our tropical rain forest, will be very much threatened. Insects play an integral role in the proper functioning of the forest ecosystem by acting as pollinators, nutrient recyclers, among others. Total protection of Lake Linumunsut and its surrounding forest will ensure the survival of these precious creatures as well as the well-being of this unique ecosystem.

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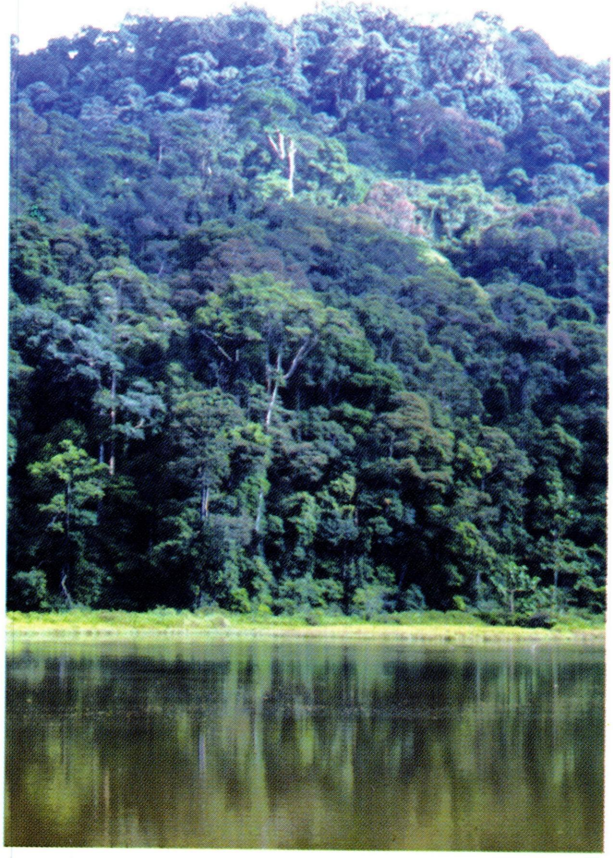

Figure 2. Lake Linumunsut and its surrounding forest.

Figure 3. *Hypochrosis binexata* Walker, a common moth in Linumunsut.

Figure 4. The Moon Moth, *Actias maenas* Doubleday.

Figure 5. *Mycalesis kina* Staudinger, a butterfly endemic to Borneo.

Figure 6. *Neorina lowii lowii* Doubleday, common in traps.

Figure 7. *Trithemis aurora* Burmeister, a dragonfly abundant in Lake Linumunsut.

Figure 8. *Euphaea subcostalis* Selys, a damselfly with metallic blue-green hindwings, common in the unpolluted Sungai Nematoi.

Figure 9. Soldiers of *Macrotermes malaccensis* Haviland, one of the biggest termites.

Appendix 1. List of moths (species and individuals) sampled by light-trap at Lake Linumunsut.

Species	16.x.01	18.x.01	21.x.01
1. Family: Cossidae			
Cossus javanus Roepke	1		
Xyleutes ceramica Walker		1	
Xyleutes mineus Cramer		1	
Xyleutes strix Linnaeus			1
Zeuzera caudata Joicey & Talbot	1		
2. Family: Limacodidae			
Cania bandura Moore	1	1	
Scopelodes pallivittata Snellen		1	
Scopelodes unicolor Westwood	1		
3. Family: Sphingidae			
Acosmeryx shervillii Boisduval			1
Ambulyx pryeri Distant	1	1	
Daphnis hypothous Cramer		1	
Daphnusa ocellaris Walker			2
Eupanacra psaltria Jordan*		1	
Theretra rhesus Boisduval	1		1
4. Family: Saturniidae			
Actias maenas Doubleday	1		
5. Family: Lasiocampidae			
Euthrix laeta Walker			1
Lebeda cognata Grunberg			2
Odonestis erectilinea Swinhoe			1
Odonestis vita Moore			1
Paralebeda lucifuga Swinhoe		3	
Trabala pallida Walker	1		
6. Family: Notodontidae			
Benbowia virescens Moore		1	

Species	16.x.01	18.x.01	21.x.01
7. Family: Lymantriidae			
Arctornis obtusa Walker		1	
Arctornis sp. 1	1	1	1
Arctornis sp. 2			1
Arctornis sp. 3			1
Imaus munda Walker		1	
Lymantria minora van Eecke			1
Lymantria singapura Swinhoe			1
Lymantria sublunata Rothschild	1		1
Nygmia guttulata Snellen	1		
?*Orvasca* sp.			1
Toxoproctis munda Walker			1
8. Family: Arctiidae			
(i) Subfamily: Lithosiinae			
Barsine lucibilis Swinhoe*	1	3	
Barsine roseororatus Butler		1	1
Barsine rubricostata Herrich-Schaffer		1	1
Cyana perornata Walker	1		
Cyana selangorica Hampson		1	
Eugoa tessellata Holloway*			1
Nishada rotundipennis Walker			1
Oeonistis altica Linnaeus	1		
?"*Tigrioides*" sp.		1	
9. Family: Drepanidae			
(i) Subfamily: Drepaninae			
Callidrepana saucia sundobscura Holloway			1
10. Family: Uraniidae			
(i) Subfamily: Uraniinae			
Lyssa menoetius Hopffer		1	1
11. Family: Geometridae			
(i) Subfamily: Geometrinae			
Comostola chlorargyra Walker			2
Indet. sp. A	1		1
Pingasa rubicunda Warren	1		
Pingasa ruginaria Guenee	1		
Tanaorhinus rafflesii Moore	1		

Species	16.x.01	18.x.01	21.x.01
(ii) Subfamily: Sterrhinae			
Scopula actuaria Walker			1
Sterrhinae sp. 1		1	
(iii) Subfamily: Larentiinae			
Ziridava rufinigra Swinhoe			1
(iv) Subfamily: Ennominae			
Celenna centraria Snellen		1	
Cleora determinata Walker	2	1	
Coremecis maculata Warren		1	
Dalima delineata Warren	1		
Diplurodes sp.	1		
Ectropidia fimbripedata Warren		1	1
Hypochrosis binexata Walker	4	2	2
Hypomecis costaria Guenee			3
Hypomecis lioptilaria Swinhoe	1		1
Hypomecis subdetractaria Prout		1	1
Hypomecis tetragonata Walker			1
Hyposidra infixaria Walker			1
Luxiaria emphatica Prout		1	
Luxiaria hyalodela Prout	1	1	
Luxiaria phyllosaria Walker			1
Omiza lycoraria Guenee	2	1	
Plutodes cyclaria Guenee		1	
12. Family: Noctuidae			
(i) Subfamily: Aganainae			
Asota egens Walker		1	
(ii) Subfamily: Amphipyrinae			
Athetis thoracica Moore			1
Mudaria tayi Holloway			1
(iii) Subfamily: Catocalinae			
Avatha rufiscripta Hampson			1
Bastilla fulvotaenia Guenee		1	
Bocula bifaria Walker		1	2
Episparis costistriga Walker	1	1	

