

Composition and structure of a lowland forest in the Core Zone of the Bukit Duabelas National Park, Jambi, Indonesia

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ABSTRACT

The objective of the study was to obtain data on composition and structure of the forest in the midsection of the Bukit Duabelas National Park core zone, designed to complement the existing data and provide new information potentials for the management of the park core zone. The study was carried out in October-November 2012. Observations were made on plots of one hectare (100 m x 100 m), which was divided into 100 subplot, measuring 10 m x 10 m each. Enumeration of tree species with diameters ≥ 10 cm revealed that as many as 540 individuals were recorded, consisting of 89 species and 36 families, with a total basal area of 30.837 m² and only three species of *Dipterocarpaceae* were registered. The forest had a low diversity as indicated by low species richness, much lower than in the undisturbed lowland primary forests in the Batang Gadis National Park in North Sumatra, where similarity was very low (5.9 %). The forest in the plot was designated as the *Dacryodes rostrata*-*Shorea leprosula* Association, named after two species with highest importance values, thus the dominant. The structure and species composition pointed to the regenerating forest after heavy disturbances. The forest has been undergoing slow natural succession, leading to the formation of the forest similar to the original climax forest. Natural recovery through succession could be enhanced and assisted by means of ecological restoration, through planting of tree species characteristics of forests in Jambi, including species of *Dipterocarpaceae*, useful species having values to maintain the livelihood of the indigenous native tribe Suku Anak Dalam and rare, endemic other species having high conservation values.

ABSTRAK

Tujuan studi ini adalah untuk memperoleh data tentang komposisi dan struktur hutan di bagian tengah zona inti Taman Nasional Bukit Duabelas. Studi dirancang untuk melengkapi data yang telah ada dan untuk menyajikan informasi baru yang berpotensi untuk digunakan dalam pengelolaan zona inti taman nasional. Penelitian dilaksanakan pada bulan Oktober-November 2012 dalam petak seluas satu hektare (100 m x 100 m), yang dibagi menjadi 100 anak-petak dengan ukuran masing-masing 10 m x 10 m. Pencacahan pohon dengan diameter ≥ 10 cm menghasilkan 540 batang, yang terdiri atas 89 jenis dan 36 suku, dengan luas bidang dasar total 30.837 m² dan hanya tercatat tiga jenis *Dipterocarpaceae*. Keanekaragaman jenis hutan rendah, seperti ditunjukkan oleh rendahnya kekayaan jenis, jauh lebih rendah dibandingkan dengan hutan primer yang tidak terganggu di Taman Nasional Batang Gadis di Sumatra Utara, yang mempunyai kesamaan hanya 5,9 % dengan Taman Nasional Bukit Duabelas. Berdasarkan dua jenis dominan dengan nilai kepentingan tinggi, komunitas pohon dalam petak dinamakan Asosiasi *Dacryodes rostrata*-*Shorea leprosula*. Struktur dan komposisi jenis menunjukkan status hutan sebagai hutan yang sedang beregenerasi setelah mengalami gangguan. Hutan sedang mengalami suksesi alami yang lambat menuju ke pembentukan hutan yang serupa dengan hutan klimaks aslinya. Pemulihan alami melalui suksesi dapat dipercepat dan dibantu dengan restorasi ekologi melalui penanaman jenis-jenis khas hutan alami Jambi, termasuk *Dipterocarpaceae*, jenis-jenis bermanfaat dan mempunyai nilai untuk keberlanjutan kehidupan dan kesejahteraan masyarakat asli Suku Anak Dalam dan jenis-jenis langka, endemik dan jenis lain yang mempunyai nilai konservasi tinggi.

Keywords: Association, disturbances, regenerating forest, ecological restoration, species richness, structure and composition

INTRODUCTION

The lowland rain forests of Sumatra constitute an important center of plant species diversity and the hub of the geography of plant families and genera within the Malesian region (Steenis 1950; Whitmore, 1986; Kartawinata, 2013). The Bukit Duabelas National Park (BDNP) contains a fraction of these lowland

rain forests (Sylviani, 2008; Setiawan, 2010) and constitutes an important biodiversity center in the middle section of Sumatra [BAPPENAS (Badan Perencanaan Pembangunan Nasional), 2003]. Much of the lowland rain forests of Sumatra, dominated by dipterocarp species, have experienced destructive and extensive commercial logging, leaving only undisturbed remnants of forests as scattered mosaics in the

lowlands. The Bukit Dua Belas National Park is also a catchment area for the Batanghari River, one of the largest rivers in Jambi (Wiriadinata & Setyowati, 2000; Setiawan, 2010). It is a unique protected area in view of the fact that it is the last home of the ethnic Suku Anak Dalam (SAD) or known also as *orang rimba* (Wiriadinata & Setyowati 2000; Setyowati, 2003; Sriyanto et al. 2003).

Conservation and management of forests within protected areas, including BDNP, require a good and correct planning. In this respect optimal and sustainable management of forest resources can be implemented well if accurate, complete and up-to-date data and information on vegetation were available. They should provide a representation of current condition of plant communities, which constitute the habitats to support the survival of numerous other organisms living in the BDNP areas.

A better knowledge on detailed description of structure, composition and ecology of lowland rain forests of Sumatra, required for better sustainable development and conservation, are relatively limited. Data and information on the vegetation and physiography of Sumatra have been summarised by Laumonier (1997). Scattered studies on vegetation, primarily forests, have been conducted in various parts of Sumatra, mainly in the national parks and other protected areas. They include those in the Batang Gadis National Park (Kartawinata et al., 2004), Berbak National Park (Silvius et al., 1984), Gunung Leuser National Park (Abdulhadi, 1991; Samsodin and Heriyanto, 2010), Harapan Tropical Rain Forest (Mansur et al. 2010), Hutan Adat Imbo Mengakadai (Elviqar, 2013; Hermawan, 2013), Hutan Danau Bangko (Polosakan, 2011), Kerinci Seblat National Park (Gillison et al., 1996), Rimbo Panti Nature Reserve (Yusuf et al., 2005), Teso Nilo National Park (Gillison, 2001). Studies on the structure and species composition in the eastern and western sections of the BDNP core zone, respectively were undertaken by Rahmah et al. (2016) and Sehati (2013).

The present phytosociological study in the midsection of the BDNP core zone was designed to complement the existing data and provide new information on the species composition, structure and the potentials of the forest in the BDNP core zone. They can be used as a scientific basis and reference for better execution of conservation and management of the park.

METHODS

The BDNP was established by the Decree of the Ministry of Forestry and Plantation (No. 258/Kpts-II/2000 dated 23 August 2000). It had a total area of 60.500 hectare, consisting of primary and secondary forests, which were converted from the permanent production forests, limited production

forests and forest designated for other uses (Sriyanto et al., 2003). The entire park was located within the lowland dipterocarp forest region of Sumatra (Lamounier, 1997; Whitmore, 1986).

