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Front cover: *Nepenthes macrophylla,* on Mount Trus Madi (Photo: Julius Kulip)

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Plant diversity in Trus Madi

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Abstract. Trus Madi Range is located in the interior part of Sabah, Malaysia, and covers three districts, namely Tambunan, Keningau and Ranau. The flora of Trus Madi is very rich and unique. Its forest reserve is managed by the Sabah Forestry Department. Even though there were many botanical collections done in Trus Madi, there are very few published reports. Areas where most botanical surveys had been carried out in Trus Madi Range were mainly in FMU 10 (Tambunan and Keningau) and some in Ranau. There are two species of *Rafflesia* found in Trus Madi, namely *R. keithii* and *R. tengku-adlinii*. *Nepenthes* x *trusmadiensis*, an endemic pitcher plant named after Mount Trus Madi, is found on the top of the mountain. In the present inventory of 2004 in Trus Madi (FMU 10), 406 species in 105 families of plants were recorded within eight plots (100-900 m^2). The flora of Trus Madi is very significant to Sabah as it can attract both researchers and tourists.

Keywords: *Nepenthes*, plant diversity, *Rafflesia*, Trus Madi

INTRODUCTION

Trus Madi Forest Reserve is located in the interior part of Sabah, Malaysia (Figure 1) and the Trus Madi Range covers three districts, namely Tambunan to the west, Keningau to the south and Ranau to the north. Trus Madi Forest Reserve was gazetted in 1962 (75,692 ha). It was regazetted in 1984 and classified as a Class II Forest Reserve covering an area of 184,527 ha. Another regazettement was done in 1992 and the forest reserve today covers an area of 175,897 ha. It is managed by the Sabah Forestry Department.

The highest mountain within the range is Mount Trus Madi (Plate 1). It is located in the middle of Trus Madi Range (5°35'N, 116°30'E) and is also the second highest mountain in Malaysia (2,642 m a.s.l.). There are several high peaks above 2,000 m, extending from southwest to northeast, and ridges generally ranging from 15 to 30°, on both sides. Slopes become steeper closer to the peaks and the upper parts of streams are deeply incised. This string of peaks seems to be a popular and challenging trekking route for hikers and such a course is not available elsewhere, even in Kinabalu Park.

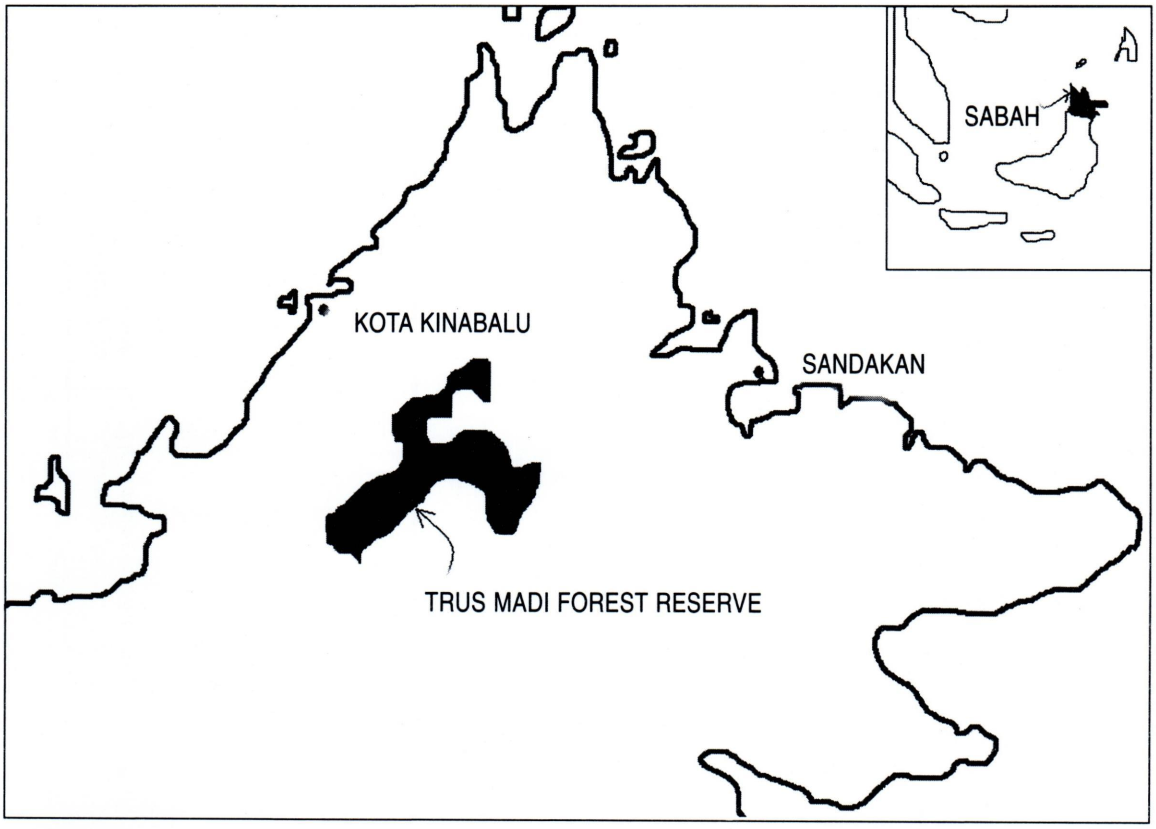

Figure 1. Location of Trus Madi Forest Reserve in Sabah, Malaysia.

The flora of Trus Madi is much less known than that of Mount Kinabalu. Even though there were many plant-collecting activities going on since 1961, there are very few published reports on the flora other than studies on the vegetation by Kitayama *et al.* (1993), on the changes in forest structures by Adam (2001), and recent studies on specific plants by Gobilik & Mashitah (2005) and Kulip (2005a, 2005b). Areas where most surveys were carried out were in FMU 10 (Tambunan and Keningau) and some in Ranau. With rolling mountain ranges above undulating lowland terrain, the original vegetation is mostly lowland and montane rain forests. There are great variations in vegetation with elevation and aspect. The lower slopes represent a transition zone where dipterocarp species mix freely with hill non-dipterocarp species. This gradually gives way to lower montane forest vegetation between 1,500 and 2,000 m a.s.l., which is dominated by tree species belonging to families of Fagaceae and Lauraceae. The height of the canopy decreases with elevation from 30 m at 2,000 m a.s.l. to about 5 m at 2,600 m a.s.l. This trend is accompanied by an increase in the abundance of moss flora. Apart from Myrtaceae, the summit vegetation is dominated by small, leathery-leafed shrubs such as from the families of Ericaceae, Theaceae, Podocarpaceae.

HISTORY OF BOTANICAL EXPLORATIONS

Botanical explorations and collections started in 1961. The chronology of events is as follows:

1961: Mrs Collenette, Betty Wade.
1962: George Mikil (Sabah Forestry Department).
1963: Dr W. Meijer (Sabah Forestry Department).
1964: J.B. Comber (Sapong Estate).
1987: Dr Kamarudin Mat Salleh (Universiti Kebangsaan Malaysia, Bangi).
1992: Julius Kulip (Sabah Forestry Department), Dr K. Kitayama, and Dr Jamili Nais (Sabah Parks). Vegetation survey.
1996: John Baptist Sugau (Sabah Forestry Department).
1998: Dr Jumaat H. Adam (Universiti Kebangsaan Malaysia, Bangi). Study on the changes in forest structures.
2001: Sabah Forestry Department and Universiti Malaysia Sabah. Scientific expedition.
2004: Julius Kulip (Sabah Forestry Department). Flora inventory.

Most of the botanical collections made were around the summit, eastern and northern parts. Vegetation survey was first done by Kitayama *et al.* (1993).

VEGETATION

There are five types of vegetation in Trus Madi, three of the upper zones were surveyed by Kitayama *et al.* (1993):

Lowland mixed dipterocarp forest (altitude 427-600 m)

Dominant large trees are the dipterocarps with 17 species. 13 species are from the genus *Shorea*.

Upland/Hill mixed dipterocarp forest (600-1,500 m)

Dipterocarps dominate the crown layers with 17 species mostly from the genus *Shorea*. Understorey plants dominated by Rubiaceae with 16 species. Other preponderant species include those from the families of Annonaceae, Leguminosae and Moraceae.

Lower montane forest (1,500-1,850/2,000 m)

The canopy and subcanopy layers below 1,700 m comprise mostly several species from the families of Myrtaceae (especially *Syzygium* spp.) and

Lauraceae (especially *Litsea* spp.). Above this altitude *Dacrycarpus imbricatus, Phyllocladus hypophyllus, Syzygium* spp. and *Schima wallichii* predominate. About seven species of dipterocarps, nine species of Rubiaceae, six species of Elaeocarpaceae and Moraceae are found here. Ericaceae is abundant from 2,000 m up to the summit, with about ten species recorded.

Rafflesia flowers are found in this area. Previous records are as follows: -

Rafflesiaceae

Rafflesia tengku-adlinii
Found in Keningau/Sook side of Trus Madi.
R. keithii (Plate 2)
Buds were found by Tambunan district forest staff.
Big host was found near Sg. Kidukaruk area in 1992 by J. Kulip.
Big bud was found by Kg. Kaingaran villagers (Supin, pers. comm. 2001). Julius Peter Indu and Tambunan district forest team found bud and open flower and reported by Kulip (2005a).

Upper montane forest (1,850/2,000-2,500 m)

The dominant canopy trees in this area are from the families Myrtaceae and Fagaceae. Herbs such as pitcher plants *Nepenthes* spp. are common in this area. The species of *Nepenthes* recorded are *Nepenthes lowii* (abundant), *N. tentaculata* and *N. macrophylla* (Plate 3). *N. macrophylla* (= *N. edwardsiana* ssp. *macrophylla*) is a montane species restricted to the upper slopes of Mount Trus Madi. It is probably the most threatened *Nepenthes* species in Sabah (Clarke 2001).

Summit scrub (2,500-2,640 m)

The plants are generally lower than 5 m in canopy height, in many places lower than 3 m. The dominant family is Myrtaceae. This zone is the habitat of the endemic naturally occurring pitcher plant *Nepenthes* x *trusmadiensis* (Plate 4) which is one of the best-known hybrids. It is derived from the cross of *N. macrophylla* and *N. lowii*. Abundant previously but becoming rare due to over-collection. At least six species of *Rhododendron* grow here.

Vegetation distribution

The zonal vegetation distribution of Trus Madi Forest Reserve (FMU 10: Tambunan and Keningau districts) is shown in Figure 2.

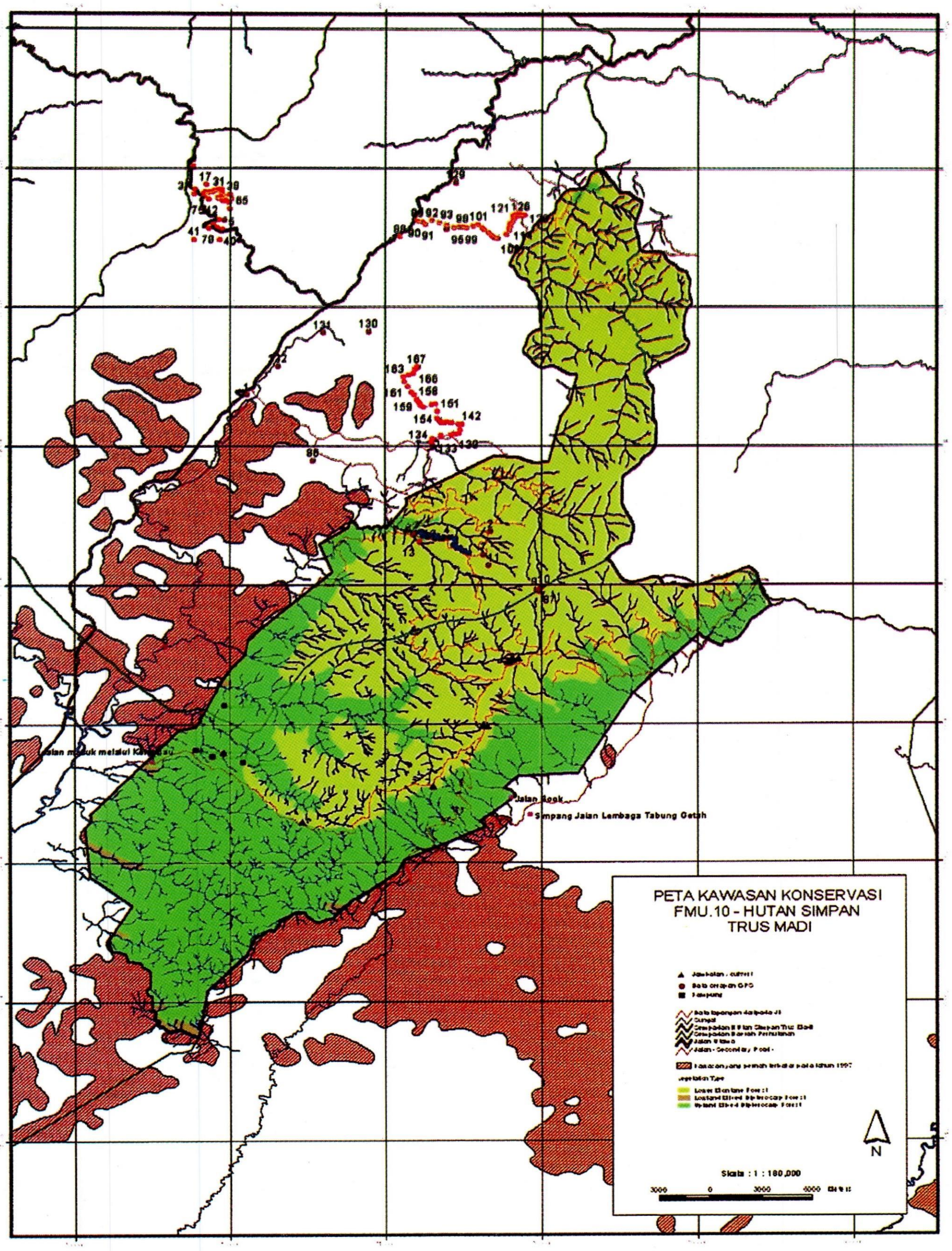

Figure 2. Zonal vegetation distribution in Trus Madi (FMU 10).
Key to vegetation zoning:
Dark green = Lowland mixed dipterocarp forest
Light green = Lower montane forest
Red = Burnt area (extensive)

FLORA INVENTORY 2004

Flora inventory was conducted in both districts of Tambunan and Keningau in 2004. It started from the lowest point at 500 m a.s.l. which is situated in Keningau district, to the highest point of Mount Trus Madi at 2,642 m a.s.l. Eight temporary plots were established in the various habitats represented in Trus Madi (FMU 10) as shown in Table 1.