Species	16.x.01	18.x.01	21.x.01
Erebus caprimulgus Fabricius			1
Erygia apicalis Guenee	1		
Pantydia metaspila Walker			1
Papuacola albisigillata Warren	1		
Tamba magniplaga Swinhoe	2		
Ugia disjungens Walker*		1	
Ugia sundana Hampson		1	
(iv) Subfamily: ?Ophiderinae			
?*Aedia* sp.			1
?*Mecodina* sp.			1
(v) Subfamily: Herminiinae			
Adrapsa ?*ereboides* Walker			1
(vi) Subfamily: Hypeninae			
Alelimma lignea Swinhoe			1
Echanella temperate Prout	1		
Hypena sp. 1			1
13. Family: Nolidae			
(i) Subfamily: Nolinae			
?"*Aquita*" sp.		1	
(ii) Subfamily: Chloephorinae			
Characoma albulalis Walker*			1

* Endemic to Borneo

Appendix 2. List of butterflies sampled by hand-net at Linumunsut.
N = No. of individuals.

Species	Locality	Date	N
1. Family: Papilionidae			
Graphium sp.	Lake Linumunsut^	20.x.2001	2
	Sungai Nematoi^	23.x.2001	1
Lamproptera meges meges Zinken	Sungai Nematoi	24.x.2001	1
Papilio memnon memnon Linnaeus	Sungai Nematoi^	18.x.2001	1
	Lake Linumunsut	20.x.2001	1
	Sungai Nematoi^	23.x.2001	1
	Sungai Nematoi^	26.x.2001	1
Pathysa delessertii delessertii Guerin-Meneville	Sungai Nematoi^	26.x.2001	1
Troides ?amphrysus flavicollis Druce	Sungai Nematoi^	18.x.2001	1
Troides brookiana brookiana Wallace	Sungai Nematoi^	18.x.2001	1
	Lake Linumunsut^	21.x.2001	1
2. Family: Pieridae			
(i) Subfamily: Pierinae			
Cepora iudith hespera Butler	Sungai Nematoi	24.x.2001	1
Pareronia valeria lutescens Butler	Sungai Nematoi^	24.x.2001	1
Saletara panda distanti Butler	Sungai Nematoi	24.x.2001	1
(ii) Subfamily: Coliadinae			
Catopsilia pomona pomona Fabricius	Sungai Nematoi^	18.x.2001	1
	Sungai Nematoi^	23.x.2001	1
	Sungai Nematoi^	26.x.2001	1
Catopsilia scylla cornelia Fabricius	Lake Linumunsut^	21.x.2001	1
Eurema sp.	Sungai Nematoi^	18.x.2001	1
	Sungai Nematoi^	23.x.2001	1
Gandaca harina elis Fruhstorfer	Sungai Nematoi	24.x.2001	3
3. Family: Nymphalidae			
(i) Subfamily: Danainae			
Idea stolli virgo Fruhstorfer	Sungai Nematoi^	18.x.2001	1
	Sungai Nematoi	23.x.2001	1
	Sungai Nematoi	24.x.2001	1
(ii) Subfamily: Satyrinae			
Coelites euptychioides euptychioides C & R Felder	Lake Linumunsut	17.x.2001	1

Species	Locality	Date	N
Mycalesis anapita fucentia Fruhstorfer	Sungai Nematoi	23.x.2001	3
	Sungai Nematoi	25.x.2001	3
Neorina lowii lowii Doubleday	Lake Linumunsut	21.x.2001	1
Ragadia makuta umbrata Fruhstorfer	Sungai Nematoi	24.x.2001	2
Ypthima baldus selinuntius Fruhstorfer	Sungai Nematoi	23.x.2001	1
	Sungai Nematoi	25.x.2001	1
(iii) Subfamily: Morphinae			
Thaumantis odana panwila Fruhstorfer	Lake Linumunsut^	21.x.2001	1
	Sungai Nematoi	24.x.2001	1
(iv) Subfamily: Nymphalinae			
Athyma pravara pravara Moore	Sungai Nematoi	23.x.2001	1
Cethosia hypsea hypsea Doubleday	Sungai Nematoi^	24.x.2001	1
Chersonesia peraka peraka Distant	Sungai Nematoi	25.x.2001	1
Chersonesia rahria rahria Moore	Sungai Nematoi	24.x.2001	1
Cupha erymanthis erymanthis Drury	Sungai Nematoi	23.x.2001	2
	Sungai Nematoi	25.x.2001	1
Euthalia monina bipunctata Vollenhoeven	Sungai Nematoi	23.x.2001	1
Junonia atlites atlites Linnaeus	Sungai Nematoi	24.x.2001	1
	Sungai Nematoi	25.x.2001	1
Kallima limborgii boxtoni Moore	Lake Linumunsut	19.x.2001	1
Moduza procris agnata Fruhstorfer	Sungai Nematoi^	18.x.2001	1
	Lake Linumunsut^	20.x.2001	1
Neptis omeroda omeroda Moore	Lake Linumunsut	19.x.2001	1
Parthenos sylvia borneensis Staudinger	Sungai Nematoi^	18.x.2001	1
	Lake Linumunsut^	20.x.2001	1
	Sungai Nematoi^	23.x.2001	1
	Sungai Nematoi^	26.x.2001	1
Vindula erota montana Fruhstorfer	Lake Linumunsut	19.x.2001	1
4. Family: Lycaenidae			
(i) Subfamily: Riodininae			
Paralaxita telesia ines Fruhstorfer	Sungai Nematoi^	18.x.2001	1
	Sungai Nematoi	23.x.2001	1
(ii) Subfamily: Miletinae			
Allotinus apries apries Fruhstorfer	Sungai Nematoi	23.x.2001	1
Allotinus fabius fabius Distant & Pryer	Sungai Nematoi	23.x.2001	1