Many important useful plants could be found in BDNP, including fruit trees such as durian (*Durio* spp.), important hard wood producing *bulian* (*Eusideroxylon zwageri*), latex producing tree species (*Dyera costulata*) and rattan producing palms such as *rotan manau* (*Calamus manan*) and *jernang* (*Daemonorops draco*). To date 41 species of orchids, 107 species of flowering plant and 27 species of fungi have been recorded to have medicinal values (Kementerian Kehutanan dan Balai TNBD, 2011). The Bukit Duabelas National Park (BDNP) contained also rare plant species, including *Eusideroxylon zwageri*, *Fagraea fragrans*, *Calamus manan*, *Daemonorops draco* and *Dyera costulata* (Kementerian Kehutanan dan Balai TNBD, 2011; Rahmah et al., 2016)

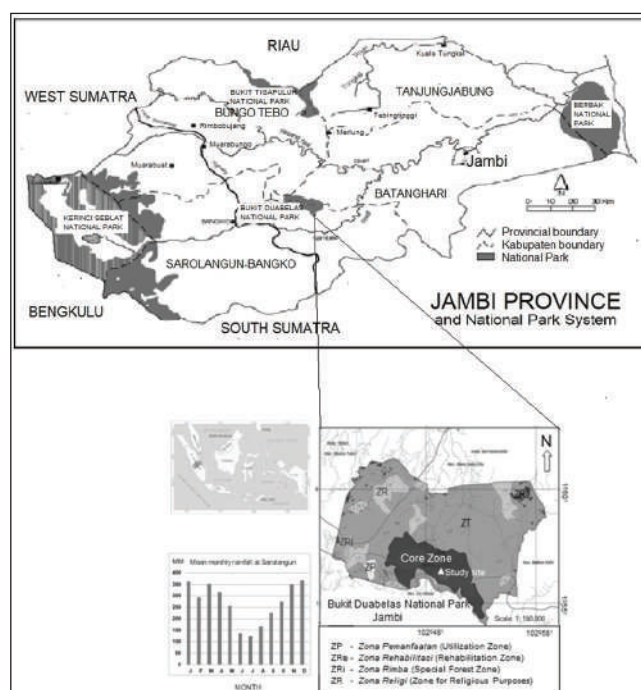


Figure 1. The map showing the geographic location and the mean monthly rainfall of the study site in the midsection of the core zone of the Bukit Duabelas National Park within the National Park System of the Jambi Province (After Rahmah et al., 2016 & Kementerian Kehutanan dan Balai TNBD, 2011; with modification)

The map of BDNP (Figure 1) shows the park geographic location at the $102^{\circ}31'37''$ - $102^{\circ}48'27''$ East and $01^{\circ}44'35''$ - $02^{\circ}03'15''$ South. The topography ranged from undulating to hilly, with the altitude of 260-400 masl (meter above sea level). The Red Yellow Podsolc soil was dominant in the area (Kementerian Kehutanan dan Balai TNBD, 2011). The 38-year record of the mean annual rainfall (Berlage, 1949) was 3224 mm. The highest mean monthly rainfall of 392.9 mm was recorded in November and the lowest of 27.1 mm in August and 52.7 mm in September [BPS

(Badan Pusat Statistik) Kabupaten Sarolangun, 2015]. The temperature range in the area was 23 – 30 °C and the humidity range was 80 - 94% (Kementerian Kehutanan dan Balai TNBD, 2011).

Specifically the sampling was undertaken in the forest at the midsection of the core zone of the park using the plot method (Cox 1967; Mueller-Dombois & Ellenberg 1972, 2016), with the plot size of one-hectare. Habitat conditions, including plot position, mean elevation, topography, gaps and tree crown coverage, soils, presence of litters, pH and air humidity were recorded. The mean elevation of the plot was measured by the method of Harms et al. (2001).

The one hectare plot (100 m x 100 m) was divided into 100 subplots of 10 m x 10 m each (Kartawinata et al., 2004; Samsodin & Heriyanto, 2010; Rahmah et al., 2016). All tree species with DBH [Diameter at Breast Height at the height of 1.30 m (Kartawinata et al., 2004; Purwaningsih & Yusuf, 2005; Heriyanto et al., 2019)] ≥ 10 cm were recorded. The records included name of species, number of trees, stem diameter (diameters of trees with buttresses were measured 20 cm above the buttresses), tree height, bole height to the first branch (Mueller-Dombois & Ellenberg, 1974, 2016) and tree position using the GPS (Global Positioning System). The subplots and the plot were made permanent, in which every tree with a DBH ≥ 10 m was numbered and labelled using an aluminum plate nailed to the stem 10 cm above the line of the diameter measurement.

Preliminary identification of species was undertaken in the field using available published keys, including guide to identification of dipterocarp trees of Sumatra (Newman et al., 1999). Voucher specimens of trees within the plot were collected and further identified and confirmed at the Herbarium Bogoriense, Center for Biological Research, LIPI at Cibinong, Bogor.

All collected data were tabulated and analysed to determine Density (D), Relative Density (RD), Frequency (F), Relative Frequency (RF), Dominance (Do), Relative Dominance (RDo), and Importance Value (IV) [Cox, 1967; Mueller-Dombois & Ellenberg, 1974, 2016]. The standard method (Mueller-Dombois & Ellenberg, 1974, 2016; Rahmah et al., 2016; Purwaningsih et al., 2017) was applied to calculate density frequency and dominance. Density was defined as the number of individuals per unit area. In the present study we were dealing with trees, hence the density per species was calculated by the number of trees of each species in the plot of one hectare. The density in the plot was the sum of the trees of all species and was presented as the number of trees per hectare. The Relative Density (RD) for each species was then computed as follows:

$$RD = \frac{\text{number of trees of a species}}{\text{total number of trees}} \times 100 \%$$

Frequency was expressed as the number of occurrences of a species in subplots within the plot and was computed as the percentage of the total number of subplots. Relative Frequency (RF) was expressed as follows:

$$RF = \frac{\text{frequency of a species}}{\text{sum of frequency of all species}} \times 100 \%$$

The dominance (Do) was determined by the stem cover, which was expressed as basal area (BA). BA was calculated with the formula of $BA = (\frac{1}{2}d)^2 \pi$, where d stands for diameter. The dominance of a species was obtained by totalling the BA values for all trees in the species. The Relative Dominance (RDo) was then computed with following formula:

$$RDo = \frac{\text{dominance of a species}}{\text{dominance of all species}} \times 100 \%$$

The Importance Value (IV) of a species was calculated by summing up RD, RF and RDo in the plot, thus:

$$IV = RD + RF + RDo$$

The Family Important Value (FIV) was computed by totaling the Importance Values of all species in a family (Kartawinata et al., 2004).

