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REGULAR ARTICLE

Ecology of the Coastal Heath Forest flora - A case study from Terengganu, Malaysia

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Abstract

This study was conducted to determine the floral diversity and biomass in a coastal heath forest at Rantau Abang, Terengganu, Malaysia. The plot included contiguously arranged 100 subplots (10 m x 10 m). Results showed that 959 trees of 63 species belonging to 52 genera and 30 families are distributed in this coastal forest. Myrtaceae is the largest family (163 trees) followed by Annonaceae (160 trees) and Lecythidaceae (100 trees). Euphorbiaceae is the most diverse family containing 6 genera and 6 species. *Syzygium claviflorum* var. *claviflorum* (15.5%) was the dominant species followed by *Polyalthia hypogaea* (12.7%) and *Barringtonia macrostachya* (10.4%). Dipterocarpaceae has a small stocking as compared to the non-dipterocarp families in this forest. This family comprised about 9% of tree density and 6% of tree species diversity. The dominant species from Dipterocarpaceae is *Shorea materialis*. The total biomass in the forest lies around 249 ton/ha. The largest contribution to the biomass comes from Dipterocarpaceae with 86 ton/ha (34.5%) followed by Myrtaceae 75.3 ton/ha (30.2%). The biomass contribution of *Shorea materialis* is78.8 ton/ha, followed by *Syzygium claviflorum* 67.8 ton/ha. The biomass of *Champereia griffithii* is 0.006 ton/ha.

Key words: Coastal Heath Forest, Floral Diversity, Ecology, Biomass

Introduction

The tropical forests are undoubtedly world's richest ecosystem and one of the most valuable natural resource in developing countries (Darus, 1982). In Malaysia these forests form a highly complex ecosystem with a rich and varied biodiversity. There are many forest types distributed in the country such as the lowland forest, mixed dipterocarp forest (MDF), peat swamp forest, mangrove forest, hill forest and heath forest. The heath forest locally known as "*Hutan Kerangas*"includes dry land sites in the lowlands and submontane zone with low stature. This special type of tropical rain forest is typically found on the Borneo Island (divided between Brunei, Indonesia and Malaysia), as well as on Belitung and Bangka (the Indonesian islands), which lies to the west of Borneo. The habitants of this special and rare type of forest are extremophils due to their extreme ecological conditions.

The soil of the heath forest areas is sandy, acidic and extremely nutrient-poor. Hence, they have adapted unconventional ways to get their nutritions, including symbiosis with some bacteria in their root nodules for nitrogen fixation (*Gymnostoma nobile*) as well as parasitism e.g., pitcher plants (*Nepenthes* spp.), sundews (*Drosera* ssp.), and bladderwort (*Utricularia* ssp). According to Proctor (1999), these forests are growing on soils which are highly acidic, such that hydrogen ion toxicity prevents the growth of non-adapted species. Heath forest soil degrade very quickly to bleached sand once the forest cover is removed, making this type of forest extremely fragile (Witmore, 1987). The soil types of this forest comprise old raised beaches and intervening depression running parallel to the present coastline. The dipterocarps together with several lowland forests are different from the heath forests. The species diversity as well as their external morphology differs to a large extent. They are not as tall as the plants in other rainforests showing single layer canopy with height varying between 4.5 to 9 meteres. They generally have large saplings and small poles. The undergrowth is composed of a thick cover of mosses and epiphytes

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and small, sclerophyllous (leathery) leaves like the maquis in the Mediterranean (Ozturk 1995; Ozturk et al., 2002, 2008, 2010). In the Heath Forest, the storey formed by the large sapling and small poles predominates. The canopy is low, uniform and usually densely closed with no trace of layering. Leaf size is smaller and trees often are densely packed and difficult to penetrate. Trees usually reach up to 20 m in height. Trees of large girth are rare but still root commoner, buttresses are small and epiphytes are common (Whitmore, 1984). The ground usually has a bryophyte cover. The streams draining areas of Heath forest are tea-coloured by transmitted light and opaque black by reflected light owing to the presence of colloidal humus. They are usually acid (pH<5.5), with low clay content, derived from rocks under ever-wet conditions (Bruing, 1974).

In Peninsular Malaysia, the detailed information about the floral diversity and biomass in the coastal heath forest is lacking as compared to other forest types, in particular the relationship between plant diversity and habitat variation which remains poorly understood. The coastal heath forests were dominated by dipterocarps like *Shorea glauca* at Tanjong Hantu on the west coast and *S. materialis* on the east coast of Peninsular Malaysia.In this paper an attempt has been made to present the composition of tree taxa and biomass in the rare coastal heath forest at Terengganu. Information on the species composition as well as the ecology of a forest type is important to support, recommend or help policy makers to decide on matters pertaining to forestry development as well as management and conservative programs.

