

## HABITAT CHARACTERISTICS OF ANOA (Bovidae: *Bubalus* spp.) IN TANJUNG PEROPA WILDLIFE RESERVE, SOUTH EAST SULAWESI

(Karakteristik Habitat Anoa - *Bubalus* spp. di Suaka Margasatwa Tanjung Peropa, Sulawesi Tenggara)

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Diterima 10 Januari 2009 / Disetujui 15 Maret 2009

### ABSTRAK

Habitat anoa di Hutan Kalobo di bagian selatan Suaka Margasatwa Tanjung Peropa, Sulawesi Tenggara terdiri atas hutan pinggiran sungai, hutan bamboo, hutan dataran rendah dan hutan yang didominasi oleh tebing batu pada ketinggian di atas 400 m dpl (cliff-forest). Jumlah jenis tumbuhan tingkat pohon (dbh > 20 cm) pada tipe-tipe habitat tersebut berturut-turut 43 jenis, 29 jenis, 55 jenis dan 36 jenis untuk hutan pinggiran sungai, hutan bamboo, hutan dataran rendah dan hutan berbatu. Di hutan pinggiran sungai, jenis tumbuhan yang dominan yaitu *Pittosporum* sp., *Diospyros malabarica*, *Ficus* spp. and *Dracontomelon mangiferum*, sedangkan di hutan bambu didominasi oleh *Schizostachyum lima* and *Schizostachyum cf brachycladum*. Di hutan dataran rendah, jenis tumbuhan terutama adalah *Diospyros malabarica*, *Canarium odoratum*, *Lophopetalum fimbriatum*, *Parkia roxburghii* dan *Tetrameles nudiflora*. Di habitat berbatu, jenis tumbuhan didominasi oleh *Barringtonia acutangula*, *Diospyros pilosanthera*, *Tetrameles nudiflora*, *Celtis philippensis*, *Rhodamnia mulleri*, dan *Mimusops bojeri*

Kata kunci : Habitat, anoa, konservasi, suaka margasatwa

### INTRODUCTION

Anoa or the dwarf buffalo have a body weight of only 100 kg and their shoulder height is 80-100 cm, yet they are the biggest of Sulawesi's rain forest ungulates. These secretive forest ungulates inhabit rain forests on Sulawesi both in protected and unprotected forests including national parks, wildlife reserves, nature reserves, recreational forests, protection forests and production forests. Populations of anoa in the latter forest category have been threatened due to the direct lost of their suitable habitats caused by the excessive forest exploitation by the forest concessionaires. While populations of anoa in conservation areas are relatively safe, yet illegal logging and poaching within the forests are still rampant indicating that populations of the rare species are in brink of extinction if there are no conservation measures devoted for the animals.

One of the conservation areas where anoa can relatively easily be observed on the island is Tanjung Peropa Wildlife Reserve. Mustari (2004) reported that anoa could be found inhabiting mangrove, beach, lowland, riverine, bamboo, rocky-cliff forests up to 900 m asl in the reserve. He also reported that the population density of anoa in this reserve was 0.9 anoa/km<sup>2</sup> and based on this density, population of anoa in this conservation area (38,927 ha) was estimated to be 350 individuals.

Mustari (1995) also reported that habitats of lowland anoa in Tanjung Amolengo wildlife reserve included

mangrove, beach and lowland forests. Syam (1977) reported that feeding ranges of anoas in Tangkoko-Batuangus Nature Reserve covered secondary forest, lowland forest and mountain forest. Browsing signs of these animals were frequently found in openings in the forest and in rugged areas where a variety of herbaceous plants were available, including many species of ferns (Wirawan 1981).

Tanjung Peropa wildlife reserve is situated between 122° 45' – 122° 45' East and 4° 35' - 4° 57' South covering a forested area of 38, 937 ha which is 140 km south of Kendari, the capital city of Southeast Sulawesi. Kalobo forest is situated in the south of the reserve covering a wide range of habitat types including patchy mangrove forest, beach forest, riverine forest, bamboo thickets, lowland forest, rocky-lowland forests and rocky-cliffs forests. Rugged terrain, rock-cliffs, dense forest, primary forest and emergent trees of up to 50 m in height are the main characteristics of the forest and in many parts of the study site the slopes are up to 90°.

Wildlife species in the reserve include Sulawesi warty pig *Sus celebensis*, bear cuscus *Ailurops ursinus* and Sulawesi dwarf cuscus *Strigocuscus celebensis*. Of the birds, this forest is the main habitat of Sulawesi red-knobbed hornbill *Rhyticeros cassidix*, Sulawesi dwarf hornbill *Penelopides exarhatus*, Tabon scrubfowl *Megapodius cumingii* and maleo *Macrocephalon maleo*.

This study aims to reveal general features of Kalobo Forest of Tanjung Peropa Wildlife. The habitats

characteristics include composition and structure of vegetation community, topography, and habitat components.

