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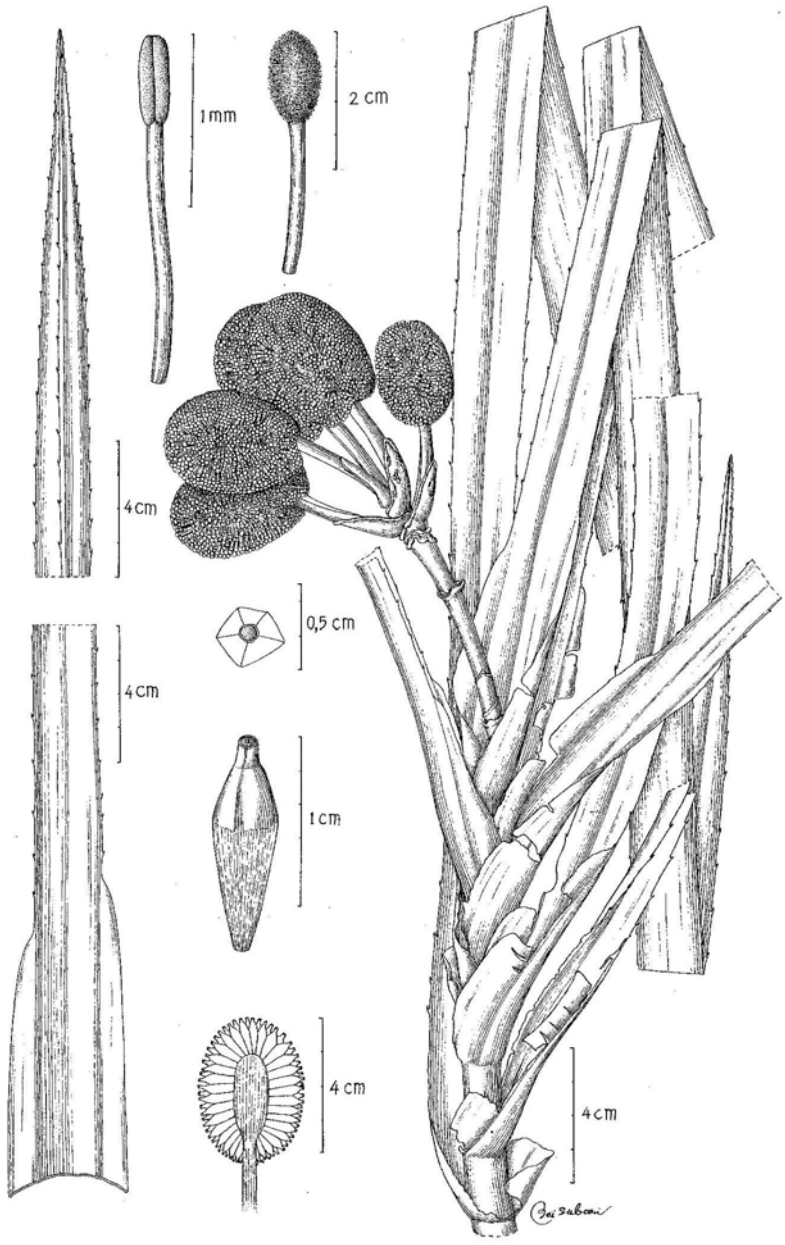

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CORIDOR Halimun–Salak National Park (Photo: H. Wiriadinata)

Central Kalimantan in Plot Plk2 at flooding time (Photo: E. Suzuki)

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TREE FLORA ON FRESHWATER WET HABITATS IN LOWLAND OF BORNEO: DOES WETNESS COOL THE SITES?

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ABSTRACT
SUZUKI, E. 2010. Tree flora on freshwater wet habitats in lowland of borneo: does wetness cool the sites?. Reinwardtia 13(2): 199–210. — The floristic records of lowland forests of Borneo in dry (not inundated) and wet (kerangas and peat swamp) habitats, and in montane forest of West Java were compared to clarify the characteristics of the flora in the lowland wet habitats. The data was flora of trees (DBH is equal to or more than 4.8 cm) in 12, 7, and 3 plots in dry lowland, wet lowland and mountain, respectively (20.9 ha in total). Plots in dry habitats had 42 to 53 families in 1 ha, except two plots on river banks (33 and 37 families). Plots in wet habitats and in mountain had 32 - 45 and 21 - 40 families, respectively. The clusters of plots in dendrogram using number of species in family mostly coincided with the difference in habitats. The preference for wet habitats existed in some families: *Aquifoliaceae, Icacinaceae, Thymelaeaceae, Guttiferae, Myrtaceae,* and *Anacardiaceae* though most families including *Dipterocarpaceae* and *Euphorbiaceae* had no tendency. *Myristicaceae, Meliaceae,* and *Sapindaceae* preferred dry habitats. Some species consisting of the flora of tropical mountains were found occasionaly in wet habitats of lowland though very rarely in dry habitats. There was a weak but singificant correlation between preference for wet habitats and abundance in Japanese tree flora of each family. These results suggest that the wet habitat where the forest floor is periodically filled with water has cooler environment than dry habitat, and families adapted cooler climate prefer the former.

Key words: flora, Borneo, peat swamp, kerangas.