Material and Methods

The study area is located within Jambu Bongkok Virgin Jungle Reserve (370 ha) at Rantau Abang, Terengganu (4°55'N, 103°21'E) (Figure 1); with altitude varying between 3-12m. This forest was delimitted in 1960, opened in 1982 and authorized on 11thJuly 1994.The study area is a coastal heath forest without any slope, with low statute, lacking emergent vegetation, thus resembling an open canopy forest. Since the trees lack many canopies, the forest receives direct sunlight.

A 1-ha study plot (50 m x 200 m) was established in the coastal heath forest (Figure 1). The plot was divided into 100 subplots of (10 m x 10 m) and each subplot was labeled using alphabets and numerals (Figure 2). All trees with 5 cm DBH (diameter at breast height) and above were enumerated, measured and identified up to the species level.

The formula used to calculate the biomass of trees is as follows:

$Y = 0.0921*(dbh)^{2.5899}$ (Roland and Lim, 1999)
Where, Y=total biomass (kg/ha) dbh=diameter at breast height (cm)
Conversion to ton/ha:-$\frac{Y \times 0.9842}{1000}$
Where, Y=total of biomass (kg/ha)

Results and Discussion

Plant diversity and ecological features

The detailed plant diversity (5 cm dbh and above) of the study area is presented in Table 1. Euphorbiaceae was found to be the most diverse family with 6 genera and 6 species, but the number of trees for Myrtaceae (163) was greater than Euphorbiaceae (51). The smallest families were Araliaceae, Olacaceae, Opiliaceae, Styracaceae and Tiliaceae. All these are represented by 1 genus, 1 species and 1 tree. The forest is dominated by non-dipterocarp species belonging to the families Myrtaceae, Annonaceae, Lecythidaceae and Guttiferae.

There are 59 species with 877 trees (94%) in the study area (Table 1). This number is greater than dipterocarp species (4 species with 82 trees-6%) (Figure 3). The percentage density of non-dipterocarp species is about 91%, which is greater than dipterocarp species (9%) (Figure 4). Non-dipterocarp species thus constitute the dominate plant diversity of the coastal heath forest. The Heath forests of Sarawak, Brunei and the Nabawah heath forests of Sabah contain 849 tree species. These forests are richer in plant species and endemics than elsewhere in the eco-region.

The 10 largest and 10 smallest families in 1-ha plot at Terengganu are shown in Table 2 and Table 3. Euphorbiaceae is the dominating family composed of 6 genera and 6 species followed by Guttiferae with 2 genera and 6 species.

The percentage composition of trees at 5 cm dbh and above in 1-ha plot in the coastal heath forest is presented in table 4. The forest is dominated by *Syzygium claviflorum* (15.5%), followed by *Polyalthia hypogaea* (12.7%) and *Barringtonia macrostachya* (10.4%).

