— Field Note —

Species Composition and Structure of Epiphytic Fern Community on Oil Palm Trunks in Malay Archipelago

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ABSTRACT Fern species composition and fern community were observed at oil palm plantation and adjacent natural forest near Kuala Lumpur in Malaysia, with respect to tree size and structure. Sixteen fern species were found on oil palm trunks. Six species of *Nephrolepis biserrata*, *Davalia denticulata*, *Vittaria ensiformis*, *Asplenium nidus*, *A. glaucophyllum* and *A. longissimum* are common on various sizes of oil palms (1-8.5m height). Early invasion of fern community on oil palm trunks is conducted by *N. biserrata* and *D. denticulata*. Microhabitat of *N. biserrata* seems to be a sunny site while that of *V. ensiformis* a shade site on oil palm trunk. Fern species composition and frequency change during oil palm development and with different height. *A. nidus* sometimes (19% of tall and 3% of all trees) occurs in natural forest; and invades on oil palms exceeding 4m height. *A. nidus* seem to be a micro-ecosystem for some insects. Such vertical vegetation cover by epiphytic ferns on tree trunk seems to contribute a high phytodiversity at narrow site and insect biodiversity as well as canopy in tropical rain forest.

Key Words: fern species composition/ frequency/ micro-ecosystem/ oil palm trunk/ vegetation process/ vertical distribution

Epiphytes are responsible for much of the biotic diversity that makes humid tropical forests the most complex of all the world's terrestrial ecosystems. Canopy-based species constitute fully one third - perhaps up to 50% - of the total vascular flora in some pluvial neotropical forest (Benzing, 1990). Epiphytic fern species contributes to higher phytodiversity in vertical space in the tropical rain forest (Page, 1979). Ferns and orchid plants produce spores and tiny seeds which are easily capable to move by wind for virgin inhabitation. Smaller size of propagules easily anchor on small spots on tree trunks and on rocks, however, which may grow slowly and have higher mortality. The systematic distribution of vascular epiphytes shows that Order Orchidales consists of 13,953 / 19,268 species and Order Polypodiales consists of 2,372 - 2,378 / 7,565 species (Kress, 1989; Benzing, 1990). High percentages of epiphytic plants among families containing over 50 epiphytic species are known on ferns (Polypodiales) of Vittariaceae as 100% (112 / 112 species), of Polypodiaceae as 94% (1029 / 1100 species), of Davalliaceae as 93% (139 / 150 species), on monocot (Orchidales) of Orchidaceae as 73% (13,951 / 19,128 species) and on dicot (Theales) of Marcgraviaceae as 73% (89 / 122 species) (Kress, 1989). Some fern families are considered to be the most specified taxa as epiphytes.

We are expressed the high coverage of ferns on oil palm trunks around Kuala Lumpur at first arrival as already suggested that "To the pterodologist, plantations of oil palms (*Elaeis guineensis*) are

of considerable interest" (Piggott, 1988). The introduction of oil palms from tropical Africa and development of the plantation might promote economic industry of Malaysia, however, the destruction of natural forest is accelerated by the plantation. We slightly expect the contribution of epiphytic ferns on oil palm plantation for the maintenance of biodiversity in Malaysia to some extent. In oil palm plantations well managed, old leaves are pruned and leaf-bases trimmed, so that the trunk resembles an enormous pineapple. Plant debris collects amongst the leaf-bases and gradually rots to form pockets of humus-ideal for the growth of ferns. After about 20 years, the slowly rotting leaf-bases start to fall (Piggott, 1988). We expect the oil palm plantation is one of semi-natural experimental stands for searching development and vegetation processes of fern community, as for the introduction of analysis in the complex natural tropical forest.

