E-1.2 Species Dynamics in Tropical Forest

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Abstract

(1) Growth parameters and phenology of trees in tropical rain forest.

Measurements of tree growth and litter fall were carried out at the Forest Reserve in Pasoh and Semangkok and FRIM campus. Among 37 species (170 individuals), ca. 50% showed less than 1 $mm \cdot yr^{-1}$ of growth rate of trunk diameter. The growing season of trunk diameter was synchronized with the precipitation. The diameter growth in some species was coincided with the leaf fall while other species fell leaves irregularly. Judging from the pattern of leaf fall, the life span of leaves was approximately six months in most species, but some had a leaf life span of more than two years.

(2) Species composition and phytodiversity of Malaysian pteridophytes

Phytodiversity of pteridophytes were surveyed at seven localities in three regions of Malay archipelago during 1992-1995. Mean number of pteridophytes species in a cube of 5 mx 5 m x 5 m was 2.5-3.1 for Semangkok, 0.7-1.3 for Kepong and 0.9-2.2 for Pasoh; and in a cube of 1 m x 1 m x 1 m was 1.2-1.6, 0.7-1.1 and 0.7-2.1, respectively. On the selected 40 cubes of 5 m x 5 m x 5 m, α-(MNS:mean number of species), β-(TNS/MNS) and γ-(total number of species) diversities (D) were culculated and shown. The highest α-D was found in Semangkok forest and the lowest is in forest gap in Pasoh. The highest β-D is found in Pasoh forest gap and the lowest was on the oil palm trunk. The highest γ-D is Semagkok and the lowest on the oil palm trunk. Relative species frequency showed a limited dominant species in natural forest in contrast to several dominance on oil palm trunks managed by human activity.

Key Words Diameter Growth, Malaysia, Phenology, Phytodiversity of Pteridophytes, Tropical Forest

1. Introduction

(1) Growth parameters and phenology of trees in tropical rain forest.

The purpose of the study is to clarify the growth characteristics of key tree species in relation to microclimate of a trbpical rain forest. Seasonality of diameter growth, shoot elongation and leaf dynamics were traced. These growth parameters might provide a fundamental information on ecophysiological characteristics of the tree species concerned in relation to such environmental factors as microclimate variation of the forest.

(2) Species composition and phytodiversity of Malaysian pteridophytes

Tropical forest is considered to have the highest biomass and phytodiversity (trees) among different types of vegetation[7]. It seems to be difficult to conclude that the highest phytodiversity is found in tropical forest, since larger size of trees and herbs dominate in tropical forest than those of arctic and temperate plants in a limited space. It is necessary to know what size of quadrat in tropic regions contains more number of plant species than those of temperate and arctic regions[11]. Epiphytic plants commonly occurs in tropical forest and which contribute a higher phytodiversity than temperate-forest in a limited square[1, 8]. Pteridophytes are one of the most important members of epiphytes in tropical forest (particularly on pteridophyts[9]).

Systematic consideration is carried out on ferns in Peninsular Malaysia[4, 5] and fern allies[15] and floristic composition has been studied by Piggott[10] and Wee[13]. Vegetation survey and ecologica-l works concerning epiphytic pteridophytes has been started recently in tropic forest[1, 8]. No guantitative measurments of phytodiversity of pteridophytes is conducted in tropical forest, however, it is considered that the tropical forest consist of larger number of pteridophytes than that in the temperate forest. Malay archipelago is convenient to survey phytodiversity at different type of habitats, since traffic road network has been developed as well as the reserved forest is limited.

Table 1. Research sites and number of species on different size of quadrats.