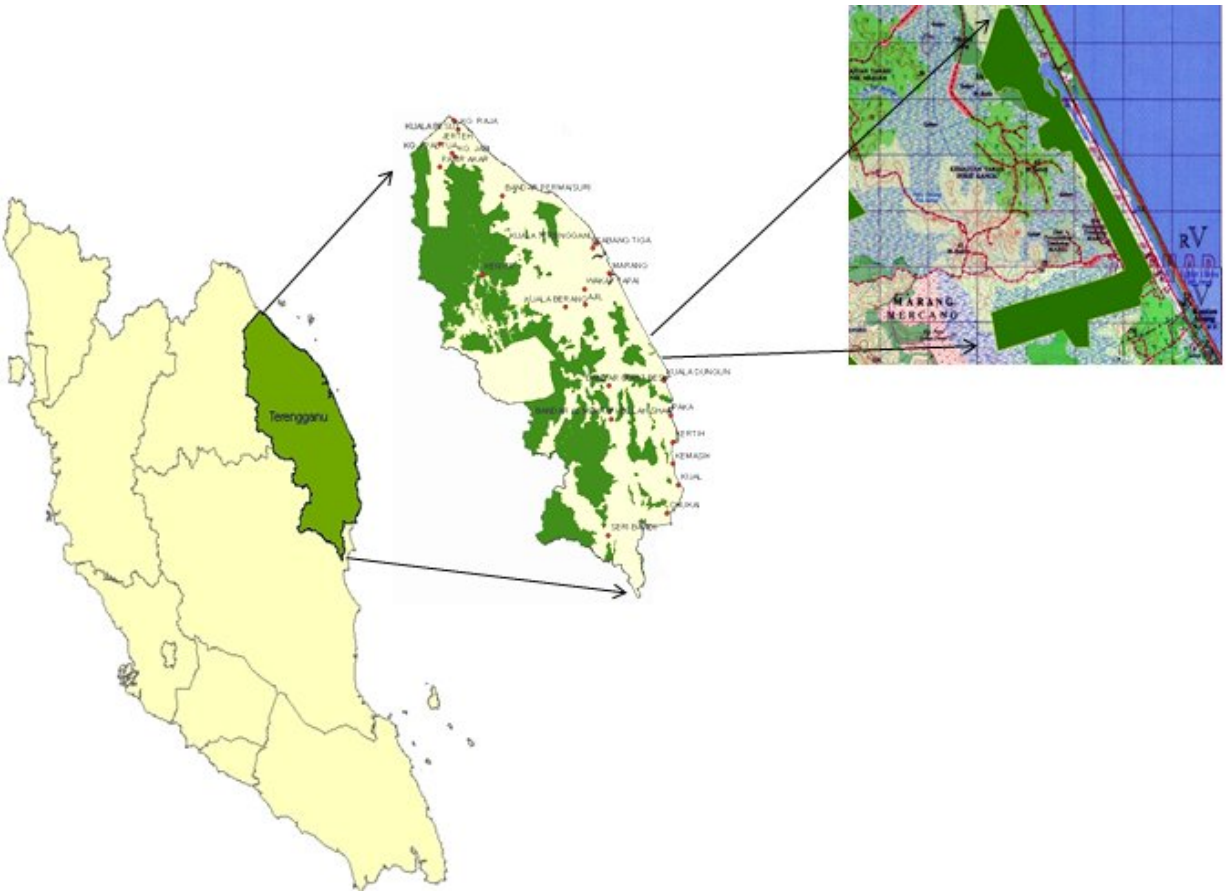

Figure 1. Study site (Costal Heath Forest at Jambu Bongkok Virgin Jungle Reserve (370 ha) at Rantau Abang, Terengganu, Malaysia.

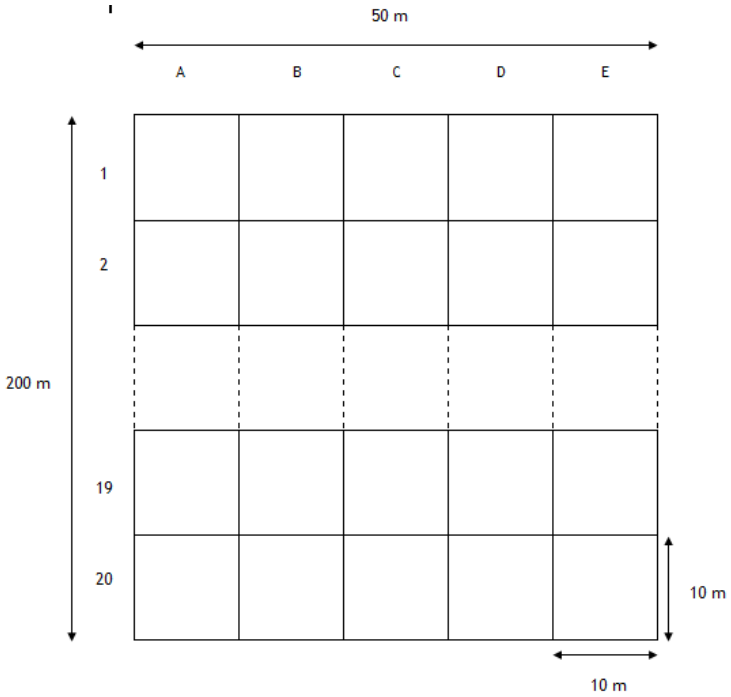

Figure 2. A detailed layout of the sample plot.

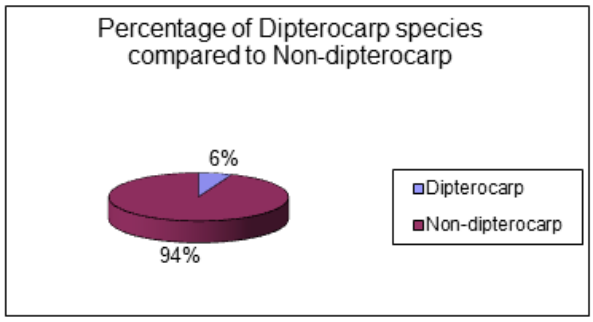

Figure 3. A comparison of Dipterocarp with Non-dipterocarp species.

