LIANA DIVERSITY AND SPECIES RICHNESS OF MALAYSIAN RAIN FORESTS

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APPANAH, S., GENTRY, A.H. & LAFRANKIE, J.V. 1993. Liana diversity and species richness of Malaysian rain forests. The contribution to woody plant diversity by lianas was examined in a lowland and hill dipterocarp forest in Peninsular Malaysia. Species richness of lianas is found to be as high as that usually found in the species-rich moist forests of South America. As in Africa and South America, lianas appear to constitute about one-quarter of the woody flora in the everwet lowland forests of Peninsular Malaysia. Consequently, the total woody plant diversity in Peninsular Malaysia is at the same level as that found in the ever wet forests of South America. The present study also confirmed the existence of intercontinental variation in liana floristics, with Annonaceae being the dominant liana family in Asia. Another distinct feature differentiating Malaysian forests from the rest of the tropics is the dominance of rattans among the Malaysian liana flora. These plants appear to be particularly abundant in the upper hill dipterocarp forests. While their role in the ecology of the forests deserves a more critical examination, the potential for cultivating them in the upper hill dipterocarp forests should also be looked into.

Key words: Tropical rain forests - woody plants - liana diversity - floristics - rattans

APPANAH, S., GENTRY, A.H. & LAFRANKIE, J.V. 1993. Kepelbagaian dan kekayaan spesies pepanjat di hutan hujan Malaysia. Penelitan telah di buat terhadap sumbangan pepanjat kepada tumbuhan berkayu di kawasan hutan pamah dan hutan bukit dipterokap di Semenanjung Malaysia. Kekayaan spesies pepanjat di dapati tinggi dan serupa seperti yang terdapat di hutan lembab Amerika Selatan. Seperti di Afrika dan Amerika Selatan pepanjat merangkumi lebih kurang satu per empat daripada tumbuhan berkayu flora yang terdapat di kawasan pamah lembah di Semenanjung Malaysia. Begitu juga jumlah kepelbagaian tumbuhan berkayu di Semenanjung Malaysia di dapati sama dengan yang terdapat di hutan lembab Amerika Selatan. Kajian terkini juga mengesahkan keujudan variasi pepanjat di antara benua, dengan Annonaceae sebagai kaum dominan di Asia. Satu lagi sifat yang boleh membedakan hutan di

* *Recently Al Gentry died in a plane crash while on a scientific expedition in Ecuador - Editor*

Malaysia berbanding dengan hutan-hutan tropika yang lain ialah dengan adanya dominan rotan di kalangan flora pepanjat di Malaysia. Tumbuhan ini banyak didapati di hutan bukit dipterokap. Memandangkan peranan mereka terhadap ekologi hutan memerlukan kajian terperinci, potensi penanaman tumbuhan ini di paras yang lebih tinggi di hutan bukit dipterokap perlu di buat.

Introduction

Tropical rain forests belonging to the same formations are structurally similar on all the three continents (Richards 1952, Dawson 1980). For example, the climax tropical rain forests in Asia, Africa and South America are composed of similar synusiae of trees and treelets, herbs, lianas, stranglers, epiphytes, saprophytes and parasites. The above conclusions were arrived at despite lack of systematic comparisons. Gentry (1988) initiated systematic investigations for pantropical comparisons, using a standardized series of 0.1 *ha* samples. From such comparisons, he concluded that forest formations all over the tropics are similar in plant species richness and floristic composition at the family level (with some notable exceptions), but are markedly different in structure. The structural difference, Gentry (1988) claimed, stems from the very low incidence of liana content in Asia compared with Africa and South America.

Lianas are an important and conspicuous component of tropical rain forests. They comprise a significant part, about 20% of the woody flora of many tropical forests (Gentry 1988), form an important structural component of the forests by "tying" the forest together (Fox 1968, Jacobs 1976, Gentry 1983, Putz 1984), contribute in terms of flowers and fruits for animals, and form important walkways for arboreal animals (Emmons & Gentry 1983). Silviculturists expend considerable effort on their eradication because they may bind numerous trees together, and during logging valuable trees reserved for future cuts can be pulled down by lianas (Appanah & Putz 1984, Putz *et al.* 1984). Gentry's Asian data sets consisted of only two samples from Borneo, Semengoh and Bako Forests in Sarawak, East Malaysia. To confirm Gentry's finding, considering their implications, we added two more sites from Peninsular Malaysia.