### RESEARCH METHODOLOGY

Line transect method was used to distribute nested plots for vegetation analysis. The nested plots were systematically placed along these transects at each of the habitat types, one every 50 m and alternating sides. A total of 112 plots sampled (26 plots in the riverine forest, 17 plots in the bamboo forest, 36 plots in the lowland forest, and 23 plots in the rocky-cliffs forest).

Plants were classified as tree, pole, sapling, seedling and undergrowth. The plot sizes were 20 m x 20 m for trees, 10 m x 10m for poles, 5 m x 5 m for saplings and 2 m x 2 m for seedlings and undergrowth. The smaller plots were nested within the bigger plots, giving nested sampling. Bamboos and rattans were recorded in the 20m by 20 m plots along with trees. The numbers of clumps of bamboos and rattans were counted (Fig.1). The habitat components

including springs, wallowing sites, water holes and cover that were frequently visited by the animals at each of the habitat types were recorded.

The dominant plant species in each of the forest types were determined by their Species-Importance-Value (SIV) (Curtis and Cottam, 1964). The SIV is based on each species' Relative Density (N %), Relative Frequency (F %) and Relative Dominancy (BA %). Relative density is the number of individuals of one species as a percentage of the total number of individuals of all species. Relative frequency is defined as the number of occurrences of one species in the plots as a percentage of the total number of occurrences of all species. Relative dominancy, which was based on the basal area of the trees (BA %), is the total basal area of one tree species as a percentage of the total basal area of all tree species. The Species Importance Value (SIV) is the total sum of N %, F % and BA % for trees, poles and sapling stages of tree species, and the sum of N % and F % for seedlings and species of the undergrowth communities.

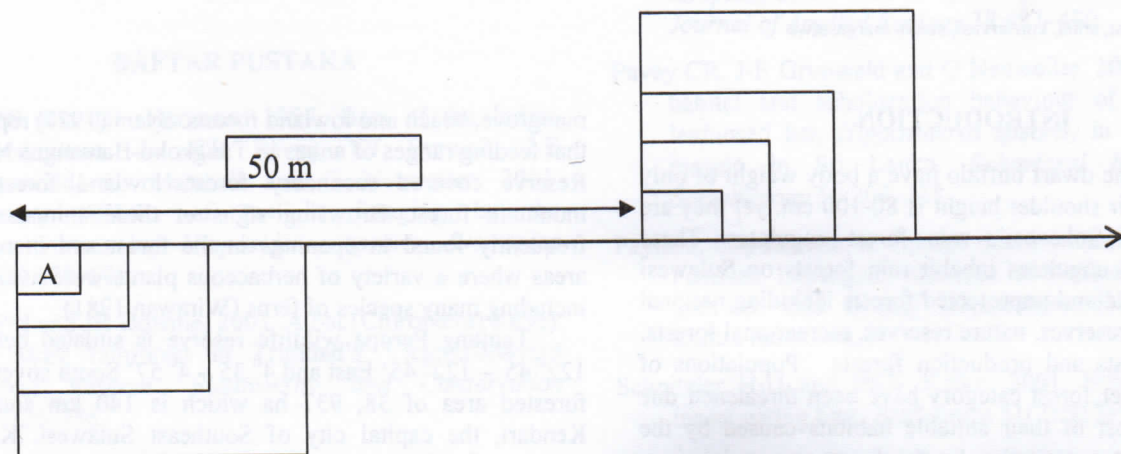


Fig. 1. Design of line transects for distribution of nested plots for vegetation analyses; larger plots enclose the smaller plots (nested sampling).

- A : 2m x 2m (seedlings and undergrowth species, height up to 1.5 m)
- B : 5m x 5m (saplings, height > 1.5 m to dbh ≤ 10cm )
- C : 10m x 10m (poles, dbh > 10 cm to ≤ 20cm)
- D : 20m x 20m ( trees dbh > 20cm, and rattan and bamboo clumps)

### RESULTS AND DISCUSSION

At least four habitat types could be determined in this forest including riverine forest, bamboo forest, lowland forest and rocky-lowland forests. As in any other lowland tropical rain forest, canopy cover of the forest types ranges from 80 to 100 %. The forests are characterised by

emergent trees having large buttresses in the valleys and along the river banks and by a dense undergrowth community particularly rich in rattans *Calamus* spp. (at least 22 rattans species were recorded in this reserve), lianas and herbs.

### Riverine Forest

Riverine forest is situated along the river influenced by both the wet conditions and by the new sediments deposited on the inside of meanders of the river. The riverine forest forms a narrow belt along the river and its tributaries, ranging from 0 to 200 m of the river banks and covering an area of 250 ha at 50-200 m elevation.