This work aims to observe and analyze the tropical forest with high biodiversity and to seek technique for biodiversity maintenance of the tropical rain forest in Malaysia under auspices of Grant by Japan Environmental Agency. Here some preliminary observation and measurements have been conducted as follows, with particular reference to *A. nidus*: (1) Frequency of epiphytic ferns (*A. nidus*) in natural forest at Pasoh and its brief environment, (2) Species composition and frequency of ferns on oil palm trunks besides natural forest, considerations of (3) vegetation process of fern community on oil palms and of (4) possible supports of epiphytic ferns (*A. nidus*) as a micro-ecosystem for insects.

STUDY SITES AND METHODS

Study sites for the natural forest are located at experimental forest station of Forest Research Institute of Malaysia (FRIM) at Pasoh (3°N, 102° W; altitude of ca. 100-150 m). Frequency of epiphytic ferns (%) in the natural forest has been calculated by number of trees with epiphytic ferns divided by the total number of trees in 6 belts of 2 m × 30 m in the forest, since the sites are surrounded by nearly 30 m height trees (Table 1). For undergrowth environment the maximum and minimum radiation (lux) were recorded on 6 belts; and number of all vascular plants were recorded on 5-6 cubes of 2 m × 2 m × 2 m. For the counting number of undergrowth species, cube of 2 m × 2 m × 2 m was estimated, because the upper canopy is hard to determine the space of a quadrangular pillar. Measurements of radiation (light intensity) were conducted by two Lux-Meter (Type-Toshiba). The relative radiation (%) was calculated as percentage of light intensity on trunk (facing to north and south) to light intensity at open sites (70,000-150,000 lux).

Vegetation cover of epiphytic ferns on oil palm trunks was observed nearby the FRIM experimental station at Pasoh. Species composition and frequency of ferns on oil palm trunks were monitored by the number of occurrence at every pocket between leaf-bases. Procedures of

Table 1. Number of trees, heights and frequency of epiphytic ferns and brief environmental conditions for undergrowth in 6 belts.

Belt No. (2 m × 30 m)	Total	Number of trees 10cm< DBH	With ferns	Hanging height (m)	Number of undergrowth (2 m × 2 m × 2 m)	Radiation of forest floor (lux)
1	69	9	2	16, 25	6, 7, 9, 9, 9	400- 600
2	58	7	1	25	6, 7, 7, 8, 10	800- 900
3	56	11	1	14	8, 9, 9, 10, 11	200- 300
4	46	3	1	18, 20	7, 10, 11, 11, 12, 15	1000-1800
5	44	10	3	7, 8	8, 10, 11, 11, 12	900-1600
6	43	8	1	25	5, 6, 6, 8, 8, 9	300- 500
Total	316	48	9	Mean 17.6 ± 6.6	8.9 ± 2.2

Fig. 1. Histograms of number of vascular plant species as undergrowth (A) and forest structure represented by size distribution of trees with epiphytic fern of *Asplenium nidus* (B). Numbers besides closed circle shows number of trees of same sizes of DBH and estimated heights. Double circle shows trees with epiphytic ferns of *Asplenium nidus*. *Drynaria* and *Pyrrosia* species are found on 2 trunks of trees.

measurement of the fern frequency are following: (1) Oil palm trunk are marked at 1m height intervals. (2) Number of pockets between leaf-bases are counted on every height. (3) Number of occurrence of each species is represented by number of pockets between leaf-bases with ferns.

Six rhizomes with roots of *A. nidus* plants were collected from breadth height trunk of oil palms of 8 - 10 m. The rhizome and roots were carefully separated for visible insect collection. Fresh 50g roots and humus debris were used for tiny insect collection by Tullgren (prepared by Dr. Takeda, Kyoto University).

Table 2. Plant architecture of oil palms and surrounding environment.