Materials and methods

Site description

The first site is in a lowland dipterocarp forest in Pasoh Forest Reserve (2° 59'N, 102°18' E; 80 *m* a.s.l.). The second site is in the upper edge of a hill dipterocarp forest in the Genting Highlands (4° 25' N, 101° 30' E; 870 - 900 *m* a.s.l.). The first site is relatively undisturbed. In the hill site, rattan collection currently occurs, and may have been practiced since about 10 - 15 years ago.

Measurements

In Pasoh, two 0.1- *ha* samples were set up along columns 30 and 40 of the 50-*ha* Pasoh Demography Plot (Kochummen *et al.* 1990). Each 0.1-*ha* sample

consisted of 10 belt transects each measuring 2×50 *m* and laid parallel to one another at 20 *m* intervals. All woody plants $\geq$ 2.5 *cm* DBH were sampled. The trees were identified through reference to the plot enumeration; we confirmed the presence, diameter and identity of each tree. Lianas were individually collected and measured. The diameter of the lianas was measured at the widest basal point using a caliper or tape. A plant's inclusion was determined by position of the midpoint of its base; vegetative clumps were counted as single individuals. Lianas were included only if they rooted within the sample area.

In Genting, one 0.1 *ha* sample was made in the most physiognomically mature part of an apparently homogeneous forest. The sample was taken from a series of ten 2×50 *m* transects laid out in directions chosen to avoid trails and clearings but roughly parallel to each other and separated by 20 *m* or more. All woody plants $\geq$ 2.5 *cm* diameter within the sample area were tabulated and identified.

The results from similar samples in Semengoh Forest, Sarawak (1°50'N, 110°05'E) and Bako National Park, Sarawak (1°52'N, 110°06'E), obtained by one of us (A.H.G.) were compared with data obtained from Peninsular Malaysia samples.

Results

The two Pasoh samples in lowland dipterocarp forest had similar structural and floristic attributes. Sample 1 (Column 30) had 121 lianas belonging to 57 species, and sample 2 (Column 40) had 111 lianas belonging to 57 species (Tables 1& 2). In the Genting sample in the upper hill dipterocarp forest, there were 72 lianas (including one strangler) belonging to *ca.* 37 species (Tables 1& 2). Overall, there is a depression of about one-third in the number of species and abundance in the hill forest.

A comparison of the liana flora between the Peninsular Malaysia (Pasoh) and the Borneo (Semengoh and Bako Forests) sites show clear differences (Tables 1 & 3). Pasoh is richer in liana diversity compared to the Semengoh and Bako samples by nearly two and a half times (57 spp. *versus* 23 - 26 spp.). Likewise, Pasoh (average 116 individuals) has nearly three times more lianas than the Borneo (average 40 individuals) samples yielded.

The predominant liana family in both Pasoh samples was Annonaceae, with 11-13 species per 0.1 *ha* (Table 1). The other most important liana families in both 0.1 *ha* samples were Connaraceae (7 - 8 species), Leguminosae (6 - 7 species) and Palmae (4 - 6 species). Although the two samples had nearly identical diversity of lianas, and similar family composition, less than half of the species (only 31 - 32) are shared between the two samples (unpublished data).

The liana flora from the hill site is quite different from the lowland site of Pasoh (Table 1). There were only 2 Annonaceae climbers and 2 Legume climbers represented in the Genting sample. On the other hand, Pandanaceae (3 climbing species), Gnetaceae (3 climbing species) and Melastomataceae (3 climbing species) were better represented in the hill forest. Connaraceae, the second most diverse Pasoh family of lianas, was dramatically absent from the hill forest.

Table 1. Number of species and individuals of woody lianas found in 0.1 *ha* samples in Pasoh lowland dipterocarp forest (columns 30 and 40 of the 50 - *ha* Plot), and Genting upper hill dipterocarp forest, Peninsular Malaysia (≥ 2.5 *cm* DBH or basal diameter; ind.= no. of individuals)