Forty three plant species with diameters of 20 cm or more at breast height were recorded in this forest (Table 1). The total density of the trees is 113 trees/ha and the total basal area is 17.9 m<sup>2</sup>/ha. Vegetation community is dominated by *Pittosporum* sp. which is a distinctive species along the river banks, some individuals of which reached 30 m in height and 1.5-2 m in diameter at breast height. Other species include *Diospyros malabarica*, *Ficus* spp. and *Dracontomelon mangiferum*, fruits of which are eaten by several mammals including particularly lowland anoa, Sulawesi warty pigs and Sulawesi black macaques and by some birds including Red-knobbed hornbill, Tarctic hornbill and doves and pigeons of the Columbidae family. The emergent trees of *Octomelos sumatrana* reached 60 m in height with a 1.5 m girth, and could be found along the river banks. This species is sought after by the local people, particularly for making boats, since it has long, straight, free boles with large diameter. Other trees that could be found along the riverine forest include *Pometia pinnata* whose fruits are eaten by the mammals and birds.

The edible fruit of *Pangium edule* and *Artocarpus* sp. are common along the river banks; some of these trees have buttresses up to 2 m in height which are frequently used by the terrestrial animals as cover. Fruits of these plants are eaten by lowland anoa, Sulawesi wild pig and Sulawesi black macaque. On the rugged areas of the river banks, the sugar palm *Arenga pinnata* is common. Of the middle-storey community, the predominant species are *Lophopetalum fimbriatum*, *Homalium tomentosum* and *Canarium odoratum*.

Of the undergrowth, the predominant species are rattans *Calamus* spp., *Elastotema rostratum* and *Leea aculeata*. Six species of rattans were recorded in this forest having a density of 695 clumps/ha which is the highest density of rattans amongst the studied habitat types. Scattered bamboo clumps could also be found in the riverine forest, providing food and cover for the lowland anoa. The 1m- tall herb *Elastotema rostratum* is the most common (3269 stems/ha) undergrowth species in this forest, particularly in sites with high humidity, specifically around water holes and springs. This herb is eaten by the lowland anoas. Other undergrowth species in this habitat type include *Donax cunnaeformis* (2019 stems/ha) and a fern *Microlepia* sp. (673 stems/ha). This fern is eaten by lowland anoa, wild pig and rusa deer in the reserves.

At least two water holes were in this forest; each was 4 m wide and 0.5 m deep. The water holes were frequented by the lowland anoa and wild pigs, and were situated 30 m from the river banks and surrounded by undergrowth such as *Pachystachys coccinea*, *Elastotema rostratum*, *Donax cunnaeformis*, bamboos and rattans. Foot-prints and dung of the anoas were frequently observed around the water holes.

### Bamboo forest

Bamboos occupy a wide range of habitats ranging from the riverine forest, lowland forest and rock-lowland forest up to 800 m above sea level. In many parts of the reserve, bamboos dominated the vegetation community with the canopy coverage represented more than 80% of the vegetation community. The bamboo forest covers an area of 250 ha extending from 50 to 200 m above sea level. The bamboo forest is situated immediately next to the riverine forest or immediately on the river banks, making the bamboo forest itself a riverine forest. Two species of bamboos were recorded in the reserve, *Schizostachyum lima* and *Schizostachyum cf brachycladum*. The first species has smaller stems, 2-3 cm diameter and 5 m tall, and is found mainly on flat areas, while the latter species has larger trunks, some of which reached 15 cm in diameter and 30 m in height, and prefers rugged areas.

The total density for *Schizostachyum lima* is 265 clumps/ha at 42 stems/ha, while for *Schizostachyum cf brachycladum* the total density is 136 clumps/ha at 30 stems/clump. The canopy cover of the bamboo forest is 80-100%. Shoots and young leaves of the bamboos are eaten by lowland anoa.

Dicotyledonous trees species that could be found in the bamboo forest include *Kjellbergiodendron celebicum*, *Dracontomelon mangiferum*, *Parkia roxburghii* and *Garcinia dulcis*, fruits of all of which are eaten by lowland anoa, wild pigs and Sulawesi black macaque. Despite the trees density in this forest being relatively high (107 trees/ha), the total basal area of trees was relatively low (7.5 m<sup>2</sup>/ha) compared to that of the riverine and lowland forests. Of the middle vegetation community, the edible leaves and fruits of *Gnetum gnemon* could be found in the bamboo forest. SIV of the trees in Bamboo are listed on Table 2.

At least two water holes were in the bamboo forest, with diameters of 6 m and 3 m respectively, and tributaries in this habitat types have become water sources for the animals. Bamboo clumps provide shelter and cover for the animals. A giant fallen hollow tree of *Pterocarpus indicus*, with a dbh 1.5 m and 15 m length, in the bamboo forest was frequently used by the animals as shelter both at night and by day and during heavy rains. Its use was indicated by the foot-prints and fresh dung of the animals inside the hollow tree.

### Lowland forest

Lowland forest in this study site is defined as forest other than the riverine, bamboo and rocky-lowland forests. The lowland forest covers vast area of the reserve, representing two-thirds of the area. In Kalobo, this forest covers an area of about 2,000 ha, 50% of the forest in this study site, ranging from 50 to 600 m asl.