RESULTS

Composition

Appendix 1 shows that in 100 subplots making up the one-hectare plot, we recorded 540 individual trees, comprising 89 species and 36 families with the total basal area (BA) of 30.837 m²/ha. The authors of the scientific names in the present study are attached to all species listed in Appendix 1. The characteristics of the composition and structure of the forest is summarised in Table 1, which shows that *Dipterocarpaceae* was not dominant, consisting only of *Shorea leprosula*, *Parashorea lucida* and *Parashorea* sp. (Appendix 1).

Appendix 1 indicates that most of species had low values of density (D), dominance expressed as basal area (BA), frequency (F) and importance value (IV). It shows that 10 species had high IV, where two of them had the highest IV, that were *Dacryodes rostrata* (IV=15.80) and *Shorea leprosula* (IV=15.58). They constituted the dominant and co-dominant species and on the basis of this dominance (Mueller Dombois & Ellenberg, 1974, 2016) the tree community in the forest of the midsection of BDNP core zone could be designated as the *Dacryodes rostrata*- *Shorea leprosula* Association. Other eight prevalent species with IV > 10 (Appendix 1), that characterized the association were *Hydnocarpus* sp. (IV=14.91), *Antidesma neurocarpum* (IV=14.30); *Dialium platysepalum* (IV=12.67), *Artocarpus odoratissimus* (IV=10.83), *Dacryodes rugosa* (IV=10.17), *Parashorea*

lucida (IV=10.11), *Mussaenda frondosa* (IV=9.33) and *Symplocos* sp. (IV=9.03).

Dacryodes rostrata had the highest density (32 trees/ha), followed by *Hydnocarpus* sp. and *Antidesma neurocarpum* (Figure 2a), while the lowest tree density occurred in 30 species with *Dacryodes rostrata* density of one tree per hectare (Appendix 1). The highest frequency was recorded in *Dacryodes rostrata* followed by *Antidesma neurocarpum* and *Hydnocarpus* sp. (Figure 2b). In terms of basal area Appendix 1 shows that three species had the highest values, they were *Shorea leprosula* (2.83 m²), *Dialium platysepalum* (2.58 m²) and *Artocarpus odoratissimus* (1.84 m²).

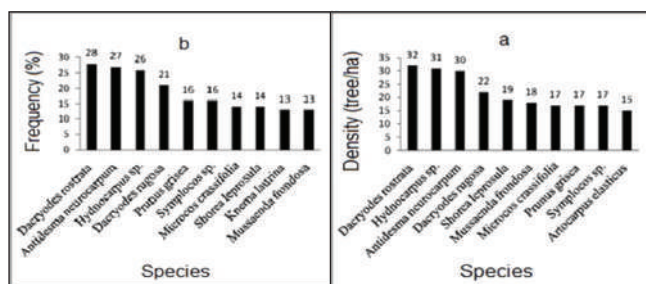


Figure 2. (a) Ten tree species with highest density (trees/ha) and (b) ten tree species with highest frequency in the forest of the mid section of the BDNP core zone.

Among the 89 tree species present in the plot, 10 species having IV > 10 jointly dominated the forest, where as mentioned above *Dacryodes rostrata* was the primary species with highest IV of 15.80 (Appendix 1). The highest IV was attributed to high density and high frequency, implying that its mean tree diameter was small (20.02 cm). It was smaller compared to diameters of *Dialium platysepalum* (45.17 cm), *Shorea leprosula* (38.20 cm), *Parashorea lucida* (37.08 cm) and *Artocarpus odoratissimus* (36.74 cm). To the contrary *Dialium platysepalum*, *Shorea leprosula*, *Parashorea lucida* and *Artocarpus odoratissimus*, which were included in the 10 dominant species were observed to have a relatively lower density and frequency compared to that of *Dacryodes rostrata*.

Table 1. Characteristics of the composition and structure of the forest in a one hectare plot at the midsection of the BNDP core zone, Jambi.

Forest characteristics	Dipterocarpaceae	Non Dipterocarpaceae	Total
Number of species	3 (3.37%)	85 (96.63%)	88
Density (Trees/ha)	36 (6.67%)	504 (93.33%)	540
Basal Area (m ²)	5.01 (16.25%)	25.827 (83.75%)	30.837
Importance Value	28.89 (9.63%)	271.11 (90.37%)	300

Figure 3 demonstrates the species-area curve expressing the pattern of tree species richness in subplots. It shows that the number of species increased as the area extended and there was no indication of the curve to flatten, implying that the one-hectare area did not represent the minimal area. This is comparable to the phenomenon in the primary lowland forests of

Sumatra and Kalimantan (Kartawinata et al., 2004; Kartawinata et al., 2008).

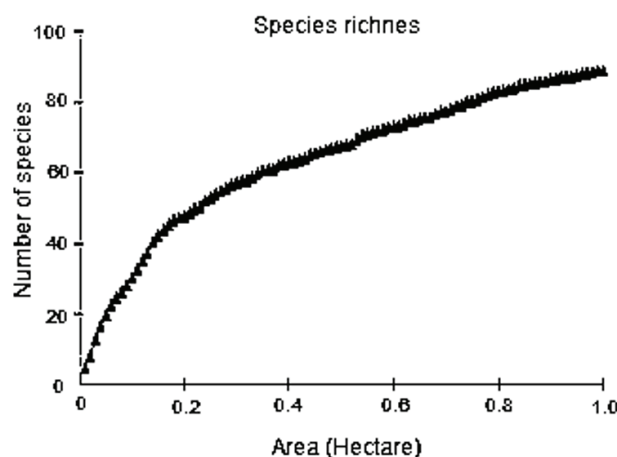


Figure 3. Species-area curve of tree species with DBH ≥ 10 cm in 100 subplots of the 100 m x 100 m plot in the forest of the midsection of BDNP core zone.

In this study we recorded 36 families and 20 of them had highest IV (Table 2). They were families commonly found in the lowland forests of Sumatra, including *Burseraceae*, *Dipterocarpaceae*, *Rubiaceae*, *Lauraceae* and *Euphorbiaceae* (Anwar et al., 1984). *Lauraceae* contained the highest number of species. It is the family characterizing the lowland forests of Southeast Asia (Yamada, 1976), including Kalimantan (Kartawinata et al., 2008). The other families with high species number were *Euphorbiaceae* and *Malvaceae*.

Euphorbiaceae and *Phyllanthaceae* commonly occurred in both primary and secondary lowland forests (Kartawinata et al., 2004). The species of these families have an adaptive capability to grow in the open areas, including gaps in primary forests (Whitmore, 1986). In the mean time 14 families (39%) contained one species each. *Dipterocarpaceae* (Table 1) was represented by only three species (*Parashorea lucida*, *Parashorea* sp. and *Shorea leprosula*) with the total basal area of 5.01 m² or 16.25% of the total (Table 1).

