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Biomass and Floristic Composition of Bangi Permanent Forest Reserve, a Twice-Logged Lowland Dipterocarp Forest in Peninsular Malaysia

(Biojisim dan Komposisi Spesies di Hutan Simpan Kekal Bangi, Suatu Hutan Dipterokarpa Tanah Rendah yang Dibalak Dua Kali di Semenanjung Malaysia)

J.J. LAJUNI & A. LATIFF*

ABSTRACT

A 1 ha permanent plot was established in Bangi Permanent Forest Reserve for this study. A total of 1018 trees with a diameter at breast height (DBH) of 5 cm and above were identified, marked and measured. Their DBH ranged from 5 to 83.6 cm, where most trees fell into the 5 to 14.9 cm DBH or Class 1 (65.71%) and 1.57% of them fell into Class 7 with DBH over 65 cm. The five largest trees were from the dipterocarp family. Species with the highest Relative Dominance Value was Shorea acuminata *with a value of 10.40. The total above ground biomass was 362.13 t/ha, which can be considered high for a twice-logged forest. The total basal area was 314.97 m^2. The species diversity Shannon-Wiener index for this plot is H=6.99 with evenness of 0.852 and 0.85 with Brillouin's Index. Species with the highest frequency (68.39%) and highest Importance Value Index (83.80%) was* Antidesma cuspidatum. *There were 171 species of trees representing 113 genera and 43 families plot. Wild fruit trees and trees with ethnobotanical potential were also identified. The results of this study indicated that this forest has high biomass content and high species diversity.*

Keywords: Biomass; distribution; flora; species composition; species diversity

ABSTRAK

Suatu 1 ha plot kekal telah ditubuhkan di Hutan Simpan Kekal Bangi untuk kajian ini. Sejumlah 1018 pokok dengan diameter pada paras dada (DBH) 5 cm dan ke atas telah dicam, ditanda dan diukurkan. DBH mereka berjulat daripada 5 kepada 83.6 cm, dengan kebanyakan pokok berada dalam Kelas I pada 5-14.9 cm DBH (65.71%) dan 1.57% daripadanya jatuh pada Kelas 7 dengan DBH lebih daripada 65 cm. Lima pokok yang terbesar adalah daripada famili dipterokarpa. Spesies yang mempunyai Nilai Kedominanan Relatif tertinggi adalah Shorea acuminata *dengan nilai 10.40. Jumlah biojisim atas tanah adalah 362.13 t/ha, yang boleh dianggap tinggi bagi hutan yang telah dibalak dua kali. Jumlah keluasan pangkal adalah 314.97 m^2. Indeks kepelbagaian spesies Shannon-Wiener adalah H=6.99 dengan kesamarataan 0.852 dan 0.85 Indeks Brillouin. Spesies yang mempunyai kekerapan tertinggi (68.39%) dan Indeks Nilai Kepentingan tertinggi (83.80%) adalah* Antidesma cuspidatum. *Terdapat 171 spesies pokok mewakili 113 genus dan 43 famili. Pokok buah liar dan pokok yang mempunyai potensi etnobotani juga telah dikenal pasti. Hasil daripada kajian ini menunjukkan bahawa hutan ini mempunyai biojisim dan kepelbagaian spesies yang tinggi.*

Kata kunci: Biojisim; flora; kepelbagaian spesies; komposisi spesies; taburan

INTRODUCTION

The future of the rainforests in Malaysia and around the world is not certain. With the present rapid rate of clearing and logging, it is predicted that there will be few primary or virgin forests exist in the future and most of what will be available then will be disturbed, logged-over or secondary forests. Biologists are concerned that disturbed, logged-over and secondary forests are not as good as primary forests in term of species diversity, composition, biomass and structure. The objective of this study was to address these concerns; by finding out if there are significant differences between primary and twice-logged forest for the above parameters.