Cube size of 5 m x 5 m x 5 m	Mean+SD (n)	TNS	TF
<Semangkok:Small soily valley:>			
S-A:Sharp slope	2.47+1.36 (n=400)	40	1203
S-B:Humid slope	3.06+1.71 (n=400)	33	986
<Kepong:60 years Kapur plantation:>			
K-A:Dry floor	0.65+0.93 (n=400)	27	260
K-B:StonY sloPe	1.30+1.17 (n=400)	27	518
<Pasoh:From natural forest to oil palm plantation>			
P-A:Natural floor	0.93+0.81 (n=400)	19	373
P-B:Natural gap	0.85+0.93 (n=400)	28	340
P-C:Palm floor	2.19+1.22 (n=400)	28	875
P-D:Palm trunk		19	1221

Cube size of 1 m x 1 m x 1 m	Mean+SD (n)	TNS	TF
<Semangkok:Small soily valley:>			
S-a:Humid valley	1.16+0.99 (n=100)	14	157
S-b:Soily valley	1.56+0.96 (n=100)	14	165
S-c:Stony valley	1.66+1.13 (n=100)	12	116
<Kepong:60 years Kapur plantation>			
K-a:Soily slope	1.06+0.76 (n=100)	6	105
K-b:Soily slope	0.67+0.68 (n=100)	6	67
K-c:Rocky slope	0.79+0.84 (n=100)	13	77
<Pasoh:From natural forest to oil palm plantation>			
P-a:10 years gap	1.03+0.39 (n=100)	6	72
P-b:Forest floor	0.73+0.69 (n-100)	3	103
P-c:Palm floor	2.09+1.12 (n-100)	15	209
P-d:Palm trunk		16	380

TNS: toal number of species. TF: Total frequency.

We selected three regions around Kuala Lumpur (Semangkok, Kepong and Pasoh) and eight localities with different types of forest structure (Table 1). α-, β- and γ-diversities of pteridophytes were calculated and compared among localities and regions. We focused on three points concerning phytodiversity on Malaysian pteridophytes: 1) Composition of pteridophytes in a limited quadrat; 2) frequency of pteridophytes among local-regional scaling; and 3) comparison of patterns in the relative species-rank curves amng localties and habitats.

2. Locations and Methods

(1) Growth parameters and phenology of trees in tropical rain forest.

The study site was selected in Pasoh forest reserve, Negeri Sembilan, west Malaysia. To study the seasonality of diameter growth, 192 sample trees (38 tree species) were selected from a 2 ha plot (Plot 1). An aluminum belt dendrometer was installed on each trunk of sample trees in August, 1991. Changes of stem diameter were monitored using a dendrometer. The measuremen intervals were fixed to two weeks from November, 1992.

Dynamics of canopy leaves were monitored from August, 1992. Four different trees of different species, *Dipterocarpus sublamellatus, Neobalanocarpus heimii, Xanthophyllum amoenum, Ptychopyxis caput-medusae* were accessible from the canopy walk way. Twenty shoots were selected from each tree. Each sample shoot was marked at the lowest leaf. The lengths of the shoots from the mark to th tips were measured. Number of leaves on the shoots were counted and the order of each leaf was recorded. The measurement was repeated monthly. One hundred litter traps of 0.5m2 catch area were located systematically in the plot 1 to monitor leaf fall, seed fall and flower fall patterns. Litter collection was started in June, 1992.

(2) Species composition and phytodiversity of Malaysian pteridophytes

Localities, habitats, quadrat size and number of pteridophytes are illustrated and summarized in Table 1. All pteridophytes species was recorded at every 5 m x 5 m x 5 m cube in 2 ha vertical space. One ha research area conslsts of 400 cubes. From the 400 cubes, 40 cubes with a large number of pteridophytes were selected for the regional comparative survey. After surveying, lists of all pterldophytes, frequency of every species and number of pteridophytes appeared in each mesh were determined. Three diversity indices, α-, β- and γ-diversities, and mean values were estimated. α-diversity is sequentially represented by the mean number of pteridophytes (MNS) by accumulating the number of sites surveyed. β-diversity is sequentially represented by the ratio of total number of species (TNS) to the mean number of species (MNS). γ-diversity is represented by accumulating the total number of species. In the present study, we applied the following equation;

$$(\alpha\text{-D}) \times (\beta\text{-D}) = (\gamma\text{-D})$$

3. Results and Discusion

(1) Growth parameters and phenology of trees in tropical rain forest.