Table 1. Temporary plots in Trus Madi Forest Reserve (FMU 10).

PLOT NO.	HABITAT	CONDITION	ALTITUDE (m a.s.l.)	PLOT SIZE (m^2)
1	Lowland mixed dipterocarp forest (LMDF)	Disturbed. Previously burnt for shifting cultivation	500	30 x 30
2	Lowland mixed dipterocarp forest (LMDF)	Disturbed. Previously logged over	500	30 x 30
3	Lowland mixed dipterocarp forest (LMDF)	Undisturbed	600	30 x 30
4	Transition forest from LMDF to highland mixed dipterocarp forest	Undisturbed	900	20 x 20
5	Highland mixed dipterocarp forest	Undisturbed	1,200	20 x 20
6	Lower montane forest	Undisturbed	1,600	20 x 20
7	Upper montane forest	Undisturbed	2,100	15 x 15
8	Summit scrub	Undisturbed	2,640	10 x 10

RESULTS OF THE INVENTORY

The full list of plants recorded during the inventory is shown in Appendix 1. The list has 406 species in 105 families of plants recorded within the eight plots.

Summary of habitats

Figure 3 shows the summary of vegetation zones along the transect between 500 and 2,642 m a.s.l. on the west slope of Trus Madi Forest Reserve (FMU 10).

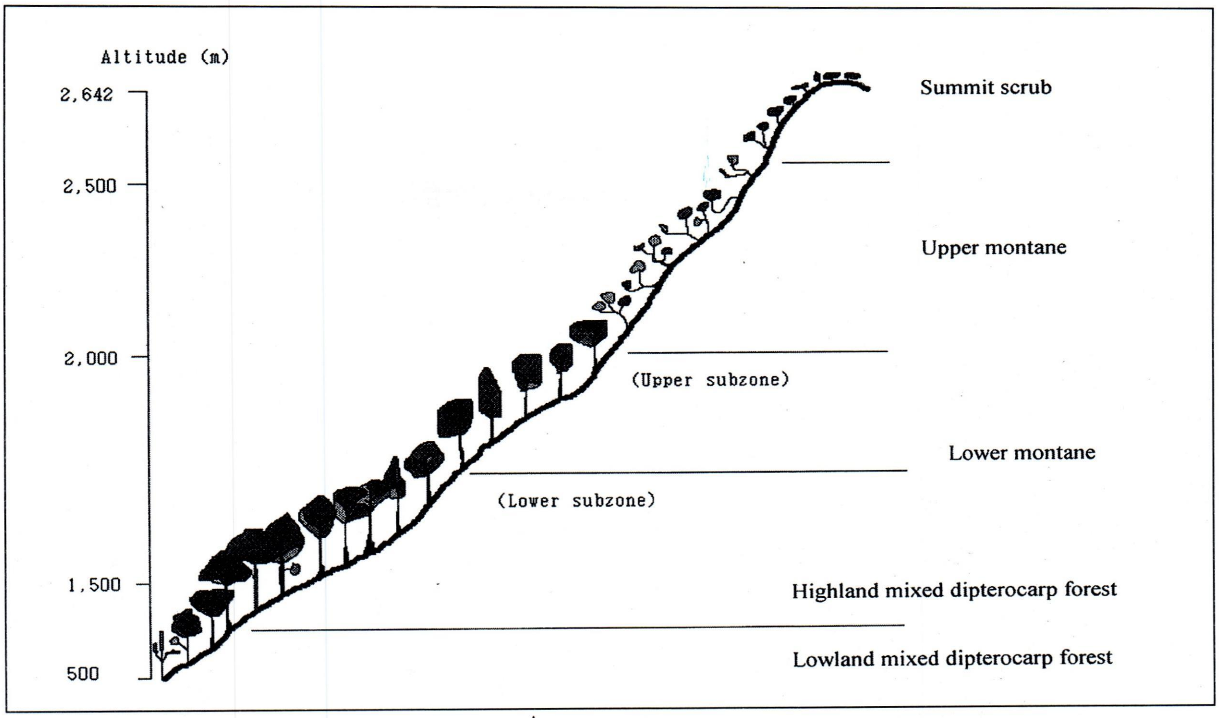

Figure 3. Summary of the vegetation zones in Trus Madi (not to scale).

Main groups of plants

There were 221 species in 57 families of plants collected previously by the Sabah Forestry Department staff (SAN Herbarium) in Trus Madi Forest Reserve. In the 2004 flora inventory, there were 406 species in 105 families of plants recorded in Trus Madi (FMU 10). Altogether, there are about 600 species in over 160 families of plants found in Trus Madi Forest Reserve so far. The most dominant families are Euphorbiaceae with at least 43 species, Rubiaceae with at least 31 species and Lauraceae with at least 23 species.

The Trus Madi Forest Reserve contains at least 17 dipterocarp species. Dipterocarp forest is found mostly at lower altitudes. There are 25 species of Zingiberaceae (Gobilik & Mashitah 2005) and at least 5 species of conifers. At least 19 species of fungi have been recorded along the trail to summit. There is one *Balanophora* sp. found at the elevation of 900 m a.s.l. The orchids are especially diverse and accessible along the trail to the summit. It was noted that the flowering period of orchids here was in

November-December. A rare *Cryptostylis arachnites* (Plate 5) was found along the trail to the summit.

Flowering rhododendrons are always seen along the trail to the summit, the commonest being *Rhododendron cuneifolium* (Plate 6) and *R. fallacinum*. At least 10 species of them are found here. *Nepenthes* can be seen from the elevation of 1,600 m a.s.l. About four species, one hybrid and one subspecies can be found here.

Special plant communities

The most exciting plant community on Trus Madi is the scrub community on the summit. It is very well developed and the area is like a garden full of flowers in bloom, e.g. *Rhododendron*, *Leptospermum* (Plate 7).

Useful plants

The utilization of trees as timber is significant in Trus Madi. Apart from timber species, there are species noteworthy for their potential usefulness such as medicinal plants. The study by Kulip *et al.* (2005) showed that there are 94 species in 40 families of plants used in traditional medicine by villagers in Kg. Kaingaran near the foot of Mount Trus Madi. A survey on the altitudinal distribution of useful plants in this area by Kulip (2005b) showed that at the altitude of about 680 m a.s.l., the highest number of useful plants (111 species with many medicinal plants) is found. Plate 8 shows *Uncaria* sp., an example of medicinal plant.

Plant species of ornamental value including ferns, *Nepenthes* spp., *Ixora* spp., *Begonia* spp. and orchids are important in horticulture in Malaysia. Wild fruit trees (*Mangifera foetida, Durio acutifolius, Canarium* spp.) and wild vegetables (*Schismatoglottis* spp.) can yield potential agricultural products. The wild populations here may be used for breeding programmes in the future.

Endemic and threatened species

Rafflesia keithii and *R. tengku-adlinii* are the two *Rafflesia* flowers found here in Trus Madi. *R. tengku-adlinii* is a very rare species which occurs only in Trus Madi and Maliau Basin, while *R. keithii* is the largest *Rafflesia* flower in Borneo. Valuable species such as *Aquilaria malaccensis* or Gaharu is also found. *Nepenthes* x *trusmadiensis*, a very rare natural hybrid between *N. macrophylla* and *N. lowii* with very large pitchers, is found only on the summit of Mount Trus Madi. It was discovered by Marabini and Briggs in 1984. The area also supports many wild orchids and fungi.

The presence of rare and endemic plants such as *Rafflesia tengku-adlinii, R. keithii* and *Nepenthes* x *trusmadiensis* suggests that this mountain is of high conservation value. Slippers orchids or *Paphiopedilum* spp. have been found in the area by local villagers.

CONCLUSION

In conclusion, the Trus Madi flora is very unique and interesting but very few reports have been published and there are many species yet to be discovered. At present there are about 600 species in over 160 families of plants known in Trus Madi. More intensive botanical explorations can be conducted to yield further information on this unique mountain.

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Plate 1. Mount Trus Madi as seen from west.

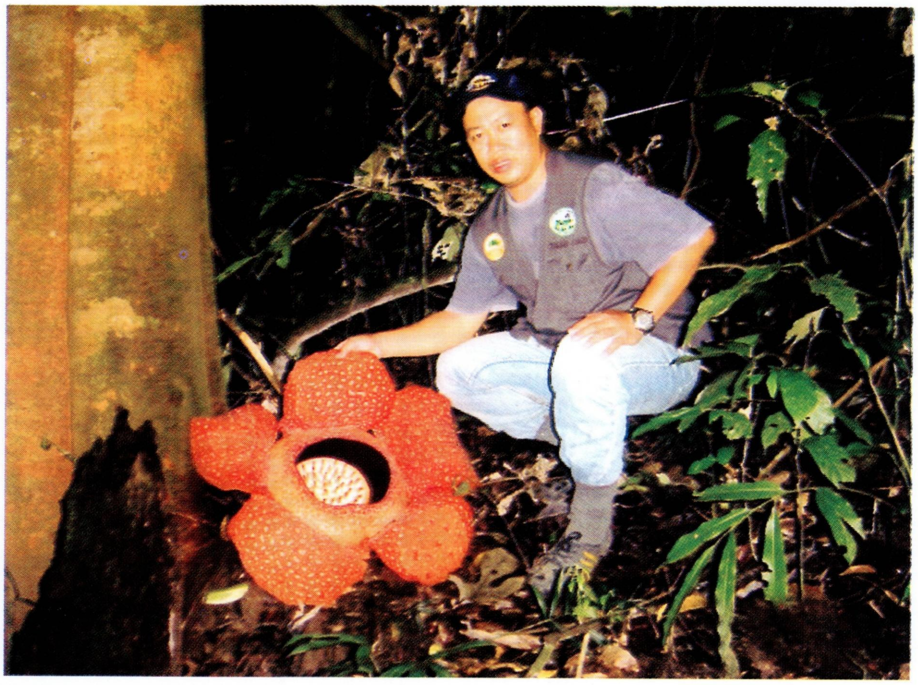

Plate 2. Author with *Rafflesia keithii* found at 900 m a.s.l.
(Photo: Luis Angkabong)

Plate 3. *Nepenthes macrophylla.*

Plate 4. *Nepenthes* x *trusmadiensis.*

Plate 5. *Cryptostylis arachnites,* a medium-sized terrestrial orchid.

Plate 6. *Rhododendron cuneifolium,* the common rhododendron along the trail to the summit.

Plate 7. Scrub vegetation on the summit of Trus Madi.

Plate 8. *Uncaria* sp., an example of medicinal plant.

Appendix 1. List of plants recorded within plots in the botanical inventory of Trus Madi Forest Reserve (FMU 10) in 2004.

Note:
1a = Lowland mixed dipterocarp forest LMDF (opened for cultivation)
1b = Lowland mixed dipterocarp forest LMDF (disturbed by logging)
1c = Lowland mixed dipterocarp forest LMDF (undisturbed)
2 = Transition forest from LMDF to highland/upland mixed dipterocarp forest (undisturbed)
3 = Highland/Upland mixed dipterocarp forest (undisturbed)
4 = Lower montane forest (undisturbed)
5 = Upper montane forest (undisturbed)
6 = Summit scrub (undisturbed)

FAMILY	SPECIES	HABITAT
ADIANTACEAE	*Acrostichum aureum*	2
ADIANTACEAE	*Acrostichum* sp.	2,3
ADIANTACEAE	*Adiantum* sp.	4,5
ANACARDIACEAE	*Dracontomelon dao*	1c
ANACARDIACEAE	*Gluta wallichii*	1b
ANACARDIACEAE	*Koordersiodendron pinnatum*	2
ANACARDIACEAE	*Pegia sarmentosa*	4
ANACARDIACEAE	*Pentaspadon motleyi*	2
ANACARDIACEAE	*Semecarpus* sp.	2
ANACARDIACEAE	*Swintonia* sp.	1a
ANISOPHYLLEACEAE	*Anisophyllea disticha*	2,3
ANNONACEAE	*Artabotrys roseus*	2
ANNONACEAE	*Desmos chinensis*	1a,1b,2
ANNONACEAE	*Fissistigma fulgens*	3
ANNONACEAE	*Fissistigma* sp.	1b,2,3,4,5
ANNONACEAE	*Mezzettia leptopoda*	2
ANNONACEAE	*Mitrephora korthalsiana*	2
ANNONACEAE	*Monocarpia marginalis*	1b,2,3
ANNONACEAE	*Orophea myriantha*	1c
ANNONACEAE	*Polyalthia cauliflora*	1a,2,3
ANNONACEAE	*Polyalthia insignis*	1a
ANNONACEAE	*Polyalthia microtus*	1c,2,3
ANNONACEAE	*Polyalthia sumatrana*	1a
ANNONACEAE	*Polyalthia xanthopetala*	1c
ANNONACEAE	*Polyalthia* sp.	2
ANNONACEAE	*Popowia pisocarpa*	1a,1b,1c,2,3
ANNONACEAE	*Uvaria borneensis*	3
ANNONACEAE	*Uvaria* sp.	2,4
ANNONACEAE	*Xylopia ferruginea*	2,4