SITE DESCRIPTION AND METHODS

Bangi Permanent Forest Reserve (BPFR) lies between 2^0 54' North and 1010 4.5' East, in the district of Hulu Langat, Selangor. This forest is bordered by the Langat river in the North and Kuala Lumpur-Seremban highway in the South and about 35 km south of Kuala Lumpur. Topographically, the area is moderately flat with an altitude of 40 to 110 m above sea level. It has several small streams which together with patches of seasonal freshwater swamps contain a flow of water, especially during the rainy season. The bedrock is made up of soft rock (Tjia 1981). This forest received its reserve status on December 31, 1906. Though this reserve falls under the strict jurisdiction of the Forestry Department, however during the Japanese occupation

(1942-1945) it was logged and again logged off for the second time in the late 1960's (Latiff 1981). The Japanese planted *Palaquium gutta* (Sapotaceae) as a source for 'gutta perca' after the first logging was completed. In addition settlements were created and rubber was planted on the fringes of this reserve. Today a portion of the reserve of about 105 ha of mixed vegetation is designated by the University as the Ecological Research Area. Another section of about the same area is now developed as the main campus of the university and several student housing areas and a few hundred hectares are being developed for various academic purposes. About 138 ha of the forest is left worth recommending for conservation (Latiff 1981), however this figure has decreased ever since.

The flora of BPFR is well studied by the staff and students of the university. Hashim (1980) surveyed the species composition of this forest and found the family of Euphorbiaceae dominates with most species being *Porterandia* sp. and *Antidesma cuspidatum*. Latiff (1981) studied and listed species from this forest with ethnobotanical value. Ramli (1981) surveyed the palms and discovered that *Salacca conferta* dominates the swampy part of this forest and *Eugeissona tristis* occupies the drier lands. Jamili (1988) for the first time enumerated 66 families that consist of 166 genera and 360 species from this forest. Syed Muzni (1991) continued Jamili's work and further enumerated 23 families from 94 genera that consist of 154 species.

The most recent study was done by Norashidah (1993) who studied the biomass and species composition of a 1 ha plot. This study yields 273.3 t/ha of above ground biomass contributed by 809 trees with DBH over 5 cm. The species count for Norashidah's (1993) 1 ha plot was 167 from 41 families. For this study a permanent 1 ha plot is a rectangle 50 by 200 m was established. This shape was chosen so that the longest portion of the rectangle goes further into the forest. The slopes were not exceeding 5^0, hence slope correction for this site was not performed. A sample was taken from each tree measured, for species identification purpose. These specimens were assigned a label corresponding to the tree where it was taken from, for example a sample from tree number one from subplot A1, thus labelled A1-1. All voucher specimens were lodged in the university herbarium (UKMB). Trees in the forest come in various shapes and forms. Many large trees are with buttresses, where others are with multiple stems. These trees need specific consideration when measuring their DBH. The measuring consideration and methods for special cases or unusual trees in this study was adapted from Petol (1995).

Biomass, which is the dry weight of plant material, is often used as a parameter in determining the productivity of a forest and forest stand and ordinarily expressed in term of tonne per hectare or t/ha. For this study the above ground biomass consists of the combined weight of all tree materials above the ground level. This, however, does not include lianes and epiphytes, which may grow on the trees. The method used to calculate the above ground biomass for this study is the regression formula developed by Kato et al. (1978). Other parameters used in this study include the Basal area, importance value index (IVI), relative density (RD), relative dominance (RD_0) and relative frequency (RF). The floristic diversity is another important aspect of this study. The diversity index indicators used for this study are Shannon-Wiener's, Simpson's and Brillouin's Indices.