Lowland forest has the highest plant species diversity, including canopy trees, middle storey and undergrowth species. A total of 55 trees with diameters of 20 cm or more at breast height are known (Table 3). The total density of the trees is 94 trees/ha and their total basal area is 10.5 m<sup>2</sup>/ha. Of the trees, the predominant species are *Diospyros malabarica*, *Canarium odora-tum*, *Lophopetalum fimbriatum*, *Parkia roxburghii*, *Tetrameles nudiflora* and *Ocrotomeles sumatrana*, which reached 50 m in height and had buttresses up to 3 m tall. The middle stratum vegetation community is predominantly composed of *Gnetum gnemon*, *Orophea enneandra*, and *Cleistanthus sumatranus*.

Rattans are the main vegetation community of the undergrowth, where nine species of rattans were recorded in this forest with a density of 250 clumps/ha, of which *Calamus zollingeri* (182 clumps/ha) was the predominant species. Other palms that could be found in this forest are *Caryota mytis* and *Livistonia rotundifolia*. As in the other habitat types, clumps of bamboos could be found all over the forest. Of the herb community, *Elastotema rostratum* (6875 stems/ha) dominated this area particularly along the water courses, and around water holes and springs in this forest.

Springs and water courses frequented by lowland anoas and wild pigs could also be found in the lowland forest. At least two permanent springs, each having a 10 m diameter, were known in this forest type. They were situated under dense bamboo clumps and undergrowth of *Pandanus* sp., and surrounded by the 2m-tall herb *Donax cunnaeformis* and the common herb *Elastotema rostratum* and tall trees of *Artocarpus* sp. Two sightings of lowland anoa and hoof-prints of the animals on the springs suggest that these springs have become focal points for the animals.

### Rocky-cliff forest

Rocky lowland forest dominated along the eastern side of Tanjung Peropa, characterized by massive rocks, caves and rock-cliff formations at 200 - 600 m elevation and covering an area of 1,500 ha. Anoa are capable of travelling in the rocky forests as indicated from their dung, foot-prints and direct encounters with the animals in this habitat type. They could also use natural paths between the rocks connecting one site to another in the forest. Since this area is rarely entered by the local people, due to its low accessibility, this habitat is important as cover and shelter for the animal. On one occasion, an adult male lowland

anoa was sighted sheltering in a cave in this forest at 260 m elevation at 1100h.

Compared with forests on deeper soils, such as the riverine, bamboo and lowland forest, forest in this rocky habitat has few trees species. A total of 36 trees with diameters of 20 cm or more at breast height were recorded in this habitat type (Table 4). The total density of trees is 96 trees/ha and the total basal area is 9.5 m<sup>2</sup>/ha. On the deeper soils in between the massive rocks and caves and in the valleys, tree species such as *Barringtonia acutangula*, *Diospyros pilosanthera*, *Tetrameles nudiflora*, *Celtis philippensis*, *Rhodamnia mulleri*, and *Mimusops bojeri* are common and some of the trees reached 40-45 m in height. The upper parts of the limestone are clothed in small trees growing 10-15 m tall out of cracks and small pockets of soil, while on the steepest cliffs, the most common trees are figs, *Ficus* spp. Clumps of bamboos could be found on the pockets of soil in the wetter parts of the forest. Plants of the undergrowth community that are frequently eaten by the lowland anoas in this area include *Leptapsis banksii*, *Elastotema rostratum*, *Microlepis* sp. and *Isachne albens*. In the forest gaps, the undergrowth community is dominated by the spiny shrub *Rubus moluccanus*.

### CONCLUSION

In their natural habitat, anoa inhabit many habitat types including riverine, bamboo, lowland and rocky-cliff forests that provide food, cover, drinking water, wallowing sites and for travel and interacting socially. These habitat types complement each other in providing these resources that are essential for the animals. Therefore an uninterrupted set of habitats ranging from mangrove and beach forests to forests at high altitude and in mountainous areas needs to be considered in any management plan for anoa.

### ACKNOWLEDGEMENTS

Financial support for this study was provided by the Australian Development Scholarship (ADS) and Edinburgh Zoo. I appreciate the help of the staffs of the Bureau of Natural Resources Conservation (KSDA) of Kendari. This study would never have been completed without the assistance of many people in the forests, especially La Tie, Ahmad S.Si., Pak La Uno, Pak Kadir, Pak Sungkono, Antu, Engu, Idar and Tia for their helps during the field work.