Table 1 shows that the total BA in the plot was 30.837 m² representing 540 trees with the mean BA of 0.057 m². Table 3 indicates that the soil surface of the one-hectare plot in the mid-section of the core zone of BDNP was mostly covered by 10 species having highest BA totalling 15.515 m² or 50.31% of the total BA. The species of *Dipterocarpaceae* having the highest BA was represented by *Shorea leprosula* with BA of 2.829 m² and *Parashorea lucida* with BA of 1.795 m² or 14.99 % of the total BA, comparable to the values elsewhere in Sumatra (Kartawinata et al., 2004) and Kalimantan (Kartawinata et al., 2008). Another dipterocarp species, *Parashorea* sp. had only an insignificant BA (0.38 m²).

Table 2. Ten families with highest number of tree species with DBH \geq 10 cm and highest IV in the one-hectare lowland forest plot at the mid-section of the BDNP core zone, Jambi.

Family	Species		Family	IV	
	Number	%		Number	%
Lauraceae	6	6.74	Burseraceae	31.60	10.53
Euphorbiaceae	5	5.62	Dipterocarpaceae	28.89	9.63
Malvaceae	5	5.62	Phyllanthaceae	23.38	7.79
Clusiaceae	4	4.49	Moraceae	22.37	7.46
Moraceae	4	4.49	Flacourtiaceae	20.21	6.74
Myristicaceae	4	4.49	Fabaceae	16.32	5.44
Olacaceae	4	4.49	Lauraceae	13.89	4.63
Phyllanthaceae	4	4.49	Rubiaceae	12.85	4.28
Rubiaceae	4	4.49	Euphorbiaceae	11.94	3.98
Sapotaceae	4	4.49	Malvaceae	10.06	3.35
Total	44	49.44	Total	191.51	63.84
Other 26	45	50.56	Other 26	108.49	36.16

Table 3. Descending Basal Area (BA) of ten tree species with DBH \geq 10 cm in the one-hectare lowland forest plot at the mid-section of the BDNP core zone, Jambi.

No	Species	Family	BA (m ²)
1	<i>Shorea leprosula</i>	<i>Dipterocarpaceae</i>	2.829
2	<i>Dialium platysepalum</i>	<i>Fabaceae</i>	2.580
3	<i>Artocarpus odoratissimus</i>	<i>Moraceae</i>	1.840
4	<i>Parashorea lucida</i>	<i>Dipterocarpaceae</i>	1.795
5	<i>Dacryodes rostrata</i>	<i>Burseraceae</i>	1.261
6	<i>Hydnocarpus</i> sp.	<i>Flacourtiaceae</i>	1.235
7	<i>Baccaurea macrophylla</i>	<i>Phyllanthaceae</i>	1.031
8	<i>Mussaenda frondosa</i>	<i>Rubiaceae</i>	1.021
9	<i>Antidesma neurocarpum</i>	<i>Phyllanthaceae</i>	0.978
10	<i>Artocarpus elasticus</i>	<i>Moraceae</i>	0.945
Total			15.515 m ² (50.31%)
79 other species			15.322 m ² (49.69%)
Total			30.837 m ² (100%)

STRUCTURE

The structure of a forest is reflected by the horizontal and vertical distribution. Horizontal distribution is generally expressed in terms of diameter class distribution (Purwaningsih & Yusuf, 2005) and vertical distribution by height stratification of tree crowns (Richards, 1996; Mirmanto, 2009).

It is always the case and is a feature of a primary tropical forest that a diameter class distribution curve forms an inverted J shape, where the tree diameters < 20 cm are dominant in the population, reflecting general characteristics of dynamic tropical rain forest (Richards, 1996). In the present plot the trees with DBH < 20 cm amounted to 292 trees or 54.07 % (Figure 4).

Table 4 shows the diameter class distribution of the 10 tree species with highest IV. *Dacryodes rostrata* was dominant at the 10-19.9 cm diameter class. It should be noted also that the ten species were well represented in the 10.9 – 19.9 cm and 30 – 30.9 cm diameter classes. The number of species decreased as the diameter increased. At the upper end of diameter class of 90-90.9 cm we recorded only two species, that were *Dialium platysepalum* and *Parashorea lucida*, while *Shorea leprosula* was present at 80 – 89.9 cm.

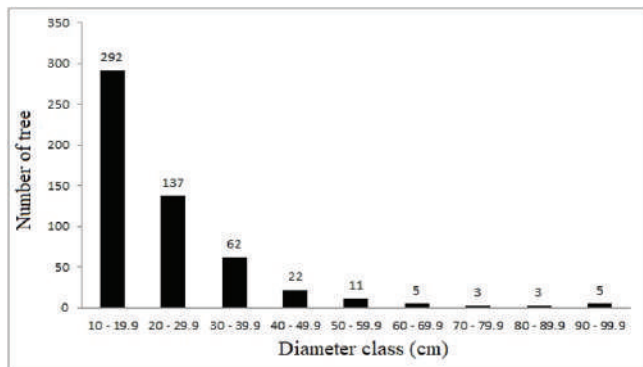


Figure 3. Species-area curve of tree species with DBH ≥ 10 cm in 100 subplots of the 100 m x 100 m plot in the forest of the midsection of BDNP core zone.

Four height classes of trees in the plot could be identified (Figure 5), comprising the A stratum (> 30 m), B stratum (20.1- 30 m), C stratum (4.1-20 m) and D stratum (1.1-4 m). The highest number of trees (452) occurred in the 4-20 m class (Figure 5). The A stratum which was the emergent stratum was dominated by *Dipterocarpaceae*, the B stratum by *Moraceae*, *Burseraceae* and *Flacourtiaceae*, the C stratum by *Burseraceae*, and the D stratum by the four families, each of which was represented by one tree.

Figure 6 is a simulated profile diagram of the forest on the plot constructed using the method of Kartawinata et al., (2004) by plotting each tree sequentially during the recording and measuring the

Table 4. Number of trees of 10 species with highest importance values (IV) along the diameter class gradient in a one-hectare plot in the forest of the midsection of the BDNP core zone, Jambi.

No	Species	Diameter class (cm)								
		10 - 19.9	20 - 20.9	30 - 30.9	40 - 40.9	50 - 50.9	60 - 60.9	70 - 70.9	80 - 80.9	90 - 90.9
1	<i>Dacryodes rostrata</i>	22	4	4	2					
2	<i>Shorea leprosula</i>	6	2	2	3	3		2	1	
3	<i>Hydnocarpus sp.</i>	14	11	4	1	2				
4	<i>Antidesma neurocarpum</i>	18	7	5						
5	<i>Dialium platysepalum</i>	4	0	2	2				1	2
6	<i>Artocarpus odoratissimus</i>	2	5	2	3	1			1	
7	<i>Dacryodes rugosa</i>	15	6	1						
8	<i>Parashorea lucida</i>	4	3	1		2	1			1
9	<i>Mussaenda frondosa</i>	6	8	3			1			
10	<i>Symplocos sp.</i>	6	7	3	1					

trees. It revealed the heights of the individual trees from 1.9 m to 45 m, forming the A, B, C and D strata. The heights of the strata in BDNP were shorter than in the undisturbed primary forest at the Batang Gadis National Park, where the A stratum was 50-60 m and the B stratum, which was the main forest canopy, was 30-50 m. The tallest tree with the height of 45 m and DBH of 86 cm was *Artocarpus odoratissimus*. The shortest trees with the height of 1-4 m were *Bombax anceps*, *Memecylon excelsum*, *Pertusadina eurhyncha* and *Madhuca sp.* with mean DBH of 12.02 cm.