Results and Discussion

Biomass and DBH Distribution

The total above ground biomass obtained from this 1 ha plot was 362.13 t/ha, derived from a total of 1018 trees with DBH of 5 cm and above. This biomass can be broken down to that of leaves at 2.5 t/ha or 0.70%, biomass of branches and twigs at 73.6 t/ha or 20.50% and biomass of stem or trunks at 282.84 t/ha or 78.10%. The DBH ranges of these trees were between 5 and 83.6 cm (Table 1). The biomass obtained is significantly higher than that obtained by Norashidah (1993) for this forest but at a different site which was 273.3 t/ha. Tami (1996) who studied the biomass of a 0.75 ha plot at Cape Rachado Forest Reserve, a primary forest, using the same formula obtained 257.6 t/0.75 ha or 343.46 t/ha. The higher biomass obtained from the present study is due to the presence of more trees, as compared with those studied by Norashidah (1993), Tami (1996) and exceed the mean tree per ha obtained by Kochummen et al. (1990) from the Pasoh Forest Reserve. The biomass obtained is also comparable with that of Soepadmo (1987) at Gunung Janing, Johor at 350 t/ha. This is an indication that this particular area of this forest is still productive.

TABLE 1. DBH distribution of a 1 ha plot in Bangi Permanent Forest Reserve

Diameter class	Number of trees
CLASS 1: 05.00 - 14.90 cm	669
CLASS 2: 15.00 - 24.90 cm	202
CLASS 3: 25.00 - 34.90 cm	67
CLASS 4: 35.00 - 44.90 cm	46
CLASS 5 : 45.00 - 54.90 cm	12
CLASS 6: 55.00 - 64.90 cm	6
CLASS 7: Above 65.00 cm	16

The dipterocarp family contributed the most above ground biomass (Table 5). This family represented by two genera, consisting of seven species has a combined above ground biomass of 141.36 t/ha or 39% of the biomass obtained. Most of the individuals from this family form the emergent layer, thus even though there are few individuals, they contributed the most in biomass. Euphorbiaceae, the largest family in this study in term of species and tree count only contributed 22.31 t/ha or 6.1% of the total biomass. Table 4 lists the biomass of each family and their ranking, whereas Table 3 lists the ten largest species in the plot.

Since biomass is an indicator of a forest's productivity (Satoo et al. 1980; Whitmore 1991) then the high biomass of BPFR indicate that this is a highly productive forest with a biomass that is comparable with a coastal primary forest productivity studied by Tami (1996). The productivity of a forest in turn is governed by several factors. These factors include the topography of the location, as suggested by Soepadmo (1987) where biomass decreases with the increase of latitude as well as with other parameters such as microclimate, soil nutrient and moisture (Ewel et al. 1983). These factors make it possible for forests stand to be unique and different from each other, even within the same ecosystem. This was illustrated by Norashidah's (1993) study as well as this study, which were conducted in the same forest (less than 200 ha) in a different site. The species composition is similar; however, the biomass is different.

The DBH distribution of trees in this study plot is summarized in Table 1. The distribution is not significantly different from that of Norashidah (1993) as illustrated in Table 2. The average DBH of trees in this plot is 15.06 cm with an average height of 18.19 m, as compared with Norashidah's average DBH at 14.7 cm and average height of 15.50 m. The largest tree *Shorea bracteolata,* measures 83.6 cm at DBH. The majority of trees studied fall into DBH Class one, meaning that this forest is an actively regenerating forest consisting of mostly young trees and saplings. The DBH distribution obtained in this study is similar to those obtained in various studies as illustrated in Table 2.

The presence of several large trees which are tall enough to form the emergent canopy indicates that Bangi Permanent Forest Reserve is on its way to reach the status of matured or climax forest. Judging from the height of these trees, it indicates that there are five layers covering this forest (Noraini 1990), namely the emergent layer, the main canopy layer, the layer of under canopy trees, the shrub layer and sapling layer. In this study 15 trees were over 40 m high. Table 3 lists the largest ten individual trees in the plot. All of these trees except for *Palaquium gutta* are commercial timber trees. In Table 2, HSCR, a primary forest has more trees that fall into Diameter class 1 and class 7, compared with the three other studies.

The basal area of trees in this study is 314.97 m^2. The 10 species that contribute the most in this parameter are listed in Table 4.