Species	Locality	Date	N
(iii) Subfamily: Curetinae			
Curetis santana malayica C & R Felder	Sungai Nematoi	24.x.2001	1
(iv) Subfamily: Lycaeninae			
Acytolepis puspa mygdonia Fruhstorfer	Sungai Nematoi	24.x.2001	1
Acytolepis ripte H.H. Druce*	Sungai Nematoi	24.x.2001	1
Anthene emolus goberus Fruhstorfer	Sungai Nematoi	23.x.2001	1
Anthene lycaenina miya Fruhstorfer	Lake Linumunsut	19.x.2001	1
	Sungai Nematoi	23.x.2001	1
Arhopala borneensis Bethune-Baker*	Sungai Nematoi	24.x.2001	2
Eooxylides etias Distant & Pryer*	Sungai Nematoi	24.x.2001	2
Hypolycaena amasa maximinianus Fruhstorfer	Sungai Nematoi	24.x.2001	1
Ionolyce helicon merguiana Moore	Sungai Nematoi	23.x.2001	1
Jamides virgulatus virgulatus H.H. Druce	Sungai Nematoi	24.x.2001	3
Loxura cassiopeia amatica Fruhstorfer	Sungai Nematoi	23.x.2001	1
	Sungai Nematoi	25.x.2001	1
Nacaduba calauria malayica Corbet	Sungai Nematoi	24.x.2001	1
Pithecops corvus Fruhstorfer	Sungai Nematoi	24.x.2001	2
Una usta usta Distant	Sungai Nematoi	23.x.2001	1
5. Family: Hesperiidae			
(i) Subfamily: Hesperiinae			
Notocrypta clavata clavata Staudinger	Sungai Nematoi	25.x.2001	1
Potanthus ganda marla Evans	Lake Linumunsut^	20.x.2001	1
Psolos fuligo fuligo Mabille	Sungai Nematoi	23.x.2001	1
Taractrocera ziclea stella Evans	Lake Linumunsut	21.x.2001	1
	Sungai Nematoi	26.x.2001	1
Zographetus ogygia ogygia Hewitson	Sungai Nematoi	23.x.2001	1

* Endemic to Borneo

^ Observed

Appendix 3. List of butterflies sampled by fruit-baited trap at Linumunsut.
N = No. of individuals.

Species	Trap	Date	N
1. Family: Nymphalidae			
(i) Subfamily: Satyrinae			
Melanitis zitenius rufinus Fruhstorfer	2	25.x.2001	1
Mycalesis kina Staudinger*	3	20.x.2001	1
	6	21.x.2001	2
	6	24.x.2001	1
Mycalesis maianeas kadasan Aoki & Uemura	3	20.x.2001	1
	5	22.x.2001	1
	2	24.x.2001	1
Mycalesis orseis borneensis Fruhstorfer	4	20.x.2001	1
	3	22.x.2001	1
Neorina lowii lowii Doubleday	6	20.x.2001	1
	4	21.x.2001	1
	4	23.x.2001	1
	5	24.x.2001	1
	3	26.x.2001	2
(ii) Subfamily: Morphinae			
Amathusia phidippus phidippus Linnaeus	3	25.x.2001	1
Discophora necho cheops C & R Felder	5	21.x.2001	1
Thaumantis odana panwila Fruhstorfer	5	25.x.2001	1
(iii) Subfamily: Nymphalinae			
Amnosia decora buluana Fruhstorfer	2	22.x.2001	1
Bassarona dunya monara Fruhstorfer	2	19.x.2001	1
	3	21.x.2001	1
	6	25.x.2001	1
Junonia atlites atlites Linnaeus	6	19.x.2001	1
Kallima limborgii boxtoni Moore	3	22.x.2001	1
Tanaecia pelea djataca Fruhstorfer	6	19.x.2001	1
	4	23.x.2001	1
2. Family: Lycaenidae			
(i) Subfamily: Lycaeninae			
Anthene lycaenina miya Fruhstorfer	2	19.x.2001	1

* Endemic to Borneo

Appendix 4. List of damselflies/dragonflies sampled by hand-net at Linumunsut. N = No. of individuals.

Species	Locality	Date	N
Zygoptera (Damselflies)			
1. Family: Calopterygidae			
(i) Subfamily: Calopteryginae			
Neurobasis longipes Hagen*	Lake Linumunsut	19.x.2001	2
	Sungai Nematoi	23.x.2001	3
	Lake Linumunsut	25.x.2001	1
2. Family: Chlorocyphidae			
Rhinocypha humeralis Selys	Sungai Nematoi	24.x.2001	1
3. Family: Euphaeidae			
Euphaea subcostalis Selys	Sungai Nematoi	23.x.2001	2
	Sungai Nematoi	24.x.2001	1
	Sungai Nematoi	26.x.2001	1
	Lake Linumunsut	26.x.2001	1
4. Family: Megapodagrionidae			
Rhinagrion sp.	Lake Linumunsut	19.x.2001	1
5. Family: Coenagrionidae			
(i) Subfamily: Agriocnemidinae			
Agriocnemis femina Brauer	Lake Linumunsut	19.x.2001	3
	Lake Linumunsut	20.x.2001	1
	Lake Linumunsut	25.x.2001	3
	Sungai Nematoi	26.x.2001	1
Agriocnemis pygmaea Rambur	Lake Linumunsut	19.x.2001	2
	Lake Linumunsut	25.x.2001	1
	Lake Linumunsut	26.x.2001	2
Amphicnemis sp.	Lake Linumunsut	25.x.2001	1
?*Amphicnemis* sp.	Lake Linumunsut^	19.x.2001	1
(ii) Subfamily: Pseudagrioninae			
?*Ceriagrion* sp.	Lake Linumunsut	19.x.2001	2
	Lake Linumunsut	20.x.2001	1
	Lake Linumunsut	25.x.2001	4
	Sungai Nematoi	26.x.2001	2
6. Family: Platystictidae			
Protosticta sp.	Lake Linumunsut	19.x.2001	1
	Sungai Nematoi	26.x.2001	1