Oil palm studied	Height (m)	No. of spots	Pockets with ferns (N)	% with ferns	Species (N)	Diameter (cm)	Radiation(%) South-North
a	1.0	35	19	54.3	2	87	2.8-2.5
b	1.0	40	18	45.0	4	-	4.9-2.1
c	1.0	80	25	31.3	3	-	9.9-5.8
d	2.0	70	18	25.7	2	73	4.6-2.8
e	2.0	80	28	35.0	3	77	5.7-4.0
f	2.0	84	44	52.4	3	80	20.1-13.1
g	4.0	240	198	82.5	4	72	3.6-20.6
h	4.5	217	105	48.4	5	87	4.3-3.1
i	4.5	231	98	42.4	7	80	5.9-4.8
j	4.5	288	107	37.2	4	90	3.0-7.3
k	5.0	216	94	43.5	6	77	14.4-10.9
l	5.0	232	55	23.7	5	60	2.8-2.8
m	5.0	272	96	35.3	6	88	5.5-3.2
n	5.5	264	92	34.9	8	67	12.3-7.3
o	5.5	288	148	51.4	8	71	6.0-32.7
p	6.0	200	120	60.0	8	58	1.6-1.8
q	6.0	224	147	65.6	7	57	1.5-2.8
r	6.0	288	108	37.5	4	87	10.4-4.3
s	6.0	288	144	50.0	6	73	4.0-4.0
t	6.5	259	110	42.5	8	67	1.9-1.5
u	6.5	315	197	62.5	8	-	7.6-1.4
v	6.5	320	95	29.7	7	75	6.9-6.1
w	7.0	312	107	34.3	4	74	2.9-3.2
x	8.0	360	197	54.7	9	-	3.0-3.4
y	8.5	344	175	50.9	11	64	5.9-5.5

-: no measurement. Diameter is estimated by margin length of trunk divided by 3 at 1 m height. Radiation (%) is measured on trunk surface (facing to north and south).

Fig.2 Distribution of numbers of species and pockets on selected three oil palms with 6.5-7.0 m height, with respect to height above ground. A: percentages of number of pockets with ferns to the total number of pockets at 1 m height intervals. B: absolute numbers of pockets with ferns (dotted bars) and no ferns (open bars). C: distribution of number of fern species and its accumulative number at 1 m height intervals. Characters of u-, v- and w- show individual oil palm trunk and correspond to those of Tables 2 and 3.

Table 3. Species composition and distribution of number of pockets with ferns on individual oil palm trunk.

Species	Individual oil palm trunk (a-y: see Table 2)																								Total / trees	
	a	b	c	d	e	f	g	h	I*	j	k	l	m	n*	o	p	q*	r	s	t	u*	v*	w*	x		y*
<i>Nephrolepis biserrata</i>	12	15	19	10	18	13	47	56	43	84	63	34	58	38	45	34	57	63	47	54	46	59	84	26	38	1060/25
<i>Davalia denticulata</i>	7	1	5	8	9	30	36	17	4	3	11	2	1	8	25	9	18	23	2	30	38	26	20	12	9	354/25
<i>Thelypteris</i> sp.	-	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	3/2
<i>Adiantum latifolium</i>	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	-	-	-	4/3
<i>Goniophlebium verrucosum</i>	-	-	-	-	1	-	-	-	-	-	3	1	-	2	-	6	1	-	-	2	2	-	-	-	16	34/9
<i>Asplenium longissimum</i>	-	-	-	-	-	1	-	-	2	-	2	-	1	5	-	8	8	-	-	-	9	2	-	16	20	74/11
<i>Pyrrosia lanceolata</i>	-	-	-	-	-	-	114	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	114/1
<i>Asplenium nidus</i>	-	-	-	-	-	-	1	2	4	-	-	-	-	5	6	-	8	7	1	4	8	2	3	9	6	66/14
<i>Vittaria ensiformis</i>	-	-	-	-	-	-	-	24	41	4	13	6	10	33	32	43	28	15	73	12	50	8	-	77	61	530/17
<i>Asplenium glaucophyllum</i>	-	-	-	-	-	-	6	3	-	2	12	5	4	2	15	27	-	14	4	9	-	-	-	-	3	106/13
<i>Stenoclea napalustris</i>	-	-	-	-	-	-	-	-	1	16	-	-	21	-	26	-	-	-	7	3	35	-	-	47	1	157/9
<i>Vittaria elongata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	1	-	-	-	-	13	22/3
<i>Drynaria spartsisera</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	8	12/2
<i>Polypodium</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	1	-	4/2
<i>Phymatosorus scolopendria</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	9/1

*:see Figs. 2 and 3.