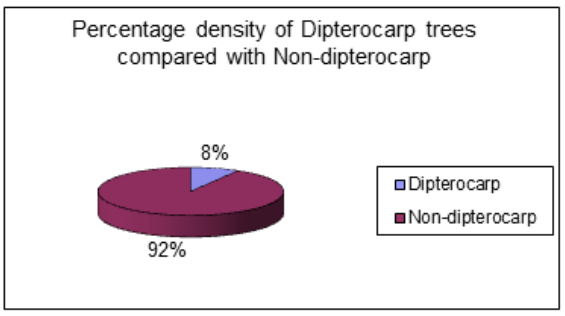

Figure 4. A compariason of the density of Dipterocarp trees with Non-dipterocarps.

Table 1. Floristic Composition of trees 5 cm dbh and above in 1–ha plot in the coastal heath forest, Terengganu.

No.	Family	No. of genera	No. of species	No. of trees
1	Anacardiaceae	3	3	24
2	Anisophylleaceae	1	1	6
3	Annonaceae	4	4	160
4	Araliaceae	1	1	1
5	Burseraceae	2	2	3
6	Dipterocarpaceae	2	4	82
7	Ebenaceae	1	2	44
8	Euphorbiaceae	6	6	51
9	Guttiferae	2	6	88
10	Icacinaceae	3	3	17
11	Ixonanthaceae	1	1	2
12	Lauraceae	4	4	50
13	Lecythidaceae	1	1	100
14	Leguminosae	1	1	12
15	Loganiaceae	1	1	2
16	Melastomataceae	1	1	5
17	Meliaceae	1	2	27
18	Moraceae	1	1	2
19	Myristicaceae	3	4	36
20	Myrtaceae	1	2	163
21	Olacaceae	1	1	1
22	Opiliaceae	1	1	1
23	Oxalidaceae	1	1	14
24	Polygalaceae	1	1	6
25	Rubiaceae	1	1	4
26	Sapindaceae	1	2	15
27	Sapotaceae	2	2	13
28	Styracaceae	1	1	1
29	Tiliaceae	1	1	1
30	Verbenaceae	2	2	28
	TOTAL	52	63	959

The plant diversity found in the study area is different from other forest types because of forest structure, soil types and drainage. Heath forests are ausually less biodiverse than other tropical plant communities (MacKinnon, 1997) These forests are generally of low stature and lack immigrants, as they are quite fragile, also due to their slow development and low productivity. The forests are growing on soils which are highly acidic, such that hydrogen ion toxicity prevents the growth of non-adapted species (Proctor, 1999). The floral diversity of organic white sand podsol soil is very distinctive,

with less than 50% of the species also occurring in MDF, usually in humult outsole soils.

The large saplings and small poles dominate the storey formed, which is also forming a tidy and orderly but forbidding phalanx due to dense impenetrable cover. The soils derived from siliceous parent materials are inherently poor in bases, commonly coarsely textured with good drainage. The soils of the forest belong to the *beris* series, with usually porous drainage.

The tree diversity in a hill forest is greater than the peat swamp forest and coastal heath forest for trees between 5-10 cm dbh (Table 5). The number of species in hill forest is about 146, peat swamp forest 93 and coastal heath forest 48. The same holds true for trees $\geq$ 10 cm dbh (Table 6) (Mazlan, 1996; Phillip, 1999; Rosewati, 2003). Heath forest is strikingly different in flora, structure and physiognomy compared to peat swamp forest and hill forest.

In all 4 species are endemic to the coastal heath forest and *Dehaasia microcarpa* Blume and *Pavetta nucleiflora* R.Br. *ex* G. Don have been recorded for the first time from the study area. Former has been recorded earlier from Kelantan, Perak, Pahang, Selangor and Malacca, later from Perlis, Kedah, Penang and Pahang.

Table 2. Dominant families (10) with number of genera and species.

Family	No. of genera	No. of species
Euphorbiaceae	6	6
Guttiferae	2	6
Annonaceae	4	4
Lauraceae	4	4
Myristicaceae	3	4
Dipterocarpaceae	2	4
Anacardiaceae	3	3
Icacinaceae	3	3
Burseraceae	2	2
Sapotaceae	2	2

Table 3. Least represented families (10) with number of genera and species.

Family	No. of genera	No. of species
Anisophylleaceae	1	1
Melastomataceae	1	1
Loganiaceae	1	1
Ixonanthaceae	1	1
Araliaceae	1	1
Moraceae	1	1
Olacaceae	1	1
Opiliaceae	1	1
Styracaceae	1	1
Tiliaceae	1	1

Table 4. Major tree species in 1-ha plot (5 cm dbh and above) with percentage frequency.