THE RELATIVE DENSITY (RD), RELATIVE FREQUENCY (RF), RELATIVE DOMINANCE (RD^0) AND THE IMPORTANCE VALUE INDEX

The value for relative density for this plot ranges from 0.09 to 11.69. This shows that the density of each species has a wide gap. The three species with the highest value for this parameter were *Antidesma cuspidatum*, *Aidia wallichiana* and *Timonius wallichianus*. *Antidesma cuspidatum* tops the list by having a value of 11.69%, which is not surprising because Norashidah (1993), who studied this forest on a different location, had this species as the most dominant. Only five of the species listed in the top ten ranges appeared in Norashidah's (1993) plot and *vice versa*.

TABLE 2. DBH distribution of BPFR and Cape Rachado Forest Reserve (HSCR) (1996) and Fraser's Hills (FH) (1995) compared (%)

DBH Class (cm)	BPFR 1996	BPFR 1993	HSCR 1996	FH 1995
05.00 - 14.90	61.71	70.00	74.30	69.30
15.00 - 24.90	19.84	16.90	12.20	16.80
25.00 - 34.90	06.58	04.90	06.00	07.60
35.00 - 44.90	04.51	04.00	03.20	03.10
45.00 - 54.90	01.17	02.60	01.70	02.00
55.00 - 64.90	00.58	00.90	00.80	00.90
Above 65	01.57	00.70	01.70	00.40

Sources: Present study (1996), Norashidah (1993), Tami (1996) and Petol (1995)

TABLE 3. The ten largest trees found in this study

Species	DBH (cm)	Height (m)
Shorea bracteolata	83.60	44.69
Shorea acuminata	83.20	44.69
Shorea acuminata	80.70	44.26
Dipterocarpus baudii	79.00	44.01
Dipterocarpus baudii	78.50	43.93
Palaquium gutta	78.00	43.90
Dyera costulata	74.30	43.35
Dyera costulata	74.25	43.24
Shorea leprosula	72.25	42.94
Shorea bracteolata	72.20	42.90

TABLE 4. Ten species with the largest basal area in cm^2

Species	Basal Area
Shorea acuminata	34887.77
Ptychopyxis costata	29064.00
Shorea bracteolata	19319.94
Artocarpus scortechinii	16366.245
Dipterocarpus baudii	14910.5
Palaquium gutta	14642.18
Shorea leprosula	13895.11
Dipterocarpus crinitus	12454.54
Dyera costulata	12373.20
Antidesma cuspidatum	12378.40

Antidesma cuspidatum also appeared in the top ten range in Jamili (1988) and Syed Muzni (1991) studies, when they conducted the floristic survey of BPFR.

Species that appeared more frequently in this plot is *Antidesma cuspidatum*, which has a frequency of 68.39%. This species tends to grow in clumps. Therefore it is not surprising to encounter them occupying an entire plot. The relative dominance of various species in this plot varies, some species such as *Lepisanthes tetraphylla* recorded the lowest value at 0.007, while *Shorea acuminata* has the highest RD° value at 10.48. Most of the species that ranked in the top 10 in RD values are from the dipterocarps which include *Shorea bracteolata, S. leprosula, Dipterocarpus baudii* and *D. crinitus*. This confirms that the relative DBH of the population of Dipterocarpaceae in this forest is larger. This family is perhaps the most expensive timber in this forest.

The importance value index is an important parameter used in determining the economic value of a forest, timber wise. If the species with the highest value happens to be a valuable timber species, the forest stands to be classified as an economically valuable stand. In this study, the IVI of timber species is not high enough to be classified as such. In this study *Antidesma cuspidatum* has the highest IVI, whereas *Shorea acuminata* and *Dipterocarpus crinitus* the two timber species which made it to this category only have a value of 22.59 and 17.87, respectively.