### REFERENCES

- Curtis JT and G Cottam. 1964. *Plant ecology work book*. Burges Publ. Co., Minnesota: p.67.
- Mustari AH. 1995. Population and behaviour of lowland anoa (*Bubalus depressicornis*) in Tanjung Amolengo

- Wildlife Reserve, Southeast Sulawesi, Indonesia. MSc. Thesis, Georg-August University, Göttingen, Germany.
- Mustari AH. 2004. Ecology and conservation of lowland anoa (*Bubalus depressicornis*) in Sulawesi, Indonesia. PhD Dissertation. University of New England, Australia.
- Syam A. 1997. Studi habitat dan populasi anoa dataran rendah (*Anoa depressicornis* H. Smith) di Cagar Alam Gunung Tangkoko Batuangus, Sulawesi Utara. BSc. Thesis. Fakultas Kehutanan Institut Pertanian Bogor, Indonesia.
- Wirawan N. 1981. Ecological survey of the proposed Lore Lindu National Park, Central Sulawesi. Universitas Hasanuddin, Ujung Pandang.

Table 1. Floristic composition of trees (dbh > 20 cm) in Riverine Forest, ranked by Species Importance Value (SIV). N=Number of trees, F=Frequency, and BA=Basal Area.

No	Botanical name	N/ha	N (%)	F	F (%)	BA (m <sup>2</sup> /ha)	BA (%)	SIV (%)
1	<i>Pittosporum sp.</i>	7	6.0	5	4.9	5.3819	28.8	39.7
2	Unknown species	11	9.4	7	6.8	0.8470	4.5	20.7
3	<i>Diospyros malabarica</i>	10	8.5	6	5.8	0.8694	4.7	19.0
4	<i>Ficus sp.</i>	4	3.4	4	3.9	2.1756	11.7	19.0
5	<i>Dracontomelon mangiferum</i>	7	6.0	6	5.8	0.8954	4.8	16.6
6	<i>Artocarpus sp.</i>	6	5.1	6	5.8	0.7032	3.8	14.7
7	<i>Pangium edule</i>	6	5.1	6	5.8	0.6205	3.3	14.3
8	<i>Canarium odoratum</i>	7	6.0	5	4.9	0.3848	2.1	12.9
9	<i>Lithocarpus sp.</i>	4	3.4	4	3.9	0.7069	3.8	11.1
10	<i>Pterocymbium tinctorium</i>	4	3.4	4	3.9	0.6620	3.5	10.8
11	<i>Pterospermum celebicum</i>	4	3.4	4	3.9	0.3711	2.0	9.3
12	<i>Macaranga gigantea</i>	4	3.4	4	3.9	0.2393	1.3	8.6
13	Unknown species	4	3.4	4	3.9	0.2285	1.2	8.5
14	<i>Homalium tomentosum</i>	4	3.4	3	2.9	0.3318	1.8	8.1
15	<i>Canarium hirsutum</i>	3	2.6	3	2.9	0.4477	2.4	7.9
16	<i>Erythrina subumbrans</i>	2	1.7	2	1.9	0.6283	3.4	7.0
17	<i>Planchonia valida</i>	2	1.7	2	1.9	0.2278	1.2	4.9
18	<i>Orophea enneandra</i>	2	1.7	2	1.9	0.1748	0.9	4.6
19	<i>Semecarpus cuneiformis</i>	2	1.7	2	1.9	0.0694	0.4	4.0
20	<i>Octomelos sumatrana</i>	1	0.9	1	1.0	0.3849	2.1	3.9
21	<i>Ficus drupacea</i>	1	0.9	1	1.0	0.3849	2.1	3.9
22	<i>Vitex cf glabrata</i>	1	0.9	1	1.0	0.3318	1.8	3.6
23	<i>Clerodendron sp.</i>	1	0.9	1	1.0	0.1964	1.1	2.9
24	<i>Fatoua pilosa</i>	1	0.9	1	1.0	0.1964	1.1	2.9
25	<i>Aglaiia edulis</i>	1	0.9	1	1.0	0.1590	0.9	2.7
26	<i>Inocarpus fagiferus</i>	1	0.9	1	1.0	0.0962	0.5	2.3
27	<i>Lophopetalum fimbriatum</i>	1	0.9	1	1.0	0.0962	0.5	2.3
28		1	0.9	1	1.0	0.0962	0.5	2.3
29	<i>Diospyros pilosanthera</i>	1	0.9	1	1.0	0.0707	0.4	2.2
30	<i>Cryptocarya infectori</i>	1	0.9	1	1.0	0.0707	0.4	2.2
31	<i>Ficus macrophyllus</i>	1	0.9	1	1.0	0.0707	0.4	2.2
32	<i>Intsia bijuga</i>	1	0.9	1	1.0	0.0707	0.4	2.2
33	<i>Syzygium luzonense</i>	1	0.9	1	1.0	0.0707	0.4	2.2
34		1	0.9	1	1.0	0.0491	0.3	2.1
35	<i>Duabanga moluccana</i>	1	0.9	1	1.0	0.0491	0.3	2.1
36	<i>Lithocarpus sp.</i>	1	0.9	1	1.0	0.0491	0.3	2.1
37	<i>Evodia speciosa</i>	1	0.9	1	1.0	0.0416	0.2	2.0