No.	Species	Family	Frequency	%
1	*Aglaia malaccensis* (Ridl.) Pannell	Meliaceae	15	1.7
2	*Aglaia odoratissima* Blume	Meliaceae	12	1.3
3	*Agrostistachys longifolia* (Wight) Benth.var.leptostachya (Pax and .Hoffm.) Whitmore	Euphorbiaceae	1	0.1
4	*Anisophyllea griffithii* Oliv.	Anisophylleaceae	6	0.6
5	*Aporusa microstachya* (Tul.) Miill. Arg.	Euphorbiaceae	3	0.3
6	*Arthrophyllum diversifolium* Blume	Araliaceae	1	0.1
7	*Baccaurea kunstleri* King ex Gage	Euphorbiaceae	4	0.4
8	*Barringtonia macrostachya*(Jack) Kurz.	Lecythidaceae	100	10.4
9	*Beilschmiedia dictyoneura* Kosterm.	Lauraceae	1	0.1
10	*Bouea oppositifolia*(Roxb.) Meisner	Anacardiaceae	5	0.5
11	*Canarium littorale* Blume	Burseraceae	1	0.1
12	*Champereia griffithii* Planch. ex Kurz.	Opiliaceae	1	0.1
13	*Clerodendrum hispidum* M.R.Hend	Verbenaceae	1	0.1
14	*Dehaasia microcarpa* Blume	Lauraceae	1	0.1
15	*Desmos dasymaschalus* Blume Safford var.dasymaschalus	Annonaceae	7	0.7
16	*Diospyros buxifolia* (Blume) Hiern	Ebenaceae	12	1.3
17	*Diospyros ferrea* (Willd.) Bakh.	Ebenaceae	32	3.3
18	*Fagraea racemosa* Jack ex Wall.	Loganiaceae	2	0.2
19	*Ficus microcarpa* L.*f.*	Moraceae	2	0.2
20	*Garcinia atroviridis* Griff. ex T.Anderson	Guttiferae	1	0.1
21	*Garcinia cowa* Roxb.	Guttiferae	17	1.8
22	*Garcinia hombroniana* Pierre	Guttiferae	2	0.2
23	*Garcinia parvifolia* (Miq.) Miq.	Guttiferae	15	1.6
24	*Ghompandra quadrifida* (Blume) Sleumer var.quadrifida	Icacinaceae	1	0.1

Table 4. Contd..

No.	Species	Family	Frequency	%
25	*Goniothalamus tapis* Miquel	Annonaceae	1	0.1
26	*Gonocaryum macrophyllum* (Blume) Sleumer	Icacinaceae	3	0.3
27	*Hopea nervosa* King	Dipterocarpaceae	13	1.4
28	*Horsfieldia sucosa* (King) Warb.	Myristicaceae	2	0.2
29	*Ixonanthes icosandra* (Jack)	Ixonanthaceae	2	0.2
30	*Knema globularia* (Lam.) Warb.	Myristicaceae	3	0.3
31	*Knema laurina* (Blume) Warb. var. laurina	Myristicaceae	24	2.5
32	*Litsea firma* (Blume) Hook.f.	Lauraceae	47	4.9
33	*Melanochyla angustifolia* Hook.f.	Anacardiaceae	13	1.4
34	*Memecylon caeruleum* Jack	Melastomataceae	5	0.5
35	*Mesua aff. assamica* (King and Prain) Kosterm.	Guttiferae	1	0.1
36	*Mesua ferrea* L.	Guttiferae	52	5.4
37	*Microcos antidesmifolia* (King) Burret.	Tiliaceae	1	0.1
38	*Monocarpia marginalis* (Scheff.) J.Sinclair	Annonaceae	30	3.1
39	*Myristica guatteriifolia* A. DC.	Myristicaceae	7	0.7
40	*Ochanostachys amentacea* Mast.	Olacaceae	1	0.1
41	*Palaquium obovatum* (Griff.) Engl.	Sapotaceae	6	0.6
42	*Pavetta nucleiflora* R. Br. ex G. Don.	Rubiaceae	4	0.4
43	*Phoebe lanceolata (Wall. ex Nees) Nees*	Lauraceae	1	0.1
44	*Pimelodendron griffithianum (Miill. Arg.) Benth.*	Euphorbiaceae	1	0.1
45	*Planchonella obovata* (R. Br.) Pierre	Sapotaceae	7	0.7
46	*Polyalthia hypogaea* King	Annonaceae	122	12.7
47	*Santiria laevigata* Blume	Burseraceae	2	0.2
48	*Sarcotheca laxa* (Ridl.) Knuth var. laxa	Oxalidaceae	14	1.5
49	*Semecarpus velutinus* King	Anacardiaceae	6	0.6
50	*Shorea materialis* Ridl.	Dipterocarpaceae	64	6.7
51	*Shorea pauciflora* King	Dipterocarpaceae	3	0.3
52	*Shorea singkawang* (Miq.) Miq. ssp. singkawang	Dipterocarpaceae	2	0.2
53	*Sindora coriacea* (Baker) Maingay ex Prain	Leguminosae	12	1.3
54	*Stemonurus scorpioides* Becc.	Icacinaceae	13	1.4
55	*Styrax benzoin* Dryand. var. benzoin	Styracaceae	1	0.1
56	*Suregada multiflora* (Juss.) Baill.var.multiflora	Euphorbiaceae	31	3.2
57	*Syzygium claviflorum* (Roxb.) ex A.M.Cowan & Cowan var. *claviflorum*	Myrtaceae	149	15.5
58	*Syzygium grande* (Wight) Walp.	Myrtaceae	14	1.4
59	*Trigonostemon laevigatus* Miill. Arg.	Euphorbiaceae	11	1.1
60	*Vitex pinnata* L.	Verbenaceae	27	2.8
61	*Xanthophyllum obscurum* A.W. Benn	Polygalaceae	6	0.6
62	*Xerospermum laevigatum* Radlk.	Sapindaceae	14	1.4
63	*Xerospermum noronhianum* (Blume) Blume	Sapindaceae	1	0.1
	TOTAL	30	959	100