Increase in diameter

Most of the trees surveyed in the present study showed very low rates of diameter increase. Forty percent of individuals showed the rate of increase in diameter of less than 1 mm per year and 85% less than 5 mm per year. Fig. 1 shows the seasonal trends of the changes in diameter of 12 individuals of different species. The rates of increase in diameter of these 12 species were more than 5 mm per year. However, the range and fluctuation of diameter changes were different between species.

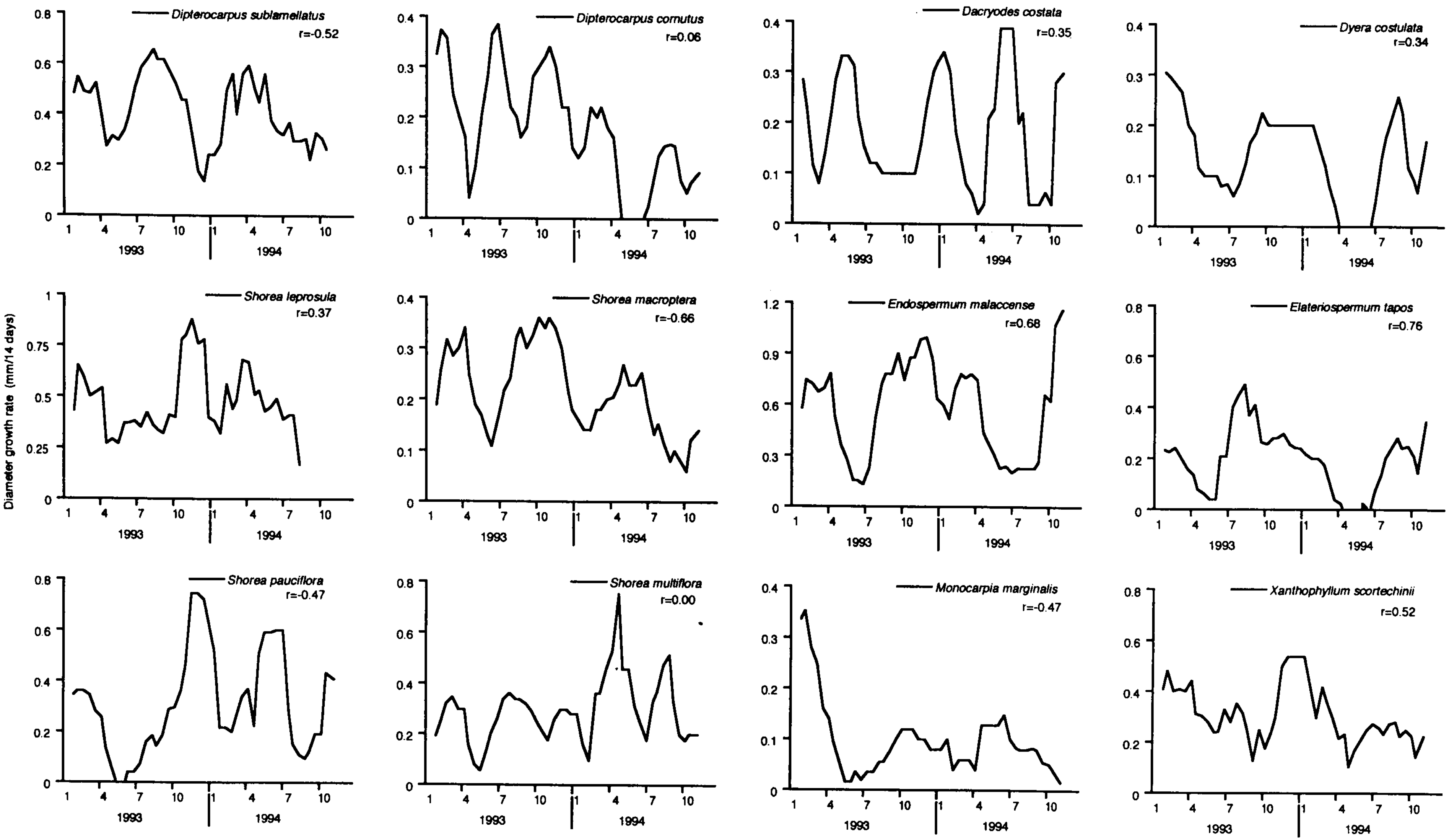

Fig. 1. The increase in DBH (Diameter at Brest Height) of 16 species grown in the Pasoh Forest Reserve. Data are the running means of five measurements. r in each sub-figure is the correlation coefficient of the relationship between data measured in 1993 and 1994.

Though the diameter increased continuously in every individuals, the period with low increase in diameter was synchronized with each other. The low increasing rate of diameter in these species was observed in March and November in 1993, January, April and August in 1994. The increase in diameter was affected by the precipitation. In the month when the increase in diameter was less than 1mm per year, the monthly precipitation was less than 100 mm. It was difficult to find out the seasonality of diameter growth from slow growing individuals, however, diameter growth was synchronized in slow growing-individuals. Even in those species with low increase in diameter, the increase in diameter was observed for four times a year. These species increased their diameter after dry season with less precipitation.

Dynamics of canopy trees

The two types, intermittent and continuous, of flushing of leaves were detected. *N. heimii*, *P. caput-medusae* and *X. amoenum* flushed their leaves periodically. Three clear peaks of leaf flush were observed. Leaves were flushed in July 1992, May 1993 and January 1994 in *N. heimii*, August to September 1992, May 1993 and January 1994 in *P. caput -medusae*, October to November 1992, May 1993 and January 1994 in *X. amoenum*.. Leaves of *D. sublamellatus* flushed continuously, but slight increases in the number of flushed leaves were detected in November 1992, May and November 1993. The occurrence of the increase in flushed leaves was observed at the end of dry period.

When new leaves were developed, old leaves were fallen. Life spans of leaves of *P. caput-medusae* and *X. amoenum* were relatively short. The result that the survivorship curves of leaf cohorts in *N. heimii* and *D. sublamellatus* overlapped suggests that new and old leaves construct a forest canopy.