ABSTRAK
SUZUKI, E. 2010. Flora pohon pada habitat basah di dataran rendah Borneo: apakah kebasahan mendinginkan lokasi?. Reinwardtia 13(2):199–210 — Hasil penelitian floristik hutan dataran rendah di Borneo di habitat daerah kering (tidak bergelombang) dan basah (kerangas dan rawa gambut), dan di hutan pegunungan di Jawa Barat dibandingkan untuk mengklarifikasi ciri-ciri flora di habitat basah dataran rendah. Data flora pohon (dengan diameter setinggi dada sama dengan atau lebih dari 4.8 cm) pada plot 12, 7 dan 3 di dataran rendah kering, dataran rendah basah dan hutan pegunungan, masing-masing (20.9 ha jumlahnya). Plot di habitat kering mempunyai 42–53 suku per 1 ha, kecuali 2 plot di sepanjang sungai (33 dan 37 suku). Plot di habitat basah dan di pegunungan mempunyai masing-masing 32 –45 dan 21–40 suku. Pengelompokan plot dalam dendrogram dengan menggunakan jumlah jenis dalam suku kebanyakan berhubungan erat dengan perbedaan dalam habitat. Beberapa suku yang menyukai habitat basah adalah: *Aquifoliaceae, Icacinaceae, Thymelaeaceae, Guttiferae, Myrtaceae*, and *Anacardiaceae* walaupun kebanyakan suku termasuk *Dipterocarpaceae* dan *Euphorbiaceae* yang tidak ada kecenderungan ke arah itu. *Myristicaceae*, *Meliaceae*, dan *Sapindaceae* lebih menyukai habitat kering. Beberapa jenis yang termasuk dalam flora pegunungan tropika umumnya ditemukan di habitat basah di dataran rendah sangat jarang ditemukan di habitat kering. Walaupun lemah tetapi korelasi positif antara menyukai habitat basah dan kelimpahannya di flora pohon di Jepang dari setiap suku. Hasil ini menyarankan bahwa habitat basah dimana lantai hutan secara periodik berisi air mempunyai lingkungan lebih dingin dari pada habitat kering, dan suku yang beradaptasi pada iklim dingin lebih disukai daripada sebaliknya.

Kata kunci: flora, Borneo, rawa gambut, kerangas.

INTRODUCTION

Borneo and some islands in the tropical zone have wide areas of flat lowlands. With the rainy climate, many areas of flat topography become wet habitats: mangrove, freshwater swamp, peat swamp, and kerangas (tropical heath). The flora of mangrove, which is affected by the salty water, is very different from other vegetations, and is not discussed here. Freshwater swamps, and peat swamps cover 3,895,000 ha and 4,403,000 ha in Kalimantan, respectively (MacKinnon *et al*. 1996.) Yamada (1997) reviewed the studies of freshwater and peat swamp forests in Southeast Asia. He stated that there were little studies of these vegetation because of the difficulty of approach. Whitmore (1984) mentioned the vegetation in the context of general description of tropical vegetations of the Far East. Browne (1952) studied kerangas lands in Sarawak. The first comprehensive study of peat swamp in

Sarawak and Sabah was made by Anderson (1963). Brunig (1974) has provided a detailed monograph and classification of heath forests of Sarawak and Brunei from 57 sampling plots. Newbery (1991) reevaluated the data of 38 plots (mostly c. 0.2 ha in size) including 636 taxa by Brunig from Brunei and Sarawak with principal component analysis. On continental part of Southeast Asia, Wyatt-Smith (1959) studied the peat swamp forest in Malaya. Suzuki & Niyomdhamn (1992) made phyto-sociological study of peat swamp in Thailand. There have been far less studies of wet habitats than those of dry habitats. To reveal the characteristics of particular vegetation, it is useful to compare it with other vegetation. This approach was rarely adopted in the floristic study of wet habitat vegetations.

The purpose of this study is to clarify the characteristics of the flora of wet habitats on lowland of Borneo by comparing it with those of dry lowland and mountain. The specimens are identified to species in most case, but not always. Long time is necessary to complete the identification. Then in this paper, the number of species in family is mainly used. Records of family level make possible to compare floral data between sites with very few common species such as Japan and Borneo.

STUDY SITES AND METHODS

The 22 study plots of 20.9 ha in total were made from 1987 to 2003 by the author and many coworkers (Table 1). All plots located in lowland (altitude between 10 to 250 m) of Borneo (Figure 1), except three mountain plots on Mt. Halimun National Park, West Java (Suzuki, *et al*. 1998). In wet habitats, where water inundated in some seasons, seven plots were set, and the total area was 5.9 ha. Two plots (Man1, Man2, unpublished data by E. Suzuki and L. Gadrinab) were from a small nature reserve in Mandor, West Kalimantan. They were kerangas forests with many *Shorea stenoptera* Burck. Nishimura & Suzuki (2001) and Miyamoto *et al*. (2003) studied the plots at Lahei, Central Kalimantan. Kohyama *et al*. (2001) described the plot in Serimbu. Plots in Merimbun Heritage Park, Brunei, Sunujuh, Betung Kerihun, and Berau were unpublished data collected by E. Suzuki *et al.* In all plots, trees equal to or bigger than 15 cm in girth (= 4.78 cm in diameter) at breast height were measured and identified.

RESULTS

Clustering of plots

Plots in dry habitats had from 42 to 53 families in 1 ha, except two plots on river banks (33 and 37 families). Plots in wet habitats and on mountain had 32–45 and 21–40 families, respectively. The plots in dry habitats were the richest in number of families. The similarity among plots was analyzed with dendrogram. There are several equations expressing (dis)similarity between sites: correlation coefficient, Euclidean distance, Standardized Euclidean distance, Generalized distance of Mahalanobis *etc* (Kobayashi 1995). The correlation