FAMILY	SPECIES	HABITAT
APOCYNACEAE	*Alstonia angustiloba*	1b
APOCYNACEAE	*Alyxia* sp.	1c,5
APOCYNACEAE	*Chilocarpus beccarianus*	3
APOCYNACEAE	*Chilocarpus* sp.	4
APOCYNACEAE	*Kopsia* sp.	1b,1c,2
APOCYNACEAE	*Leuconotis anceps*	4,5
APOCYNACEAE	*Leuconotis* sp.	4
APOCYNACEAE	*Parameria* sp.	1b
APOCYNACEAE	*Urnularia* sp.	5
AQUIFOLIACEAE	*Ilex* sp.	4
ARACEAE	*Alocasia* sp.	2,4
ARACEAE	*Philodendron* sp.	4
ARACEAE	*Scindapsus* sp.	1b,2,3,5
ARALIACEAE	*Schefflera elliptica*	4,5
ARALIACEAE	*Schefflera* sp.	1b,4,6
ARISTOLOCHIACEAE	*Aristolochia* sp.	1b,2,3
ASCLEPIADACEAE	*Dischidia* sp.	4
ASCLEPIADACEAE	*Hoya* sp.	2,3,5
ASPLENIACEAE	*Asplenium nidus*	1a,2,3,5
ASPLENIACEAE	*Asplenium* sp.	4
ASPLENIACEAE	*Diplazium* sp.	1b
ASPLENIACEAE	*Tectaria* sp.	1b,5
BEGONIACEAE	*Begonia* sp.	2,3
BLECHNACEAE	*Blechnum orientale*	5
BLECHNACEAE	*Blechnum* sp.	4
BLECHNACEAE	*Blechnum* sp.	5,6
BOMBACACEAE	*Durio acutifolius*	2,3
BURSERACEAE	*Canarium denticulatum*	1b,1c
BURSERACEAE	*Canarium megalanthum*	1c
BURSERACEAE	*Dacryodes rugosa*	1a,1b,2,3,4
BURSERACEAE	*Santiria laevigata*	1c,2
BURSERACEAE	*Santiria tomentosa*	4
BURSERACEAE	*Santiria* sp.	1b
CAPPARIDACEAE	*Capparis floribunda*	4
CECROPIACEAE	*Poikilospermum suaveolens*	1b,3
CHLORANTHACEAE	*Chloranthus erectus*	1b
COMPOSITAE	*Eupatorium odoratum*	2
COMPOSITAE	*Vernonia arborea*	1c,2
CONNARACEAE	*Agelaea* sp.	1b,2
CONNARACEAE	*Connarus* sp.	3
CONVOLVULACEAE	*Erycibe borneensis*	2
CONVOLVULACEAE	*Erycibe* sp.	2
CONVOLVULACEAE	*Ipomoea littoralis*	3
CONVOLVULACEAE	*Merremia borneensis*	1b,2,3

FAMILY	SPECIES	HABITAT
CORNACEAE	*Mastixia* sp.	1b
CORNACEAE	*Mastixia* sp.	4
COSTACEAE	*Costus speciosus*	2,4
COSTACEAE	*Costus* sp.	1c
CUCURBITACEAE	*Benincasa hispida*	4
CUCURBITACEAE	*Gynostemma* sp.	3,4
CUCURBITACEAE	*Trichosanthes beccarii*	2,3
CYATHEACEAE	*Cyathea* sp.	1c
CYPERACEAE	*Carex* sp.	1b,2,3,4,5,6
CYPERACEAE	*Cyperus* sp.	2,4,6
DAVALLIACEAE	*Davallia* sp.	1b,2,4,5
DICHAPETALACEAE	*Dichapetalum gelonioides*	1b
DICHAPETALACEAE	*Dichapetalum* sp.	3
DILLENIACEAE	*Dillenia borneensis*	1b,1c
DILLENIACEAE	*Tetracera scandens*	1b
DIOSCOREACEAE	*Dioscorea* sp.	2
DIPTERIDACEAE	*Dipteris conjugata*	5
DIPTERIDACEAE	*Dipteris* sp.	1b
DIPTEROCARPACEAE	*Shorea acuminatissima*	3
DIPTEROCARPACEAE	*Shorea gibbosa*	2,3
EBENACEAE	*Diospyros macrophylla*	3
ELAEOCARPACEAE	*Elaeocarpus stipularis*	4
ELAEOCARPACEAE	*Elaeocarpus* sp.	1c,4,5,6
ERICACEAE	*Diplycosia* sp.	4
ERICACEAE	*Rhododendron* sp.	5,6
ERICACEAE	*Vaccinium* sp.	2,4,5,6
EUPHORBIACEAE	*Antidesma neurocarpum*	1b,1c,2,3
EUPHORBIACEAE	*Antidesma* sp.	2
EUPHORBIACEAE	*Aporusa confusa*	3
EUPHORBIACEAE	*Aporusa elmeri*	2,3
EUPHORBIACEAE	*Aporusa nitida*	1a,1c,2,3
EUPHORBIACEAE	*Aporusa* sp.	3
EUPHORBIACEAE	*Baccaurea angulata*	5
EUPHORBIACEAE	*Baccaurea lanceolata*	1c
EUPHORBIACEAE	*Baccaurea tetrandra*	1b,1c,2
EUPHORBIACEAE	*Baccaurea* sp.	1b
EUPHORBIACEAE	*Baccaurea* sp.	3,4
EUPHORBIACEAE	*Blumeodendron tokbrai*	1c
EUPHORBIACEAE	*Cleistanthus* sp.	3
EUPHORBIACEAE	*Drypetes kikir*	1c,2,3,4
EUPHORBIACEAE	*Drypetes* sp.	1a,3,4
EUPHORBIACEAE	*Drypetes* sp.	1b
EUPHORBIACEAE	*Glochidion rubrum*	1b,2,3,4
EUPHORBIACEAE	*Glochidion* sp.	1a,2,3

FAMILY	SPECIES	HABITAT
EUPHORBIACEAE	*Macaranga beccariana*	1c,2
EUPHORBIACEAE	*Macaranga costulata*	1c
EUPHORBIACEAE	*Macaranga gigantea*	1c
EUPHORBIACEAE	*Macaranga gigantifolia*	3
EUPHORBIACEAE	*Macaranga hosei*	1b
EUPHORBIACEAE	*Macaranga tanarius*	1b,2
EUPHORBIACEAE	*Macaranga triloba*	1b,1c,2
EUPHORBIACEAE	*Macaranga* sp.	1b,2,3,4
EUPHORBIACEAE	*Mallotus floribundus*	1c
EUPHORBIACEAE	*Mallotus korthalsii*	3
EUPHORBIACEAE	*Mallotus lackeyi*	1b
EUPHORBIACEAE	*Mallotus mollissimus*	1b,1c,2
EUPHORBIACEAE	*Mallotus paniculatus*	1b
EUPHORBIACEAE	*Mallotus penangensis*	1c,2,3
EUPHORBIACEAE	*Mallotus philippensis*	2
EUPHORBIACEAE	*Mallotus stipularis*	2
EUPHORBIACEAE	*Mallotus wrayi*	1a,2
EUPHORBIACEAE	*Mallotus* sp.	3
EUPHORBIACEAE	*Neoscortechinia forbesii*	1b,1c
EUPHORBIACEAE	*Omphalea* sp.	1b,3,5
EUPHORBIACEAE	*Phyllanthus nirruri*	4
EUPHORBIACEAE	*Sauropus* sp.	1c
FAGACEAE	*Castanopsis* sp.	1c,4,5
FAGACEAE	*Lithocarpus gracilis*	1c,4,5
FAGACEAE	*Lithocarpus leptogyne*	3
FAGACEAE	*Lithocarpus* sp.	1b,3,4,5
FAGACEAE	*Quercus* sp.	2
FAGACEAE	*Trigonobalanus verticillata*	5
FLACOURTIACEAE	*Flacourtia rukam*	1a,1b,2,3,4
FLACOURTIACEAE	*Hydnocarpus borneensis*	2,3
FLACOURTIACEAE	*Hydnocarpus gracilis*	3
FLACOURTIACEAE	*Hydnocarpus woodii*	1b,1c,2
FLACOURTIACEAE	*Hydnocarpus* sp.	2
FLACOURTIACEAE	*Ryparosa hulletti*	3
FLACOURTIACEAE	*Ryparosa* sp.	3
GESNERIACEAE	*Aeschynanthus* sp.	1b,3,5,6
GESNERIACEAE	*Cyrtandra angularis*	3
GESNERIACEAE	*Cyrtandra* sp.	1b,1c,2,4,6
GESNERIACEAE	*Didymocarpus* sp.	3,4
GESNERIACEAE	*Paraboea* sp.	4
GLEICHENIACEAE	*Dicranopteris linearis*	1b,2,4
GLEICHENIACEAE	*Gleichenia* sp.	1a
GLEICHENIACEAE	*Sticherus hirtus*	5
GNETACEAE	*Gnetum* sp.	3,4

FAMILY	SPECIES	HABITAT
GRAMINEAE	*Axonopus compressus*	1a
GRAMINEAE	*Dinochloa* sp.	2,4
GRAMINEAE	*Imperata cylindrica*	1a
GRAMINEAE	*Paspalum conjugatum*	2
GROSSULARIACEAE	*Polyosma integrifolia*	3,5
GROSSULARIACEAE	*Polyosma* sp.	4,5,6
GUTTIFERAE	*Calophyllum* sp.	2,3,4
GUTTIFERAE	*Garcinia parvifolia*	2
GUTTIFERAE	*Garcinia* sp.	1c,4
HYPERICACEAE	*Cratoxylum arborescens*	1b,1c
HYPERICACEAE	*Cratoxylum* sp.	1b,4
HYPOXIDACEAE	*Curculigo latifolia*	1b,2,3,4,5
ICACINACEAE	*Stemonurus scorpioides*	1c
LAURACEAE	*Actinodaphne glomerata*	2
LAURACEAE	*Alseodaphne bancana*	2
LAURACEAE	*Alseodaphne* sp.	2
LAURACEAE	*Beilschmiedia micrantha*	3
LAURACEAE	*Beilschmiedia* sp.	1c,3
LAURACEAE	*Cinnamomum griffithii*	1c,3
LAURACEAE	*Cinnamomum* sp.	2
LAURACEAE	*Cryptocarya crassinervia*	1a
LAURACEAE	*Cryptocarya kurzii*	2,3,4
LAURACEAE	*Cryptocarya* sp.	3
LAURACEAE	*Dehaasia caesia*	1c,3,4
LAURACEAE	*Dehaasia incrassata*	1b,1c
LAURACEAE	*Litsea cauliflora*	3
LAURACEAE	*Litsea elliptica*	3
LAURACEAE	*Litsea firma*	1a,1c,3
LAURACEAE	*Litsea fulva*	1a,3
LAURACEAE	*Litsea garciae*	1a
LAURACEAE	*Litsea ochracea*	1c,2
LAURACEAE	*Litsea odorifera*	1b
LAURACEAE	*Litsea* sp.	2,3,4,6
LAURACEAE	*Neolitsea* sp.	2,3,4
LAURACEAE	*Phoebe macrophylla*	1b,1c,2
LECYTHIDACEAE	*Barringtonia macrostachya*	1c
LECYTHIDACEAE	*Barringtonia sarcostachys*	2
LECYTHIDACEAE	*Planchonia valida*	2
LEEACEAE	*Leea aculeata*	4
LEEACEAE	*Leea indica*	1b,1c,2
LEGUMINOSAE	*Albizia* sp.	2
LEGUMINOSAE	*Archidendron* sp.	1a,2
LEGUMINOSAE	*Bauhinia* sp.	1a,1b,2,4
LEGUMINOSAE	*Callerya* sp.	2

FAMILY	SPECIES	HABITAT
LEGUMINOSAE	*Derris* sp.	1b
LEGUMINOSAE	*Desmodium* sp.	2,3,4
LEGUMINOSAE	*Fordia splendidissima*	1a,1c,3
LEGUMINOSAE	*Saraca declinata*	1c,2
LEGUMINOSAE	*Spatholobus* cf. *gyrocarpus*	3
LEGUMINOSAE	*Spatholobus* sp.	1b,2,4
LINACEAE	*Indorouchera griffithianum*	1c
LINACEAE	*Reinwardtia* sp.	3
LOGANIACEAE	*Fagraea* sp.	1a,4
LORANTHACEAE	*Loranthus* sp.	3
LORANTHACEAE	*Macrosolen* sp.	5
LYCOPODIACEAE	*Lycopodium cernuum*	5
LYCOPODIACEAE	*Lycopodium* sp.	3
MAGNOLIACEAE	*Magnolia candollii*	1c,3
MAGNOLIACEAE	*Magnolia* sp.	1a,2
MARANTACEAE	*Donax* sp.	1c,3
MARATTIACEAE	*Angiopteris* sp.	1b
MELASTOMATACEAE	*Anerincleistus* sp.	3,6
MELASTOMATACEAE	*Catanthera* sp.	4
MELASTOMATACEAE	*Creaghiella* sp.	1c
MELASTOMATACEAE	*Diplectria divaricata*	3
MELASTOMATACEAE	*Diplectria* sp.	4
MELASTOMATACEAE	*Dissochaeta* sp.	1c,2,4,5
MELASTOMATACEAE	*Macrolenes* sp.	4
MELASTOMATACEAE	*Medinilla crassifolia*	4
MELASTOMATACEAE	*Medinilla* sp.	1b,3
MELASTOMATACEAE	*Melastoma malabathricum*	1a,2,3
MELASTOMATACEAE	*Melastoma* sp.	4,6
MELASTOMATACEAE	*Memecylon laevigatum*	1b,2
MELASTOMATACEAE	*Memecylon* sp.	2,3
MELIACEAE	*Aglaia affinis*	2,3
MELIACEAE	*Aglaia elliptica*	4
MELIACEAE	*Aglaia tomentosa*	3
MELIACEAE	*Aglaia* sp.	1a,1c,2
MELIACEAE	*Chisocheton* sp.	2
MENISPERMACEAE	*Pericampylus* sp.	1b
MENISPERMACEAE	*Stephania corymbosa*	4
MORACEAE	*Artocarpus anisophyllus*	1c
MORACEAE	*Artocarpus elasticus*	1a,2,3
MORACEAE	*Artocarpus odoratissimus*	1a
MORACEAE	*Ficus megaleia*	1b,1c,2
MORACEAE	*Ficus* sp.	1a,1b,1c,2,3,4,5
MUSACEAE	*Musa* sp.	1a,2,3
MYRISTICACEAE	*Gymnacranthera* sp.	1c

