

**STRUCTURE, FLORISTIC DIVERSITY AND DYNAMICS
OF A SEASONAL RAIN FOREST, SAKAERAT,
NORTHEAST THAILAND**

1. STRUCTURE AND FLORISTIC COMPOSITION

**โครงสร้างป่า ความหลากหลายชนิดและ
การเปลี่ยนแปลงของป่าดิบแล้งที่สะแกราช
ในภาคตะวันออกเฉียงเหนือของประเทศไทย
1. โครงสร้างป่าและองค์ประกอบของชนิด**

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ABSTRACT

Structure and floristic composition of seasonal rain forest was investigated in 1 ha plot at Sakaerat Biosphere Reserve, northeast Thailand. All woody plants ≥ 4.5 cm DBH (D) were enumerated in 100, 10 \times 10 m quadrats, those below 4.5 cm D with over 1.30 m height (H) in 100, 4 \times 8 m quadrats and woody plants and herbs of $H \leq 1.30$ m in 100, 1 \times 8 m quadrats placed in the 10 \times 10 m quadrats. Woody plant composition in 1 ha area consists of 72 species belonging

to 43 families and 62 genera of trees and lianas with $D \geq 4.5$ cm of which 57 species belonging to 30 families and 49 genera are trees and 15 species belonging to 13 families and 13 genera are lianas. Woody plant density is $1,612$ stems ha^{-1} ($1,488$ stems ha^{-1} for trees and 124 stems ha^{-1} for lianas). Those below this size limit are also described. Stratification of the canopy trees shows three strata with the third stratum possibly divided further into 2 substrata. Size-structure determined by D distribution follows the negative power function model and height distribution is approximately a bell-shaped curve with slightly negative skewness. Species composition investigated separately among 3 size-class categories reveals that 2 highest IVI values of woody plants ($D \geq 4.5$ cm) are for Hopea ferrea and Memecylon ovatum with the abundance of lianas, Ancistrocladus tectorius and Ventilago harmandiana having highest IVI values in the first size-class. The abundance of Hopea ferrea is found in all 3 size-class categories suggesting a monodominant stand of this species with low species abundance but rather high density of other woody plants in lower 2 size-classes and herbs as undergrowth. Species-area relationships of woody plants having $D \geq 4.5$ cm is well fitted to a positive power function model suggesting a rapid increase of species number in a few small plot sizes and shows plateauing at around $6,400$ m^2 of plot area.

บทคัดย่อ

การตรวจสอบโครงสร้างและองค์ประกอบของชนิดพืชพรรณไม้ในป่าดิบแล้งในแปลงขนาด 1 เฮกแตร์ (6.25 ไร่) ที่บริเวณหุบเขาสะแกกราชในภาคตะวันออกเฉียงเหนือของประเทศไทย โดยการตรวจนับและวัดพืชพรรณยืนต้นที่มีขนาดเส้นผ่าศูนย์กลางที่ระดับสูง 1.30 ม.เหนือพื้นดิน ตั้งแต่ 4.5 ซม. ขึ้นไปในแปลงขนาด 10×10 ม. จำนวน 100 แปลง พืชพรรณไม้ที่มีขนาดเส้นผ่าศูนย์กลางเล็กกว่า 4.5 ซม. แต่สูงกว่า 1.30 ม. ในแปลงขนาด 4×8 ม. จำนวน 100 แปลง และ พืชพรรณไม้ยืนต้นกับพืชล้มลุกที่มีความสูงน้อยกว่า 1.30 ม. ในแปลงขนาด 1×8 ม. ที่วางลงไป