Figure 1. Map showing the plot site

Table 1. Plots description

Area	Locality	Long. Lat.	Alt. (m)	Plot Name	Habitat type	Plot size (ha)	No. of trees	No. of family
WK	Mandor	0° 19'N 109° 19'E	10	Man1	Wet(Kerangas)	0.6	968	45
WK	Mandor	0° 19'N 109° 19'E	10	Man2	Wet(Kerangas)	0.3	473	34
CK	Lahei	1° 55'.S 114° 10'E	20	PLK4	Wet(Kerangas)	1.0	2,271	32
CK	Lahei	1° 55'.S 114° 10'E	20	PLK1	Wet(Kerangas)	1.0	2,146	37
CK	Lahei	1° 55'.S 114° 10'E	20	PLK2	Wet(Peat)	1.0	1,560	32
Br	Merimbun	4° 35'N 114° 40'E	20	Mr2	Wet(Peat)	1.0	1,691	34
Br	Merimbun	4° 35'N 114° 40'E	20	Mr3	Wet(muddy Peat)	1.0	1,909	40
Br	Merimbun	4° 35'N 114° 40'E	20	Mr1	Dry	1.0	1,206	53
Br	Merimbun	4° 35'N 114° 40'E	30	Mr4	Dry	1.0	1,440	48
WK	Serimbu	0° 43'N 110° 05'E	250	S1	Dry	1.0	1,337	48
WK	Serimbu	0° 43'N 110° 05'E	250	S2	Dry	1.0	1,408	47
WK	Sunujuh	1° 26'N 109° 27'E	300	SU1	Dry	1.0	1,335	47
WK	Sunujuh	1° 26'N 109° 27'E	160	SU2	Dry	1.0	1,401	46
WK	Betung Kerihun	0° 59'N 113° 15'E	200	BK1	Dry	1.0	1,531	45
WK	Betung Kerihun	0° 59'N 113° 15'E	240	BK2	Dry	1.0	1,808	44
EK	Berau	2° 22'N, 117° 12'E	30	Be1	Dry(River bank)	1.0	1,332	37
EK	Berau	2° 22'N, 117° 12'E	30	Be2	Dry(River bank)	1.0	1,037	33
EK	Berau	1° 55N, 117° 11'E	80	Be3	Dry	1.0	1,395	43
EK	Berau	1° 55N, 117° 11'E	80	Be4	Dry	1.0	1,516	42
WJ	Halimun	06° 43.5'S, 106° 29'E	1700	Ha1	Mountain	1.0	925	21
WJ	Halimun	06° 45.3'S, 106° 32.5'E	1100	Ha2	Mountain	1.0	978	38
WJ	Halimun	06° 44.7'S, 106° 33'E	1100	Ha3	Mountain	1.0	1,587	40
Total						17.9	27,764	72

WK:West Kalimantan, CK:Central Kalimantan, Br:Brunei, EK:East Kalimantan; WJ:West Java.

coefficient was inappropriate for this data set because it was not in a normal distribution. Because the Euclidean distance is affected by the absolute value of abundance, it can not express the dissimilarity exactly among plots if the abundance of each family is different. The Standardized Euclidean distance can avoid this defect. The generalized distance of Mahalanobis can avoid defect caused by the correlation between families, though it has the same default caused by the absolute value of abundance. Then the Standardized Euclidean distance of each plot was calculated from the data of the number of species in each family in each plot (Appendix 1), and they were clustered with group average method (UPGMA) (Figure. 2).

In most cases, the wet and dry habitats gathered in lower and upper parts of the figure, respectively. The two in three plots on mountain in West Java were out of branch gathering the plots on lowland of Borneo, though the remainder was in the branch and more similar to plots in wet habitats than those in dry habitats. At the bottom of the figure, three plots in kerangas made a group of kerangas (PLK1, and 4 in Central Kalimantan, and Man2 in West Kalimantan) except Man1. Three plots in peat swamp made a group of Peat adjacent the group of kerangas. The two groups of kerangas and peat swamp were combined in one upper group, and it was connected with one plot on mountain in Java (Ha1). Be1 and Be2 on a river bank of dry habitats were the most similar plots to those of wet habitats. They were on flat land of sandy alluvial soil along small stream, which seemed to be an intermediate between dry and wet habitats.

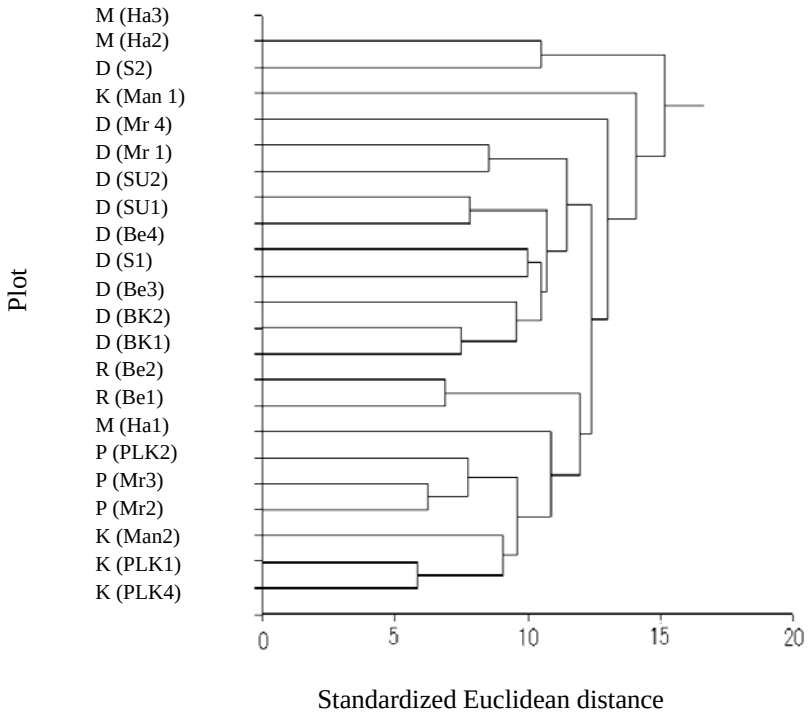

Figure 2. Dendrogram of plot similarity expressed by standardized Euclidean distance of species number in each family. Type: M:Mountain, D:Dry habitats, R:River bank(in dry habitats), K:Kerangas, and P: Peat swamp.

Preference for wet habitats

Table 2 shows the number of species in each family found in plots of wet and dry habitats in lowland of Borneo. In total, 1279 species of 72 families were found. In wet and dry plots, 432 and 1059 species were found, respectively. The ratio was 0.408 (432/1059). I designate an index, Index of wet preference (*IWP*) for each family as follow, *IWP* = number of species in wet plot/number of species in dry plot/0.408.

