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JILID 1

ECOLOGICAL STUDIES IN PRIMARY HILL DIPTEROCARP FOREST AT SEMANGKOK FOREST RESERVE, SELANGOR

by

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Abstract: A six-hectare ecological plot was established in 1992 to study the community structure and dynamics of major tree species in a primary hill dipterocarp at Semangkok Forest Reserve. The plot dimension was 200 x 300 m. The six-hectare plot were divided to 150 20 x 20 m quadrats and 2400 5 x 5 m sub-quadrats. All young and mature trees > 5 cm diameter-at-breast height (dbh) were tagged, mapped, measured and identified to species level. To date 5 recensus has been conducted. A sub-sampling of seedlings and saplings below 5 cm dbh were also collected. The main objective of the study was to clarify the life history of major species in primary hill dipterocarp forest. The paper presented findings on the species diversity, abundance and spatial pattern assessment from the last ten years of research.

Keywords: Community structure, frequency, density, abundance, hill dipterocarp forest, Seraya-Ridge Forest

INTRODUCTION

Many plots have been established in the tropics for ecological study. Although, these plots vary in sizes and shape, they have been used to determine species diversity, species changes along altitudinal gradients, and the structure and dynamics of forest ecosystem (Niiyama et al. 1999a). In Peninsular Malaysia a 50-ha plot in lowland dipterocarp forest of Pasoh Forest Reserve was established in 1985 (Manokaran et al. 1990; Kochumen et al. 1990). In 1992, a 6-ha plot was established in a primary hill dipterocarp forest to clarify the population structure and dynamics of major tree species through out their whole life-cycle. The paper presented some results on species diversity, abundance, spatial pattern and community structure analysis of major trees in the 6-ha plot. We also highlighted the potential impact of timber management practices on sustainable management on this forest type based on the assessment of stocking density, size-structure and species composition.

MATERIALS AND METHODS

Site description

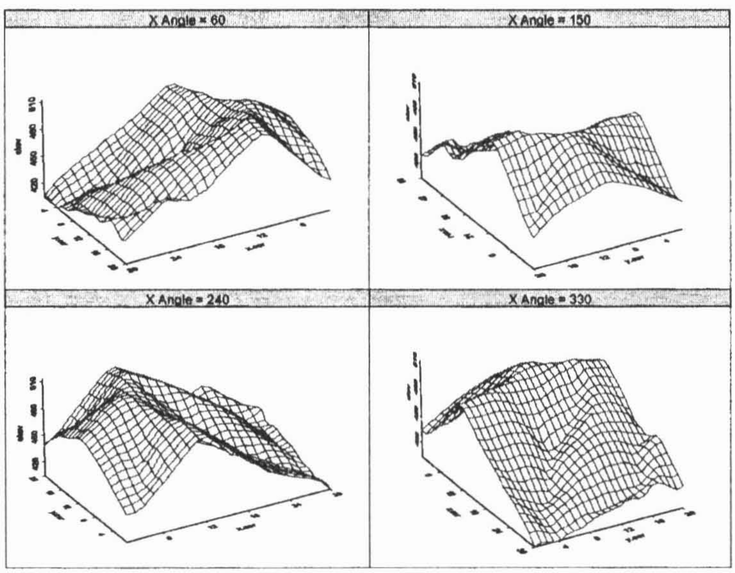
The study site is located at Compartment 30, Semangkok Forest Reserve about 60 kilometer north of Kuala Lumpur, after Kuala Kubu Baru on the way to Fraser's Hill. Compartment 30 is the only Virgin Jungle Reserve in the Semangkok Forest Reserve. It is surrounded by second growth forest, mostly selectively logged in the 1980's (Niiyama *et al.* 1999a). The typical hill dipterocarp forest occurred on the narrow ridge and steep slope, categorized as Seraya-Ridge forest due to the predominance of by mature and over-mature trees and semi-gregariously distributed *Shorea curtisii,* and a stemless palm, *Eugeissona tristis,* which frequently form a dense ticket in the understorey. It is the most common type of hill forest in Peninsular Malaysia (Wyatt-Smith 1995). The plot consisted of a main ridge an two steep slopes facing the east and western aspects. The altitude range from 400 to 520 m asl (Figure 1). *Shorea curtisii* saplings can tolerate shade. Kominami et al. (2000) found that the distribution of *Shorea curtisii* saplings was not related to the light condition, and its density was not significantly different between opening gaps and under closed canopy.