ในแปลงขนาด 10 × 10 ม. จำนวน 100 แปลง องค์ประกอบของชนิดพืชพรรณยืนต้นในพื้นที่ 1 เฮกแตร์ มีไม้ยืนต้นและเถาวัลย์ที่มีขนาดเส้นผ่าศูนย์กลางมากกว่า 4.5 ซม. จำนวนรวมทั้งสิ้น 72 ชนิด ใน 43 วงศ์ และ 62 สกุล ในจำนวนนี้เป็นไม้ยืนต้นจำนวน 57 ชนิด ใน 30 วงศ์ และ 49 สกุล เป็นเถาวัลย์จำนวน 15 ชนิด ใน 13 วงศ์ และ 13 สกุล ความหนาแน่นของพืชพรรณยืนต้นทั้งสิ้น 1,612 ต้นต่อเฮกแตร์ (ไม้ยืนต้น 1,488 ต้นต่อเฮกแตร์และเถาวัลย์ 124 ต้นต่อเฮกแตร์) รวมทั้งพืชพรรณอื่น ๆ ที่มีขนาดจำกัดต่ำกว่าที่กำหนด ผลของการแบ่งชั้นพรรณไม้ในชั้นเรือนยอดพบว่า มี 3 ชั้น โดยในชั้นที่สามสามารถแบ่งออกได้เป็นสองชั้นย่อย โครงสร้างด้านขนาดที่วัดเมื่อแจกแจงขนาดเส้นผ่าศูนย์กลางจะแสดงลักษณะที่สอดคล้องตามรูปแบบที่เป็นฟังก์ชันยกกำลังลบและการแจกแจงขนาดความสูงมีลักษณะเป็นรูประฆังคว่ำโดยประมาณ โดยมีลักษณะเบี่ยงเบนไปทางซ้ายเล็กน้อย เมื่อตรวจสอบองค์ประกอบของชนิดแยกกันระหว่างทั้ง 3 ชั้นขนาด พบว่าพืชพรรณไม้ยืนต้น (มีขนาดมากกว่า 4.5 ซม.) ที่มีค่าดัชนีความสำคัญสูงสุดมี 2 ชนิด คือ ไม้ตะเคียนหิน (*Hopea ferrea*) และ ไม้พลองกินลูก (*Memecylon ovatum*) โดยมีเถาวัลย์ 2 ชนิดที่จัดอยู่ในชั้นขนาดจำกัดดังกล่าว มีค่าดัชนีความสำคัญสูงสุด คือ เถาวัลย์หน่อตีหมา (*Ancistrocladus tectorius*) และเครือปลอก (*Ventilago harmandiana*) ความหลากหลายของไม้ตะเคียนหินที่พบทั้ง 3 ชั้น เป็นหมู่ไม้ที่ประกอบด้วยพรรณไม้ชนิดเดียวที่โดดเด่นแต่มีความหลากหลายของชนิดต่ำ แต่มีพืชพรรณชนิดอื่นที่มีความหนาแน่นค่อนข้างสูงในชั้นล่างลงมา 2 ชั้น และมีพืชล้มลุกเป็นพืชชั้นล่าง ความสัมพันธ์ระหว่างจำนวนชนิดกับพื้นที่ของไม้ยืนต้นที่มีขนาดตั้งแต่ 4.5 ซม.ขึ้นไปจะสอดคล้องกับรูปแบบที่เป็นฟังก์ชันยกกำลังบวกซึ่งแสดงให้เห็นว่าจำนวนชนิดของพืชพรรณขนาดจำกัดจะเพิ่มขึ้นอย่างรวดเร็วเมื่อเพิ่มขนาดของแปลงตัวอย่างขนาดเล็กขึ้น และจะมีจำนวนชนิดค่อนข้างคงที่เมื่อแปลงตัวอย่างมีขนาดประมาณ 6,400 ตร.ม.

INTRODUCTION

Seasonal rain forest¹ or tropical semi-evergreen rain forest² or tropical seasonal evergreen forest³ is generally known as dry evergreen forest by foresters⁴ following the classification of Champion⁵ and Champion and Seth⁶. On a regional scale this forest type may be found in India, northern Sri Lanka⁷, Burma (Myanmar), Laos,