When species ratio of species number in wet plots to that in dry plots in a given family is the same with the average of all species, *IWP* = 1. When the family has more species in wet plots than the average, *IWP* > 1. It can show the tendency whether the family has more species in wet or dry habitats. In Table 2, the families are divided into two groups: one with more than four species, another with less than five species. The former and the latter are shown in upper and lower parts of Table 2. In each group, the families were arranged in the order of *IWP*.

Figure 3 shows frequency distribution of *IWP* for families with more than four species. The mode was near 1, and many families had species evenly in both habitat types. There was, however, a small peak in the class of 1.5–1.7 which imply the existence of family adapted to wet habitats.

i. Families preferring wet habitats

As shown in Figure 3, there was a group of families with *IWP* around 1.6, I considered that families with *IWP* >1.5 prefer wet habitats: *Aquifoliaceae* (6 spp in total), *Icacinacea*e (8 spp), *Thymelaeaceae* (11 spp), *Guttiferae* (52 spp), *Myrtaceae* (64 spp), *Anacardiaceae* (39 spp), *Theaceae* (9 spp), *Palmae* (5 spp), and *Symplocaceae* (5 spp), *Apocynaceae* (8 spp), and *Oleaceae* (5 spp). Though it is possible that the families with a few species have a big value of *IWP* by chance, families with many species such as *Anacardiaceae* probably prefer the wet habitats.

Aquifoliaceae has only one genus, *Ilex* in tree flora of Sabah and Sarawak (Soepadmo *et al.* (eds.) 2002). Though the species do not become tall tree or dominant ones, *Ilex cymosa* Bl., *I. wallichii* Hook. f. were often found in wet habitats. *Icacinaceae* and *Thymelaeaceae* are more common families. *Stemonurus* in *Icacinaceae* and *Gonystylus* in *Thymelaeaceae* look to prefer wet habitats. The latter often becomes the dominant species, and produces most valuable wood in swamp area, “lamin” in local name. These families were not so big ones as the following families, but seemed to prefer wet habitats. *Guttiferae, Myrtaceae*, and *Anacardiaceae* had many species, and were common both in wet and dry habitats. Because we found these families in every plot, they seemed not

Table 2. Number of species in each family found in wet and dry habitat plots, respectively. IWP = (Sp. No. in Wet/Sp. No. in Dry)/(total Sp. No. in Wet/total Sp. No. in Dry) Sp. No. = number of species Japan: number of species in Japanese tree flora. (Satake *et al*. ed., 1989)

No	Family	*IWP*	Number of species			
			Sum	Wet	Dry	Japan
	<Family with 4 or more species>					
1	*Aquifoliaceae*	4.90	6	4	2	23
2	*Icacinaceae*	2.94	8	6	5	1
3	*Thymelaeaceae*	2.10	11	6	7	15
4	*Guttiferae*	1.79	52	27	37	1
5	*Myrtaceae*	1.74	64	37	52	5
6	*Anacardiaceae*	1.63	39	20	30	7
7	*Palmae*	1.63	5	2	3	6
8	*Symplocaceae*	1.63	5	2	3	21
9	*Theaceae*	1.63	9	4	6	18
10	*Apocynaceae*	1.47	8	3	5	3
11	*Oleaceae*	1.47	7	3	5	25
12	*Leguminosae*	1.31	36	15	28	30
13	*Magnoliaceae*	1.23	6	2	4	6
14	*Rutaceae*	1.23	8	3	6	20
15	*Lauraceae*	1.17	71	29	61	25
16	*Ebenaceae*	1.14	52	20	43	5
17	*Celastraceae*	1.13	15	6	13	19
18	*Elaeocarpaceae*	1.11	13	5	11	4
19	*Bombacaceae*	1.09	11	4	9	
20	*Myrsinaceae*	1.09	12	4	9	13
21	*Rubiaceae*	1.09	44	16	36	31
22	*Fagaceae*	1.05	18	6	14	22
23	*Lecythidaceae*	1.05	8	3	7	2
24	*Melastomataceae*	0.98	23	8	20	6
25	*Burseraceae*	0.90	46	14	38	
26	*Moraceae*	0.85	28	8	23	20
27	*Sapotaceae*	0.84	44	12	35	1
28	*Dipterocarpaceae*	0.82	106	29	87	
29	*Sterculiaceae*	0.82	15	4	12	4
30	*Euphorbiaceae*	0.79	117	34	106	32
31	*Tiliaceae*	0.77	18	5	16	8
32	*Annonaceae*	0.72	60	15	51	
33	*Chrysobalanaceae*	0.61	9	2	8	
34	*Polygalaceae*	0.61	20	5	20	
35	*Verbenaceae*	0.57	15	3	13	18
36	*Myristicaceae*	0.53	53	10	46	
37	*Dilleniaceae*	0.49	5	1	5	
38	*Sapindaceae*	0.49	27	5	25	4
39	*Meliaceae*	0.26	50	5	48	1
40	*Flacourtiaceae*	0.22	12	1	11	3
41	*Alangiaceae*	0.00	5		5	2

No	Family	*IWP*	Number of species			
			Sum	Wet	Dry	Japan
	<Family with 4-1 species>					
1	*Anisophylleaceae*	0.61	4	1	4	
2	*Olacaceae*	0.61	4	1	4	1
3	*Oxalidaceae*	1.23	4	2	4	
4	*Pandanaceae*	1.63	4	2	3	2
5	*Proteaceae*	0.61	4	1	4	1
6	*Rosaceae*	0.61	4	1	4	103
7	*Crypteroniaceae*	7.35	3	3	1	
8	*Escalloniaceae (Saxifragaceae)*	1.23	3	1	2	32
9	*Linaceae*	2.45	3	2	2	
10	*Ochnaceae*	2.45	3	2	2	
11	*Rhizophoraceae*	0.82	3	1	3	3
12	*Saurauiaceae (Actinidiaceae)*	0.00	3		3	1
13	*Ulmaceae*	0.00	3		3	11
14	*Violaceae*	0.00	3		3	
15	*Combretaceae*	0.00	2		2	3
16	*Connaraceae*	2.45	2	1	1	
17	*Ixonanthaceae*	2.45	2	1	1	
18	*Loganiaceae*	2.45	2	1	1	1
19	*Podocarpaceae*	1.23	2	1	2	2
20	*Simaroubaceae*	1.23	2	1	2	1
21	*Araliaceae*		1	1	1	17
22	*Juglandaceae*		1	1	1	3
23	*Tetrameristaceae*		1	1	1	
24	*Trigoniaceae*		1	1	1	
25	*Araucariaceae*		1	1		
26	*Capparidaceae*		1	1		1
27	*Erythroxylaceae*		1	1		
28	*Convolvulaceae*		1		1	
29	*Leeaceae*		1		1	
30	*Rhamnaceae*		1		1	17
31	*Santalaceae*		1		1	2
32	Family unknown		47	15	35	
	Total		1279	432	1059	602