The emergent top A stratum (> 30 m) consisted of only of 16 trees of the 10 prevalent species, which were dominated by species of *Dipterocarpaceae* consisted of five trees or 31,3% of the total. Dominance of *Dipterocarpaceae* in the upper canopy is a general characteristics the forests in Sumatra (Anwar et al., 1984; Kartawinata et al., 2004). The B stratum was dominated by big trees, including *Artocarpus odoratissimus* (mean DBH of 36.74 cm), *Dacryodes rostrata* (mean DBH of 20.02 cm), *Dialium platysepalum* (mean DBH of 45.17 cm) and *Shorea leprosula* (mean DBH of 38.20 cm). In C & D strata (1-20 m) the trees were dominated by species of *Burseraceae* (12,1%), *Phyllanthaceae* (7,0%), *Flacourtiaceae* (6,8%), *Lauraceae*

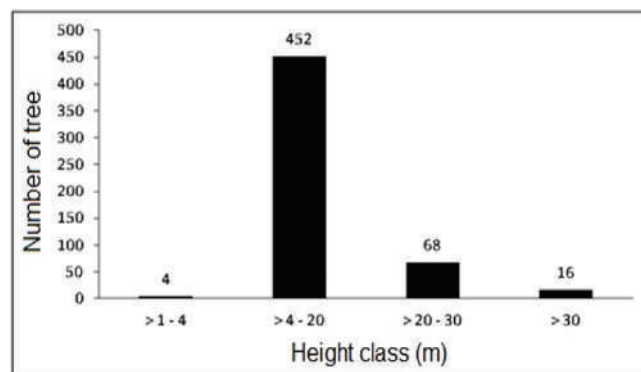


Figure 5. histogram of height class distribution of trees with DBH ≥ 10 m in a one-hectare plot in the forest of the midsection of the BDNP core zone, Jambi.

(6,6%) and *Dipterocarpaceae* (5,3%). The B stratum (20.1-30 m) was dominated by species of the families *Moraceae* (13,2%), *Burseraceae* (11,8%), *Dipterocarpaceae* (10,3%) and *Flacourtiaceae* (10,3%).

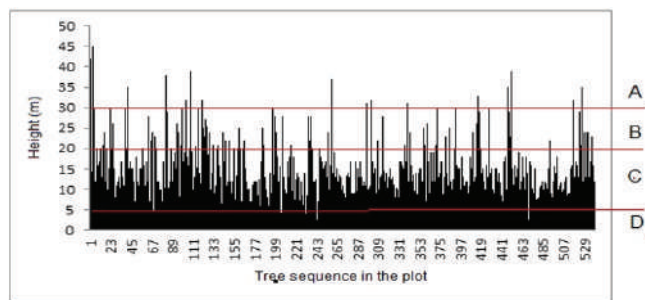


Figure 6. Simulated profile diagram of the forest on the plot constructed by plotting the height of each tree and sequential tree position from tree no. 1 in the 1st subplot up to the tree no 529 in the 100th subplot in the mid-section of the BDNP core zone.

Abiotic Factor

The topography of the one-hectare study plot is indicated in Figure 7. The forest in the study site was the lowland primary forest with topography ranging from undulating to hilly. The altitude ranges from 265 m to 327 m asl, with slopes vary from 2 to 45 %. The soil had pH of 5.6-7.36, mean daily temperature was 26.630 C, and the relative humidity ranged from 60.3% to 88.5%.

We recorded that the highest number of trees was recorded at the altitude of 290 - 299 m asl (193 trees) and the lowest number at 330 -339 m asl (3 trees). The highest number of trees (371) occurred at the slopes of 0 - 8 % and the lowest number (46) at the slope of 16-45 %. It was comparable to the situation in Mt. Galunggung (Pratiwi, 1989) and in the Mt. Gede-Pangranago National Park (Siagian, 2000).

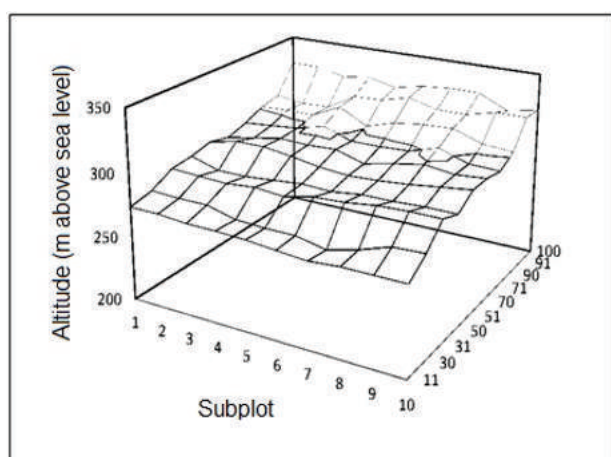


Figure 7. Topographic configuration of the (10 mx 10 m) subplots in relation to the one-hectare (100 m x 100 m) study plot at the mid-section of the BDNP core zone, Jambi.

DISCUSSION

Figure 8 shows the comparison of the species richness and the tree density in one-hectare plot in the present study to the findings in one-hectare plots of other studies in lowland forests of Sumatra and Kalimantan. The species richness refers to “the

number of species in a sampling unit” (McCune & Grace, 2002), which indicates species diversity at the first level or alpha diversity (Whittaker, 1972). In the present study the species richness was the lowest amounted to only 89 species per hectare, comparable to those at the research plots in Sarolangun, Jambi (Elviqar, 2013; Hermawan, 2013; Sehati, 2013 and Rahmah et al., 2016). It was much smaller than the species richness in the typical undisturbed primary lowland forests at the Batang Gadis National Park in North Sumatra (Kartawinata et al., 2004) and at Malinau in East Kalimantan (Sheil et al., 2010) with the number of 205 species, respectively.

The implication of this phenomenon points to the conditions of the forests in the present study as well as in the other studies in Sarolangun, Jambi (Elviqar, 2013; Hermawan, 2013; Sehati, 2013 and Rahmah et al., 2016). They must have been, in one way or another, disturbed by human activities, including highly destructive selective logging by commercial forest concessionaires and less destructive harvesting by the indigenous Suku Anak Dalam (SAD). As indicated by Sriyanto et al., (2003) the forests at BDNP had a total consisted of primary and secondary forests, which were converted from the permanent production forests, limited production forests and forest designated for other uses. It should be noted that the forests constituting the national park were set aside for the protection of the livelihood of of the SAD inhabiting the natural ecosystems of the area.