Table 5. A comparison of the species diversity with other forest types (for 5-10 cm dbh in 1-ha study plot).

Forest types	No. of species
Coastal heath forest (Syuharni, 2003)*	48
Peat swamp forest (Phillip, 1999)**	93
Hill forest (Mazlan, 1996)***	146

(Source : Syuharni, 2003)

Table 6. A comparison of species diversity with other forest types (for ≤ 10 cm dbh in 1-ha study plot) (Source: Rosewati, 2003).

Forest types	No. of species
Coastal heath forest (Rosewati, 2003) Jambu Bongkok Forest Reserve, Rantau Abang, Terengganu	50
Peat swamp forest (Phillip, 1999) Kuala Langat North Peat Swamp Forest, Selangor	103
Hill forest (Mazlan, 1996) Ulu Muda Forest Reserve, Kedah	189

Table 7. Endemics and new records from the study area.

No	Species	Family	Description	Status
1	*Clerodendrum hispidum* M.R. Hend.	Verbenaceae	Shrub to 1.5 m tall; Tg, Ph; endemic	Endemic
2	*Dehaasia microcarpa* Blume	Lauraceae	Tree to 24 m tall; lowland forest by streams; Kl, Pk, Ph, Sl, Ml	New Record
3	*Horsfieldia sucosa* (King) Warb.	Myristicaceae	Medium to big tree to 27 m (rarely 23) tall; 1.5 girth. Lowlands and hills. Throughout the Peninsular Malaysia. Endemic in Peninsular Malaysia.	Endemic
4	*Pavetta nucleiflora* R.Br. *ex* G. Don	Rubiaceae	Shrub to 4 m tall; lowland forest, sometimes on limestone; Ps, Kd, Pn, Ph	New record
5	*Polyalthia hypogaea* King	Annonaceae	Tree to 30 m tall; hill forest; Kd, Tg, Pk, Ph, Sl, NS, Jh, endemic	Endemic
6	*Sarcotheca laxa* (Ridl.) Knuth var.*laxa*	Oxalidaceae	Shrub or tree to 23 m tall; swamps and forest margin; Ps, Kd, Kl, Tg, Pk; endemic variety	Endemic

Table 8. Total biomass in 1-ha plot of the study site on the basis of families.