38	<i>Palaquium obtusifolium</i>	1	0.9	1	1.0	0.0416	0.2	2.0
39	<i>Solanum verbascifolium</i>	1	0.9	1	1.0	0.0380	0.2	2.0
40	<i>Goniothalamus sp.</i>	1	0.9	1	1.0	0.0380	0.2	2.0
41	<i>Nauclea calycina</i>	1	0.9	1	1.0	0.0380	0.2	2.0
42	<i>Schefflera elliptica</i>	1	0.9	1	1.0	0.0314	0.2	2.0
43	<i>Dendrocnide cf. peltata</i>	1	0.9	1	1.0	0.0314	0.2	2.0

Table 2. Floristic composition of trees (dbh > 20 cm) assemblage in the **Bamboo Forest**, ranked by Species Importance Value (SIV). N=Number of trees, F=Frequency, and BA=Basal Area.

No	Botanical name	N/ha	N (%)	F	F (%)	BA (m <sup>2</sup> /ha)	BA (%)	SIV (%)
1	<i>Kjelbergiodendron celebicum</i>	16	15.1	6	13.0	1.1230	22	50.0
2	<i>Dracontomelon mangiferum</i>	6	5.5	4	8.7	0.3855	8	21.7
3	<i>Parkia roxburghii</i>	16	15.1	1	2.2	0.0962	2	19.1
4	<i>Archidendron lucyi</i>	16	15.1	1	2.2	0.0380	1	18.0
5	<i>Lithocarpus sp.</i>	4	4.1	3	6.5	0.3240	6	17.0
6	<i>Diospyros venenosa</i>	4	4.1	3	6.5	0.2160	4	14.9
7	<i>Diopyros malabarica</i>	3	2.7	2	4.3	0.3220	6	13.4
8	<i>Ficus drupacea</i>	1	1.4	1	2.2	0.5027	10	13.4
9	<i>Orophea emeandra</i>	4	4.1	2	4.3	0.2278	4	12.9
10	<i>Artocarpus dasyphyllus</i>	3	2.7	2	4.3	0.2642	5	12.2
11	Unknown species	3	2.7	2	4.3	0.1571	3	10.2
12	<i>Celtis philippensis</i>	3	2.7	2	4.3	0.1087	2	9.2
13	<i>Sterculia foetida</i>	1	1.4	1	2.2	0.2827	6	9.1
14	<i>Syzygium polyanthum</i>	3	2.7	1	2.2	0.1346	3	7.5
15	Unknown species	1	1.4	1	2.2	0.1964	4	7.4
16	<i>Spondias sp.</i>	1	1.4	1	2.2	0.1257	2	6.0
17	<i>Canarium sp.</i>	1	1.4	1	2.2	0.0855	2	5.2
18	<i>Canarium sp.</i>	1	1.4	1	2.2	0.0707	1	4.9
19	<i>Heritiera trifoliata</i>	1	1.4	1	2.2	0.0707	1	4.9
20	<i>Pterocymbium tinctorium</i>	1	1.4	1	2.2	0.0707	1	4.9
21	<i>Drypetes cf globosa</i>	1	1.4	1	2.2	0.0491	1	4.5
22	<i>Nephelium lappaceum</i>	1	1.4	1	2.2	0.0380	1	4.3
23	<i>Barringtonia racemosa</i>	1	1.4	1	2.2	0.0380	1	4.3
24	<i>Mimusops bojeri</i>	1	1.4	1	2.2	0.0346	1	4.2
25	<i>Octomelos sumatrana</i>	1	1.4	1	2.2	0.0314	1	4.2
26	<i>Ixora imitans</i>	1	1.4	1	2.2	0.0314	1	4.2
27	<i>Dehaasia caesia</i>	1	1.4	1	2.2	0.0314	1	4.2
28	<i>Cryptocarya infectori</i>	1	1.4	1	2.2	0.0314	1	4.2
29	<i>Alphonsea javanica</i>	1	1.4	1	2.2	0.0314	1	4.2

Table 3. Floristic composition of trees (dbh > 20 cm) assemblage in the **Lowland Forest**, ranked by Species Importance Value (SIV). N=Number of trees, F=Frequency, and BA=Basal Area.