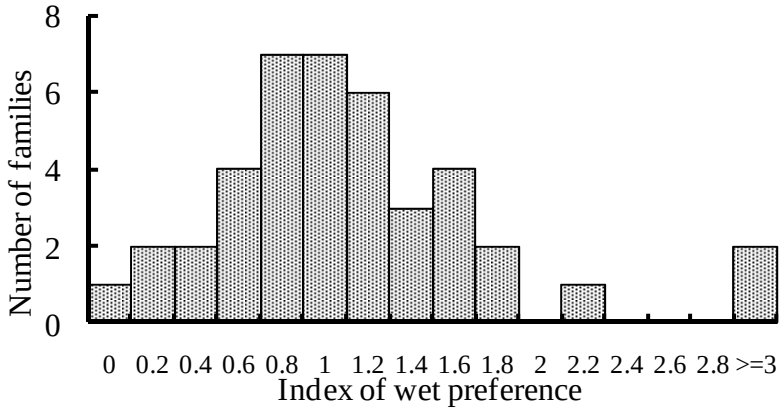

Figure 3. Frequency distribution of index of wet preference (*IWP*) for families with five or more species.

to be specialized in wet habitats, though they have many species there. *Buchanania, Campnosperma,* and *Gluta* in *Anacardiaceae* often become the dominant trees in swamps. *Syzygium* (=*Eugenia*) in *Myrtaceae* is very diversified and taxonomically most difficult genera, though apparently it has many species in wet habitats.

Some small families have specialists in wet habitats. *Dactylocladus stenostachys* Oliver (*Crypteroniaceae*), *Combretocarpus rotundatus* Danser (*Anisophylleaceae*) are example of such species, which often become one of the dominant canopy trees in wet habitats.

ii Neutral Families

Most families have no tendency of biased distribution in wet or dry habitats, as the aggregating distribution of *IWP* around 1.0 (Figure 3). *Rubiaceae, Myrsinaceae, Bombacaceae, Fagaceae, Lecythidaceae, Melastomataceae,* and *Burseraceae* had *IWP* between 0.9 and 1.1. They have no clear tendency. *Leguminosae, Rutaceae, Magnoliaceae, Lauraceae, Ebenaceae, Celastraceae,* and *Elaeocarpaceae* have a little greater value of *IWP*. They might prefer wet habitats a little. *Moraceae, Sapotaceae, Dipterocarpaceae, Sterculiaceae, Euphorbiaceae, Tiliaceae,* and *Annonaceae* had a little small value of *IWP*. It is unclear whether these small differences have some meaning or not. Even in these families, they have some species specialized in wet habitats. In *Dipterocarpaceae*, *Dryobalanops rappa* Becc., *Shorea balangeran* Vidal, *S. rugosa* Heim., and *S. teysmanniana* Dyer ex Brandis, are important emergent trees of wet habitats, and not found in dry habitats. In *Sapotaceae*, *Madhuca motleyana* J. F. Macbr. (=*Ganua motleyana*), *Palaquium leiocarpum* Boerlage are common in swamp forest.

iii Families preferring dry habitats

Verbenaceae, Myristicaceae, Dilleniaceae, Sapindaceae, Meliaceae, Flacourtiaceae, and *Alangiaceae* had the value of *IWP* less than 0.6. Especially Meliaceae had 50 species and *IWP* was only 0.25, apparently preferring dry habitats.

DISCUSSION

Clustering the plots

The dendrogram (Figure 2) separated most plots in wet and dry habitats into different clusters. The used data was only number of species in family though it appeared to successfully separate the plots into some reasonable groups. In the montane plots, one was in the cluster of Borneo and more similar to the plots in wet habitats than those in dry habitats, though the remaining two plots were out of the cluster of Borneo. It might suggest the mountain flora was rather similar to that in wet habitats than in dry habitats in the lowland vegetations.

Preference of wet habitats

Table 2 suggests that there is some preference for the wetness of habitats at family level. Among large families, *Anacardiaceae* and *Meliaceae* preferred wet and dry habitats, respectively. *Dipterocarpaceae* seemed to be neutral. The taxonomic monographs usually describe the habitats for each species in addition to the taxonomic description. Though some families in Malesia have no comprehensive monographs, many families have. The number of species, which are described as growing in wet habitats (swamp, kerangas and so on), was counted in *Anacardiaceae* (Ding Hou, 1978), *Dipterocarpaceae* (Ashton, 1982), and *Meliaceae* (Mabberley *et al*., 1995) in Flora Malesiana. They are bigger families with more than 100 species in Malesia. *Anacardiaceae* had the highest both in *IWP* and in the ratio of species in wet habitats among the three. *Meliaceae* had the lowest in *IWP* though the second in the ratio of wet habitats. The descriptions in monographs partly coincides with the result of this study, but not completely. It seemed that different author described the habitats in different level. Some author seems to describe only typical habitats, another do all possible habitats. It is difficult to compare data strictly.