Species	Locality	Date	N
Anisoptera (Dragonflies)			
1. Family: Gomphidae			
(i) Subfamily: Epigomphinae			
Macrogomphus sp.	Lake Linumunsut	19.x.2001	1
2. Family: Corduliidae			
(i) Subfamily: Macromiinae			
Macromia sp.	Lake Linumunsut	19.x.2001	1
3. Family: Libellulidae			
(i) Subfamily: Libellulinae			
Orthetrum pruinosum schneideri Forster	Lake Linumunsut	19.x.2001	1
Orthetrum sabina Drury	Lake Linumunsut	19.x.2001	2
	Lake Linumunsut	20.x.2001	1
Orthetrum testaceum Burmeister	Lake Linumunsut	17.x.2001	2
	Lake Linumunsut	19.x.2001	1
	Lake Linumunsut	20.x.2001	1
	Lake Linumunsut	25.x.2001	1
	Lake Linumunsut	26.x.2001	1
(ii) Subfamily: Sympetrinae			
Diplacodes trivialis Rambur	Lake Linumunsut	19.x.2001	3
	Sungai Nematoi	23.x.2001	1
Neurothemis fluctuans Fabricius	Lake Linumunsut	20.x.2001	1
	Lake Linumunsut	21.x.2001	4
	Lake Linumunsut	25.x.2001	1
(iii) Subfamily: Trithemistinae			
Trithemis aurora Burmeister	Lake Linumunsut	17.x.2001	1
	Lake Linumunsut	18.x.2001	1
	Lake Linumunsut	20.x.2001	2
	Lake Linumunsut	21.x.2001	3
	Lake Linumunsut	25.x.2001	1
	Lake Linumunsut	26.x.2001	3
?*Trithemis* sp.	Lake Linumunsut	21.x.2001	1
	Lake Linumunsut	25.x.2001	1
(iv) Subfamily: Trameinae			
Rhyothemis triangularis Kirby	Lake Linumunsut	25.x.2001	2

* Endemic to Borneo

^ Observed

Appendix 5. List of termites sampled at Linumunsut in October 2001.
N = No. of vials.

Species	Plot	Substrate	N
1. Family: Rhinotermitidae			
(i) Subfamily: Rhinotermitinae			
Schedorhinotermes sarawakensis Holmgren	4	ex termite mound	1
	5	ex humus layer	1
2. Family: Termitidae			
(i) Subfamily: Termitinae			
Pericapritermes latignathus Holmgren	3	ex humus layer	1
(ii) Subfamily: Macrotermitinae			
Hypotermes xenotermitis Wasmann	3	ex fallen rotting branch	1
Macrotermes malaccensis Haviland	4	ex fallen rotting branch	1
(iii) Subfamily: Nasutitermitinae			
Bulbitermes constrictus Haviland*	1	ex floor leaf litter	1
	1	ex dead tree base	1
Bulbitermes flavicans Holmgren	3	ex fallen rotting branch	2
Nasutitermes regularis Haviland	5	ex fallen rotting branch	3

* Endemic to Borneo

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NOTES

A note on the preparation of compost

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Composting is a method of speeding up the natural process causing organic material to rot under conditions which can be controlled. Any organic material like coconut husks, cocoa husks, damp leaves and grasses, etc. will eventually rot to form a compost, all that is required is oxygen in the air, water, micro-organisms and organic material itself. Oxygen is available in the air, water is either already in the organic material (e.g. damp leaves, grasses, etc.) or can be added, and the micro-organisms (bacteria and fungi) are also present on the organic matter, in the air or soil (Bowen & Chow 1984). In the past, chicken manure and cow dung had also been added in the preparation of compost at the Forest Research Centre nursery in Sepilok, but due to the unhygienic conditions of these materials, they are not used anymore. At present urea and rock phosphate are used instead.

The composting process has some very basic requirements. Apart from adequate moisture and oxygen, there must be a proper balance of carbon and nitrogen. Composting is often a task for the not so busy times in the nursery, when labour is available to collect and process wastes, build piles and turn the compost (Miller & Jones 1995).

A good compost contains a rich supply of nutrients and also improves the texture of the soil and its properties, hence ensuring a healthy and vigorously growth of the plant. Anonymous (1978), Poincelot (1972) and Miller & Jones (1995) have written some useful information on composting.

The method now being practised at the Forest Research Centre nursery is by using purely sawdust as base. The sawdust collected from the sawmill must be sieved before use in order to separate the impurities and pieces of wood which will slow down the process of rotting.

The compost is prepared in layers or sandwiches to form a heap. Usually one layer or sandwich consists of the following ingredients:-

15 cm thick of sieved sawdust
2 kg of NPK (17:17:17)
2 kg of urea (46% N)
1.5 kg of rock phosphate
Reasonable amount of Ipil-Ipil (*Leucaena leucocephala*) leaves
Reasonable amount of water

Compost is always prepared in as short a time period as possible so that the whole process is uniform in all aspects. So, before preparing a compost heap, one has to ensure that all the necessary ingredients are available (Bowen & Chow 1984).

The daily temperature of the heap is taken using a thermometer. If the temperature of the lower portion of the heap is higher than the upper portion, it is because the micro-organisms are only carrying out their functions at the bottom of the heap which will not build up a good compost. However, this will not occur if all the necessary ingredients are prepared and available immediately before starting the preparation of the compost heap (Bowen & Chow 1984).

The heap of moist organic materials heats up as the micro-organisms feed and multiply, and the heat is kept in the heap by the insulating properties of the organic materials. Many species of micro-organisms, mostly bacteria and fungi, are involved in the decomposition of the organic materials. These micro-organisms will start doing the work of decomposition as soon as the moisture and oxygen concentrations are favourable. The most suitable temperature for the micro-organisms to stay in the heap is between 40°C and 50°C. They will die if the temperature is over 60°C (Anonymous 1978).

When the heap reaches a temperature of 50°C and above, it needs turning. The whole heap must be turned thoroughly in order to reduce the heat and to permit the micro-organisms to work more effectively. The best way to turn the compost heap is to throw it up to permit good aeration. Usually two men do the turning, one using a hoe to chop the heap vertically and the other using a scoop to throw the compost from one bin to another. Thus, always make sure that there are two compost bins for preparing compost (Bowen & Chow 1984). During turning and aeration, the interior temperature of the heap may drop 5°C to 10°C. However, studies with compost indicate that the pile returns to its initial temperature within a few hours (Poincelot 1972).