The floristic similarity between the present study plot and that in the eastern core zone of BDNP (Rahmah et al., 2016) was 40.8 % and with those at Hutan Adat Imbo Mengkadai (HAIM) 1 and HAIM 2 was 8.3 %, respectively, while with the Batang Gadis NP was 5.9 %, thus showing a totally different composition. It implies that differences were due to disturbances, leading to diverse compositional development of the disturbed forests resulting from the close association of the regrowth of original forest tree species and the late successional secondary forest species (Connell, 1978; Slik et al., 2008; Sheil & Burslem, 2003;).

The two dominant species in the plot, *Dacryodes rostrata* and *Shorea leprosula* (Appendix 1) signified the secondary nature of the forest. Yusuf (2005) noted that in West Sumatra *Dacryoides rostrata* occurred only in 20-30 years old secondary forests and was not found in 10 years old secondary forest. Secondary forest species recorded in the present study plot included *Cratogeomys cochinchinense*, *Macaranga hypoleuca*, *Macaranga tanarius*, *Mallotus mollissimus*, *Mussaenda frondosa*, *Neonauclea calycina* and *Shorea leprosula*. *Shorea leprosula* is a primary lowland rain forest species but often behaves like secondary forest species or even like a pioneer species invading canopy gaps and forest edges (Whitmore, 1986).

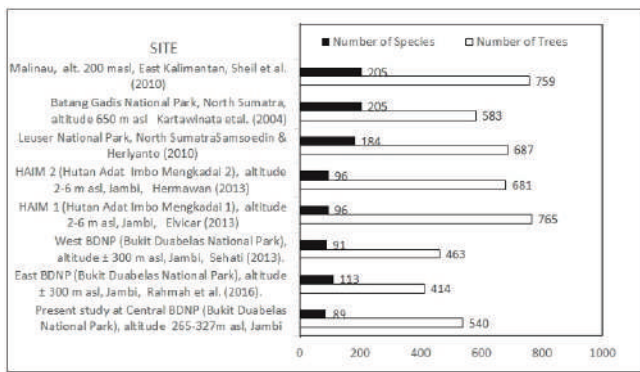


Figure 8. Comparison of the number of species and number of trees in one-hectare plots in forests of Sumatra and Kalimantan reported in various studies and the present investigation.

The presence of only three species of *Dipterocarpaceae* with D (density) of 36 trees/ha and BA (basal area) of 5.01 m² was unusual in view of the fact that in undisturbed lowland forests of Sumatra, the species of *Dipterocarpaceae* are generally dominant. It was exemplified by the lowland forest at the Batang Gadis National Park, which contained 16 dipterocarp species with D of 122 trees/ha and BA of 18.99 m² (Kartawinata et al., 2004). We assumed that this phenomenon was due to intensive selective logging of dipterocarp species which mostly have high commercial values. The heights of the strata in BDNP (Figure 6) were shorter than in the undisturbed primary forest at the Batang Gadis National Park, where the A stratum was 50-60 m and the the B stratum, which was the main forest canopy was 30-50 m. Structurally it points to the disturbed condition of the forest at the midsection of the core zone of BDNP.

The widespread distribution of *Dacryodes rostrata* as shown by high frequency value of 28 % was apparently related to its fruits, which were palatable to birds and primates (Balgooy, 1998), thus functioned as dispersers. Fruits of *Dacryodes rostrata* were reported to have high nutritive values, where 100 g of fruits contained 241 kcal energy, 35 mg protein, 399 mg K, 83 mg Ca and 83 mg Mg (Hoe & Siong, 1999).

Distribution of a species is generally not dependent on the distribution of other species, implying the absence of association among species. It was revealed by the association of species having frequencies > 5 % , indicating the Jaccard Coefficient of < 0.4 (Figure 9). It was further confirmed by X² test (df = 1 and α = 0.05) for 5 species with highest frequency, which showed negative association (X² < X² Table).

In the plot, we recorded only two species that were listed in the IUCN Red List of having high IUCN conservation status. They were *Parashorea lucida* and *Shorea leprosula*. *Parashorea lucida* had only 12 trees and was listed in the category of *Critically Endangered*, while *Shorea leprosula* had only 19 trees and listed in the category of *Endangered* (Table 5). The entire area of

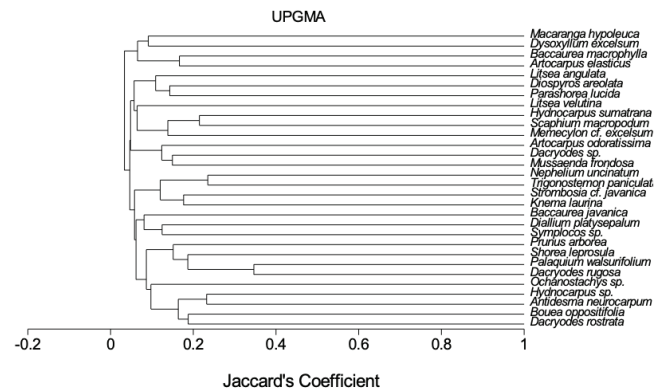


Figure 9. Association dendrogram of species having frequency > 5 %.

Table 5. The status of tree species occurring in the mid-section of the core zone of the BDNP as listed in the IUCN Red List Species.

No	Scientific name	Family	IUCN Status	D	F	Do	IV
1	<i>Parashorea lucida</i>	Dipterocarpaceae	CE	12	10	1.79	10.11
2	<i>Shorea leprosula</i>	Dipterocarpaceae	E	19	14	2.83	15.58
3	<i>Dacryodes rostrata</i>	Burseraceae	LR/LC	32	28	1.26	15.80
4	<i>Prunus grisea</i>	Rosaceae	LR/LC	17	16	0.70	8.72
5	<i>Scaphium macropodum</i>	Malvaceae	LR/LC	10	9	0.63	5.75
6	<i>Diospyros areolata</i>	Ebenaceae	LR/LC	7	6	0.18	3.12
7	<i>Aglaiia odoratissima</i>	Meliaceae	LR/LC	6	5	0.19	2.75
8	<i>Knema latifolia</i>	Myristicaceae	LR/LC	4	4	0.13	1.98
9	<i>Alangium javanicum</i>	Cornaceae	LR/LC	1	1	0.01	0.43

Legend: CE = Critically Endangered; E = Endangered; LR/LC = Lower Risk/Least Concern

BDNP, however, contained also rare plant species, including *Eusideroxylon zwageri*, *Fagraea fragrans*, *Calamus manan*, *Daemonorops draco* and *Dyera costulata* (Kementerian Kehutanan dan Balai TNBD, 2011; Rahmah et al., 2016).