Spatial and temporal variation of leaf litter fall

Leaf litter was sorted for selected 44 species, which were relatively abundant and easy to identify. Leaf weight of each species showed a good correlation with basal area of the species in the plot. The amount of monthly litter fall was ca. 50 g m^{-2} $month^{-1}$. This value is comparable to other reported values in tropical forests[2)]. Although the amount of leaves fallen fluctuated with time, no clear seasonality could be detected. *Dipterocarpus sublamellatus* showed an oscillation with short span, while*Shorea* spp. showed rather random patterns. *Sindra*, *Elateriospermum*, *Scaphium* showed distinct peaks. To know the characteristic periodisities of leaf fall pattern for each species, power spectral analysis was carried out for the three species. *Dipterocarpus sublamellatus* showed a clear spectral peak of 0.2 $month^{-1}$. *Elateriospermum* also showed a clear peak of 1-year period, which is correspond to the well-known habit of this species, i.e., this species exchanges all leaves annually and develops new red leaves from February to May. *Shorea leprosula,* on the other hand, showed no clear spectral peak with random and unpredictable leaf fall patterns.

In the same species, the leaf fall pattern is different between individuals. *Koompassia* is a good example. Leaf litter collected from four different traps attributed to four different individuals. Although the time when leaves were fallen is different between individuals, each tree showed a clear leaf shed timing with an interval of approximately one year. A clear relationship between diameter growth and leaf fall pattern was observed in some species. Leaf shed pattern of *Elateriospermum tapos* had a clear negative correlation with a diameter growth rate.

(2) Species composition and phytodiversity of Malaysian pteridophytes

Mean number of species per 5 m x 5 m x 5 m cube (3.1 - 2.5) was twice of that per 1 m x 1 m x 1 m cube (1.2 - 1.7) in Semangkok. Mean number of species varied from 0.7 to 2.2

in both sizes of cubes in Kepong and Pasoh. Except for Semangkok, pteridophytes co-occurred in a small sized cube in the forest, since no clear difference of the mean number of species was found between cube sizes. Frequency was much less in Kepong forest than those of Semangkok or Pasoh forest.