The resemblance to mountain flora

The dendrogram of Figure 2 suggests that the flora of wet habitats in lowland of Borneo has some similarity with mountain flora on West Java. In wet habitats, we sometimes found strange distributions of plants: exceptional distributions of mountain flora on lowland. *Acer laurinum* Hassk (=*A. niveum* Bl.), a common tree on Mt. Halimun, was found in lowland of Lahei, Central Kalimantan (E. Suzuki, personal observation; Simbolon & Mirmanto, 2000). Malesia area has only this species in *Acer*, and widely distributed on mountains (Bloembergen, 1948). *Engelharditia serrata* Bl. in *Juglandaceae* also has similar tendency. *Syzygium* are dominant everywhere in tropical area, but more common in wet habitats of low altitude and mountains.

Conifers are less common in the tropical zone than in the cool temperate and boreal zone. Though they often dominate on the mountain forests such as Kinabalu, where *Dacrycapurs imbricatus* de Laub., *Dacrydium pecitinatum* de Laub, *Falcatiflium falciforme* de Laub. are common conifers (Aiba *et al.*, 2004). They are rare in the tropical lowland especially in dry habitats. They seem to be, however, rather common in wet habitats. *Agathis borneensis* Warb. (= *A. dammara* Richard) was also found in wet habitats in Lahei, and common on mountain. It has scattered distribution in upland rain forest from low elevation to 1200 m (de Laubenfels, 1986). In *Podocarpaceae*, I found *Nageia wallichiana* O. K. (= *Podocarpus blumei*) (on Halimun, Lahei and Serimbu), and *Dacrydium pectinatum* (in Mandor and Lahei). De Laubenfels (1988) mentions that "quite a number of conifers grow, sometimes in great quantity, on alluvial sand flats or on podosolized sands and stand stone (kerangas) and in peat-swamps, but they are not always limited to such habitats, as both *Dacrydium pectinatum* and *Agathis borneensis* are also commonly met as scattered individuals in middle elevations rain-forest."

Aquifoliaceae have only a genus *Ilex*, which is also one of the common genera in warm temperate Japan and mountain flora of West Java. In lowland forest, *Ilex* is a rare genus, but it was frequently found in wet habitats. In peat swamp forest in Sumatra, two species of *Ilex* (*I. cymosa* and *I. pleiobrachiata* Loes.) are common (Shimamura & Momose, 2005). In "Tree Flora of Sabah and Sarawak (Soepadmo *et al*., (eds.) 2002), this family consists of 22 species of *Ilex*, distributing from mangrove, peat swamp to montane forest until altitude of 3500m. In 15 species found in lowland, seven species distribute in swamp and/or kerangas. Nearly half of lowland species grows in wet habitats. This genus (family) seems to prefer wet habitats in the tropical lowland, tropical mountain, and warm temperate forests, though it seems not to be common in dry habitats of tropical lowlands.

To explain the existence of mountain flora on

Table 3 Rate of species growing on wet habitat from description in Flora Malesiana.

Family	A. Number of all species	B. Number of species on wet habitat	Rate (B/A)
Anacardiaceae	150	46	0.31
Dipterocarpaceae	386	49	0.13
Meliaceae	225	44	0.20

Data source: Ding Hou (1978), Ashton (1982), Mabberley *et al.* (1995)

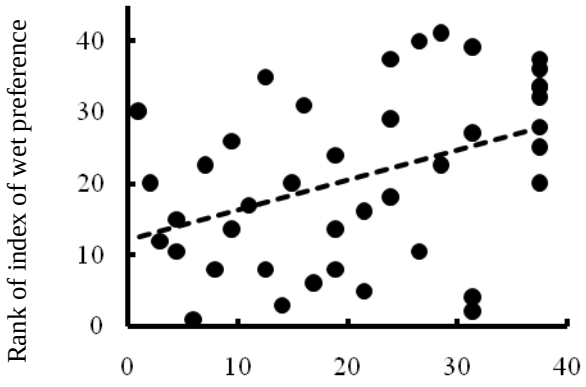

Figure 4. The relationship between abundance in Japanese tree flora and Index of wet preference among families. The rank data ordered from bigger to smaller was used.

lowland wet habitats, the difference of species richness between dry and wet habitats can be considered. The dry habitats on the lowland had more species than wet habitats. It may affect the competition among species. When some mountain species try to enter the lowland, the dry habitats may have stronger competitor than wet habitats. This can also explain the resemblance of families between the wet habitats and the mountains.

The resemblance to flora in cooler zone

The resemblance of wet habitat flora in tropical lowland to that in cooler climate was considered in this section. To compare the preferences for tropical wet habitats and cool climate, the right side column in Table 3 shows number of tree species in Japanese tree flora from Satake *et al*. (1989), as an representative of flora in cooler climate of humid Asia. All families with *IWP*>1.1 had tree species in Japan though several families with *IWP*<1.1 did not. Because the distribution of number of species in each family was not normal distribution, the correlation between *IWP* and number of species in Japan was analyzed with Spearman's coefficient of rank correlation (Sokal & Rohlf, 1995). Figure 4 shows the relationship between rank of species abundance in Japan and rank of *IWP*. The coefficient was statistically significant at the level of 0.05 (r=0.416, n=41). Families with the higher *IWP* seemed to be commoner in Japan.

Environment of Wet habitats

It seems that families distributing into subtropical and temperate zone in Japan prefer wet habitats in the tropical lowlands. Inside of forest in wet habitats filled with water are cooler than that in the dry habitats. Though the field works in wet habitats were more difficult and harder than those in dry habitats, one of the better conditions was its coolness, especially in the flooded forests. It may allow the growth of plants adapted to cooler climate. The wetness in wet habitats may cool the microenvironment of the forest and have some effect on the plant distribution. The plant distribution is affected not only by temperature but also by many factors. Deficit of oxygen and nutrient in the inundated soil is also one of the severe limiting factors for plants. As the result, the relationship is vague as shown in the low value of the above coefficient. The difference between dry and wet habitats in species richness or the number of the potential competitors may also have some effects on the results shown here. We need further study of plant physiology and microenvironment in wet habitats to explain the reason for resemblance of family compositions in the lowland wet habitats, tropical mountain, and Japan.