The concept of Hubbell & Foster (1986) states that if on the average, a species had one or fewer individuals per hectare, it can be considered as a rare species on the local scale. Applying this concept, 59 species of 32 families occurring in the plot can be considered as rare in view of the fact that they had the percentage of number of trees of 1-5 %. Of 32 families, 15 of them were represented by one individual each (Table 5). This phenomenon should not be in any way perceived on the global scale as defined by IUCN criteria of rareness.

CONCLUSION

The one-hectare study plot contained 540 trees, comprising 89 species and 36 families. On the basis of two dominant species we designated the tree community in the forest as the *Dacryodes rostrata-Shorea leprosula Association*. Foltristically it was a poor community with low species richness and non-dipterocarp species were prevalent. The one hectare plot should not in any way considered as the minimal area representing the surrounding forests, but it sufficiently provided an illustration of the forest locally. The plot was established as a permanent plot so that it can be used for monitoring dynamic processes

and future studies in various aspects valuable to support sustainable management of the BDNP and the livelihood of SAD.

Structurally and floristically the forest represented a developing and regenerating disturbed forest, with heterogenous species composition as reflected by very low frequency and density in the majority of the species. The core zone of the BDNP has undergone changes from dipterocarp dominated forest to that dominated by non-dipterocarps, due to human activities.

A natural succession has been taking place in the forest of the core zone, leading to the formation of forest similar to the original one prior to disturbance. This rate of natural succession is, however, extremely slow. It can be enhanced and assisted by means of ecological restoration through planting of tree species characteristics of forests in Jambi. They include species of *Dipterocarpaceae*, useful species having values to maintain the livelihood of the SAD, rare and endemic species and others with high conservation values. Species that were persistent and would maintain themselves in the forest in the future are currently represented in almost all diameter classes, although with low density.

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Appendix 1. Density (D = trees/ha), frequency (F in %) and BA (Basal Area in m sq.) of tree species in a one-hectare plot of a lowland forest at the midsection of the core zone of the Bukit Duabelas National Park, Jambi.

NO	Scientific name	Family	Local name	D (trees/ha)	F (%)	BA (m ²)	IV (%)
1	<i>Dacryodes rostrata</i> (Blume) H.J.Lam	Burseraceae	Jagul besak	32	32	1.261	15.80
2	<i>Shorea leprosula</i> Miq.	Dipterocarpaceae	Meranti bungo	19	19	2.829	15.58
3	<i>Hydnocarpus</i> sp.	Flacourtiaceae	Kelat merah	31	31	1.235	14.91
4	<i>Antidesma neurocarpum</i> Miq.	Phyllanthaceae	Kelat putih	30	3	0.978	14.30
5	<i>Dialium platysepalum</i> Baker	Fabaceae	KerANJI umbut	11	11	2.580	12.67
6	<i>Artocarpus odoratissimus</i> Blanco	Moraceae	Terap kangkung	14	14	1.840	10.83
7	<i>Dacryodes rugosa</i> (Blume) H.J.Lam	Burseraceae	Kedundung tunjuk	22	22	0.542	10.17
8	<i>Parashorea lucida</i> Kurz	Dipterocarpaceae	Tengkawang bukit	12	12	1.795	10.11
9	<i>Mussaenda frondosa</i> L.	Rubiaceae	Berumbung	18	18	1.021	9.33
10	<i>Symplocos</i> sp.	Symplocaceae	Kayu garam	17	17	0.795	9.03
11	<i>Prunus grisea</i> (Blume ex Müll.Berol.) Kalkman	Rosaceae	Mesuai	17	17	0.698	8.72
12	<i>Palaquium walsurifolium</i> Pierre ex Dubard	Sapotaceae	Balam merah	17	17	0.611	8.02
13	<i>Artocarpus elasticus</i> Reinw. ex Blume	Moraceae	Terap nasi	15	15	0.945	7.49
14	<i>Ochanostachys</i> sp.	Olacaceae	Petaling putih	11	11	0.775	6.62
15	<i>Knema laurina</i> Warb.	Myristicaceae	Menerah	14	14	0.311	6.29
16	<i>Memecylon excelsum</i> Blume	Melastomataceae	Kelat jambu	14	14	0.364	6.25
17	<i>Baccaurea macrophylla</i> (Müll.Arg.) Müll.Arg.	Phyllanthaceae	Medang labu	7	7	1.031	5.88
18	<i>Scaphium macropodum</i> (Miq.) Beumée ex K.Heyne	Malvaceae	Muaro kepayang	10	1	0.629	5.75
19	<i>Trigonostemon</i> sp.	Euphorbiaceae	Banit putih	13	13	0.200	5.74
20	<i>Dacryodes</i> sp.	Burseraceae	Kedundung kedal	11	11	0.471	5.63
21	<i>Hydnocarpus sumatrana</i> Koord.	Flacourtiaceae	Medang seluang	9	9	0.611	5.30
22	<i>Bouea oppositifolia</i> (Roxb.) Adalb.	Anacardiaceae	Temeras	10	1	0.194	4.55
23	<i>Nephelium uncinatum</i> Radlk.	Sapindaceae	Idan tunjuk	8	8	0.193	3.76
24	<i>Litsea angulata</i> Blume	Lauraceae	Medang pawas	7	7	0.284	3.66
25	<i>Litsea velutina</i> (Blume) Hook. f.	Lauraceae	Medang cempako	7	7	0.237	3.51
26	<i>Strombosia javanica</i> Thwaites	Olacaceae	kayu tulang	7	7	0.223	3.47
27	<i>Gluta</i> sp.	Anacardiaceae	Terentang	2	2	0.768	3.27
28	<i>Parashorea</i> sp.	Dipterocarpaceae	Anai baik	5	5	0.381	3.20
29	<i>Ficus elastica</i> Roxb. ex Hornem.	Moraceae	Kayu aro	2	2	0.729	3.15
30	<i>Diospyros areolata</i> King & Gamble	Ebenaceae	Banit hitam	7	7	0.180	3.12
31	<i>Dysoxylum excelsum</i> Blume	Meliaceae	Jagul tunjuk	7	7	0.156	3.04
32	<i>Macaranga hypoleuca</i> (Rchb.f. & Zoll.) Müll.Arg.	Euphorbiaceae	Mang	6	6	0.192	2.97
33	<i>Pternandra azurea</i> (DC.) Burkill	Melastomataceae	Kayu ubi	7	7	0.177	2.90
34	<i>Polyalthia sumatrana</i> (Miq.) Kurz	Annonaceae	Balam putih	3	3	0.521	2.86
35	<i>Archidendron bubalinum</i> (Jack) I.C.Nielsen	Fabaceae	Kabau	5	5	0.250	2.77
36	<i>Baccaurea javanica</i> (Blume) Müll.Arg.	Phyllanthaceae	Tungau	6	6	0.129	2.77
37	<i>Aglia odoratissima</i> Blume	Meliaceae	Idan cuko	6	6	0.186	2.75
38	<i>Madhuca</i> sp.	Sapotaceae	Putat talang	6	6	0.181	2.73
39	<i>Neonauclea calycina</i> (Bartl. ex DC.) Merr.	Rubiaceae	Medang kuning	5	5	0.273	2.64
40	<i>Lithocarpus sundaicus</i> (Blume) Rehder	Fagaceae	Barangan benar	4	4	0.390	2.63
41	<i>Litsea</i> sp.	Lauraceae	Medang kalo	5	5	0.181	2.55
42	<i>Durio oxleyanus</i> Griff.	Bombacaceae	Barangan babi	5	5	0.177	2.53
43	<i>Neolitsea cassifolia</i> Merr.	Lauraceae	Medang so	3	3	0.342	2.28
44	<i>Gonocaryum gracile</i> Miq.	Cardiopteridaceae	Meribung	4	4	0.171	2.12
45	<i>Sterculia cordata</i> Blume	Malvaceae	Kelumpang batu	4	4	0.142	2.03
46	<i>Claoxylon longifolium</i> (Blume) Endl. ex Hassk.	Euphorbiaceae	Medang pangkat	2	2	0.371	1.99
47	<i>Knema latifolia</i> Warb.	Myristicaceae	Cemunik	4	4	0.129	1.98
48	<i>Gordonia excelsa</i> (Blume) Blume	Theaceae	Kayu bulan	2	2	0.298	1.75
49	<i>Diospyros curranii</i> Merr.	Ebenaceae	Kayu cingkul	3	3	0.136	1.62
50	<i>Cryptocarya crassinervia</i> Miq.	Lauraceae	Medang batu	3	3	0.087	1.46
51	<i>Palaquium ridleyi</i> King & Gamble	Sapotaceae	Pinang baik	3	3	0.080	1.43
52	<i>Callophyllum tetrapterum</i>	Clusiaceae	Selancar	3	3	0.074	1.42
53	<i>Sterculia rubiginosa</i> Zoll. ex Miq.	Malvaceae	Semasam	3	3	0.072	1.41
54	<i>Durio zibethinus</i> L.	Bombacaceae	Durian mas	2	2	0.189	1.19
55	<i>Neouvaria</i> sp.	Annonaceae	kalintang tanggo	2	2	0.103	1.12
56	<i>Madhuca sericea</i> (Miq.) S.Moore	Sapotaceae	Putat tasik	1	1	0.219	1.10
57	<i>Lithocarpus encleisocarpus</i> (Korth.) A.Camus	Fagaceae	Cemening babi	2	2	0.042	0.92
58	<i>Artocarpus anisophyllus</i> Miq.	Moraceae	Berkil	2	2	0.036	0.90
59	<i>Elaeocarpus glaber</i> Blume	Elaeocarpaceae	Keniti	2	2	0.030	0.88