No.	Family	Total of biomass (kg/ha)	Total of biomass (ton/ha)
1	Anacardiaceae	3181.015	3.131
2	Anisophylleaceae	151.845	0.149
3	Annonaceae	8762.369	8.624
4	Araliaceae	63.848	0.063
5	Burseraceae	546.683	0.538
6	Dipterocarpaceae	87351.148	85.971
7	Ebenaceae	1414.952	1.393
8	Euphorbiaceae	2518.686	2.479
9	Guttiferae	23660.0	23.286
10	Icacinaceae	1553.441	1.529
11	Ixonanthaceae	61.757	0.061
12	Lauraceae	7540.499	7.421
13	Lecythidaceae	6077.074	5.981
14	Leguminosae	428.862	0.422
15	Loganiaceae	17.540	0.017
16	Melastomataceae	257.390	0.253
17	Meliaceae	1341.100	1.320
18	Moraceae	12146.213	11.954
19	Myristicaceae	2980.421	2.933
20	Myrtaceae	76519.064	75.310
21	Olacaceae	11.277	0.011
22	Opiliaceae	5.950	0.006
23	Oxalidaceae	1392.418	1.370
24	Polygalaceae	1384.338	1.362
25	Rubiaceae	38.008	0.037
26	Sapindaceae	955.216	0.940
27	Sapotaceae	2318.550	2.282
28	Styracaceae	22.110	0.022
29	Tiliaceae	33.105	0.033
30	Verbenaceae	10323.109	10.160
	TOTAL	253057.998	249.058

Table 9. Total biomass in 1-ha plot of the study siteon the basis of species.

No	Species	Total biomass (kg/ha)	Total biomass (ton/ha)
1	*Aglaia malaccensis* (Ridl.) Pannell	221.431	0.218
2	*Aglaia odoratissima* Blume	1119.669	1.102
3	*Agrostistachys longifolia* (Wight) Benth.var.*leptostachya* (Pax and .Hoffm.) Whitmore	138.513	0.136
4	*Anisophyllea griffithii* Oliv.	151.845	0.149
5	*Aporusa microstachya* (Tul.) Miill. Arg.	538.378	0.530
6	*Arthrophyllum diversifolium* Blume	63.848	0.063
7	*Baccaurea kunstleri* King ex Gage	239.077	0.235
8	*Barringtonia macrostachya* (Jack) Kurz.	6077.074	5.981
9	*Beilschmiedia dictyoneura* Kosterm.	164.169	0.162
10	*Bouea oppositifolia* (Roxb.) Meisner	193.591	0.191
11	*Canarium littorale* Blume	24.976	0.025
12	*Champereia griffithii* Planch. ex Kurz.	5.950	0.006
13	*Clerodendrum hispidum* M.R.Hend	9.541	0.009
14	*Dehaasia microcarpa* Blume	11.739	0.012
15	*Desmos dasymaschalus* Blume Safford var. *dasymaschalus*	59.480	0.059
16	*Diospyros buxifolia* (Blume) Hiern	909.378	0.895
17	*Diospyros ferrea* (Willd.) Bakh.	505.574	0.498
18	*Fagraea racemosa* Jack ex Wall.	17.540	0.017
19	*Ficus microcarpa* L.*f.*	12146.213	11.954
20	*Garcinia atroviridis* Griff. ex T.Anderson	181.218	0.178
21	*Garcinia cowa* Roxb.	6000.754	5.906
22	*Garcinia hombroniana* Pierre	392.207	0.386
23	*Garcinia parvifolia* (Miq.) Miq.	4273.726	4.206
24	*Ghompandra quadrifida* (Blume) Sleumer *var.quadrifida*	17.005	0.017
25	*Goniothalamus tapis* Miquel	19.780	0.019
26	*Gonocaryum macrophyllum* (Blume) Sleumer	188.552	0.186
27	*Hopea nervosa* King	4616.429	4.543
28	*Horsfieldia sucosa* (King) Warb.	672.216	0.662
29	*Ixonanthes icosandra* (Jack)	61.757	0.061
30	*Knema globularia* (Lam.) Warb.	307.365	0.303
31	*Knema laurina* (Blume) Warb. var. *laurina*	1418.164	1.396
32	*Litsea firma* (Blume) Hook.f.	7321.907	7.206
33	*Melanochyla angustifolia* Hook.f.	1752.461	1.725
34	*Memecylon caeruleum* Jack	257.390	0.253
35	*Mesua aff. assamica* (King and Prain) Kosterm.	43.724	0.043
36	*Mesua ferrea* L.	12768.371	12.567
37	*Microcos antidesmifolia* (King) Burret.	33.105	0.033
38	*Monocarpia marginalis (*Scheff.) J.Sinclair	2937.344	2.891
39	*Myristica guatteriifolia* A. DC.	582.676	0.573
40	*Ochanostachys amentacea* Mast.	11.277	0.011
41	*Palaquium obovatum* (Griff.) Engl.	1404.776	1.383
42	*Pavetta nucleiflora* R. Br. ex G. Don.	38.008	0.037
43	*Phoebe lanceolata* (Wall. ex Nees) Nees	42.684	0.042
44	*Pimelodendron griffithianum* (Miill. Arg.) Benth.	38.673	0.038
45	*Planchonella obovata* (R. Br.) Pierre	913.774	0.899
46	*Polyalthia hypogaea* King	5745.765	5.655
47	*Santiria laevigata* Blume	521.707	0.513
48	*Sarcotheca laxa* (Ridl.) Knuth var. *laxa*	1392.418	1.370
49	*Semecarpus velutinus* King	1234.963	1.215
50	*Shorea materialis* Ridl.	80097.693	78.832
51	*Shorea pauciflora* King	2449.331	2.411
52	*Shorea singkawang* (Miq.) Miq. ssp. *singkawang*	187.695	0.185
53	*Sindora coriacea* (Baker) Maingay ex Prain	428.862	0.422
54	*Stemonurus scorpioides* Becc.	1347.884	1.327
55	*Styrax benzoin* Dryand. var. *benzoin*	22.110	0.022
56	*Suregada multiflora* (Juss.) Baill.var.*multiflora*	1403.870	1.382