RESULTS

In a natural forest epiphytic *Asplenium nidus* plants were observed on rather large trees with 12-75 cm DBH and 8-25 m height. Among 316 trees in 6 belt transects 9 trees had epiphytic *A. nidus*. On 2 of the 9 trees other epiphytic plants of *Drynaria* and *Pyrrosia* species were observed, however not determined species (Fig. 1). Only 2.8% of the total and 18.8% of trees above 10cm DBH permit occurrence of epiphytic ferns in the forest. No epiphytic *A. nidus* is found below 10 cm DBH trees in the natural forest (Fig. 1B and Table 1). Mean number of undergrowth vascular plant species was 8.9 per 2 m × 2 m × 2 m cube (Fig.1A).

Table 2 shows brief architectural performance of oil palm trunks, distribution pattern of number of species per individual oil palm and light intensity on tree trunks. Trunk diameter ranges 60-80 cm. No clear difference was found the relative radiation between north and south facing of oil palm trunk.

Mean frequency of fern occurrence on trunks was 45.2±13.4% (Min. 25.7 - Max. 82.5%). No dependency was found between the relative frequency and oil palm height. Number of species gradually increase from 2-11 with increasing size of oil palms.

Table 3 shows fern species composition and frequency on individual 25 oil palm trunks with

Fig.3 Changes in frequencies of six common ferns on different size of oil palms, with respect to height above ground. Five samples with the six ferns are selected and exemplified (see Table 3; i, n, q, u, y). NB: *Nephrolepis bisserrata*. DD: *Davalia denticulata*. VE: *Vittaria ensiformis*. AN: *Asplenium nidus*. AG: *Asplenium glaucophyllum*. AL: *Asplenium longissimum*.

respect to different heights. The most common ferns on oil palm trunk was *N. bisserrata* with occurrence of 1060 spots on 25 trunks. Two species of *N. bisserrata* and *D. denticulata* were found on every size of oil palms (1-8.5 m). Four fern species of *Vittaria elongata*, *Drynaria sparsisera*, *Polypodium* sp and *Phymatosorus scolopendria* were found only on trees above 5.5 m height. *Asplenium nidus*, *A. glaucophyllum*, *Vittaria ensiformis* and *Stenocleanea palustris* are rather popular on the trunks above 4 m height.

Changes in frequency of epiphytic ferns with height above ground on individual trunk are exemplified on 3 oil palms of 6.5-7.0 height (u, v, w individuals; see Table 2) (Fig. 2). Number of species varied from 4 to 8 on individual trunk with same height. Range of 2-5 fern species was found at every 1 m intervals height. Thus we can see various patterns of species composition and frequency of ferns on individual oil palm trunks. There is a tendency that slightly higher frequency and number of pockets with ferns were found on upper part of trunk than those on the bottom part. Various patterns of coverage and species composition were found even on same size of oil palms. The

Fig.4 Frequency distribution of *Asplenium nidus* on oil palms. Bars indicate frequency. Length of arrows indicates number of *A. nidus* individuals on each oil palm trunk. Number of cubes show number of oil palms with *A. nidus* (dotted cube) and without *A. nidus* as a function of oil palm height. Dotted bars indicate distribution of number of *A. nidus* individuals as functions of hanging height and oil palm height.

percentages of number of pockets with ferns to the total pockets gradually increase towards upper part of trunk (Fig. 2, -A)

Frequency of common 6 ferns on different size of oil palms is illustrated in Fig. 3, with respect to heights above ground at 1 m intervals. Clear difference of the frequencies was found between *Nephrolepis bisserrata* and *Vittaria ensiformis*. *N. bisserrata* dominates on the upper part of trunk, while *V. ensiformis* does on the bottom of trunk.