Tange et al. (1998) conducted a soil survey in the plot. They found that the bedrock of the plot is granitic acid volcanic rock, which is poor in bases. The soils are classified as Acrisol (FAO-UNESCO). The average annual rainfall is 2414 mm. Minimum and maximum temperature falls between 21.9 to 33.0 C (Saifuddin et al. 1991).

Establishment and layout of plots

A 6-ha plot with dimension of 200 m x 300 m was established in 1992. The plot was subdivided to smaller of 20 m x 20 m (N=150), 10 m x 10 m (N=600), and 5 m x 5 m (N=2400). All trees above 5 cm dbh were recorded for dbh and identified to species level. The plot contour map and 3-D plot are shown in Figure 1. Recensus of all trees in the plot were carried out in 1993, 1995, 1997, and 1999. Detail of the plot layout is given by Niiyama et al. (1999a).

Figure 1: 3-dimensional graph of the 6-ha plot. Vertical axis is the elevation above sea level.



Data analysis

All data analysis was done on tree greater than 5 cm dbh.

<u>Species richness</u>: We presented the findings by Abd Rahman et al. (2000a) on species richness and number of species within major families.

<u>Species-Area curve</u>: The relationship between species diversity and sample area is fundamental in ecology (Plotkin et al. 2000). The common question of interest is how much biodiversity can an area support. The species-area curve provides information on the number of species for given sample size, and determine the adequacy of sample size in

community data set. We evaluate the species-area curve based on the 20m x 20m subplots ($400m^2$) using PC-ORD multivariate analysis software. A data matrix of sample plots versus species abundance was prepared for the analysis. The resulting species area-curve includes the species confidence bands. We predicted the species richness for Semangkok 6-ha plot based on species-area curve differential equation model (Plotkin, *personal communication*). The model enables one to predict the large-scale species diversity from small-scale data samples more accurately than any other species area curve model (e.g. power law).

Ranking of species based on Importance Value: Several censuses have been carried out since the establishment of the plots. We used data taken in 1999 to rank the species based on Importance Value. The Importance Value was calculated by averaging the relative frequency, relative density, and relative dominance of each species in the 6-hectare plot (McCune and Mefford 1999). The basic calculation is explained in Table 1 below.

Community structure analysis: We presented the findings on community structure analysis based on Abd. Rahman et al. (2000b) and Niiyama et al. (1999b). Abd. Rahman et al. (2000b) used hierarchical cluster analysis to group the sites based on the community types, and ordination overlays were used to describe the association of community types to topography, slope inclination and aspect. Indicator Species Analysis was used to determine the appropriate level of cluster for the community types and indicator species of that cluster. All analysis was done in PC-ORD (McCune and Mefford 1999). The study aim to determine indicator species and its site preference. Niiyama et al. (1999b) described the spatial patterns of tree species to topography, canopy gaps and other vegetation. Species were group using cluster analysis based on dissimilarity index. Spatial pattern were analysed by Morisita's $I\delta$-index where significance of aggregation or randomness was tested using F-value.

Table 1: Summaries of individual tree data. N=number of sample units, A=N x sample unit area =150 x $400m^2$=6 ha.

Fj: number of sample units containing species j in all sample units (N=150)
Tj: number of trees of species j in all sample units
Bj: total basal area of species j in all sample units
Fj (%) = Fj/N
Dj = Tj/A Dj: density (trees/ha)
BAj = Bj/A BAj: basal area (m^2/ha)
Relative frequency = RFj = 100 x Fj/ΣFj
Relative density = RDj = 100 x Dj/ΣDj
Relative dominance = RBj = 100 x Dj/ΣBj
Importance Value = IVj = (RFj + RDj + RBj)/3

Spatial patterns of major trees

The spatial patterns of tropical rain forest are important key to understanding the coexistence and abundance of tree species. The assemblages of tree species having specific spatial patterns, i.e., random, even, or cluster, has been used to describe the tree community in temperate forest (Masaki et al. 1992) and tropical forest (Manokaran et al. 1990; Niiyama et al. 1999b; Plotkin et al. 2000). We presented different types of spatial patterns of several common trees in the plot and illustrate its species-site environment relationship describe in the community structure analysis (Niiyama et al. 1999b; Abd. Rahman et al. 2000b).