The highest α-diversity was found on Semangkok forest floor and the lowest was found on Pasoh forest floor. The highest β-diversity was found on forest gap in Pasoh and the lowest was found on oil palm trunk. The highest γ-diverslty was found in Semangkok and the lowest was found on oil palm trunk in Pasoh. The artificial managements of oil palm gave rather high α-diversity but maintained the lowest β- and γ-diversities in the 5 m x 5 m x 5 m cube, however, pterldopytes abundance in one ha was higher on oil palm-trunk.

Frequency of pteridophytes and its relative abundance are arranged as species-rank curve. Different patterns were found on communities of oil palm trunk and natural forest floor in Pasoh. Other communities in Semangkok and Kepong showed an intermediate patterns of species-rank curves. Only one or two species were dominant in the natural forest, while several species dominate on the oil palm trunk and the plantation floor. Human disturbance can partially enhance α-diversity in a very limited area but γ-diversity can be maximized in a wide natural reservation teritories [3, 12].

References

1. Benzing,David H. 1990 Vacular epiphytes. Cambridge University Press, Cambridge, 354pp.
2. Burghouts, T.B.A., Campbell, E.J.F. & Koldemman, P.J. 1994. Effects of tree species heterogeneity on leaf fall in primary and logged dipterocarp forest in the Ulu Segama Forest Reserve, Sabah, Malaysia. Joumal of Tropical Ecology, 10: I-26.
3. Ehrlich,P.R., and E.O.Wilson 1991 Biodiversity studies: science and policy. Sclence 253: 758-762.
4. Holttum, R.E. 1954 Flora of Malaysia Voll.II Ferns.Government Printing Office, Singapore. 653pp.
5. Holttum,R.E. 1959 Flora Malaysiana. Series II - Pteridophyta, (Ferns and fern allies). Kebun Raya Indonesia (Botanic gardens of Indonesia), Bogor, Indonesia and the Rijks Herbarium, Reyden, Holland sponsored by the Netherland Foundation for Pure Scientific Research (Z.W.O.) pp.64, Vol.1 (1).
6. Johnson Anne 1977 A student guide to the ferns of singapore island. Singapore University Presds, Singapore 126pp.
7. Kohyama, T. 1993 Stability and coexistence of size-structured tree populations in gap-dynamic forest. J. Eco. 81: 131-143.
8. Luttge,U.(ed.) 1989 Vascular plants as epiphytes. Ecological Studies 76, Springer-Verlag. pp.87-107; pp.234-261.
9. Page, C.N. 1979 Experimental biology of ferns. Cambridge University Press, 1-50 pp.
10. Piggott,A.G. 1988 Ferns of Malaysia in Colour. Tropical Press SDN. BHD. Kuala Lumpur. 458pp.
11. Sato,T., Kudo,G., H.Takahashi 1994 A quantitative analysis of vegetation structure in eastern Siberia, with respect to biodiversity and coexistence. 104-108. In: G.Inoue ed. Proceedings of 2nd Sympo. on the Joint Siberian Permafrost Studies between Japa~ and Russia in 1933, Tsukuba 231pp.
12. Sinclair,A.R.E, Hik,D.S. Schmitz,O.~J., Rcudder,G.G.E., Turpin,D.H. and N.C.Larter. 1995 Biodiversity and the need for habitat renewal. Ecological Applications 5: 579-587.
13. Wee Y. C. 1983 A guide to the ferns of slngapore. Singapore Science Center, Singapore 72pp.

14. Wee Y.C. and A.N.Rao 1977 The fern flora of Singapore. Bull. Fern Soc. Palm Beach County, 1: 5-26.
15. Wong Khoon Meng 1983 Critical observations on Peninsula Malaysian Selaginella. Offprint from Gardens' Bulletin 35: 107135.