At each turning of the heap, a small quantity of the compost (sawdust) is taken and sent to the Seed Laboratory to test for moisture content. The moisture content of a compost heap is very important. If it is below 40%, the organic matter will not decompose rapidly. On the other hand, if it is over 60% moisture, the heap tends to become anaerobic, i.e. no oxygen. It is therefore best to have a moisture content of between 50% and 55% (Anonymous 1978). In practice, sawdust-based composts appear to work more satisfactorily at 55% to 60% moisture, and this is the figure used at the Forest Research Centre nursery (Bowen & Chow 1984). If the moisture content drops below 40%, then a reasonable amount of water is to be added to the heap. During the process of the first few turnings, it usually produces a strong odour of ammonia. This is due to the presence of urea. The odour will eventually become less. The compost heap should not be compacted during the turning or watering or measuring of temperature (Bowen & Chow 1984).

The whole heap is ready for use if there is no more odour of any kind and the temperature remains constant. This usually takes about three months. The standard potting mixture recommended for raising seedlings at the Forest Research Centre nursery is 7 parts of soil to 3 parts of sand to 2 parts of compost. Advantages of using compost in the potting mixture for raising seedlings are that it is more economical, and usually no fertilizers are needed for the seedlings at least for the first two to three months after pricking out into the polythene bags.

ACKNOWLEDGEMENTS

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Figure 1. A small quantity of the compost (sawdust) is taken and sent to the Seed Laboratory to test for moisture content before turning the compost heap.

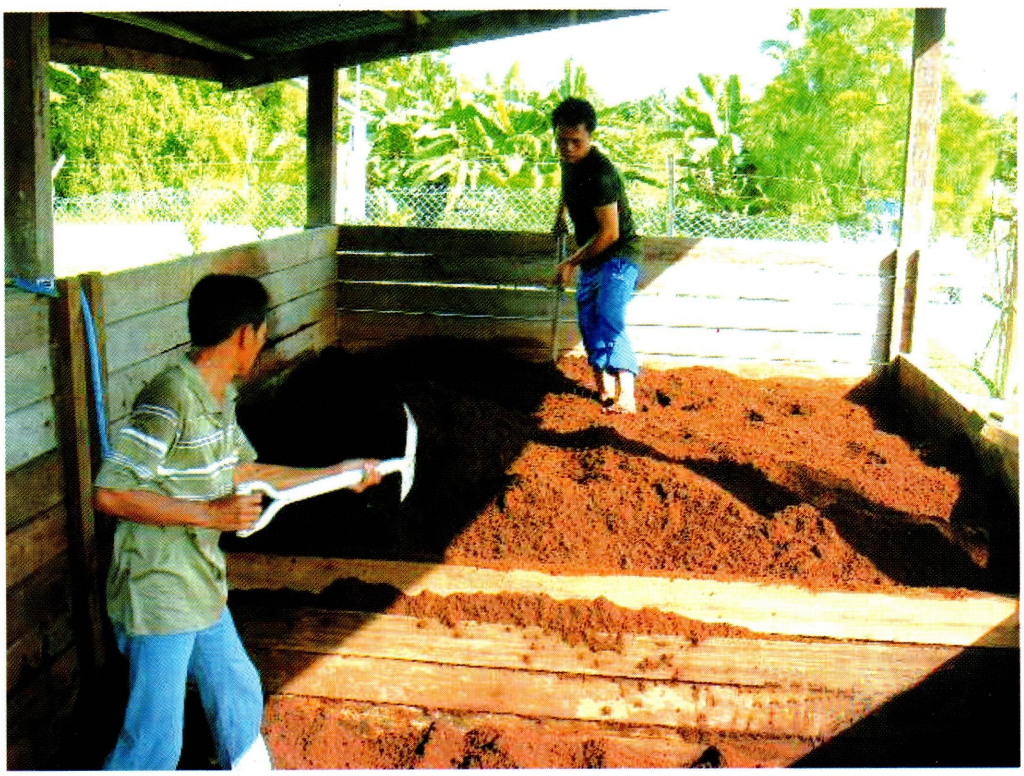

Figure 2. Process of turning the compost heap.

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Mass aggregation of *Lebeda intermedia* (Lepidoptera: Lasiocampidae) caterpillars on a Ketapang tree

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The Ketapang tree *Terminalia catappa*, which is also known as 'pokok payung', is often planted as an ornamental tree, providing deep shade with its large leaves. It belongs to the family Combretaceae and grows to 35 m tall, with an upright, symmetrical crown and horizontal branches. As the tree gets older, its crown becomes more flattened to form a spreading, vase shape. The tree is dry-season deciduous. Before falling, the leaves turn pinkish-reddish or yellow-brown, due to pigments, such as violaxanthin, lutein, and zeaxanthin. The leaves, as well as the bark, are traditionally used as medicine for various purposes because of their chemical properties.

Thousands of the hairy caterpillar *Lebeda intermedia* (Lepidoptera: Lasiocampidae) were found aggregating on a Ketapang tree in front of the Sepilok Forest Research Centre in early June, 2007 (Figure 1). The Ketapang is a new record as a host plant for *L. intermedia* (Robinson *et al.* 2001). The caterpillars were gathering in clusters of various sizes from the basal main trunk up to about 10 m high. According to Fitzgerald & Costa (1999), aggregation allows caterpillars to collectively defend themselves against the attacks of predators and parasitoids. Such defence could be passive or active. Passive modes of collective defence involve dilution effects since the probability that any one individual will be randomly singled out by a predator decreases with group size. Individuals also gain protection from predators by surrounding themselves with others. The aposematic appearance of the aggregated hairy caterpillars is also an effective way to frighten the intruders and predators.

Besides for defence purposes, some social caterpillars aggregate for collective and cooperative foraging (Anonymous 2007). Social caterpillars exhibit a few basic foraging patterns. Patch-restricted foragers obtain all of the food required during the social phase of their larval development from the leaves found in a single contiguous patch or from several closely-related patches, e.g. the spindle tree caterpillar, *Yponomeuta cagnagella* (Yponomeutidae) and the ugly nest caterpillar, *Archips cerasivoranus* (Tortricidae). Nomadic foragers establish only temporary resting sites and make frequent moves from one patch to another, e.g. the forest tent caterpillar *Malacosoma disstria* (Lasiocampidae) and the spiny elm caterpillar *Nymphalis antiopa* (Nymphalidae). Central-place foragers construct a permanent or semi-permanent shelter from which they launch intermittent forays to distant sites in search of food, e.g. other *Malacosoma* species. The most sophisticated form of cooperative foraging exhibited by caterpillars is recruitment communication in which caterpillars recruit siblings to their trails and to their food-finds by marking pathways with pheromones, e.g. the *Malacosoma* tent caterpillars.