FAMILY	SPECIES	HABITAT
MYRISTICACEAE	*Knema laurina*	2,3,4
MYRISTICACEAE	*Knema* sp.	1a,2
MYRISTICACEAE	*Myristica* sp.	1b,4
MYRSINACEAE	*Ardisia* sp.	1a,1b,1c,4,5
MYRSINACEAE	*Embelia* sp.	1b,4,5
MYRTACEAE	*Leptospermum flavescens*	5,6
MYRTACEAE	*Syzygium alcinae*	1c,3,4,5
MYRTACEAE	*Syzygium cerasiformis*	2
MYRTACEAE	*Syzygium chrysantha*	1a,1c,2,3,5
MYRTACEAE	*Syzygium elopurae*	3,4
MYRTACEAE	*Syzygium ochneocarpa*	1c,3
MYRTACEAE	*Syzygium tawahense*	2
MYRTACEAE	*Syzygium* sp.	1a,2,4,5,6
NEPENTHACEAE	*Nepenthes lowii*	5,6
NEPENTHACEAE	*Nepenthes macrophylla*	6
NEPENTHACEAE	*Nepenthes rajah*	5
NEPENTHACEAE	*Nepenthes* x *trusmadiensis*	6
NEPENTHACEAE	*Nepenthes* sp.	4,5,6
NEPHROLEPIDACEAE	*Nephrolepis* sp.	1b,2,3,4,5,6
OCHNACEAE	*Ouratea borneensis*	2
OLACACEAE	*Ochanostachys amentacea*	1c
OLEACEAE	*Chionanthus pluriflorus*	2,5
OLEACEAE	*Chionanthus porcatus*	1c
OLEACEAE	*Chionanthus ramiflorus*	1c,2,5
OLEACEAE	*Chionanthus* sp.	1a,1b,2,4
ORCHIDACEAE	*Aerides* sp.	4
ORCHIDACEAE	*Arachnis* sp.	4
ORCHIDACEAE	*Bulbophyllum* sp.	3,4,5,6
ORCHIDACEAE	*Coelogyne* sp.	1b,2,5,6
ORCHIDACEAE	*Dendrobium* sp.	4,5
ORCHIDACEAE	*Eria* sp.	2,3,5,6
ORCHIDACEAE	*Spathoglottis* sp.	4
PALMAE	*Arenga undulatifolia*	1a,2
PALMAE	*Calamus pogonacanthus*	1a
PALMAE	*Calamus* sp.	2,3,4,5,6
PALMAE	*Caryota* sp.	1b,1c
PALMAE	*Daemonorops sabut*	1a
PALMAE	*Pinanga* sp.	1c,4
PANDACEAE	*Galearia fulva*	2
PANDACEAE	*Galearia maingayi*	1a
PANDANACEAE	*Pandanus* sp.	2,3,4
PIPERACEAE	*Piper* sp.	1b,2,3,4
PODOCARPACEAE	*Dacrydium* sp.	4,5
PODOCARPACEAE	*Phyllocladus hypophyllus*	4,5,6

FAMILY	SPECIES	HABITAT
PODOCARPACEAE	*Phyllocladus pluriflorus*	5
POLYPODIACEAE	*Crypsinus trilobus*	4
POLYPODIACEAE	*Drynaria* sp.	2
POLYPODIACEAE	*Microsorum* sp.	1b,2,3,4
PROTEACEAE	*Helicia fuscotomentosa*	1c
PROTEACEAE	*Helicia pterygota*	1c,2
PROTEACEAE	*Helicia serrata*	3
RAFFLESIACEAE	*Rafflesia keithii*	2
RHAMNACEAE	*Zizyphus borneensis*	3
RHIZOPHORACEAE	*Carallia borneensis*	1b,4
ROSACEAE	*Prunus arborea*	1c,2
ROSACEAE	*Prunus javanica*	2
ROSACEAE	*Prunus* sp.	2,4,5,6
ROSACEAE	*Rubus glomeratus*	1b,1c,2,3,4
ROSACEAE	*Rubus* sp.	3
RUBIACEAE	*Acranthera* sp.	1c,3
RUBIACEAE	*Canthium confertum*	2
RUBIACEAE	*Canthium* sp.	1c
RUBIACEAE	*Cephaelis elongata*	3
RUBIACEAE	*Hedyotis capitellata*	1b
RUBIACEAE	*Hedyotis costata*	4
RUBIACEAE	*Hedyotis* sp.	5,6
RUBIACEAE	*Ixora* sp.	1b,1c,2,3,4
RUBIACEAE	*Lasianthus* sp.	3
RUBIACEAE	*Lucinaea membranacea*	4
RUBIACEAE	*Lucinaea* sp.	1b
RUBIACEAE	*Maschalocorymbus corymbosus*	2
RUBIACEAE	*Mussaenda* sp.	3,4
RUBIACEAE	*Myrmeconauclea strigosa*	1b
RUBIACEAE	*Myrmeconauclea* sp.	2
RUBIACEAE	*Nauclea bernardoi*	1c
RUBIACEAE	*Neonauclea* sp.	2
RUBIACEAE	*Pavetta* sp.	1c
RUBIACEAE	*Pleiocarpidia sandakanica*	1b
RUBIACEAE	*Pleiocarpidia* sp.	2,3,4,5
RUBIACEAE	*Praravinia suberosa*	1b
RUBIACEAE	*Psychotria agamae*	4,5
RUBIACEAE	*Psychotria* sp.	1b
RUBIACEAE	*Timonius flavescens*	1a,3
RUBIACEAE	*Timonius villamilii*	2
RUBIACEAE	*Timonius* sp.	1b,2,3,4,5
RUBIACEAE	*Uncaria borneensis*	4
RUBIACEAE	*Uncaria cordata*	4
RUBIACEAE	*Uncaria* sp.	1a,2,3,4

FAMILY	SPECIES	HABITAT
RUBIACEAE	*Urophyllum* sp.	3
RUTACEAE	*Acronychia* sp.	4
RUTACEAE	*Melicope luna-akenda*	4
SABIACEAE	*Meliosma sumatrana*	1c,3,4
SAPINDACEAE	*Guioa pleuropteris*	3
SAPINDACEAE	*Guioa* sp.	1b
SAPINDACEAE	*Lepisanthes fruticosa*	1a,1b,3
SAPINDACEAE	*Lepisanthes* sp.	2
SAPINDACEAE	*Nephelium maingayi*	2
SAPINDACEAE	*Nephelium ramboutan-ake*	3
SAPINDACEAE	*Paranephelium hypophyllus*	2
SAPINDACEAE	*Paranephelium nitidum*	2,3
SAPINDACEAE	*Paranephelium xestophyllum*	1a,1b,2
SAPOTACEAE	*Madhuca* sp.	1c,2
SAPOTACEAE	*Palaquium* sp.	1c,4
SAURAUIACEAE	*Saurauia* sp.	1b,1c,2,4
SELAGINELLACEAE	*Selaginella* sp.	3,5
SIMAROUBACEAE	*Irvingia malayana*	1c
SMILACACEAE	*Smilax leucophylla*	1b,2,3,5
SMILACACEAE	*Smilax* sp.	4
SONNERATIACEAE	*Duabanga moluccana*	2
STERCULIACEAE	*Heritiera* sp.	2,3
STERCULIACEAE	*Leptonychia* sp.	1a
STERCULIACEAE	*Pterospermum elongatum*	1b
STERCULIACEAE	*Scaphium affine*	1c
STERCULIACEAE	*Sterculia* sp.	2
SYMPLOCACEAE	*Symplocos fasciculata*	2,3,4,5,6
SYMPLOCACEAE	*Symplocos* sp.	4,5
THEACEAE	*Adinandra dumosa*	1b,5
THEACEAE	*Adinandra* sp.	3,6
THEACEAE	*Pyrenaria* sp.	1b
THEACEAE	*Schima wallichii*	1b
THEACEAE	*Schima* sp.	4,6
THEACEAE	*Ternstroemia aneura*	5
THEACEAE	*Ternstroemia* sp.	1c,3,4,5,6
THYMELAEACEAE	*Aquilaria malaccensis*	1b
THYMELAEACEAE	*Gonystylus bancanus*	2,3
THYMELAEACEAE	*Wikstroemia tenuiramis*	1b
TILIACEAE	*Grewia acuminata*	4
TILIACEAE	*Microcos antidesmifolia*	1c,2
TILIACEAE	*Microcos cinnamomifolia*	2
TILIACEAE	*Microcos crassifolia*	1c
TILIACEAE	*Microcos* sp.	1b,2
TILIACEAE	*Pentace laxiflora*	2

FAMILY	SPECIES	HABITAT
TILIACEAE	*Pentace* sp.	1b,1c,2
ULMACEAE	*Gironniera* sp.	1b
URTICACEAE	*Astrothalamus* sp.	1b
URTICACEAE	*Dendrocnide elliptica*	2
URTICACEAE	*Dendrocnide* sp.	1b
URTICACEAE	*Elatostema* sp.	2
URTICACEAE	*Elatostema* sp.	5
URTICACEAE	*Laportea* sp.	1b
URTICACEAE	*Leucosyke* sp.	1a,1b,2,3
VERBENACEAE	*Clerodendrum* sp.	1b,1c
VERBENACEAE	*Petraeovitex ternata*	4
VERBENACEAE	*Teijsmanniodendron* sp.	1b,3
VIOLACEAE	*Rinorea* sp.	3
VITACEAE	*Cayratia geniculata*	3
VITACEAE	*Cayratia* sp.	1b,2
VITACEAE	*Cissus hastata*	1b
VITACEAE	*Cissus* sp.	1b,1c
VITACEAE	*Tetrastigma* sp.	1b,2,3,4
XANTHOPHYLLACEAE	*Xanthophyllum adenotus*	2
XANTHOPHYLLACEAE	*Xanthophyllum affine*	1b,1c,3
XANTHOPHYLLACEAE	*Xanthophyllum ellipticum*	3
XANTHOPHYLLACEAE	*Xanthophyllum* sp.	4
ZINGIBERACEAE	*Alpinia* sp.	2
ZINGIBERACEAE	*Etlingera elatior*	1a
ZINGIBERACEAE	*Globba pendula*	1b,2,3,4

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Income of local sellers of non-timber forest products in Sabah, Malaysia

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Abstract. Non-timber forest products (NTFPs) are traded in *tamu* (open market) mostly by the local communities in Sabah. Through this activity, the local sellers can generate their income. This study was based on surveys in 2004 with the objective of examining the contribution of NTFPs to the household economy of the local sellers. About 60% of the total respondents were dependent on selling NTFPs as their main source of income. The mean monthly income generated from NTFPs through *tamu* was only RM194. The results show that selling NTFPs contributed to 35% and 14% of the variation in total monthly income and monthly expenditure of the local sellers respectively.

Keywords: income, local communities, non-timber forest products, *tamu*

INTRODUCTION

Malaysia is rich in natural biological resources, particularly non-timber forest products (NTFPs). Many of the NTFPs have provided useful and important goods and services for socio-economic development of the country in terms of state revenue collection, industrial development, employment opportunities, international trade, protection of the environment, recreation opportunities, and so forth (Mohd. Azmi *et al.* 2002). Many NTFPs hold a high market value and have the potential to provide a much-needed source of income to forest dependent people who are often living far below the poverty line. Valuations of forest sites have been interpreted to indicate that the potential income from sustainable harvesting of NTFPs could be considerably higher than timber income, as well as income from agricultural or plantation uses (Peters *et al.* 1989). This has led to initiatives to provide and expand markets for more locally produced NTFPs, in order to meet an increasing demand for this cornucopia of harvestable wealth from tropical forests. Forest managed for NTFPs has a potential to yield better economic returns compared to a similar forest managed for timber alone (Peters *et al.* 1989).

The local or indigenous communities, who make up about 60% of the estimated 2.6 million people living in Sabah, comprise more than 30 ethnic groups. About 70% of the local or indigenous communities live in rural areas. Many of the land-based local or indigenous communities rely on the diverse plants and animals in the forest for food, medicine, fuel, building material and other household needs. Their cash income is derived from surplus food crops, cash crops, forest produce and fish sold in the local market and in *tamu* (open market). The involvement of the local communities in NTFPs is confined mostly to food, traditional medicine and handicrafts (Tongkul 2002).

The main objective of this study was to examine the contribution of NTFPs to the household economy of the local sellers, especially in terms of generation of income at the various *tamu* in Sabah.

METHODS

This study was based on surveys of the traded NTFPs conducted in September until November 2004 (Kodoh 2005). Ten *tamu* were surveyed, namely Tamu Kudat, Tamu Kota Marudu, Tamu Tandek, Tamu Tenom, Tamu Keningau, Tamu Tambunan, Tamu Kiulu, Tamu Tamparuli, Tamu Telipok and Tamu Donggonggon.

A structured questionnaire consisting of three main aspects was used in the surveys:

(a) Respondent's background
It covers age, gender, race, education level, household and employment.

(b) Inventory of NTFPs sold by the respondent
It covers species, uses, prices, sources, number of harvesting per month, number of working days per month, quantity harvested (kg/month) and number of persons involved per month.

(c) Contribution of NTFPs towards the economy of the respondent
It covers total monthly income, total income from selling NTFPs and monthly expenditure.

The data obtained were statistically analysed using Statistical Package for Social Sciences (SPSS) to obtain the descriptive statistics and comparison of means. Regression analysis by using Ordinary Least Square (OLS) model was conducted to determine the relationship between total monthly income and total monthly expenditure of the various respondents within the ten *tamu*.

RESULTS & DISCUSSION

Socio-economic characteristics of the respondents

The total number of people interviewed was 102, comprising 8 males and 94 females (Kodoh 2005). The majority of the respondents were Kadazan/Dusun ethnic group (76%), followed by Rungus (13%) and Murut (6%). Their age was categorized into seven groups. The largest group was 46-55 years old (32%), followed by 36-45 years old (25%) and 26-35 years old (17%). The average age of the respondents was 46 years old. The average household size was 7 persons, with the majority (45%) of them having 5 to 8 persons per household.

For 60% of the respondents, selling NTFPs was their main source of income. The majority of the respondents used van or car as the main mode of transport, either by hired vehicle (40%), car pool (35%) or own vehicle (20%), and only 5% were on foot. Most of the NTFPs came from forest (76%), the rest came from their own farm (10%), rivers (3%) and other sellers (11%). The average distance travelled by the local traders was 2.1 km. The average number of harvesting of NTFPs per month per species was 3.5 times. The results also indicate that the average number of working days per month per species was 4 days, and the average quantity of NTFPs harvested per month per species was 4.2 kg, with an average of 1 person involved per month per species.

Most of the respondents were self-employed (71%), mainly in agriculture. About 21% were unemployed, the rest worked in government (4%) and private (4%) sectors. Almost half of the respondents were uneducated with no schooling (49%), whereas 51% had some form of education. The mean income of the respondents was RM451.45 per month. Thus, it can be said that the respondents were of the lower-income group. The average income from selling NTFPs was RM194.05 per month and RM257.40 per month from other sources of income. The respondents spent on average about RM320.52 per month and their average monthly saving was about RM131.42.

Income from NTFPs traded in *tamu*

Most of the local sellers traded their NTFPs at the *tamu* regularly, during weekends and weekdays. Selling of NTFPs provided important income to the local people, especially to the full-time sellers. For the part-time sellers, trading NTFPs at *tamu* gave them supplementary income. The mean monthly income generated from transaction of NTFPs by local sellers at *tamu* was RM194.05.

The prices of NTFPs traded at the *tamu* were fixed by the sellers and most of the NTFPs were sold at similar prices in all *tamu*, except for the seasonal plants, such as wild fruit trees and some of the medicinal plants. The most expensive of NTFPs was Buah Mentayang (*Caesalpinia bonduc*) with a selling price of RM1,000 per kg. It was followed by Jerangau Merah or Akar Bumi (*Boesenbergia stenophylla*) at RM500 per kg and Lumut Gunung (*Usnea* sp.) at RM400 per kg. All of these species are medicinal plants.