Vietnam, Thailand and some rain shadow areas of New Guinea², and it is known as mesophyll vine forest⁸ or evergreen seasonal rain forest⁹ in eastern Australia. Despite of its forest type nomenclature arguments, this forest type is among the main evergreen forest types widely distributed on the major parts of the mainland, excluding the southern region of Thailand where the climate has an alternate dry and wet period in a year and at altitude lower than 900 m a.s.l. It is particularly found on low hill range, along the moist valley mountain ravines, foot-hills and sometimes on the depression of penplain. Where it is found in a narrow strip over the banks of large water courses in some open broad valley basins, a gallery forest type, another name of this forest is usually noticeable¹⁰. Its main feature is less tall than the tropical evergreen rain forest in southern peninsular Thailand where the climate is generally wetter. Trees of Dipterocarpaceae family are the main canopy component of this forest type representing the most valuable timbers next to teak (*Tectona grandis*), i.e., *Dipterocarpus alatus*, *D. castanea*, *D. turbinatus*, *Hopea odorata*, *Hopea ferrea*, as well as other species, i.e., *Lagerstroemia calyculata*, *Gmelina arborea* and so on. Stratification always shows 3 layers with the main canopy of trees being higher than 25 m up to 35 m, 10–25 m of middle and less than 10 m in lower tree layers, comprising several plant species. The most remarkable feature of this forest type is the abundance of undergrowth including seedlings and saplings of upper tree layers, shrubs, herbs, palms, ferns and lianas, but grasses either large bamboo or small grass are less common. Soils underneath this forest type are both calcareous and non-calcareous types but a granitic loamy soil is rather frequent. Soil profile is usually deep and moisture retention capacity is relatively high. Present condition of this forest type in Thailand is left in patches under the conservation areas either in national parks, wildlife sanctuaries or along water courses of some main tributaries in the slightly lower hill ranges. Most areas are under the pressure of agricultural area expansion and infrastructure construction. The quantitative ecological studies of this forest type is extremely scarce and not well documented. The present study reports the structural analysis and floristic composition investigation in a long-term 1 ha

permanent study plot established for a monitoring of species diversity, population dynamics and nutrient cycling in this forest type under the Sakaerat Biosphere Reserve and environmental research program. Thus this report forms part of this long-term study while other aspects will be dealt with in other papers of this series. The information reported in the present study is considered to serve as a basis for understanding the relative extent of plant species composition and its importance for conservation and management of this forest type.

Study area

The study was conducted in a strictly reserved forest of Sakaerat Environmental Research Station, SERS ($14^{\circ} 31' N$ latitude and $101^{\circ} 55' E$ longitude), Nakhon Ratchasima Province, northeast Thailand. The area has been designated as a Biosphere Reserve since 1978 after the station establishment in 1967. It is located on the southeastern fringe of the Korat Plateau (315–560 m a.s.l.). The total area cover of SERS is 81 km^2 of which the seasonal rain forest covers 30 km^2 (36 % of the total area)¹¹, mainly on the southwest side of the main area apart from the dry dipterocarp forest (12 % of the total area) and disturbed area which has been rehabilitated after abandoning the swidden practice for more than 20 years. The location of this study area was presented elsewhere¹². The main part of the seasonal rain forest is considerably flat, generally less than 20° slopes with two intermittent streams flowing eastward. Underneath this forest is a deep soil derived from the sandstone formed during the Triassic to Cretaceous periods and classified as a Korat group (*Pra Wihan* formation)¹³. Soils of the site is residium and colluvium with thick Ao-layer (averaged 3.5 cm) and clearly shows 2 horizons of A (A_1 and A_2) and 3 horizons of B (B_1 , B_2 and B_3) with abundant root distribution down to 70 cm and being very dense in 0–60 cm depth. Textural composition of soils are classified for the upper layer as sandy clay loam and clay for subsoils. Gravel content is relatively abundant in the whole soil horizon similar to that in dry dipterocarp forest. It is a strong acidic soil with pH ranging between 4.4–4.8 throughout the whole horizon and

5.65% organic matter in surface soil and 1.03–4.57% in subsoil. The nutrient contents vary between 777–2,910 ppm N, 2–10 ppm P, 61–132 ppm K, 13–187 ppm Ca, 0.8–263 ppm Mg and 0.8–79 ppm Fe, and the cation exchange capacity ranges between 7–9 meq (100 g soil)⁻¹ for all soil depths¹⁴.

Climate of the site is under the monsoonal influences by which bimodal rainfall pattern is prominent, one occurring in mid May and the other in September with the monthly rainfall greater than 100 mm and 250 mm, respectively. The dry period lasts for about 4 months from mid November to mid March in which the definite dry period (without rainfall) is in the dry cool season during December through February. The average annual rainfall of the site is 1,240 mm. Mean annual temperature is 26.2°C with an average monthly minimum of 21.6°C in December and maximum of 28.7°C in March^{12,14}.