The Ketapang tree was severely infested by *L. intermedia* caterpillars in early July. Interestingly, the complete defoliation was only confined to branches directly connected to the main trunk (Figure 2). The leaves of a few side stems of the same tree were not severely defoliated although occasionally some caterpillars were found within those patches. Adjacent Ketapang trees were also not seriously attacked. This indicates that the *L. intermedia* caterpillars are patch-restricted foragers.

Many social caterpillars are heliotherms, that is, they elevate their temperature by basking in the sun, and it is markedly enhanced by aggregation (Anonymous 2007). The thermal gains are also attributable to the trapping of the metabolic heat generated by the caterpillars as they process food. From the observation on *L. intermedia*, most of the caterpillars aggregated on the Ketapang trunk throughout the day, but during night time, there were movements of various clusters from time to time, to the canopy to feed on the leaves. Leaves consist largely of non-digestible components, and it has been suggested that nearly half of the energy which some caterpillars ingested is excreted as faecal pellets. This was observed from the large quantities of faecal pellets on the ground, and one could even hear and feel the rain of faecal pellets when standing under the Ketapang tree.

Some caterpillars, such as the social pierid *Eucheira socialis* and the lasiocampid tent caterpillars, aggregate to build communal shelters, exclusively from silk. The shelters are multifunctional, to facilitate basking and thermoregulation, moulting, and anti-predator defence. This behaviour, however, was not observed in *L. intermedia.*

A mature caterpillar of *L. intermedia* could measure up to 80 mm. It was black or dark brown in colour and was covered with long tufts of hairs, arranged in rows. When fully grown, the caterpillar sought protected areas on the ground or hidden areas between lower branches to pupate. The pupa was dark brown in colour and was encapsulated in a silky cocoon with debris. Many of the pupae were found at the basal trunk area hidden inside the lumps of faecal pellets. About three weeks later, the adult emerged. Like the caterpillar, the adult moth was also dull in colour, plain brown with two whitish bands and a black dot on the forewing. Other details are given by Holloway (1987). Despite the impressive size of the caterpillar, the adult was comparatively smaller. The female, with a body length up to 50 mm and a wingspan of 80 mm, was larger than the male which was only about 30 mm in length and 50 mm in wingspan (Figure 3). Both male and female appeared clumsy when flying. Shortly after emerging from the cocoon, the female moth secreted a pheromone which drew males to her (Figure 4). However, even without mating, the female could also produce and oviposit its eggs. Many clusters of *L. intermedia* eggs were found on the shrubs within the circumference of the Ketapang tree. The spherical eggs were whitish, about 1 mm in size, and would eventually turn brownish (Figure 5). Generally, the male moth might live for a week or more but the female died soon after laying her eggs.

After 10 days, tiny caterpillars of about 3 mm hatched and fed on the young and tender leaves of Ketapang (Figure 6), and the cycle might go on. However, there might not be another mass aggregation because the caterpillars might starve to death since the tree had been severely defoliated. Other factors that would reduce the caterpillar population were predators, parasitoids and diseases. As the tree was left with very few leaves, the caterpillars were easily detected by birds and other animals that fed on them. Various parasitic flies and wasps were seen hovering around the tree, as many had emerged from the previous batch of caterpillars. The dead caterpillars and the large quantities of faecal pellets attracted pathogen-carrying insects, such as flies that would eventually attack the caterpillars. The defoliated tree experienced no lasting damage after the caterpillar attack.

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Figure 1. Aggregation at the Ketapang trunk.

Figure 2. Defoliation of the Ketapang tree.

Figure 3. Male (bottom) and female moths of *L. intermedia*.

Figure 4. Mating in progress. Female on top.

Figure 5. A cluster of *L. intermedia* eggs.

Figure 6. Early instars of *L. intermedia*.

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Vegetative propagation of Bangkal Kuning

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Nauclea subdita (Korth.) Steud. or better known as Bangkal Kuning belongs to the Rubiaceae family. It is widely distributed in Malaysia and commonly found throughout the lowland forests, and occasionally up to hill forests. Bangkal Kuning is a secondary successional species that grows well along streams and rivers. To date, the utilization of Bangkal Kuning in Sabah is insignificant with a volume of extraction at only 2,632.91 m^3 recorded in 2006. However, it has a huge potential in veneer and plywood production (Anonymous 2008). In the Philippines, it is planted to stabilize river banks and slopes (Sosef *et al.* 1998). The species is also used for forest rehabilitation and restoration in the Kinabatangan Wildlife Sanctuary (Davison 2002).

Bangkal Kuning is reported to be easily propagated by seed and stem cuttings (Sosef *et al.* 1998). However, there is no detailed documentation or publication to verify this claim. The main objective of this experiment is to investigate rooting ability of Bangkal Kuning. The production capacity of cuttings from well-managed stockplants of the species was also observed.

The experiment was conducted from May 2004 to January 2007 in the nursery at Kolapis B, a research station located approximately 20 km from Beluran, Sandakan. Twenty potted seedlings of Bangkal Kuning were separated into 2 groups: labelled as Groups A and B. Single-node stem cuttings were taken basipetally from the above stockplants. The leaves were trimmed by two-thirds of the original size. Cuttings derived from Group A were applied with rooting hormone (Seradix 3) whereas no hormone was applied for those from Group B (referred here as Control). These cuttings were then inserted onto the rooting media of basically fine river sand in a non-mist propagation box (Plate 1). Data recorded from the weekly observation on the cuttings were sign of rooting, number and length of roots. The temperature and relative humidity (RH) within the propagation box were also recorded daily. Similar procedures were repeated 18 times which were regarded as cycles.

Stockplants (potted materials in Groups A and B) were maintained as other plants in the nursery. Fertilizer (NPK) was regularly applied to the stockplants throughout the study. New shoots were produced as early as 2 weeks after the harvest of shoots. New shoots were ready in an interval of 1 to 4 months, for the next cutting experiments. In total, there were 18 cycles of shoot harvest and hence the same number of cutting experiments conducted. Number of shoots was recorded at every cycle.

The results show that rooting in Bangkal Kuning began as early as 1 week and lasted for 3 to 12 weeks. There were significant differences in rooting percentage when cuttings were applied with rooting hormone (t test, $P < 0.05$) for all the cycles. Cuttings applied with rooting hormone had a mean rooting percentage of 89% whilst the Control had 80%. Overall, node 1 or the tip of shoot had better rooting ability (up to 94% success) compared to the other nodes. Similarly, the rooting hormone gave significant differences in the number of roots produced (t test, $P < 0.05$). However, the rooting hormone did not give significant differences in the length of roots (t test, $P > 0.05$) (Table 1).