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REFERENCES

AIBA, S., KITAYAMA K., & TAKYU, M. 2004. Habitat associations with topography and canopy structure of tree species in a tropical montane forest on Mount Kinabalu, Borneo. *Plant Ecology* 174: 147 –161.

ANDERSON, J. A. R. 1963. The flora of the peat swamp forests of Sarawak and Brunei including a catalogue of all recorded species of flowering plants, ferns and fern allies. *Gardens Bulletin Singapore* 20: 131–228.

ASHTON, P. S. 1982. *Dipterocarpaceae*. *Flora Malesiana Ser.* 1. 9(2): 237–552.

BLOEMBERGEN, S. 1948. *Aceraceae*. *Flora Malesiana Ser.* 1. 4(1): 3–4.

BROWNE, F. G. 1952. The kerangas lands of Sarawak. *Malayan Forester* 15: 61–73.

BRUNIG, E. F. 1974. *Ecological Studies in the Kerangas Forests of Sarawak and Brunei*. Borneo Literature Bureau, Keching, Malaysia. 238 pp.

DE LAUBENFELS, D. J. 1988. *Coniferales*. *Flora Malesiana Ser.* 1. 10(3): 337–453.

DING HOU. 1978. *Anacardiaceae*. *Flora Malesiana Ser*. 1. 8(3): 395–548.

KOYBAYASHI, S. 1995. *Multivariate analysis of biological communities.* Soju Shobo, Tokyo, (in Japanese). 194 pp.

KOHYAMA, T., SUZUKI, E., PARTOMIHARDJO, T., & YAMADA, T. 2001. Dynamic steady state of patch -mosaic tree size structure of a mixed dipterocarp forest regulated by local crowding. *Ecological Research* 16: 85–98.

MACKINNON, K., HATTA, G., HALIM, H. & MANGALIK, A. 1996. *The Ecology of Kalimantan*. Periplus Editions (HK) Ltd. 802 pp.

MABBERLEY, D. J., PANNEL, C. M. & SING, A. M. 1995. *Meliaceae. Flora Malesiana Ser.* 1. 12(1): 1–407.

NEWBERY, D. McC. 1991. Floristic variation within kerangas (heath) forest: re-evaluation of data from Sarawak and Brunei. *Vegetatio* 96: 43–86.

SATAKE, Y., HARA, H., WATARI, S., & TOMINARI, T. 1989. *Wild Flowers of Japan*. Woody Plants. Heibonsha, Tokyo. (in Japanese).

SHIMAMURA, T. & MOMOSE, K. 2005. Organic matter dynamics control plant species coexistence in a tropical peat swamp forest. *Proceedings of the Royal Society B* 272: 1503–1510.

SIMBOLON, H. & MIRMANTO, E. 2000. Checklist of plant species in the peat swamp forests of Central Kalimantan, Indonesia. In IWAKUMA *et al.* (Eds.) *Proceedings of the International Symposium on: Tropical Peatlands*. :179–190. Hokkaido Univ. and RDCB-LIPI.

SOEPADMO, E., SAW, L. G., & CHUNG, R. C. K. (eds.) 2002. *Tree Flora of Sabah & Sarawak* 4: 1–388. Ampang Press Sdn. Bhd., Kuala Lumpur.

SOKAL, P. & ROHLF, F. J. 1995. *Biometry*. (third ed.) 887 pp, W. H. Freeman and Company, New York.

SUZUKI, E., YONEDA, M., SIMBOLON, H., FANANI, Z., NISHIMURA, T. & KIMURA. M. 1998. Monitoring of vegetational change in permanent plots on Gn. Halimun National Park. In SIMBOLON, H., YONEDA, M. & SUGARDJITO, J. (Eds.). *Research and Conservation of Biodiversity in Indonesia*. 4: 60–81. LIPI-JICA-PHPA, Bogor.

SUZUKI, K., & NIYOMDHAM, C. 1992. Phyto-sociological studies on tropical peat swamps 1. Classification of vegetation at Narathiwat, Thailand. *Tropics* 2: 49–65.

WHITMORE, T. C. 1984. *Tropical Rain Forest of the Far East*. (2nd ed.). Clarendon Press, Oxford. 352 pp.

WYATT-SMITH, J. 1959. Peat swamp forest in Malaya. *Malayan Forester* 23: 5–32.

YAMADA, I. 1997. *Tropical rain forests of Southeast Asia. A forest ecologist's view*. University of Hawaii Press. 392 pp.

Appendix 1. Number of tree species in each family and plot.
Habitat type: K: Kerangas, P: Peat, D: Dry, R: Riverbank (Dry habitat), and M: Mountain.