The mean monthly income from selling NTFPs for respondents aged below 15 years, between 16 to 25 years, and between 46 to 65 years ranged from RM115 to RM166; whereas the mean monthly income from selling NTFPs for respondents aged between 26 to 45 years and above 66 years ranged from RM241 to RM260. The mean monthly income from selling NTFPs for household size of less than 5 persons and above 8 persons was below RM200; whereas the mean monthly income from selling NTFPs of household size between 5 to 8 persons was RM237. The mean monthly income from selling NTFPs for local sellers who were uneducated, had primary education, diploma, was less than RM200. But the mean monthly income of sellers of NTFPs who had school education up to secondary level ranged from RM240 to RM333. The mean monthly income of female and male sellers of NTFPs was not much different with RM191.30 for male and RM194.30 for female. The mean monthly income from selling NTFPs of married sellers was RM201.30, and RM169.20 for singles and RM110 for widows. Table 1 shows the percentage of mean monthly income from selling NTFPs to the total monthly income. Most of the monthly income from selling NTFPs contributed less than 50% of the total income.

Table 1. Percentage of mean monthly income from selling NTFPs to the total monthly income.

Tamu	**Mean total monthly income** (RM)	**Mean monthly income from selling NTFPs** (RM)	**Percentage of mean monthly income from selling NTFPs to the total monthly income** (%)
Kiulu	282.50	100.00	35.40
Tamparuli	848.57	352.86	41.58
Telipok	473.75	138.33	29.20
Donggonggon	730.31	401.88	55.03
Kota Marudu	291.00	107.67	37.00
Tandek	166.00	96.00	57.83
Kudat	270.27	120.73	44.67
Tambunan	483.57	177.14	36.63
Keningau	383.57	172.14	44.88
Tenom	325.00	130.00	40.00
All	451.45	194.05	42.98

Relationship between total monthly income and monthly income from selling NTFPs

The relationship between total monthly income and monthly income from selling NTFPs is explained by using the following linear regression model.

$$TMI_{i,j} = \alpha + \beta \, NTFPs\,IN_{i,j} + \varepsilon_{i,j}$$

where

TMI = total monthly income
NTFPs IN = income from NTFPs
i = *tamu*
j = respondent
ε is error with mean zero and common variance $\varepsilon_i \sim iid\ N(0, \delta^2)$

The estimated model is:

$$\hat{TMI}_{i,j} = \hat{\alpha} + \hat{\beta} NTFPsIN_{i,j}$$

$\hat{\alpha}$, $\hat{\beta}$ are parameters to be estimated. The model was estimated using OLS. The results are presented in Table 2.

Table 2. Results of regression analysis of monthly total income and monthly income from selling NTFPs.

Variable	Parameter	Coefficient	Std. error	t-ratio
Constant	$\hat{\alpha}$	190.74	53.83	3.544*
NTFPs IN	$\hat{\beta}$	1.34	0.181	7.404*
N	102			
R^2	0.354			
F	54.82			

*Significant at the 0.05 level

The results show that about 35.4% of the variation in total monthly income was explained by the monthly income from selling NTFPs. The results obtained also indicate that if the monthly income from selling NTFPs is increased by RM1, the total monthly income would be increased by RM1.34.

Relationship between monthly expenditure and monthly income from selling NTFPs

The objective of this analysis is to find the relationship between mean monthly expenditure and mean monthly income from selling NTFPs. The model is specified as:

$$ME_{i,j} = \alpha + \beta \, MI\ NTFPs_{i,j} + \varepsilon_{i,j}$$

where

ME = monthly expenditure
MI NTFPs = monthly income from selling NTFPs
i = *tamu*
j = respondent
$\varepsilon_{i,j}$ is assumed to be normally distributed with mean zero and common variance $\varepsilon_{i,j} \sim N(0, \delta^2)$.

The estimated model is:

$$\hat{ME}_{i,j} = \hat{\alpha} + \hat{\beta} MINTFPs_{i,j}$$

$\hat{\alpha}$, $\hat{\beta}$ are parameters to be estimated. The model was estimated using OLS. The results are presented in Table 3.

Table 3. Results of regression analysis of monthly expenditure and monthly income from selling NTFPs.

Variable	Parameter	Coefficient	Std. error	t-ratio
Constant	$\hat{\alpha}$	237.07	31.057	7.633*
MI NTFPs	$\hat{\beta}$	0.43	0.105	4.107*
N	102			
R^2	0.144			
F	16.870			

*Significant at the 0.05 level

The results show that about 14.4% of the variation in monthly expenditure was explained by the monthly income from selling NTFPs. The results obtained also indicate that if the monthly income from selling NTFPs is increased by RM1, the monthly expenditure would be increased by RM0.43.

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Sepilok Bulletin 4: 31-39 (2006)

The abrasive resistance of mangrove timber

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Abstract. The abrasive resistance of the timber of three mangrove species, namely Bangkita (*Rhizophora apiculata*), Bakau Kurap (*Rhizophora mucronata*) and Lenggadai (*Bruguiera parviflora*) was assessed and compared with that of Merbau (*Intsia palembanica*) and Nyatoh (*Palaquium beccarianum*), the two common flooring timbers. The results show that the timber of the three mangrove species was equivalent if not better than Merbau. Their timber resistance to wear was far superior to Nyatoh. These mangrove species are considered suitable for heavy traffic flooring.

Keywords: abrasive resistance, flooring, mangrove timber, parquet

INTRODUCTION

A review of the past and current status of mangrove management in Sabah by Kugan (2003) revealed that the mangroves of Sabah are regarded mainly as protection areas for the past three decades. Owing to the anticipated shortage of timber supply from commercial forests in the near future and shortfall in revenue from forestry, the State Government has very little choice but to look for alternative sources of timber and revenue. This includes looking into commercialisation and sustainable utilisation of timber from mangroves.

Most of the mangrove species produce very high density timber. However, it has been utilised for a limited range of products mainly by the local communities for building material, firewood and charcoal production. There is a need to diversify the utilisation of mangrove timber and one option is the use of the timber as a flooring material. Mangrove timber is normally available in very short length due to the knots and the small size of the trees. In view of the dimensional constraints in the sawn form, mangrove timber may be suitable for parquet and strip flooring only. If mangrove timber or any other timber for that matter, is tested for its suitability as a flooring material, the process may prove to be expensive, difficult to duplicate and also may require a long period of monitoring. Therefore, the abrasive resistance of mangrove timber, as ascertained in the laboratory, is used as an indicator for its suitability as a flooring material.

Using an abrasion testing machine, the abrasive resistance of timber for three mangrove species, namely Bangkita (*Rhizophora apiculata*), Bakau Kurap (*Rhizophora mucronata*) and Lenggadai (*Bruguiera parviflora*) was investigated as part of a study on the diversification of utilisation of mangrove timber. The results obtained were compared to those obtained from two common flooring timbers, namely Merbau (*Intsia palembanica*) and Nyatoh (*Palaquium beccarianum*).

MATERIALS & METHODS

(a) Preparation of test materials

Boards of Bangkita, Bakau Kurap and Lenggadai were chosen from material previously used in an air-seasoning study, while the boards of Merbau and Nyatoh were chosen from the air-dried material being kept in the sawmill at Forest Research Centre (FRC), Sepilok, Sandakan. The two types of specimens, i.e. the radial and tangential face specimens were obtained from these boards. The cutting pattern and their final dimensions are shown as in Figure 1 and Table 1, respectively. The test specimens were drilled to make a 9 mm diameter circular central hole and then seasoned for 24 hours or longer in a conditioned atmosphere (laboratory at 50% relative humidity and 20-25°C) to a moisture content of about 12% before testing.

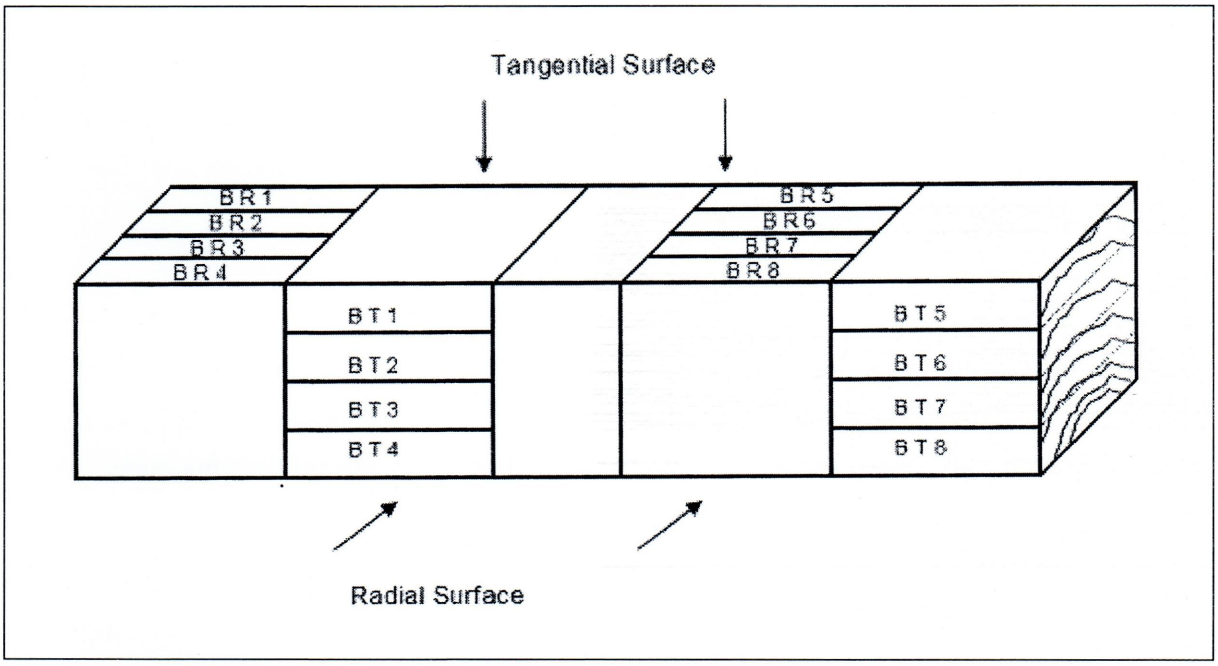

Figure 1. Cutting pattern of test specimens.

Table 1. Specimens for the abrasive resistance test.

Species	Face	Number of samples	Dimensions (W x L x T cm)
Bangkita (*Rhizophora apiculata*)	Tangential Radial	8 9	10 x 10 x 1.2 10 x 10 x 1.2
Bakau Kurap (*Rhizophora mucronata*)	Tangential Radial	8 9	10 x 9.4 x 1.2 10 x 9.4 x 1.2
Lenggadai (*Bruguiera parviflora*)	Tangential Radial	8 5	10 x 9.4 x 1.2 10 x 9.4 x 1.2
Merbau (*Intsia palembanica*)	Tangential Radial	9 8	10 x 9.3 x 1.2 10 x 9.4 x 1.2
Nyatoh (*Palaquium beccaranium*)	Tangential Radial	8 8	10 x 9.4 x 1.2 10 x 9.4 x 1.2

W = Width   L = Length   T = Thickness

(b) Testing procedure

The test procedure adopted in this study was in accordance with the American Society for Testing and Materials (ASTM) D-4060 (Anonymous 2004). The test was performed at the Timber Research and Technical Training Centre (TRTTC), Kuching, Sarawak by using the abrasion testing machine (Model 5151 Digital Abrasers with LED Readout) as shown in Figure 2. Characteristic rub-wear action of abrasers is produced by the contact of a test sample turning on a vertical axis, against the sliding rotation of two abrading wheels. The wheels are driven by the sample in opposite directions about a horizontal axis displaced tangentially from the axis of the sample. Figure 3 shows the relative positions of sample and abrading wheels and the direction of their rotation. The weight loss of the specimens was measured after every 200, 400, 500, 800 and 1000 revolutions of the H-18 Calibrade wheel operating under 1000 gram load.

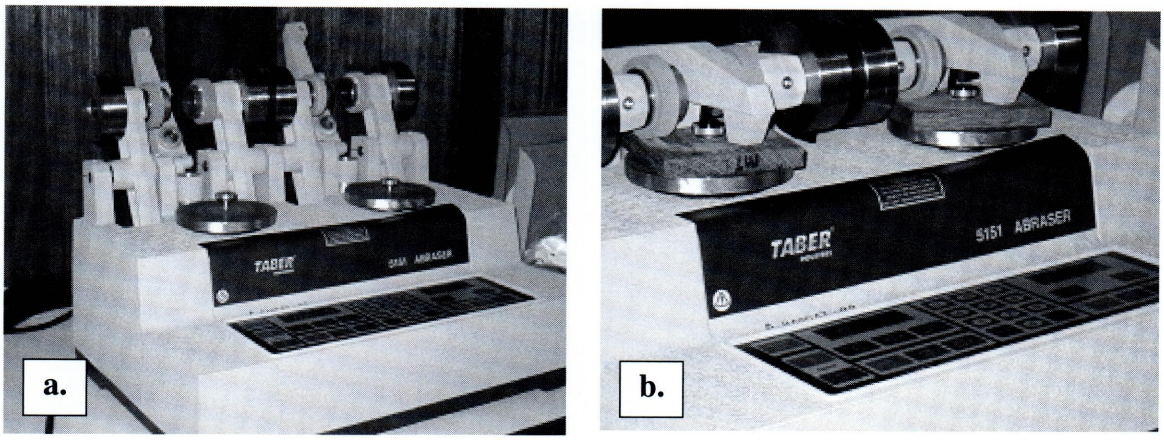

Figure 2. Model 5151 Digital Abrasers with LED Readout.
a. Without test specimen
b. With test specimens

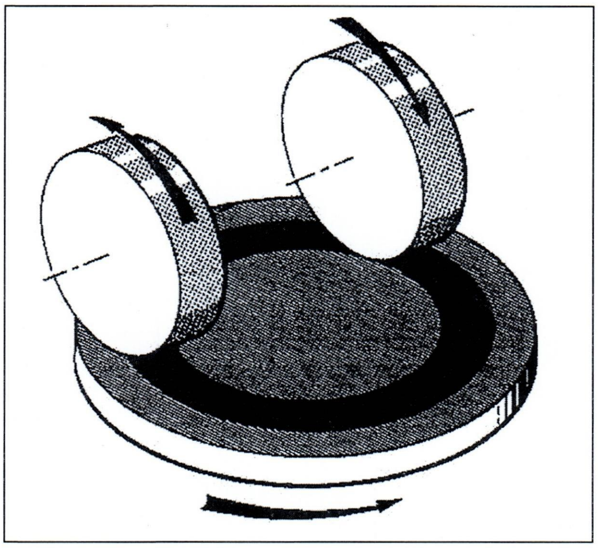

Figure 3. Operational diagram of the abrasers (Source: Anonymous 2004).