Table 1. Mean number and length of roots in Bangkal Kuning, with and without rooting hormone.

Cycle	Mean no. of roots with Seradix	Mean no. of roots in Control	Mean length of roots with Seradix (cm)	Mean length of roots in Control (cm)
1	10.18	3.98	0.94	1.25
2	10.04	4.34	1.76	1.88
3	10.36	7.61	1.33	2.36
4	8.29	4.41	0.74	0.81
5	9.76	4.74	1.48	1.13
6	9.67	4.48	1.48	1.29
7	8.92	5.64	1.53	1.46
8	10.13	5.21	2.03	1.93
9	7.61	2.45	2.95	1.59
10	12.62	7.70	1.37	1.61
11	6.94	2.75	1.92	1.81
12	7.84	1.63	1.84	1.41
13	3.60	3.15	1.08	2.36
14	8.61	3.85	1.37	2.24
15	13.75	6.91	2.75	2.64
16	7.93	2.67	1.45	2.35
17	11.70	6.33	2.01	1.50
18	4.00	1.50	0.85	0.25

The length of roots in the Control was much longer particularly in Cycles 1, 2, 3, 4, 10, 13, 14 and 16. The temperature and relative humidity within the propagation box were 24-34°C and 40-72%, respectively.

It was observed that in the first 10 cycles (first 24 months), the shoot production interval ranged from 2 to 5 months. Shoot production interval in Cycles 11 to 18 was reduced to just 1 month. Figure 1 shows the number of shoots produced throughout the study.

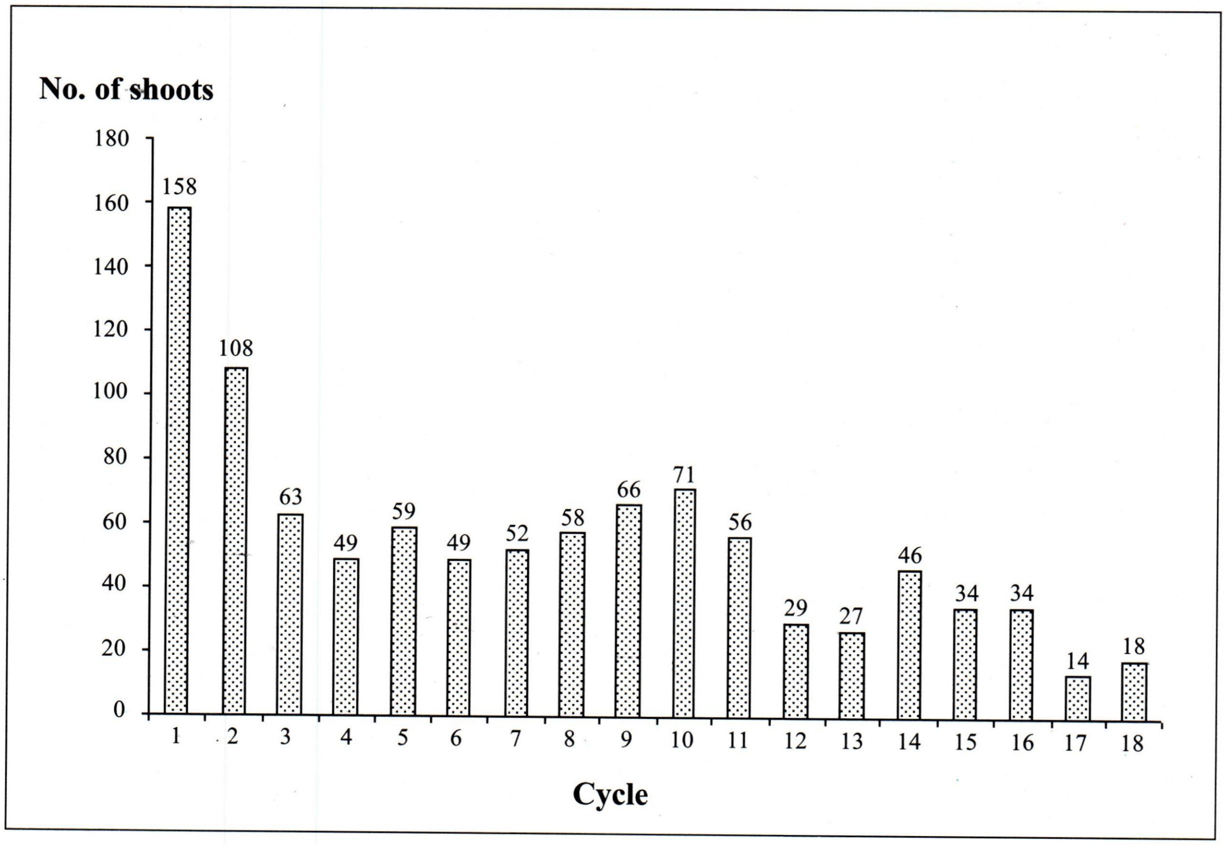

Figure 1. Shoot production of Bangkal Kuning (May 2004 to January 2007).

The overall results show feasibility in rooting of Bangkal Kuning, consistent with previous reports. Rooting hormone (Seradix 3) had significantly assisted the initiation of roots. It however did not facilitate the further development of the roots. It was also noted that the high rooting success (94%) could be obtained from cuttings taken from node 1. Apparently, there were no direct effects of climatic factors (the temperature and relative humidity) on rooting success. The temperature exceeded the range in the study by Leaky *et al.* (1982) and the relative humidity was way below the optimal humidity required in most species (80% and above).

The production capacity of the stockplants declined with time despite regular application of fertilizer. High doses of fertilizer are detrimental to both survival of stockplants and rooting of cuttings according to Aminah & Lokmal (2002), and they suggested an application of 1 g fertilizer per plant monthly. Sadly, the amount of fertilizer applied in this study was not set. However, based on the results, it is recommended that the stockplants of Bangkal Kuning are maintained and managed up to Cycle 10 (24 months) only.

ACKNOWLEDGEMENTS

The authors are indebted to Mr David Gubud and Mdm Rupinah Laining who helped in the preparation of cuttings, maintenance of the stockplants and collection of data throughout the study. This is a continuation of the IRPA (Intensification of Research Priority Areas) Project No. 01-04-05-0002 EA001.

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Plate 1. Non-mist propagation box.

Plate 2. Bangkal Kuning stockplants.