RESULTS

Species richness

Abd. Rahman et al. (2000a) reported that Semangkok F.R. 6-ha plot contained 457 tree species with 64 families. The families with the highest number of species were Euphorbiaceae (55) followed by Myrtaceae (26), Lauraceae (24), Meliaceae (22), and Annonaceae (22). Dipterocarps falls on rank eight with 18 species.

Species-Area curve

The species area curve indicated that the variation in species is higher when sub-sampling of smaller number of plots (Table 3). The curve began to stabilize at 40 subplots with 358.34 $\pm$12.64 species richness. The 40 subplots is equivalent to 40 x 400m^2 = 16000m^2 or 1.6 ha. At 20 subplots (0.8 ha) the species richness reached more than half of the number of species in the 6-ha plot.

The predicted model of species-area curve by Plotkin (pers. Comm., 2002) indicated that at 50 ha, the expected species is 676 species. Plotkin found that the prediction for 6ha is about 9% lower than suggested that the observed value (507) and suspect that the prediction for 50 ha is about 15% off from the true value (Table 3).

Table 2: Mean number of species and its standard deviation at different level of sub-plots.

Area (ha)	Number of 400 m^2 subplots	Number of species	
		Mean	Standard Deviation
0.4	10	189.16	18.02
0.8	20	271.85	15.96
1.6	40	358.34	12.64
3.2	80	441.89	7.81
6.0	150	506.39	0.85

Table 3: Predicted number of species based on Plotkin (2000)

Area (ha)	0.5	1	5	6	10	20	30	40	50
Number of Species	161.00	232.83	435.63	458.96	521.78	597.78	635.98	660.03	677.94

Ranking based on the Importance Value

Shorea curtisii was ranked highest in all parameters with an Importance Value of 11.5. The species represent 27 % (11.9 m^{2}ha^{-1}) of the stand basal area and covers 77 % of the plot. The second highest IV ranking was *Scaphium macropodum* (Kembang semangkok) 2.9, while thid species was *Lithocarpus wallichiannus* (Mempening) with 2.3. The ten most common species represented more than 50 % of the stand basal area (Table 4a).

In terms of Family, Dipterocarpaceae scores the highest Importance Value ranking with 16.6, followed by Euphorbiaceae (6.8) and Burseraceae (5.2). The high score of Dipterocarp is contributed largely by the relative dominance i.e., representing one-third of the stand basal area. In relative density, Dipterocarp is lower than Euphorbiaceae. This is reflected by the mean size of dbh of Dipterocarpaceae (25.2 cm) which was much higher than Euphorbiaceae (9.9 cm) (Abd. Rahman K. unpublished). The first three families were distributed in more than 90 % of the plot (Table 4b).

Community structure analysis

Niiyama et al (1999a) found that most species exhibit significant aggregated pattern, and two species were randomly distributed, *Scaphium macropodum* (Figure 2b) and *Payena lucida* (Figure 2c) were well distributed over the entire plot. Thirteen species showed significant positive association with topography, two species were associated with valley, ten species with ridge, and one species with slope. *Shorea curtisii* (Figure 2a), *Lithocarpus wallichianus* (Figure 2d) and *Eurycoma longifolia* (Figure 2e) and a few others were positively correlated with typical ridge sites and/or the distribution of palms. Abd. Rahman et al (2000b) found that the diagram of hierarchical cluster and associated indicator species provide a simple and intuitive way to express species assembly of the indicator species and their site preferences. Indicator species were identified at different level of site clusters. Abd. Rahman et al

(2000b) classified the species into generalist (1 species, *Scaphium macropodum* (Figure 2b)), species favoring lower elevation (19 species) and upper elevation including ridges (19 species). Highly specialist species with narrower niche breath were identified at the lowest level of cluster. The clusters is associated with the topographic position i.e. ridges, slope and valley. *Shorea curtisii* (Figure 2a) was identified as species preferring upper elevation of the plot, covering the ridges, upper and middle slope. *Knema conferta* (Figure 2f) was identified as species preferring lower elevation and valley. Several species such as *Drypetes polyneura (*Figure 2g) and *Gironierera parvifolia* (Figure 2h) are species that preferred narrower niche.