To know how invade the epiphytic ferns to oil palm plantation number of individuals of *A. nidus* is selected and counted in relation to oil palm sizes and hanging height (Fig.4), since *A. nidus* occurs both trunks of natural forest trees and oil palm in plantation. *A. nidus* occurs in the range of 1-6 m heights above ground on rather tall oil palms more than 4 m.

Six rhizomes with roots of *A. nidus* were collected and separated carefully for insects collection. About 20 species of insects were collected under intact observation. The largest insects were cockroach in length 1-2 cm. Every life phase of earwig was found in the micro-ecosystem of rhizomes and roots of *A. nidus*.

DISCUSSION

These data were arranged under considerations through macro-, meso- and micro-scaling approaches to some extent. Here macro-scaling analysis starts from the natural forest observations along belt transects, and the micro-scaling does from *A. nidus* rhizomes and roots as for micro-ecosystem for insects.

Percentages of trees with epiphytic ferns was rather small as 3% in the natural forest at Pasoh. The reason why Pasoh forest has not much of epiphytes might be dryness of forest floor, isolation from mountains and surrounding by plantation. The short tall trees dominate since the tree density is rather high at the sites. For anchoring epiphytic ferns the wide canopy with horizontal branches seems to be necessary.

Meso-scaling analysis concerning to fern species composition and frequency on oil palm trunk is the most noteworthy data through these primary field note. We have to conclude that epiphytic ferns on oil palm trunk consist of rather poor fern flora with 16 species at most, however, every trunk looks to be covered with large amount of fern foliage. This means that oil palm trunk is well managed and performs an uniform habitat over the plantation. On the other hand we can recognize the vegetation pattern changes in fern species composition and frequencies in a micro-scale along height and ages of pockets between leaf-bases during 20 years. Clear displacement of dominance from *N. bisserrata* to *V. ensiformis* during aging of oil trunks shows one of vegetation processes of fern communities on semi-natural conditions.

Oil palm trunks usually grow up 15 m in 20 years through expanding every 2 leaves per month (personal communication by Dr. Hemson), and they are cut as they exceeded for human harvesting oil nuts. Above 15 m trunks have no leaf base and then habitat of the ferns diminish in 20 years. Only *V. ensiformis* scarcely hold on the smooth trunks. Invading speed of *N. bisserrata* and *Davallia denticulata* seems to be fast because the both ferns occur on 1 m height oil palm trunk (2-3 years). Once anchored the both ferns long creeping rhizomes reach to the upper part of tall oil palms. On tall oil palm trunks high frequency of *N. bisserrata* is found only upper part of the trunk (Fig. 3). On the other hand *V. ensiformis*, *Asplenium glaucophyllum* and *Stenoclaena palustris* seems to be species of late invading ferns since they occur only trunks exceeding 4.5 m height (Table 3).

From both data concerning *A. nidus* epiphytes from both natural forests and oil palms, critical size seems to be necessary for growing of *A. nidus* as exceeding 10 cm DBH for natural forest and 4m height for oil palms (Figs. 1 and 4). Rhizomes and roots of *A. nidus* seem to be one of micro-ecosystem for some insects, since cockroach and earwig inhabit in all 6 samples from oil palm trunks. Further insect identification is in progress; and further insect fauna information is necessary on rhizomes and roots of *A. nidus* on tall trees in natural forest, if possible.