SPECIES DIVERSITY

The maximum possible species diversity index is also obtained from this plot using the Shannon-Wierner and Brillouin diversity indices. The maximum species diversity possibility index obtained in this study (Shannon-Wiener's H'= 7.451 and Brillounnin = 0.854) indicate a good species diversity, bearing in mind that BPFR is a twice logged forest. These indices are not as high as those obtained from a primary forest. Tami (1996) in his study at Cape Racado Forest Reserve (HSCR) stated the indices were D=0.2537 with Simpson's and H'=13.594 with the Shannon-Weiner index. Manokaran and Swaine (1994) also recorded a much higher species count in their study of a primary forest. These indices show the kind of diversity a species rich forest should have.

The lower diversity index measure result obtained in this study definitely indicates that logging, even done on a selective basis contribute to species loss. The last logging activities in BPFR reserve was more than 20 years ago, yet the species diversity has not recovered and only half as diverse as that contained in a primary forest. However this study in the species diversity aspect is not conclusive because the original species number and composition of this forest is not known.

SPECIES AND FLORAL COMPOSITION

BPFR is a lowland dipterocarp forest that has been selectively logged and showing signs of regenerating. The presence of *Bertam* or *Eugeissona tristis* and *Palas* or *Licuala glabra*, indicator species in the study plot is prominent, to an extent that movement is restricted. One has to walk carefully to avoid being pricked their razor and needle sharp spikes. A total of 171 species from 112 genera and 42 families found in this plot. The largest family in this plot is Euphorbiaceae with 10 genera and 19 species. Jamili and Latiff (1990) in their study showed that BPFR harbours 31 species from this family. The second largest family is Burseraceae with 5 genera and 18 species. Previous studies (Jamil 1990; Norashidah 1993; Syed Muzni 1991) obtained similar results. Interestingly Jamili and Latiff (1990) listed Myrtaceae as one of the largest families in BFR with 11 species, of which ten of them were found in the present study. Table 5 lists the largest ten families from this study. Tami (1996) and Manokaran and Swaine (1994) who studied primary lowland dipterocarp forests also found this family as one of the largest in their studies. The results from these different studies showing this family as the largest in itself is interesting because a lowland dipterocarp forest should be dominated by the family Dipterocarpaceae (Whitmore 1991). The largest 10 families according to the species count from Jamili (1988) and Syed Muzni (1991) is not included here, because their studies were not restricted to trees with a diameter of 5 cm and larger, in addition several of the families were not trees.

The gregarious *Antidesma cuspidatum* which usually form a clump, appear to be the most frequent, dominant and with the highest density value in this study. It is perhaps safe to say that judging from the frequent incidence of this species in the three other study, Jamili (1988), Norashidah (1993) and Syed Muzni (1991), that this species is probably common in BFR. However in the studies involving primary forest, Tami (1996) and Soepadmo (1987), this species was not prominent. Many genera in this study are represented only by one species and at times with only one individual. Examples of these genera include *Bouea, Buchanania, Ilex, Mezzetia, Magnolia, Aquilaria* and *Eurycoma*. The number of species represented with only one individual in this plot is 59.

As mentioned earlier, no two sites within a forest have the same species composition, as shown by the species difference obtained by this study and another by

TABLE 5. The ten largest families in this study according to species count

Family	No. of genera	No. of species
Euphorbiaceae	10	19
Burseraceae	5	18
Myristicaceae	3	10
Myrtaceae	4	10
Lauraceae	8	9
Fabaceae	7	8
Dipterocarpaceae	2	7
Anacardiaceae	6	7
Rubiaceae	7	7
Polygalaceae	2	6

Norashidah (1993). There were 47 species which appear in this study that were not in Norashidah (1993) plot.

CONCLUSION

The floral composition in the family level found in this study is not significantly different from those found in a primary forest. However, the difference is significant at the species level. The species count found in this study is markedly different from the results found in studies conducted in primary forests. In terms of biomass, the result obtained from this study is comparable with those obtained from studies conducted in the virgin forest.

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Pusat Pengajian Sains Sekitaran dan Sumber Alam
Fakulti Sains dan Teknologi
Universiti Kebangsaan Malaysia
43600 Bangi, Selangor
Malaysia

*Corresponding author; email: latiff@ukm.my

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