Table 4: Summary statistics of ten most common (a) species and (b) families. Detail explanation of the code is shown in Table 1.

(a)

Species	Fj	Tj	Fj(%)	Dj	Bj	RFj	RDj	RBj	IVj
Shorea curtisii	116	424	77.3	70.7	11.9	2.3	5.7	26.6	11.5
Scaphium macropodum	86	137	57.3	22.8	2.3	1.7	1.8	5.0	2.9
Lithocarpus wallichianus	63	215	42.0	35.8	1.2	1.3	2.9	2.6	2.3
Teijsmanniodendron coriacea	70	187	46.7	31.2	0.6	1.4	2.5	1.3	1.7
Myristica iners	53	68	35.3	11.3	1.3	1.1	0.9	2.9	1.6
Antidesma cuspidatum	78	164	52.0	27.3	0.4	1.6	2.2	1.0	1.6
Shorea leprosula	29	36	19.3	6.0	1.5	0.6	0.5	3.4	1.5
Diospyros latisepala	70	142	46.7	23.7	0.4	1.4	1.9	1.0	1.4
Dacryodes rostrata	54	77	36.0	12.8	0.9	1.1	1.0	2.0	1.4
Swintonia floribunda	28	31	18.7	5.2	1.2	0.6	0.4	2.8	1.3
Others	-	5805	-	967.5	23.2	86.9	80.2	51.4	-
All species	-	7286	-	1214.3	44.9	100.0	100.0	100.0	-

(b)

Family	Fj	Tj	Fj(%)	Dj	Bj	RFj	RDj	RBj	IVj
Dipterocarpaceae	139	709	92.7	118.2	16.0	4.5	9.5	35.7	16.6
Euphorbiaceae	139	840	92.7	140.0	2.1	4.5	11.3	4.6	6.8
Burseraceae	136	488	90.7	81.3	2.1	4.4	6.6	4.7	5.2
Fagaceae	107	376	71.3	62.7	2.5	3.5	5.1	5.6	4.7
Ebenaceae	129	419	86.0	69.8	1.0	4.2	5.6	2.2	4.0
Myristicaceae	125	279	83.3	46.5	1.8	4.0	3.8	4.1	4.0
Leguminosae	110	283	73.3	47.2	1.9	3.6	3.8	4.2	3.8
Sterculiaceae	97	160	64.7	26.7	2.3	3.1	2.2	5.1	3.5
Myrtaceae	115	237	76.7	39.5	1.1	3.7	3.2	2.5	3.1
Verbenaceae	108	317	72.0	52.8	0.7	3.5	4.3	1.6	3.1
Others	-	803.4	-	31.5	39	55.4	70.3	54.8	-
All species	-	7286	-	1214.3	44.9	100.0	100.0	100.0	-

GENERAL REMARKS

The need for similar replication in other forest types

A network of large plot for long-term ecological studies are being emphasized particularly in mixed tropical forest (Kochumen et al 1990; Manokaran et al 1990; Plotkin et al. 2000). These plots contribute to the understanding of community and population dynamics in mixed tropical forest. However due to its large plot size and the enormous efforts required to collect data, systematic study of many aspects of community and population are not covered. A thorough analysis of the tree population dynamics require demographic data through out the life cycle of trees (Niiyama et al. 1999a) Among these are life history of tree species from flowering, fruiting, seedling establishment and growth to advanced growth tree. The 6-ha plot at Semangkok Forest Reserve is sufficient to study species diversity and demography of common trees e.g. *Shorea curtisii* and *Scaphium macropodum.* In Peninsular Malaysia, the lowland evergreen forest has been classified to many sub-types. Various aspects of community and population structure analysis have been conducted. Perhaps similar plot design can be established in other forest sub-types to compare the community and population dynamics of trees in the remaining primary forest.