(c) Method of evaluating test results

The results are expressed as a wear factor in percentage of loss in weight or numerical abrasion index of the specimens. The Taber wear index (rate of wear) is the loss in weight in milligrams per thousand cycles of abrasion for a test performed under specific set conditions. The lower the wear index, the better the abrasive resistance of the material.

RESULTS & DISCUSSION

Quantitative results of the abrasive test on the five species, Bangkita, Bakau Kurap, Lenggadai, Merbau and Nyatoh, are shown in Table 2. Average values for the wood density, loss in weight after 200, 400, 500, 800 and 1000 revolutions, and percentage loss in weight after 1000 revolutions of the abrasive wheels are given for the two faces tested, i.e. tangential and radial faces.

Table 2. Loss in weight of Bangkita, Bakau Kurap, Lenggadai, Merbau and Nyatoh.

Species	Density (g/cm^3)	Surface abraded	Loss in weight after n revolutions of the abrasive wheels (g)					Percentage loss in weight after 1000 revolutions (%)
			200	400	500	800	1000	
Bangkita *Rhizophora apiculata*	0.91	Radial Tangential	0.225 0.178	0.421 0.344	0.497 0.448	0.567 0.567	0.784 0.755	0.62 0.60
Bakau Kurap *Rhizophora mucronata*	0.90	Radial Tangential	0.104 0.105	0.193 0.214	0.498 0.266	0.560 0.374	0.647 0.419	0.55 0.37
Lenggadai *Bruguiera parviflora*	0.82	Radial Tangential	0.107 0.096	0.179 0.223	0.265 0.222	0.322 0.296	0.449 0.358	0.42 0.34
Merbau *Intsia palembanica*	0.78	Radial Tangential	0.154 0.153	0.293 0.282	0.397 0.305	0.531 0.471	0.728 0.576	0.71 0.68
Nyatoh *Palaquium beccarianum*	0.60	Radial Tangential	0.370 0.397	0.466 0.424	0.538 0.580	0.688 0.669	0.882 0.749	1.21 1.08

All species tested showed that the wearing resistance of timber at the radial face was lower than that of tangential face. The percentage loss in weight at radial face after 1000 revolutions was 0.62%, 0.55%, 0.42%, 0.71% and 1.21% for Bangkita, Bakau Kurap, Lenggadai, Merbau and Nyatoh, respectively. While the percentage loss in weight at tangential face was 0.60%, 0.37%, 0.34%, 0.68% and 1.08% for Bangkita, Bakau Kurap, Lenggadai, Merbau and Nyatoh, respectively. The least resistance to wear at radial face was also observed for the timber of Kempas and rubber (Mohd. Shukari 1983).

The percentage loss in weight of tested species, radial and tangential, was plotted against the number of revolutions as in Figures 4 and 5, respectively. All species showed an increasing amount of loss in weight with a marked difference after 1000 revolutions.

The best average wear index was obtained for Lenggadai, followed by Bakau Kurap, Merbau, Bangkita and Nyatoh, both at radial and tangential faces (Figure 6). This difference was perhaps due to the obvious difference in their densities. However, it has been proven that besides density, other factors related to the anatomical structures of the wood, in particular the size, arrangement and distribution of the pores and structure of the fibres, also play important roles in influencing the resistance to wear (Lim 1983, Mohd. Shukari 1983).

Wong (1974) published a list of Malaysian timbers suitable for parquetry, heavy and general utility flooring based on hardness, resistance to abrasion, working properties, strength and nailing properties. Lim (1983) gave an updated account of Malaysian timbers suitable for flooring after the types of flooring were reclassified into heavy, medium and light traffic conditions. Based on his list, Merbau is considered as suitable for heavy traffic flooring preferably for use under medium traffic conditions. Nyatoh is considered as suitable for medium traffic with preferred usage under light traffic conditions. The average wear index at both radial and tangential faces of Lenggadai and Bakau Kurap was lower than that of Merbau but was not significantly different (Table 3). The average wear index of Bangkita was higher than Merbau but was also not significantly different ($P > 0.05$). Bakau also appears as one of the species denoted as suitable for heavy traffic flooring in the list by Lim (1983). The current research provides additional information, being more specific to the three mangrove species.

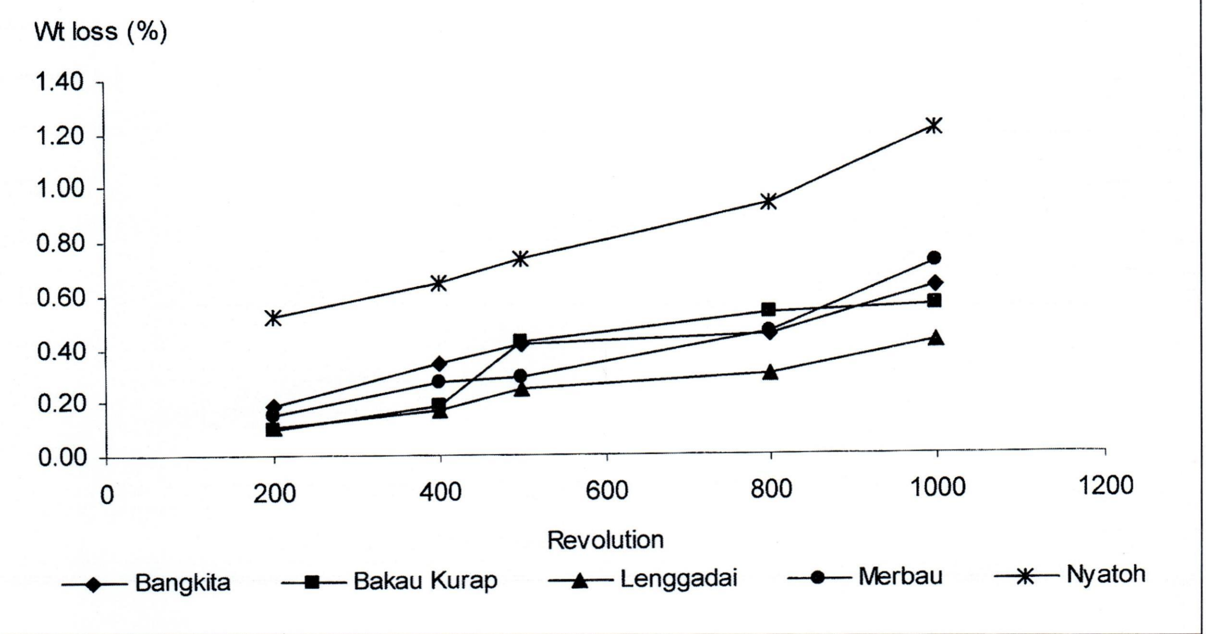

Figure 4. Percentage loss in weight at radial face of species.

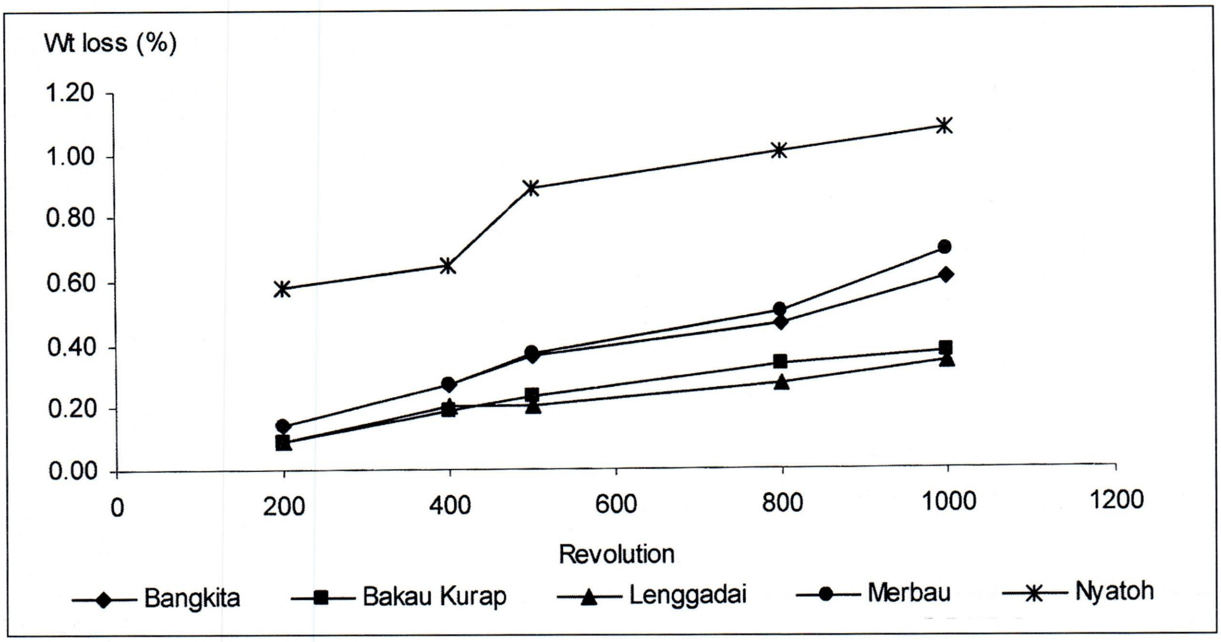

Figure 5. Percentage loss in weight at tangential face of species.

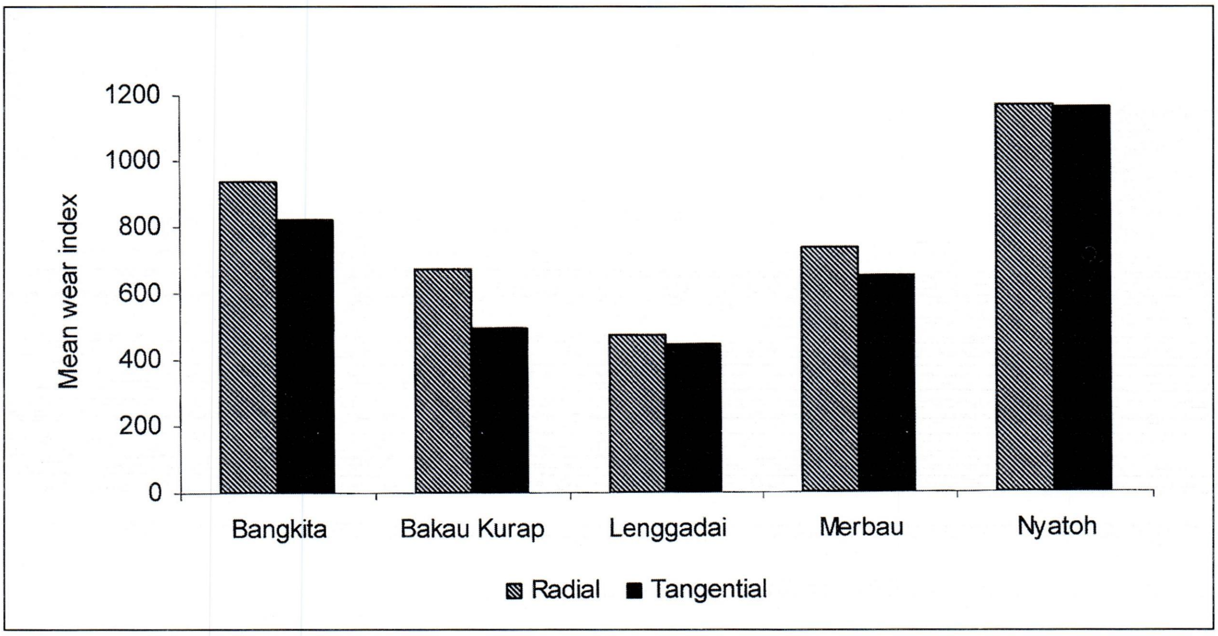

Figure 6. Average wear index of species.

Table 3. Duncan's test on wear index of species.

Species	Average wear index at radial face	Average wear index at tangential face
Lenggadai	472.80[a]	441.90[a]
Bakau Kurap	669.10[ab]	495.70[a]
Merbau	737.65[ab]	649.10[ab]
Bangkita	932.85[b]	821.95[b]
Nyatoh	1166.60[c]	1158.05[c]

Means with same alphabet are not significantly different at 95% confidence level

CONCLUSION

The results obtained from this study show that the three mangrove species, Lenggadai, Bakau Kurap and Bangkita were equivalent or rather more resistant to wear than Merbau. Obviously, the resistance to wear of the three mangrove species was far superior to Nyatoh. These species are considered as suitable for use as heavy duty flooring material.

The results also show that the tangential face was more resistant to wear compared to the radial face. This means that tangential boards make better floor boards than radial boards, and that for heavy duty floors, tangential boards should be preferred.

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Preliminary report of the thalloid liverworts from Gunung Halimun-Salak National Park, Bogor, Indonesia

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Abstract. A total of 25 species of thalloid liverworts in ten genera and seven families was collected from Gunung Halimun-Salak National Park. The ten genera were *Metzgeria, Aneura, Riccardia, Pallavicinia, Jensenia, Marchantia, Dumortiera, Cyathodium, Reboulia* and *Riccia*. The most dominant family was the Marchantiaceae, followed by the Metzgeriaceae.

Keywords: bryophytes, Gunung Halimun-Salak National Park, Marchantiales, Metzgeriales, thalloid liverworts

INTRODUCTION

There are two main types of liverworts one of which is the thallose form. Generally, thalloid liverworts have a dorsiventrally flattened gametophyte (thallus), resembling more or less a green ribbon. The thallus is usually dichotomously branched (pinnate in *Riccardia*) and variable in its internal structure. The thalloid liverworts are divided into two orders, Marchantiales and Metzgeriales.

In the Marchantiales, the thallus is internally differentiated, having green chlorophyllous tissue on the dorsal side, usually located in air chambers that open by specialized pores to the upper thallus surface; towards the ventral surface, the thallus of the specialized forms is made up of colourless storage tissue (Gradstein *et al.* 2001). The walls of the air chambers are usually visible on the dorsal thallus surface as thin lines, forming a reticulate pattern. The pores are surrounded by concentric rings of cells. The oil bodies are complex and sometimes solitary in specialized cells. This group has two types of unicellular rhizoids: smooth (attachment) and tuberculate or pegged (thickenings on inner wall of rhizoid, conduction).