Undergrowth of the natural forest floor at Pasoh had larger leaves and individual size than those of temperate forest floor in Japan as well as taiga and tundra in eastern Siberia. As shown in Fig. 1 the mean number of undergrowth species is at most 9 in the tropics. The number was about half of that in the temperate and the 1 / 3 of tundra per 2 m × 2 m × 2 m cube (Sato, 1993). In a small scale larger size of plants may interfere with coexistence of many species. In a larger quadrats exceeding 100 m × 100 m and 1 km × 1 km in tropic regions may contain larger number of plant species than those in the temperate and arctic regions (Whitmore, 1984). Recent summary of elevational distribution of pteridophyte taxa and their life forms on Mt. Kinabalu shows that the highest phytodiversity and the highest proportion of epiphytic life form were found around 1500 m elevation where is a sites with high humidity in the cloud (Parris *et al.*, 1992). Same patterns were known in Southern and Eastern

Africa (Jacobsen and Jacobsen, 1989) and Central Europe (Sato *et al.*, 1989). Lowland of tropical regions with large trees may not to be an optimum zone for high phyto-diversity of pteridophyte.

ACKNOWLEDGEMENTS The present study is a part of a Joint Research Project between Forest Research Institute of Malaysia (FRIM), Universiti Pertanian Malaysia and National Institute for Environmental Studies (NIES) of Japan. The study was carried out under auspices of Global Environment Research Programme granted by Japan Environmental Agency, Grant No. E-2. Present authors express sincere thanks to Drs. M. Yasuda (University of Tokyo), Y. Maruyama (FFPRI), I. E. Hemson (PORIM), T. Ishihara (JAICA) and H. T. Chan (FRIM) for their cooperation and facilities during field survey in Malaysia. Authors also thank to anonymous examiner for invaluable comments on this manuscript.

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Received Aug. 29, 1996

佐藤利幸, 伊藤日出夫, 工藤 岳, Yap Son KHEONG, 古川昭雄 マレー半島のオ
イルヤシの幹における着生シダ植物の種構成と群集構造

熱帯多雨林では着生植物やつる植物が多いことが一つの特徴である。シダ植物やラン植物の胞子や種子は10-20ミクロンメートルと小さく、直立する樹木の樹幹や枝分かれした部位のくぼみに定着する。クアラルンプールに到着すると、オイルヤシ植林地が目立ちその樹幹に着生するシダ植物が目にはいる。環境庁の国立環境研究所とマレーシア森林研究所の国際共同研究のひとつに、熱帯林生態系の環境及び構造解析に関する研究のプロジェクトがある。巨大な熱帯雨林の構造解析を開始する手始めの一端として、半自然環境のオイルヤシ樹幹の着生シダの種構成と群集の解析と若干の自然林における着生率を求めた。パソ保護林（標高 100-150 m, 北緯 3 度, 東経 102 度）はマレーシア半島では比較的降水量が少なく、孤立した森林である。*Asplenium nidus*（シマタニワタリ）の着生率は全樹木の3%, 胸高直径 10 cm 以上の樹木の 19% であった。オイルヤシ樹幹には 16 種のシダ植物が確認された。いろんなサイズのオイルヤシ樹幹 25 本に普通に見られる種は以下の 6 種, *Nephrolepis bisserrata*（ホウビカンジュ）, *Vittaria ensiformis*（ヒメシシラン）, *Davalia denticulata*, *Stenoclaena palustris*, *Asplenium glauccophyllum*, *A. nidus* であった。小さな樹幹から侵入でき、樹幹上部に優占するシダは *N. bisserrata* と *D. denticulata* であり、もっとも遅く侵入し樹幹下部で頻度が高いシダは *V. ensiformis* である。*A. nidus* はオイルヤシ樹幹が 4 m を越えて侵入し、大型なロート型の葉群を発達させる。その根茎と根には必ずゴキブリとハサミムシの仲間が確認できた。着生シダは自然林・人工林において、昆虫にとってのマイクロ生態系を提供し、狭い範囲（ミクロスケール）での植物多様性を高めている可能性がある。もう少し広いメソスケールではシダ植物多様性は中高度（1500 m）の雲霧帯で最大となるう。