	Pasoh				Genting	
	Column 30		Column 40			
Family	spp.	ind.	spp.	ind.	spp.	ind.
Acanthaceae	1	1	-	-	-	-
Annonaceae	13	18	11	13	2	2
Apocynaceae	2	2	2	5	2	3
Combretaceae	2	10	2	4	-	-
Connaraceae	7	15	8	14	-	-
Convolvulaceae	-	-	1	1	-	-
Dichopetalaceae	1	1	1	1	-	-
Dilleniaceae	3	7	1	1	1	1
Gnetaceae	1	1	1	2	4	7
Hippocrateaceae	2	5	2	5	1	1
Icacinaceae	1	1	-	-	-	-
Leeaceae	-	-	-	-	1	1
Leguminosae	6	12	7	15	2	8
Leucinaceae	-	-	-	-	1	1
Linaceae	1	4	1	1	-	-
Loganiaceae	2	2	1	1	-	-
Melastomataceae	-	-	-	-	3	3
Menispermaceae	1	1	-	-	-	-
Moraceae	1	1	3	3	1	1
Myrsinaceae	-	-	2	2	1	1
Oleaceae	1	1	1	1	-	-
Palmae	4	18	5	20	8	29
Pandanaceae	-	-	-	-	3	4
Passifloraceae	1	1	-	-	-	-
Piperaceae	-	-	-	-	1	2
Rhamnaceae	1	2	1	1	1	1
Rubiaceae	2	5	4	7	2	2
Rutaceae	-	-	-	-	1	3
Smilaceae	-	-	-	-	1	1
Sterculiaceae	1	1	1	12	-	-
Theaceae	-	-	-	-	1	1
Thymelaceae	-	-	1	1	-	-
Verbenaceae	3	12	1	1	-	-
Total	57	121	57	111	37	72

However, the most diverse liana family in Genting was the Palmae (Table 1). The climbing members of this family, the rattans, were very abundant, being the first and second most common species in the Pasoh samples, and making up about 20% of the lianas (Table 2). But in the Genting sample, they were double in abundance. They were the three most common species (Table 2), and all the rattans comprising of 29 individuals belonging to 8 species, made up 40% of the liana density (Table 1).

The floristics of the Borneo samples resembled quite closely the Pasoh samples, but for being generally poorer. The most common family in both sites

Table 2. Commonest species (as represented by 4 or more individuals) of lianas found in three 0.1 *ha* samples of two forest types in Peninsular Malaysia

Species	Abundance
Pasoh Column 30:	
Daemonorops venticillata	13
Combretum sp. 1	
Aglaia borneensis	4
Combretum sp. 2	4
CONNARACEAE	4
Dichopetalum sp.	4
Huaonia sp.	4
Milletia sp.	4
RUBIACEAE	4
Tetracera sp.	4
Pasoh Column 40:	
Bytteria sp.	12
Daemonorops venticillata	10
Caesalpinia sp.	
Bauhinia sp.	4
Daemonorops geniculata	4
PALMAE (rattan)	4
Randia sp.	
Genting Highlands:	
Daemonorops sp.	9
Daemonorops geniculata	7
Spatholobus sp.	7

Table 3. Liana families, number of species and individuals found in the Borneo 0.1 *ha* samples (collected by A. H. Gentry)

	Semengoh		Bako	
Family	Species	Individuals	Species	Individuals
Annonaceae	5	6	6	14
Apocynaceae	5	5	1	1
Combretaceae	-	-	1	1
Connaraceae	2	2	2	5
Convolvulaceae	1	1	-	-
Dilleniaceae	1	1	2	10
Gnetaceae	1	1	1	1
Icacinaceae	1	1	-	-
Ixonanthaceae	-	-	1	1
Leguminosae	1	1	4	8
Liliaceae	1	1	-	-
Loganiaceae	4	4	3	7
Moraceae	-	-	1	1
Palmae	-	-	1	1
Rubiaceae	-	-	3	6
Thymeliaceae	1	1	-	-
Total	23	24	26	56

Table 4. Liana and tree species diversity and abundance among the Peninsular Malaysia and Borneo 0.1-*ha* samples (# = abundance of individuals)

	Lianas		Trees		Total	
Site	Spp.	#	Spp.	#	Spp.	#
Pasoh 30, P. Malaysia	57	121	155	279	212	400
Pasoh 40, P. Malaysia	57	111	158	284	215	395
Gentings, P. Malaysia	37	72	152	270	189	342
Semengoh, Sarawak	23	24	211	445	234	469
Bako, Sarawak	26	55	115	332	141	387

was Annonaceae. Other important families found in the Pasoh samples like Leguminosae, Loganiaceae, Rubiaceae, Dilleniaceae and Connaraceae were relatively well represented in the Borneo samples too. But the Loganiaceae appeared to be slightly better represented in the Borneo samples than the Pasoh samples though, and Verbenaceae, well founded in Pasoh (3 species, 12 individuals), was absent in the Borneo samples. A notable exception was the unusual poverty of Palmae (rattan) in the Borneo samples (1 species in Bako; none in Semengoh) compared to the Pasoh samples (4 - 5 species) (Table 3).

In addition, the diversity of liana in Pasoh comprises about 30% of the woody plants. In Genting, the percentage of lianas drops to 20%, while the Borneo samples are even poorer (10 and 18% only) (Table 4).