In Metzgeriales, the thallus is smooth and translucent as compared to Marchantiales. The thallus is internally simple and multistratose throughout, or composed for most of its width of a single layer of cells (the thallus wings) while the central portion is multistratose, resembling a midrib. Thallus cells may have chloroplasts and oil bodies, with smooth rhizoids.

Thalloid liverworts have antheridia as male reproductive organs. The antheridia are produced on the thallus surface, naked or surrounded by an involucre, or inside the thallus, in special antheridial chambers. In *Marchantia*, the antheridial chambers are located on stalked receptacles, the antheridiophores. The antheridial chambers are below the upper surface of the antheridiophore and open to the exterior by a small pore.

The female reproductive organs, the archegonia are on the thallus surface or embedded inside the thallus, and usually surrounded by an involucre. In some genera there are two involucres (e.g. *Pallavicinia*), the inner one is called the pseudoperianth. In the Aneuraceae, there is no involucre, the young sporophyte is surrounded by a fleshy calyptra. In the Marchantiales, the archegonia are often located on receptacles which may become stalked after fertilization, and known as archegoniophores.

A collection of thalloid liverworts was carried out at Gunung Halimun-Salak National Park. The park is located in the island of Java, Indonesia and holds the largest remaining tropical montane rain forest in the whole of West Java. The park covers an area of 113,357 ha, and is located within three districts (Bogor, Sukabumi and Lebak) of West Java and Banten Provinces. Vegetation within the park varies according to the altitude and it can be classified in three zones: Colline Zone (500-1,000 m a.s.l.), Submontane Zone (1,000-1,500 m a.s.l.) and Montane Zone (1,500-2,000 m a.s.l.).

METHODOLOGY

A three-day collecting trip of thalloid liverworts was made around Gunung Halimun-Salak National Park during the training course, BIOTROP Third Regional Training Course on Biodiversity Conservation of Bryophytes and Lichens, in September 2005. General collecting was done along the trail from the Cikaniki Guest House to the summit of Mount Kendeng, Macan Waterfall, Citalahab Tea Plantation and around the Cikaniki Guest House, with an approximate elevation of 930-1,620 m a.s.l. A total of 41 specimens of thalloid liverworts was collected from the study area and they were subsequently studied in the laboratory.

RESULTS & DISCUSSION

For the first time, a report on the thalloid liverworts from Gunung Halimun-Salak National Park was done.

We collected a total of 41 specimens. Out of these, we identified 25 species in ten genera and seven families of thalloid liverworts within the study area (Table 1). Largest family in terms of number of collected species was Marchantiaceae, followed by

Metzgeriaceae. Most of the specimens collected were found attached to soil, moist boulders, decaying or rotten logs, and on tree trunks, branches, roots and leaves. A key to these specimens was constructed and is given in this paper.

Most of the specimens were identified only to the generic level because of limited literature (especially the key) and the lack of studies on thalloid liverworts in the region. Further research on the group is necessary.

Table 1. Summary of taxa of thalloid liverworts collected at Gunung Halimun-Salak National Park.

Order	Family	Species	Specimen No.
Metzgeriales	Metzgeriaceae	*Metzgeria* sp.1 (Figure 1)	15, 16
		Metzgeria sp.2	17
		Metzgeria sp.3	18, 19
		Metzgeria sp.4	20
		Metzgeria sp.5	21(a)
		Metzgeria sp.6	22
	Aneuraceae	*Aneura pinguis* (L.) Dumort.	32, 33
		Riccardia sp.1	40, 41(a)
		Riccardia sp.2	34-38, 41(b)
		Riccardia sp.3	39
	Pallaviciniaceae	*Pallavicinia lyellii* (Hook.) Carruth.	28, 29, 30, 31
		Pallavicinia sp.1	23, 24, 25
		Pallavicinia sp.2	27
		Jensenia decipiens (Mitt.) Grolle	26
Marchantiales	Marchantiaceae	*Marchantia geminata* Reinw., Blume & Nees	3
		Marchantia treubii Schiffner	4 (a), 4 (b)
		Marchantia emarginata Reinw., Blume & Nees	5
		Marchantia sp.1	7
		Marchantia sp.2	6
		Marchantia sp.3	8
		Marchantia sp.4	9
		Dumortiera hirsuta (Sw.) Nees (Figure 2)	12, 13, 14, 21(b)
	Cyathodiaceae	*Cyathodium foetidissimum* Schiffner	10
	Aytoniaceae	*Reboulia hemisphaerica* (L.) Raddi	11
	Ricciaceae	*Riccia* sp.	2

Key to the thalloid liverworts from Gunung Halimun-Salak National Park

1. Cells with only 1(-2) large chloroplast. Capsules linear, green, turning black after dehiscence, opening gradually from the apex downwards (over a period of weeks or months), by 2 valves .... Hornworts
1. Cells with numerous small chloroplasts. Capsules rounded to ellipsoidal, black when mature (before dehiscence), opening at once, usually by 4 valves.. 2 (Thalloid liverworts)

2. Plants very small, thallus lobes less than 5 mm wide, usually forming small green rosettes on soil. Dorsal surface of thallus with a groove along the midline. Sporophyte produced inside the thallus .... *Riccia* sp.
2. Plants larger, thallus lobes usually more than 5 mm wide, not forming rosettes. Thallus surface without median groove 3

3. Upper surface of thallus with pores (appearing as tiny, colourless or whitish dots) or distinctly reticulate. Thallus with air chambers (thallus cross-sections) 4
3. Thallus surface without pores and not reticulate. Air chambers lacking 10

4. Gemma cups present on dorsal surface of thallus 5
4. Gemma cups absent 8

5. Male and female parts present 6
5. Male and female parts absent (unknown) .... *Marchantia* sp.

6. Female receptacle with more than 6 lobes, the lobes not bifid .... *Marchantia emarginata*
6. Female receptacle with 3-6 lobes, the lobes deeply bifid 7

7. Number of female lobes constant, 4 (rarely 6) .... *Marchantia geminata*
7. Number of female lobes variable, 3-6. .... *Marchantia treubii*

8. Thallus very delicate and thin, translucent. Sporophyte (when present) embedded in the thallus, not on stalked receptacles which are absent .... *Cyathodium foetidissimum*
8. Thallus thicker, not translucent. Sporophyte on stalked receptacles 9

9. Ventral scales in 2 rows only, with long cilia at the margin. Pores simple. Male receptacles not stalked. Thallus without midrib .... *Reboulia hemisphaerica*
9. Ventral scales in 4-8 rows, without cilia. Pores compound, of several layers of cells. Male receptacles stalked. Thallus sometimes with a midrib .... *Marchantia* sp.

10. Thallus large, more than 10 mm wide .... *Dumortiera hirsuta*
10. Thallus less than 10 mm wide 11

11. Thallus with midrib. Archegonia and antheridia on the dorsal or ventral side of the midrib 12
11. Thallus with no midrib (sometimes present on small branches). Archegonia and antheridia at the thallus margins 16

12. Thallus growing erect from a creeping rhizome .... *Jensenia decipiens*
12. Thallus creeping 13

13. Thallus narrow, less than 3 mm wide, translucent (1 cell thick), thallus margins with numerous long, unicellular hairs. Archegonia and antheridia on the ventral side of the midrib .... *Metzgeria* sp.
13. Thallus more than 3 mm wide, not translucent, thallus margins without long hairs. Antheridia and archegonia on the dorsal side of the midrib 14
(*Pallavicinia* sp.)

14. Thallus more than 7 mm wide .... *Pallavicinia* sp.1
14. Thallus less than 6 mm wide 15

15. Thallus dark green, creeping on soil and humus, midrib 0.4 mm wide ....
Pallavicinia lyellii
15. Thallus pale green, creeping on decaying logs, midrib nearly 1 mm wide...........................
Pallavicinia sp.2

16. Thallus 5-8 mm wide, simple, creeping .... *Aneura pinguis*
16. Thallus 1-3 mm wide, pinnate, creeping or erect .... *Riccardia* sp.

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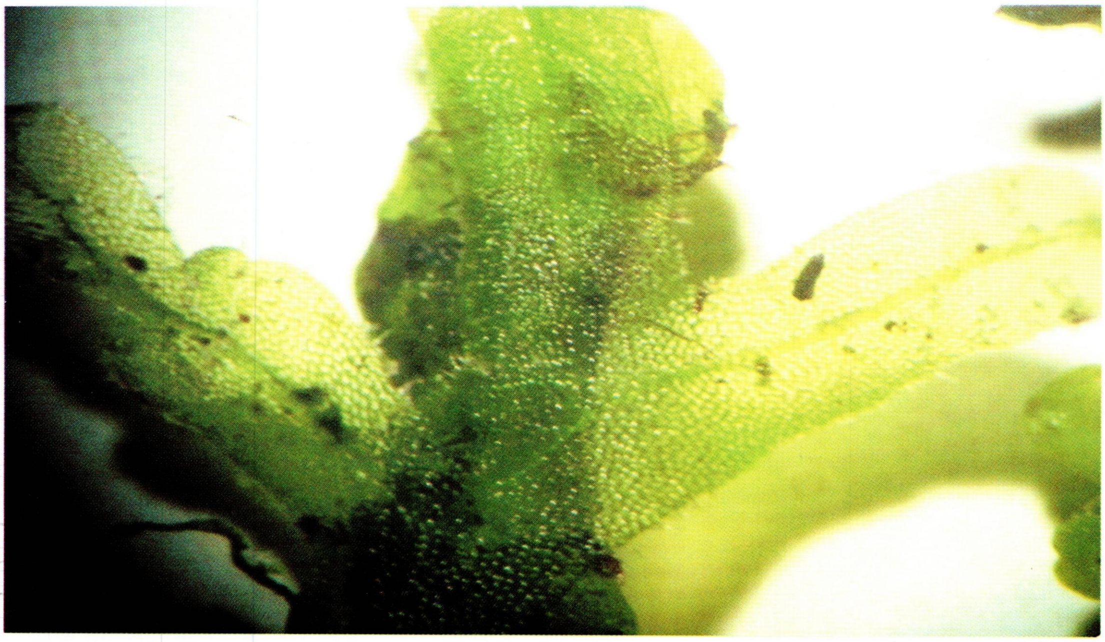

Figure 1. *Metzgeria* sp.1.

Figure 2. *Dumortiera hirsuta* (Sw.) Nees.

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NOTES

Problems and difficulties in studying hepatological cytology with reference to *Dumortiera hirsuta* (Sw.) Nees

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Hepatics or liverworts can be divided into two groups namely, leafy and thalloid (Duddington 1970). *Dumortiera hirsuta* is included in the thalloid group and known to be one of the problematic plant groups because of its minute chromosomes, which do not exceed 2 µm in length and are cytologically difficult (Loo *et al.* 2005).

The counting of chromosomes via microphotographs is not very effective due to the limitations of the phase contrast microscope and the attached photomicrograph that records the observations automatically (Figure 1). This has degraded the quality of the photos because automatic adjustment usually produces moderate results. As for manually controlled photomicrograph, one can adjust the lighting and focusing powers, but it requires handling experience and skills. Referring to the studies by Inoue & Himeno (1978), Kanda & Okada (1993) and Newton (1979), their published photos show chromosomes that are not separated well either. Nevertheless, the counting of chromosomes directly via microscope is very useful. In fact, clear photo is the main proof in any cytological work.

Measuring one chromosome in a single cell can be done by using lensal and object micrometers. In studying *D. hirsuta*, lensal micrometer is better compared to object micrometer because of its 360° flexibility. This allows the uneven distribution of chromosomes to be measured precisely. Calibration should be carried out by utilizing the object micrometer before measurements are made. Since the smallest scale for lensal micrometer is only 1 µm, errors need to be calculated (using SPSS software) for each of the cytoforms.

The small size of chromosomes ranging from 0.5 µm to 2.0 µm has caused difficulty in determining the shape of the chromosomes. This also happened to the study reported by Akiyama *et al.* (2003) and limited their efforts in carrying out karyotyping. On the other hand, Schuster (1966) noted that the karyotype formula for any taxa under the order Marchantiales with basic chromosomal numbers: $x = 9$, is V(H) + 3V + 4J + m(h). This means that one set of chromosomes consists of the largest chromosome and is given the H symbol, V shaped or metacentric or subcentric, h symbol is given to the smallest chromosome and known as m-chromosome, J symbolizes the telocentric or acrocentric shape of a chromosome. Hypothetically, the chromosomes of *D. hirsuta* have the shapes explained by Schuster (1966).

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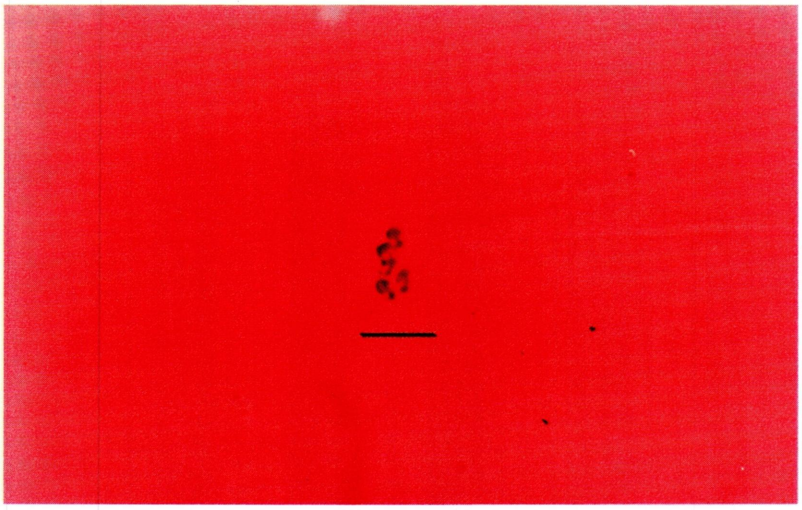

Figure 1. Chromosomes of *Dumortiera hirsuta* (100X) (Scale bar = 10 μm).

Sepilok Bulletin 4: 53-55 (2006)

Culm production management for Poring bamboo (*Gigantochloa levis*) plantation

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Poring bamboo or *Gigantochloa levis* Blanco (Merrill) is commonly found and cultivated in Sabah mainly for handicrafts, building materials and vegetables (Kulip & Matunjau 1994). This species has been suggested as a plantation species due to its excellent culm characteristics and potential usage (Abd. Razak *et al.* 1995). Although this species has been recommended for plantation, information on culm production management is still lacking. This note attempts to give some basic information on culm production management in a planted Poring bamboo stand.