No	Botanical name	N/ha	N (%)	F	F (%)	BA (m <sup>2</sup> /ha)	BA (%)	SIV (%)
1	<i>Diospyros malabarica</i>	6	6.7	7	5.8	0.8129	5.4	17.9
2	Unknown species	5	5.2	5	4.2	0.7815	5.2	14.5
3	<i>Canarium odoratum</i>	5	5.2	6	5.0	0.5311	3.5	13.7
4	<i>Lophopetalum fimbriatum</i>	4	4.4	5	4.2	0.5661	3.8	12.4
5	<i>Parkia roxburghii</i>	2	2.2	3	2.5	1.0210	6.8	11.5
6	<i>Homalium tomentosum</i>	3	3.7	5	4.2	0.5282	3.5	11.4
7	<i>Drypetes cf globosa</i>	4	4.4	6	5.0	0.1951	1.3	10.7
8	<i>Planchonia valida</i>	3	3.0	4	3.3	0.5285	3.5	9.8
9	<i>Celtis philippensis</i>	4	4.4	3	2.5	0.3407	2.3	9.2
10	<i>Orophea enneandra</i>	3	3.0	4	3.3	0.3974	2.6	8.9
11	<i>Clerodendron sp.</i>	3	3.0	4	3.3	0.3015	2.0	8.3
12	Unknown species	1	1.5	2	1.7	0.6990	4.6	7.8
13	<i>Palaquium obtusifolium</i>	2	2.2	3	2.5	0.4437	2.9	7.7
14	<i>Canarium sp.</i>	1	1.5	2	1.7	0.6617	4.4	7.5
15	<i>Pterospermum celebicum</i>	3	3.0	3	2.5	0.2906	1.9	7.4
16	<i>Pittosporum sp.</i>	1	1.5	2	1.7	0.6283	4.2	7.3
17	<i>Nephelium lappaceum</i>	3	3.7	3	2.5	0.1637	1.1	7.3
18	<i>Erythrina subumbrans</i>	2	2.2	3	2.5	0.3271	2.2	6.9
19	<i>Lithocarpus sp.</i>	2	2.2	3	2.5	0.3227	2.1	6.9
20	<i>Vitex cf glabrata</i>	1	1.5	2	1.7	0.5439	3.6	6.8
21	<i>barringtonia acutangula</i>	2	2.2	2	1.7	0.3809	2.5	6.4
22	<i>Tetrameles nudiflora</i>	2	2.2	3	2.5	0.2285	1.5	6.2
23	<i>Mitrephora celebica</i>	2	2.2	2	1.7	0.2533	1.7	5.6
24	<i>Aglaia edulis</i>	1	1.5	2	1.7	0.3534	2.3	5.5
25	<i>Diospyros venenosa</i>	2	2.2	2	1.7	0.2143	1.4	5.3
26	<i>Ficus drupacea</i>	1	0.7	1	0.8	0.5027	3.3	4.9
27	<i>Canarium hirsutum</i>	1	1.5	2	1.7	0.2513	1.7	4.8
28	<i>Mimusops bojeri</i>	1	1.5	2	1.7	0.1571	1.0	4.2
29	<i>Dracontomelon mangiferum</i>	1	1.5	2	1.7	0.1414	0.9	4.1
30	Unknown species	1	1.5	2	1.7	0.1021	0.7	3.8
31	<i>Ficus sp.</i>	1	0.7	1	0.8	0.2827	1.9	3.4
32	<i>Pangium edule</i>	1	0.7	1	0.8	0.2827	1.9	3.4
33	<i>Nauclea calycina</i>	1	0.7	1	0.8	0.1964	1.3	2.9
34	<i>Kjelbergiodendron celebicum</i>	1	0.7	1	0.8	0.1964	1.3	2.9
35	<i>Fatoua pilosa</i>	1	0.7	1	0.8	0.1590	1.1	2.6
36	<i>Octomelos sumatrana</i>	1	0.7	1	0.8	0.1257	0.8	2.4
37	<i>Litsea grandis</i>	1	0.7	1	0.8	0.1257	0.8	2.4
38	<i>Heritiera trifoliata</i>	1	0.7	1	0.8	0.1257	0.8	2.4
39	<i>Spondias sp.</i>	1	0.7	1	0.8	0.1257	0.8	2.4

Table 3. Continued

No	Botanical name	N/ha	N (%)	F	F (%)	BA (m <sup>2</sup> /ha)	BA (%)	SIV (%)
40	<i>Eugenia sp.</i>	1	0.7	1	0.8	0.1257	0.8	2.4
41	<i>Clerodendrum</i>	1	0.7	1	0.8	0.0962	0.6	2.2
42	<i>Goniothalamus sp.</i>	1	0.7	1	0.8	0.0804	0.5	2.1
43	<i>Pterospermum diversifolium</i>	1	0.7	1	0.8	0.0491	0.3	1.9
44	<i>Streblus asper</i>	1	0.7	1	0.8	0.0491	0.3	1.9
45	<i>Solanum verbascifolium</i>	1	0.7	1	0.8	0.0491	0.3	1.9
46	<i>Syzygium lineatum</i>	1	0.7	1	0.8	0.0491	0.3	1.9
47	<i>Vites cofasus</i>	1	0.7	1	0.8	0.0380	0.3	1.8
48	<i>Cordia xa</i>	1	0.7	1	0.8	0.0380	0.3	1.8
49	<i>Alphonsea javanica</i>	1	0.7	1	0.8	0.0380	0.3	1.8
50	<i>Garuga floribunda</i>	1	0.7	1	0.8	0.0346	0.2	1.8
51	<i>Vitex pinnata</i>	1	0.7	1	0.8	0.0314	0.2	1.8
52	<i>Dendrocnide microstigma</i>	1	0.7	1	0.8	0.0314	0.2	1.8
53	<i>Acalypha boehmerioides</i>	1	0.7	1	0.8	0.0314	0.2	1.8
54	<i>Canarium sp.</i>	1	0.7	1	0.8	0.0314	0.2	1.8
55	<i>Gymnachranthera paniculata</i>	1	0.7	1	0.8	0.0134	0.1	1.7

Table 4. Floristic composition of trees (dbh &gt; 20 cm) in Rocky-Lowland Forest, ranked by Species Importance Value (SIV). N=Number of trees, F=Frequency, and BA=Basal Area.