Plot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Habitat type	K	K	K	K	P	P	P	D	D	D	D	D	D	R	R	D	D	D	D	M	M	M
Plot	Man 1	Man 2	PLK 4	PLK 1	PLK 2	Mr2	Mr3	Mr1	Mr4	S1	S2	SU1	SU2	Be1	Be2	Be3	Be4	BK1	BK2	Ha1	Ha2	Ha3
Aceraceae																					1	1
Alangiaceae								1	1	1	2			2	2				1			
Anacardiaceae	5	8	3	3	4	1	6	4	7	6	7	9	9	3	1	7	6	7	7		1	1
Anisophylleaceae						1		3	2	1	2						1	1	1			
Annonaceae	7	5	8	7	3	2	7	8	8	3	14	7	7	16	16	12	9	3	6		2	1
Apocynaceae	2						1	2	2	2	1		1	2		1			1			
Aquifoliaceae		2	2	2	1	1	2				2										1	1
Araliaceae	1												1	1								1
Araucariaceae			1	1																		
Bombacaceae	2	1				1	1	1	3	3	2	3	2			5	2	2	3		1	1
Burseraceae	8	8	4	5	4	3	1	13	11	14	18	9	12	2	2	7	7	9	11			1
Capparidaceae	1	1																				
Caprifoliaceae																						1
Celastraceae	4	3	2	1	2		1	1	1	5	4	3	2	1	3	3	3	3	4			
Chrysobalanaceae	2		1	1	1	1	1	4	1	2	3	2	4			1	3	1	1		1	1
Combretaceae												1		1	1							
Compositae																				1		
Connaraceae	1															1			1			
Cornaceae																					1	1
Cunoniaceae																						1
Convolvulaceae																		1	1			
Crypteroniaceae			1		1	1	2	1	1										1			
Dilleniaceae						1	1	2		1	2	1	1	1	1	1		1				
Dipterocarpaceae	12	9	11	12	4	4	5	6		18	20	20	16	7	10	20	21	27	34			
Ebenaceae	11	8	6	7	4	1	3	6	1	7	9	13	6	14	12	7	3	4	9			
Elaeocarpaceae	1	2	2	2	1	3	2	3	4	1	2	2	2	1	1			1		2	3	3
Erythroxylaceae	1																					
Escalloniaceae	1	1							1			1	1					1		1	1	1
Euphorbiaceae	13	11	8	7	2	8	16	31	14	31	38	16	18	15	13	24	21	25	26	1	11	7
Fagaceae	2	4	5	4			1	4		1	1	3	3			2	4	3	2	6	6	7
Flacourtiaceae	1	1						2	3	1	1	2	1	1		3	2	5	6		2	1
Guttiferae	4	4	13	16	7	5	4	8	7	10	9	10	6	4		8	5	10	13		3	3
Hamamelidaceae																					1	1
Icacinaceae	3	2	4	1	1	1	1	2	1	1	2					2	1	2	2	1	3	3
Ixonanthaceae					1			1	1	1		1	1			1						
Juglandaceae	1		1	1							1										1	1
Lauraceae	9	10	4	8	3	4	10	20	15	15	23	8	5	8	7	4	10	9	13	6	14	13
Lecythidaceae					1	2	2	2	2	3	1	2		4	1	3	2	1	1			
Leeaceae														1	1							
Leguminosae	7	2	3	5	3	7	5	6	6	10	7	4	4	4	6	6	8	7	7			
Linaceae						1	2	1	1									1				
Loganiaceae	1							1									1					
Magnoliaceae	2	1	1	1				1		2	2	1		1	1	2	1	1	1		2	1
Melastomataceae	3	2		3	2	2	3	3	4	4	3	5	5	2	2	5	5	4	4	1	4	4
Meliaceae	4	2	1	3	1	1	2	6	2	15	22	5	9	14	9	7	9	9	7	1	3	4
Moraceae	5	1	1	2		1	2	5	6	4	9	6	6	3	3	4	4	2	4		7	5
Myristicaceae	8	5	4	5	2	2	3	9	11	14	16	9	8	4	5	9	8	14	12		3	3
Myrsinaceae			1	3			1	2	1	1		2	1		1	1	1	1	1	2	1	2
Myrtaceae	9	8	14	14	7	11	9	12	10	19	14	11	7	8	5	7	10	9	11	3	8	7
Ochnaceae					1	1	1		1		1	1	1			1						
Olacaceae		1			1			2	1	3	3	2				2	2	2	1			
Oleaceae				1	1		1	2	1	2	1	1	1	1	1	1	2	3	3	1	1	
Oxalidaceae	1	1				1	2	1	1	1				2			3					
Palmae						2	2	1	1	2							1			1	2	2
Pandanaceae	1						1	2	1	1		1	1		1			1				1
Podocarpaceae				1	1						1		1							1		3
Polygalaceae	2	1	1	1		1	3	4	2	12	10	4	5	2	1	4	4	8	8			
Proteaceae		1						1		1	1	1				1		1			2	1

Plot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Habitat type	K	K	K	K	P	P	P	D	D	D	D	D	D	R	R	D	D	D	D	M	M	M
Plot	Man 1	Man 2	PLK 4	PLK 1	PLK 2	Mr2	Mr3	Mr1	Mr4	S1	S2	SU1	SU2	Be1	Be2	Be3	Be4	BK1	BK2	Ha1	Ha2	Ha3
Rhamnaceae											1											
Rhizophoraceae				1				2	2	1	2			1		1	1	1				1
Rosaceae	1		1	1				2	2			2	1							1	2	1
Rubiaceae	5	2	6	7	2	4	4	11	9	9	5	7	6	5	3	7	8	5	3	1	6	5
Rutaceae	2			1	2			1	2	1	1	1	2	1			2			1	2	1
Santalaceae													1					1	1			
Sapindaceae	5	3	3	3	1	1	1	3	4	6	7	2	2	9	6	4	3	4	5		1	
Sapotaceae	5	4	5	5	2	1	1	3	4	9	14	10	9	3	3	7	9	3	5		3	1
Saurauiaceae								1				1	1	1	1						1	1
Simaroubaceae				1				1	1	1	1	1	1				2					
Staphyleaceae																				1	1	1
Sterculiaceae	4	2	2	3				2		1	2	2	3	2	2	5	3	1	3	1		
Symplocaceae					1		1					2	2			1	2	1	1	2	1	
Tetrameristaceae	1					1		1	1													
Theaceae	3		2	2	1				1	1	2					1			2	3	4	3
Thymelaeaceae	3	2	2	2		1	1	2	1	3	3	2	2			1	3	2	3			
Tiliaceae	1	2			1		2	2	3	2	2	3	3	3	4	3	4	3	4			
Trigoniaceae	1									1		1	1									
Ulmaceae								2	2	3	3		1			1	1	1	1			
Urticaceae																					1	
Verbenaceae	1					1	2	1	2			2	1		3	1	2	2	4		1	
Violaceae												1		1	1				1			
Family unknown	5	2	4	2	1	2	2	4	5	4	6	2	1	7	7		3	1	6		1	1
Species number	172	122	127	145	70	81	118	222	174	260	303	205	184	158	136	194	202	204	242	38	110	99
Family number	45	34	32	37	32	34	40	53	48	48	47	47	46	37	33	43	42	45	44	21	38	40

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