60	<i>Dialium indum</i> L.	Fabaceae	KerANJI batu	2	2	0.028	0.87
61	<i>Macaranga tanarius</i> (L.) Müll.Arg.	Euphorbiaceae	Sengkubung	1	1	0.096	0.70
62	<i>Knema globularia</i> (Lam.) Warb.	Myristicaceae	Anggung	1	1	0.064	0.60
63	<i>Scorodocarpus borneensis</i> (Baill.) Becc.	Olacaceae	Kulim	1	1	0.052	0.56
64	<i>Nephelium mutabile</i> Blume	Sapindaceae	Samak ketan	1	1	0.051	0.56
65	<i>Gynotroches axillaris</i> Blume	Rhizophoraceae	Kayu buluh	1	1	0.045	0.54
66	<i>Mallotus mollissimus</i> (Geiseler) Airy Shaw	Euphorbiaceae	Setarak	1	1	0.044	0.53
67	<i>Oncosperma horridum</i> (Griff.) Scheff.	Arecaceae	Bayas	1	1	0.039	0.52
68	<i>Diospyros hermaphrodita</i> (Zoll.) Bakh. ex Steenis	Ebenaceae	Nilau nasi	1	1	0.029	0.49
69	<i>Garcinia parvifolia</i> (Miq.) Miq.	Clusiaceae	Kandih burung	1	1	0.023	0.48
70	<i>Dysoxylum</i> sp.	Meliaceae	Tampoi kuro-kuro	1	1	0.023	0.47
71	<i>Syzygium cymosum</i> (Lam.) DC.	Myrtaceae	Kelat samak	1	1	0.022	0.46
72	<i>Eurycoma longifolia</i> Jack	Simaroubaceae	Semedu tanah	1	1	0.021	0.46
73	<i>Knema mandaharan</i> Warb.	Myristicaceae	Benal	1	1	0.020	0.46
74	<i>Timonius timon</i> (Spreng.) Merr.	Rubiaceae	Itam telutuk	1	1	0.020	0.46
75	<i>Pittosporum moluccanum</i> Miq.	Pittosporaceae	Kalumpang Beras	1	1	0.019	0.45
76	<i>Paranephelium nitidum</i> King	Sapindaceae	Kemangar	1	1	0.017	0.45
77	<i>Garcinia</i> sp.	Clusiaceae	Inggi daro	1	1	0.015	0.44
78	<i>Microcos opaca</i> Burret	Malvaceae	Sesumpit	1	1	0.015	0.44
79	<i>Garcinia atrovirens</i> Griff. ex T.Anderson	Clusiaceae	Asam gelugur	1	1	0.013	0.43
80	<i>Cratoxylum cochinchinense</i> (Lour.) Blume	Hypericaceae	Semampat	1	1	0.013	0.43
81	<i>Bombax anceps</i> Pierre	Malvaceae	Kakabu	1	1	0.013	0.43
82	<i>Memecylon edule</i> Roxb.	Melastomataceae	Belimbing hutan	1	1	0.013	0.43
83	<i>Ochanostachys amantacea</i> Mast.	Olacaceae	Petaling merah	1	1	0.013	0.43
84	<i>Gironniera hirta</i> Ridl.	Cannabaceae	Medang sailok	1	1	0.011	0.43
85	<i>Pertusadina eurhyncha</i> (Miq.) Ridsdale	Rubiaceae	Kayu pisang	1	1	0.011	0.43
86	<i>Neolitsea</i> sp.	Lauraceae	Medang pergam	1	1	0.011	0.43
87	<i>Alangium javanicum</i> (Blume) Wangerin	Comaceae	Nilau ruso	1	1	0.010	0.43
88	<i>Baccaurea dulcis</i> (Jack) Müll.Arg.	Phyllanthaceae	Tampoi kerawak	1	1	0.010	0.43
89	Unidentified		Akar jangat	1	1	0.032	0.49
Total				540	540	30.837	300