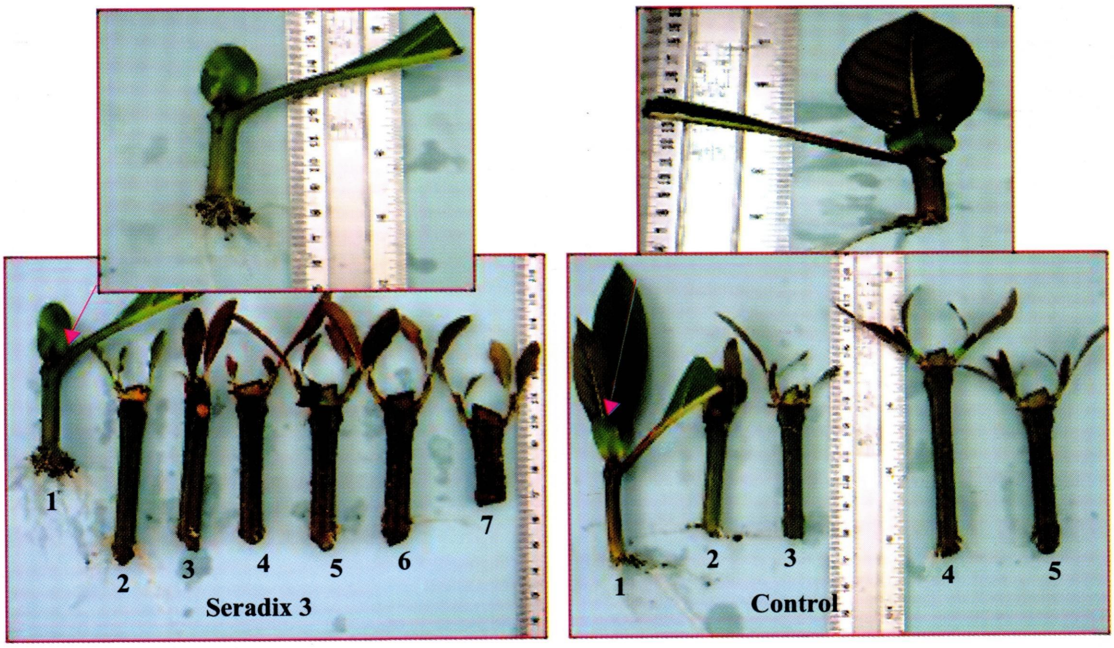

Plate 3. Four-week-old rooted cuttings (nodes 1-7).

Plate 4. Rooted cuttings derived from node 1.

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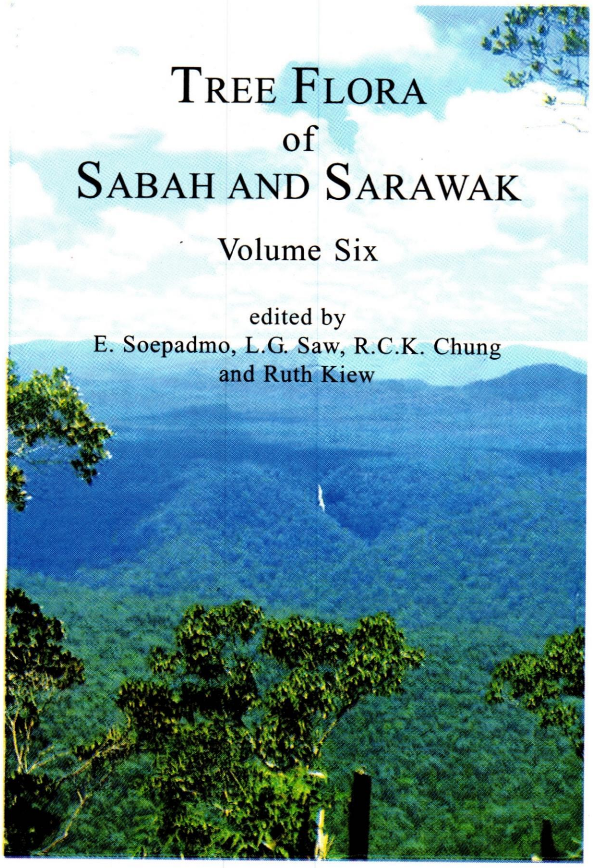
BOOK REVIEW



Tree flora of Sabah and Sarawak. Volume Six. Edited by E. Soepadmo, L.G. Saw, R.C.K. Chung & Ruth Kiew. Published by Forest Research Institute Malaysia, Sabah Forestry Department & Sarawak Forestry Department, 2007. Pp. 335. ISBN 978-983-2181-89-7.

Reviewed by M. Ajik

The Tree Flora of Sabah and Sarawak project was initiated in 1991 and its debut Volume 1 was published in 1995. Subsequently, much has been done to document and update the taxonomic status of all tree species native to Sabah and Sarawak.

This is the publication of Volume 6 covering 180 tree species (18 genera) from 4 families namely Cunoniaceae (R.C.K. Chung), Hernandiaceae (L.G. Saw), Meliaceae (David J. Mabberley and Caroline M. Pannell, with contributions by Jennifer M. Edmonds and Anne M. Sing) and Polygalaceae (W.J.J.O. de Wilde and Brigitta E.E. Duyfjes). As mentioned in the Foreword, 72 species are endemic to Sabah and Sarawak (or Borneo), 22 taxa (species, subspecies and varieties) are new to science (published elsewhere), 98 species can reach timber size (with a dbh of 30 cm or larger), and 10 species produce edible fruits (e.g. *Aglaia*, *Lansium* and *Sandoricum*). The publication is a thorough revision and update of the taxonomy of the 4 families.

The distribution, ecology and uses of each family are presented in the book. There is also a key to subfamilies/genera/species which is a useful tool to plant taxonomists. The scientific drawings of species are nicely done. Readers will also enjoy the colourful pictures of some selected species of the families Cunoniaceae, Meliaceae and Polygalaceae. Surprisingly there are no pictures representing the Hernandiaceae family.

Every botanist/taxonomist should have a copy of this publication. On the whole, Volume 6 of the Tree Flora of Sabah and Sarawak marks another milestone in achieving the overall objective of documenting the species richness of the trees of Sabah and Sarawak. However, it is sad to note that for all the volumes published thus far, none of the editors are based in Sabah or Sarawak.

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Front cover: The large, charismatic firefly, *Lychnuris opaca* (Photo: Chey Vun Khen)