All bamboo species found in Sabah have sympodial rhizome system (Dransfield 1992). The sympodial rhizome system typically results in a cluster of closely spaced culms which have underground connections forming distinct clumps (Wong 1995). Thus culm density is affected by this sympodical system. Abd. Razak & Hashim (1993) reported that about 80-90% of new culms emerge towards the outside of bamboo clump. Bamboo culms are relatively young and immature towards the outside of a clump and comparatively old towards the centre of the clump. In general, bamboo culms older than 3 years are regarded as mature and ready to be harvested. In this regard, mature clump should not be congested and needs to be thinned from time to time to allow new culm production. It has been thought that without thinning, culm production rate will be low and will stagnate when the clump is too congested.

A thinning study was carried out in a 13-year-old unthinned *G. levis* plot in Kolapis A at Lungmanis Forest Reserve (5°44'N, 117°40'E), approximately 61 km west of Sandakan. Mean annual temperature and rainfall in Sandakan were 27.8°C and 3112 mm respectively. The soil in Kolapis A is loam and clay loam of the Tanjung Lipat family (Acres & Folland 1975). This experiment consisted of 4 replications and 5 treatments. Each replication consisted of 4 clumps. Thinning intensities were based on 10, 20, 40, 60 and 80% of the total culms/clump.

Analysis of variance showed that culm production significantly increased after thinning ($P < 0.015$) and 80% thinning gave the highest rate of culm production compared with other thinning intensities (Figure 1). These results suggest that higher intensity of thinning would result in higher rate of bamboo culm production. It was also found that culm production stagnated 4 years after thinning. Thus one option for bamboo thinning method might be culms should be thinned at first from the centre of the clump in order to harvest the mature culms, and to allow new shoots to emerge, and second thinning could be conducted from the outer part of the clump possibly 4 years after the first thinning, and subsequent thinning could be done in this manner.

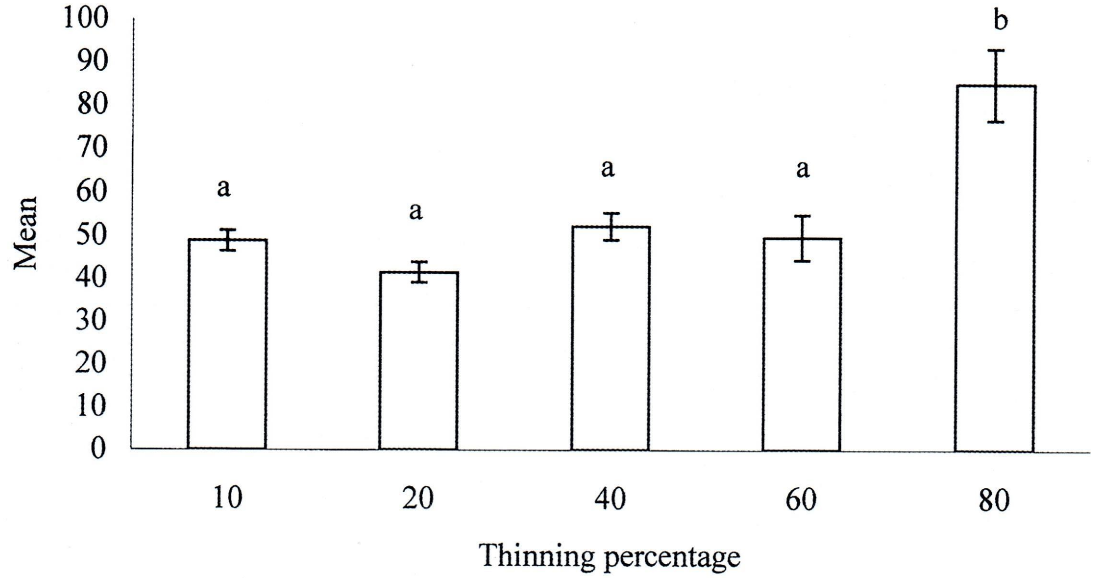

Figure 1. Mean culm production (with standard error) after thinning. Means with the same letter are not significantly different at 5% level [Duncan's multiple range test ($P < 0.05$)].

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Sepilok Bulletin 4: 57-59 (2006)

Jati Laut

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Jati Laut, suggested as the Sandakan City Tree, is a native conifer. The tree, also known as sea teak, is being considered by the Sandakan Municipal Council as the City Tree to be launched in June 2006 in conjunction with the Sandakan Fest.

Jati Laut is an elegant evergreen tree with a conical crown, and grows slowly but steadily, like the City Tree of Kota Kinabalu, *Gymnostoma nobile* (Whitmore) Johnson, of the family Casuarinaceae. It is found in coastal areas, and like many ornamental trees growing in harsh urban environment, can adapt well on most sites. The young cones (reproductive organs) are golden yellow in colour and quite attractive.

Following is some scientific information on Jati Laut.

Botanical name:
Podocarpus polystachyus R. Br. *ex* Endl. (Podocarpaceae)

Vernacular names:
Jati Laut, Kayu China, Podo Laut, Mayu Serai, Kayu Karamat

Distribution and origin of *Podocarpus*

Podocarpus is a genus of 105 species, in the family Podocarpaceae, which is a family of conifers. *Podocarpus* is distributed mainly in the southern hemisphere and is believed to have originated in the ancient supercontinent of Gondwanaland, which broke up into Africa, South America, Australia-New Guinea, New Zealand and New Caledonia. *Podocarpus* is believed to have spread into the Malay Archipelago and mainland Asia from Australia-New Guinea.

In Sabah, there are ten species of *Podocarpus* (de Laubenfels 1988), namely *P. brevifolius* (Stapf) Foxw. – (Mt. Kinabalu), *P. borneensis* de Laub. – (Tawai), *P. confertus* de Laub. – (Mt. Silam), *P. gibbsii* N. E. Gray – (Mt. Kinabalu), *P. globulus* de Laub. – (Mt. Silam), *P. laubenfelsii* Tiong – (Trusmadi and Mt. Kinabalu), *P. micropedunculatus* de Laub. – (Papar and Tawao), *P. neriifolius* D. Don – (Mt. Kinabalu; Mt. Wullersdorf; Trusmadi; Maliau Basin; Bukit Tangkunan, Telupid), *P. polystachyus* R. Br. *ex* Endl. – (coastal areas of Sabah) and *P. rumphii* Blume – (Selangan Island).

P. polystachyus differs from its close sister species (*P. rumphii*) in having smaller leaves [5-9(15) cm long] and shorter male cones.

Description of the species

Small tree up to 20 m tall. Bark reddish brown, fibrous, peeling in strips. Leaves linear, apex acute to rounded, 5-9 cm long x 7-8 mm wide, larger when juvenile, narrowed at the base to a short petiole about 2 mm long. Pollen cones cylindrical, golden yellow in colour, 2-3 cm long x about 3 mm in diameter, grouped in small sessile clusters. Seeds solitary, round, about 8 mm long x 5 mm diameter, each on a peduncle 3-6 mm long.

Habitat

Sea teak is found widely from Malaysia to New Guinea. In Sabah, it is common along the coastal areas from Sipitang to northern part of Sabah, including Balambangan and Malawali islands (Sugau & Tangah 2004). As the east coast of Sabah is dominated by mangrove swamps, sea teak is less common there.

Other notes

P. polystachyus can be propagated via stem cutting and air layering (also known as 'marcotting') (Yang 2003).

Wood density: low 560 kg/m^3; medium 610 kg/m^3; high 640 kg/m^3. Moisture content 15%.

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We thank Dr Francis S.P. Ng who kindly commented on this article.

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Photos of Jati Laut (*Podocarpus polystachyus*) taken at Sandakan Airport.

Figure 1. General habit of Jati Laut
Podocarpus polystachyus.
(Photo: Y.F. Lee)

Figure 2. Golden yellow pollen cones of Jati Laut. (Photo: V.K. Chey)

Figure 3. Close up of leafy twigs with some older cones. (Photo: Y.F. Lee)

Sepilok Bulletin 4: 61-63 (2006)

The pandan caterpillar

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During the last rainy monsoon in February 2006, a potted ornamental pandan plant (*Pandanus baptistii*, Pandanaceae) on the corridor of the Forest Research Centre (FRC) in Sepilok was attacked by an army of seven caterpillars.

The caterpillar was pandan-green in colour with a black head as well as a black kidney-shaped anal orifice (Figure 1). Each of its body segments appeared to be slightly ribbed. It was astonishing how the soft-looking caterpillar could feed on the stiff pandan leaves (Figure 2).

The caterpillar was found to occur singly. It could secrete copious silk used for rolling up the leaf, and it fed within the rolled-up leaf safe from predators. It generally fed from the tip of the leaf downwards, and could reach a body length of about 6 cm. The caterpillars were collected and put into rearing cages in the FRC insectarium for observation.

After a period of feeding, it pupated within the leaf-roll which was sealed with whitish silk. Each leaf-roll though rather long had only 1 pupa. The quiescent pupal stage lasted about 2 weeks.

The adult butterflies after emergence flew around rapidly when disturbed. They were skippers which resembled moths, but with hooked antennae. The species was identified as *Unkana ambasa batar*a Distant (Lepidoptera: Hesperiidae) (Maruyama 1991), or commonly known as the Hoary Palmer. It is a dark brown butterfly and sexually dimorphic, the female has the basal two-thirds of its hindwing whitened and the male is smaller in size (Figure 3). The forewing of both sexes has 3 hyaline spots arranged triangularly in the centre and several smaller spots near the tip.

According to Corbet & Pendlebury (1992), the species is found in lowland forest and open country, and the butterfly can be seen at flowers at dusk. It is distributed from N.E. India to Sundaland and the Philippines. Recorded hostplants of the caterpillar are another pandan, *Pandanus fascicularis* (= *odoratissimus*) and *Psychotria viridiflora* (Rubiaceae). Its congeners also feed on various pandans including *Pandanus atrocarpus* and *P. tectorius* (Robinson *et al.* 2001).

The attacked pandan sprouted new leaves and looked elegant once again a couple of months later.

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My colleague at FRC Mr Selamat Mail informed me of the caterpillar. Mr Momin Binti and Mr Willibrord Jimin of the Entomology Section assisted me in the rearing.

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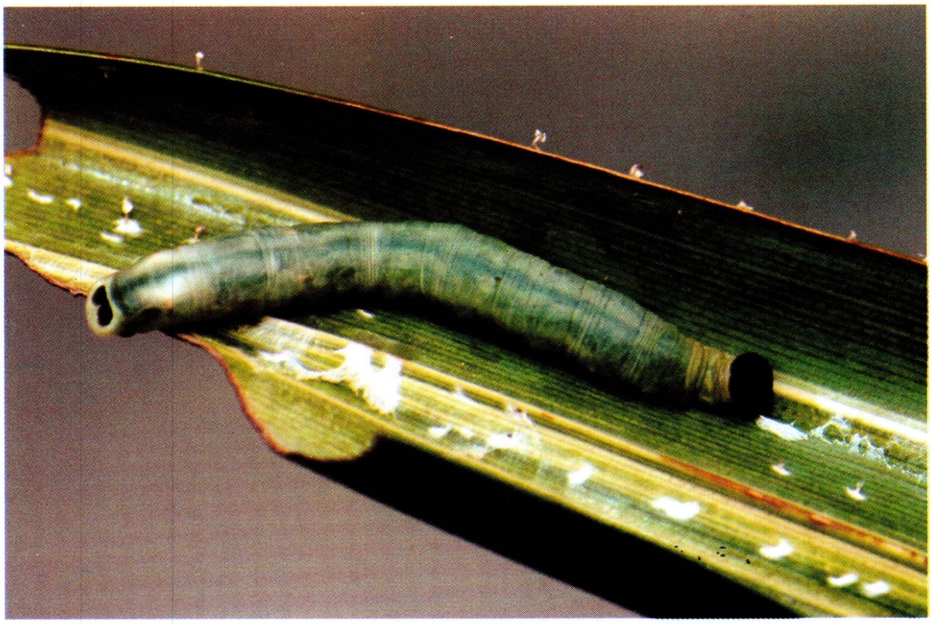
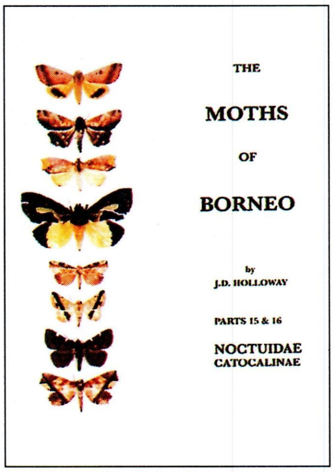


Figure 1. The pandan caterpillar within rolled-leaf.

Figure 2. The ornamental pandan.

Figure 3. *Unkana ambasa batara*. Male (top, wingspan 4.5 cm) and female (wingspan 5.5 cm).

BOOK REVIEW



The moths of Borneo. Parts 15 & 16. Noctuidae: Catocalinae by J.D. Holloway. Published by Malaysian Nature Society, Kuala Lumpur, 2005. Pp. 529. ISBN 983-40053-7-7.

Reviewed by V.K. Chey

Dr Jeremy Holloway of the Natural History Museum in London has been consistently publishing this series on the moths of Borneo since 1983. The present double issue focuses on the Catocalinae. Many moths of this group, medium to large in size, are found in secondary forests.

Apart from butterflies, moths are the best-known insect group in Borneo. Being bigger in species number, more easily sampled and mainly herbivores, moths are considered the best indicators of forest biodiversity. The book, as with previous books in the series, is used primarily as a species identification tool important in biodiversity assessment.

In the Foreword, the author warns the reader for major changes to previously accepted taxonomic placements. Many members of Ophiderinae, e.g. *Ischyja* spp. have been moved to Catocalinae. Prior to this, the main illustrated account on Catocalinae/Ophiderinae is included in the excellent AN INTRODUCTION TO THE MOTHS OF SOUTH EAST ASIA by Dato' Henry Barlow, published in 1982. Barlow successfully illustrated many of the frequently encountered moths. Readers who want to identify the less common species, however, will need a copy of this new book by Holloway.

The book is the biggest in the moths of Borneo series, with 27 colour plates of adult moths covering 591 species. In Borneo, there are altogether about 4,000 moth species excluding micros, so this book covers more than a tenth of its moth fauna. Each species is described with details on its taxonomy, geographical range, habitat preference and biology. The plates are splendidly produced, showing set specimens in natural colour. There is also a colour plate with pictures of two caterpillars by Mr Hok Kim Loong. I for one wish that there are more pictures of caterpillars, the stage one normally encounters on the various hostplants.

So far fifteen out of a planned eighteen parts of the moths of Borneo have been published. The remaining three parts are scheduled to come out in the next two years. We in Borneo are indeed thankful to Holloway for his invaluable contribution. The book is also published as Volume 58 (Parts 1-4) of the Malayan Nature Journal.

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