No	Botanical name	N/ha	N (%)	F	F (%)	BA (m <sup>2</sup> /ha)	BA (%)	SIV (%)
1	<i>Barringtonia acutangula</i>	8	8.0	7	9.5	0.9543	11.0	28.4
2	<i>Diospyros venenosa</i>	11	11.4	7	9.5	0.6017	6.9	27.7
3	<i>Tetrameles nudiflora</i>	8	8.0	5	6.8	0.4418	5.1	19.8
4	<i>Celtis philippensis</i>	8	8.0	5	6.8	0.377	4.3	19.0
5	<i>Rhodamnia mulleri</i>	3	3.4	3	4.1	0.7029	8.1	15.5
6	<i>Ficus drupacea</i>	2	2.3	2	2.7	0.8561	9.8	14.8
7	<i>Pterospermum diversifolium</i>	5	5.7	3	4.1	0.3787	4.3	14.1
8	<i>Ficus sp.</i>	3	3.4	3	4.1	0.4182	4.8	12.3
9	<i>Pongamia pinnata</i>	2	2.3	2	2.7	0.5439	6.2	11.2
10	<i>Mallotus sp.</i>	3	3.4	3	4.1	0.2461	2.8	10.3
11	<i>Kleinhovia hospita</i>	3	3.4	2	2.7	0.2344	2.7	8.8
12	<i>Orophea enneandra</i>	3	3.4	3	4.1	0.0943	1.1	8.5
13	Unknown species	4	4.5	1	1.4	0.1964	2.3	8.2
14	<i>Ficus variegata</i>	2	2.3	2	2.7	0.2553	2.9	7.9
15	<i>Pterocarpus indicus</i>	1	1.1	1	1.4	0.3849	4.4	6.9
16	<i>Intsia bijuga</i>	2	2.3	2	2.7	0.1198	1.4	6.4
17	<i>Clerodendron sp.</i>	2	2.3	2	2.7	0.0805	0.9	5.9



Table 4. Continued

No	Botanical name	N/ha	N (%)	F	F (%)	BA (m <sup>2</sup> /ha)	BA (%)	SIV (%)
18	<i>Mitrephora celebica</i>	2	2.3	2	2.7	0.0694	0.8	5.8
19	<i>Pterocymbium tinctorium</i>	2	2.3	2	2.7	0.0628	0.7	5.7
20	<i>Vitex pinnata</i>	1	1.1	1	1.4	0.1964	2.3	4.7
21	<i>Lithocarpus sp.</i>	1	1.1	1	1.4	0.1964	2.3	4.7
22	<i>Palaquium amboinensis</i>	1	1.1	1	1.4	0.1964	2.3	4.7
23	<i>Archidendron lucyi</i>	2	2.3	1	1.4	0.0628	0.7	4.3
24	<i>Drypetes cf globosa</i>	1	1.1	1	1.4	0.159	1.8	4.3
25	<i>Brucea javanica</i>	1	1.1	1	1.4	0.159	1.8	4.3
26	<i>Erythrina subumbrans</i>	1	1.1	1	1.4	0.1257	1.4	3.9
27	<i>Fatoua pilosa</i>	1	1.1	1	1.4	0.1257	1.4	3.9
28	<i>Artocarpus dasyphyllus</i>	1	1.1	1	1.4	0.0962	1.1	3.6
29	<i>Mimusops bojeri</i>	1	1.1	1	1.4	0.0962	1.1	3.6
30	<i>Canarium odoratum</i>	1	1.1	1	1.4	0.0707	0.8	3.3
31	<i>Nephelium lappaceum</i>	1	1.1	1	1.4	0.0707	0.8	3.3
32	<i>Sterculia macrophylla</i>	1	1.1	1	1.4	0.038	0.4	2.9
33	<i>Lophopetalum fimbriatum</i>	1	1.1	1	1.4	0.0346	0.4	2.9
34	<i>Homalium tomentosum</i>	1	1.1	1	1.4	0.0314	0.4	2.8
35	<i>Palaquium obtusifolium</i>	1	1.1	1	1.4	0.0177	0.2	2.7
36	<i>Canarium sp.</i>	1	1.1	1	1.4	0.0134	0.2	2.6