Table 9. Contd..

No	Species	Total biomass (kg/ha)	Total biomass (ton/ha)
57	*Syzygium claviflorum* (Roxb.) ex A.M.Cowan & Cowan var. *claviflorum*	68873.028	67.785
58	*Syzygium grande* (Wight) Walp.	7646.036	7.525
59	*Trigonostemon laevigatus* Miill. Arg.	160.175	0.158
60	*Vitex pinnata* L.	10313.575	10.151
61	*Xanthophyllum obscurum* A.W. Benn	1384.338	1.362
62	*Xerospermum laevigatum* Radlk.	725.299	0.714
63	*Xerospermum noronhianum* (Blume) Blume	229.917	0.226
	TOTAL	253057.998	249.058

Table 10. Comparison of biomass value with other forest types. (Sources : Syuharni, 2003*; Rosewati, 2003**)

	Biomass (ton/ha) 5-10 cm dbh*	Biomass (ton/ha) ≥10 cm dbh**
Peat swamp forest (Phillip, 1999)	28.4	268.3
Coastal heath forest	7.2	242.0

Biomass

Biomass is defined as the weight of living material in all parts of an organism, population or ecosystem used to provide fuel or energy. It is usually expressed as dry matter/unit area, e.g. ton/ha, kg/ha or g/m^2 (Brown, 1997). The information on biomass can be used to give us an idea of the fluxes of matter and energy within the ecosystem. Also the detrimental effects of harvesting and fertilization mainly related with bad agricultural practices, can be assessed through biomass data, which is important to evaluate the methods used so far in order to create the basis of a proper forest management (Lim, 1993).

Details of the dominant families and species in terms of total biomass are shown in tables 8 and 9. Dipterocarpaceae has the largest biomass of 86.0 ton/ha, followed by Myrtaceae 75.3 ton/ha and Guttiferae 23.3 ton/ha. The biomass tends to increase with an increase in the number of stems in the families (Table 8). The largest biomass obtained from a single species is 78.8 ton/ha (*Shorea materialis*) followed by *Syzygium claviflorum* 67.8 ton/ha (Table 9).

A comparison of biomass data in the study area with other forest types reveals that the peat swamp forest has a higher biomass value (28.4 ton/ha) than the coastal heath forest (7.2 ton/ha) for 5-10 cm dbh. Same is true for ≥ 10 cm dbh as is clear from the values like 268.3 ton/ha for peat swamp forest and 242.0 ton/ha for coastal heath forest (Table 10). The reason for this is the diversity in the peat swamp forest is greater than the coastal heath forest; due to the differences in the soil type, soil condition, topography, climate, temperature, and drainage, as well as the structure, texture and colour of the forest. The heath forest is considerably brighter in colour than lowland dipterocarp. The total biomass is always greater when the number and girth of trees is greater (Lim, 1993).

Conclusions

The family Dipterocarpaceae has a small stocking as compared to the non-dipterocarp. Dipterocarpaceae comprises about 9% of the trees found in the plot. *Shorea materialis* is dominating this coastal heath forest in the east coast of Peninsular Malaysia. The species composition and total biomass in coastal heath forest is lower as compared to the peat swamp forest and hill forest because of differences in the soil types, soil nutrients, climate, disturbance regime, succession status, topographic position and human impacts. However, the composition of tree diversity is not much different from other heath forest in Malaysia such as Bako National Park. Family Myrtaceae has been recorded in both the forest types and this family is a dominant family for 5 cm dbh and above in a coastal heath forest at Rantau Abang, Terengganu. The reason why Myrtaceae dominates this forest type could be due to the soil conditions and structure of the forest because these are suitable for their optimal growth and survival. The total biomass is greater whenever the trees are greater in terms of stem number and size.

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