Implication to sustainable forest management

Although the plot establishment was design for ecological study, the data is useful for evaluation of impact of management practices on future productivity of Seraya-Ridge Forest. Seraya-Ridge Forest is one of the most productive forest stand. The stand volume reached 248 m^3ha^{-1} for all trees above 15 cm dbh (Abd. Rahman et al. 2001a), thus the site can be categorized as "Hutan Terbaik" under National Forest Inventory III classification. The stand basal area of 44.5 m^2ha^{-1} is on the upper side of the basal area range (probably 18 to 50 m^2ha^{-1}) in tropical rain forest (Dawkins 1958). Due to its high stocking of timber trees, residuals growing stock in Seraya-Ridge Forest are prone to damage when present minimum diameter limit approach is applied (Abd. Rahman et al. 2001a). The stocking density, size-structure and species composition can serve as a reference of stand condition at its maximum carrying capacity. Abd. Rahman et al. (2001a) simulate the potential impact of varying harvesting intensity on the residual growing stock and suggested imposing a maximum harvestable limit for Seraya-Ridge Forest to avoid excessive damage and sufficient growing stock is retained after harvesting. Abd. Rahman et al. (2002) suggested alternative method to assess growing stock in Seraya-Ridge Forest and illustrated example to design residual stand condition by manipulating stocking, size-structure and species composition to achieved the desired management objective target.

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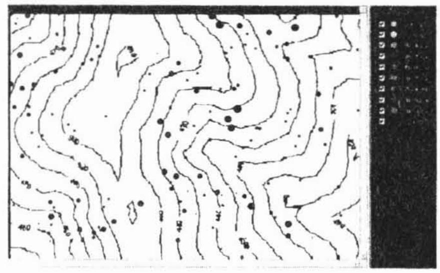
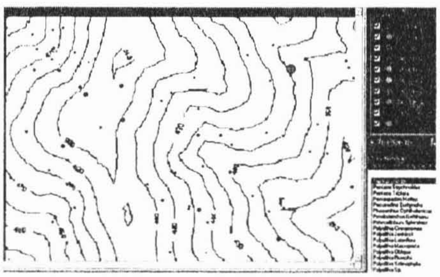
Figure 2: Spatial distribution of selected tree species in the 6-ha plot

(a) *Shorea curtisii*

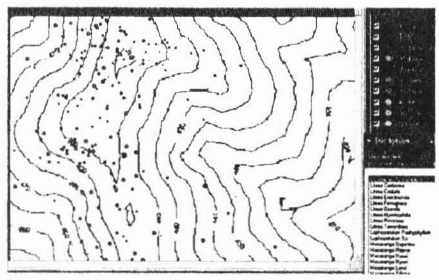
(b) *Scaphium macropodum*



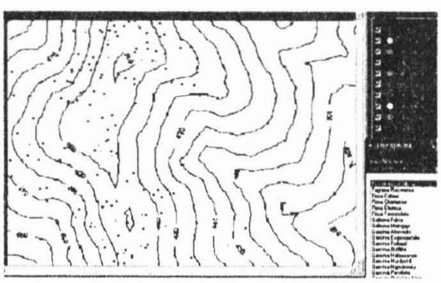
(c) *Payena lucida* (Nyatoh)



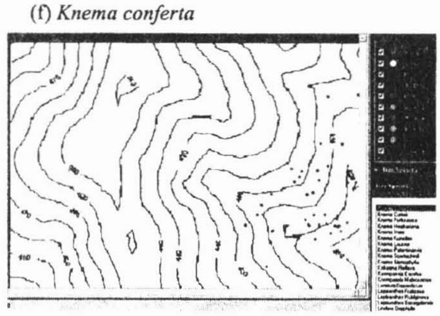
(d) *Lithocarpus wallichianus*



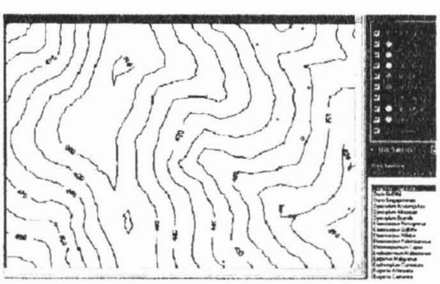
(e) *Eurycoma longifolia*



(f) *Knema conferta*



(g) *Drypetes polyneura*



(h) *Gironierera parvifolia*