Discussion

The striking similarity of the two 0.1 *ha* Pasoh samples, in terms of species richness and density, despite a large difference in floristic composition, suggests that the 0.1 *ha* belt transect is a reliable tool for initial comparative studies.

The liana diversity values for Pasoh are at the high end of the world-wide liana figures (see Gentry 1988). The neotropical high figures were found in Jatun Sacha, Ecuador, with 59 species and 94 individuals, and Mishana, Peru, with 55 species and 89 individuals (Gentry unpublished). The African examples include Mount Cameroon, Cameroon, with 49 species and Makokou, Gabon, with 47 species and 103 individuals. The Pasoh results clearly refute the earlier claim that Asian forests are poor in diversity and abundance of lianas compared to the African and South American forests (Emmons & Gentry 1983, Gentry 1988). Appanah and Putz (1984) also reported liana densities in Peninsular Malaysia to be similar to neotropical values. Therefore, no intercontinental differences in the structure of the tropical forests resulting from differences in liana diversity and abundance exist. Likewise, arguments that Malaysian forests may not be as rich in plant diversity when the liana flora is included (Gentry 1988) may need a second scrutiny as well.

The low liana density of Borneo which contributed to the speculation that Malaysian liana flora are poor, may perhaps be a peculiarity of the Borneo forests. One possible explanation for the lowered liana density in Borneo may be attributable to the greater presence of emergents like the dipterocarps. Bako

sample is not a valid one because it is close to the kerangas type of vegetation. The Semengoh sample provides a good case for comparison with Pasoh. In Semengoh, there were 58 dipterocarp individuals belonging to 18 species, compared to Pasoh's 25 individuals and 12 species, although these figures include all stems above 2.5 *cm* DBH (Appanah *et al.* unpublished). The forest in Semengoh also appears to be much taller, with bigger dipterocarp trees and a more uniform canopy cover (personal observations). Such a canopy may occlude to a higher degree the light needed for germination and establishment of lianas in the early phase of growth at the ground level. Lianas, like pioneers, need much light to germinate and establish (Putz & Appanah 1987). This would mean lianas may be more dependent on tree fall gaps for germination and establishment in Semengoh. In comparison, Pasoh forest appears much more broken up, and its canopy appears less continuous. Such a habitat is more likely to support liana establishment. This influence of dipterocarps needs further confirmation though. Nonetheless, the relatively fewer lianas in the two Borneo samples appear most intriguing.

The Genting hill forest has fewer lianas compared to Pasoh. This may perhaps be a feature of hill forests, but it is difficult to confirm since many of the rattans are being harvested by man, and other lianas are cut by foresters (Appanah & Putz 1984).

At Pasoh the lianas contribute about 27% of the woody species ≥ 2.5 *cm* DBH in the 0.1 *ha* samples. If lianas contribute one quarter of the woody flora, the 50 - *ha* Demography Plot flora of 820 tree species (Kochummen *et al.* 1990) might be increased to over 1000 woody species. The legitimacy of scaling up by such a factor has been established with neotropical community studies for everwet forests (Gentry 1987, Gentry & Dodson 1987). There too, the lianas consisted of about one quarter of the woody vegetation.

Based on the Borneo data, Gentry (1988) suggested that the Annonaceae are unusually dominant in the liana flora in the Asian forests. The data from Peninsular Malaysia confirm this view. In this context it should be pointed out that each of the major tropical regions seems to have floristically a very different liana flora. In the neotropics Bignoniaceae are the dominant lianas and in Africa Apocynaceae (Gentry 1988). As far as the Pasoh samples go, they seem to set some kind of a "world record" for Connaraceae lianas as well.

Another unique feature of lianas from Peninsular Malaysia compared to the African and Neotropical samples is the presence of rattans. All the samples from Pasoh and Genting have many rattan species, but interestingly they are the most common lianas in the upper hill dipterocarp forest. Rattans are widespread from West Africa to Fiji, and from South China to Queensland, Australia, but are most concentrated in Southeast Asia. In the primary forests of Malaysia, rattans are a significant feature, especially in the understorey where juveniles of climbing species are joined by non-climbing species. Their relative scarcity in the African region, and complete absence in the neotropics could mean important differences in the liana ecology of the three regions. This might lead to differences in the structure of the three forests, nevertheless.

Some of the rattan species are commercially important (Dransfield 1979). Therefore, the role of rattans in the ecology of the Malaysian forests deserves a more critical study. An important finding is the higher presence of rattans in the hill forest. Now that there is a great interest in their cultivation, perhaps the upper hill sites may be more useful for rattan cultivation than for timber harvesting.

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