MATERIALS AND METHODS

One permanent 100 × 100 m square plot (1 ha) was established in 1982 in the seasonal rain forest located on the east side of an observation tower. The location of this plot is almost coincidental with the former observation plot of Smitinand and his collaborators¹⁵ but they used a tower as a center, therefore, the present study plot may be partly overlapped with that former plot but no relict of their plot mark remained to be clearly observed. The plot was subdivided into 100 (10 × 10 m) quadrats for further investigation of the number of woody plant species and the number of individual counts. All individuals of living trees and lianas ≥ 4.5 cm DBH (diameter at 1.30 m aboveground or at breast height) were counted, species identified, DBH (D) measured, numbering tagged, H (total tree height) and H_B (height to the lowest living branch) measured, mean crown diameter averaged (\bar{R}) from twice measurement of crown projection to the ground perpendicularly

using tree bole as a center, stem position mapped and stand profile along a 10 × 10 m belt transect sketched. Tree folking and multistem occurring below 1.30 m aboveground were counted and measured separately among each individual. Leaning trees and climbing woody lianas were practically measured for their DBH at the point marked at 1.30 m from the stump base along the bole length. Woody plants (trees, shrubs and lianas) with $D \leq 4.5$ cm and $H \geq 1.30$ m were investigated in 4 × 8 m quadrats in each 10 × 10 m quadrats. Those with $H \leq 1.30$ m including herbs were in 1 × 8 m quadrats located along the middle part of the 4 × 8 m quadrats. Plant species identification was consulted with the standard specimens of the Royal Forest Department Herbarium in Bangkok and plant nomenclatures followed Phya Winit Wanandorn¹⁶ and Smitinand¹⁷.

Floristic composition of the stand was arrayed by their size-class categories using their importance value indices (IVI)¹⁸ calculated basing on the summation of % relative density, % relative frequency and % relative dominance with 300 % total for the first two categories and 200 % total for the last one. The absolute values for each species parameter were obtained from the individual of each species counts for density, occurrence number of each species in 10 × 10 m quadrats counts for frequency and total basal area of trunk at 1.30 m aboveground of each species summed for dominance. They were then divided by total species attributes and multiplied by 100 for the percentage relative values. For the small component species, they were limited to the first two parameters obtained by the same way as for the large size plants.

Stratification of the canopy layer was obtained by adopting Ogawa's method of crown-depth and $H-H_p$ diagram analyses¹⁹. Relative light intensity inside the forest at ground level was measured using twin Minolta illuminators simultaneously read outside and inside the plot in one day (January 15, 1983) and supplemented by the subsequent study in 1992 and 1993²⁰.

RESULTS AND DISCUSSION

Stand density and floristic organization

Stand parameters of the seasonal rain forest is shown in Table 1 by which all plant composition is subdivided into 3 size-classes. The stand is considered to be relatively dense with 1,488 stems ha^{-1} of trees ($D \geq 4.5$ cm) and 123 stems ha^{-1} of woody lianas of the same size-class. Furthermore, very abundant trees, lianas and herbs in the lower 2 size-classes suggest that this forest is a fairly close forest type showing the proportion among total woody plants in 3 categories as 1:13:285. The total number of families of trees in this forest type is 30 with 13 families of lianas although the number of families is fewer in the subsequent lower size-classes and these families make up 49 genera of trees and 13 genera of lianas.

Table 1. Stand density, number of family, genus, species and total basal area at breast height of a seasonal rain forest

Stand parameter	Size-class		
	$D \geq 4.5$ cm	$D \leq 4.5$ cm, $H \geq 1.30$ cm	$D \leq 4.5$ cm, $H \leq 1.30$ m
Stand density (No ha^{-1})	1,488 (1,612)	14,063 (20,313)	413,750 (458,750) (490,000)*
Number of family	30 (43)	10 (17)	15 (28) (33)*
Number of genus	49 (62)	11 (18)	19 (32) (37)*
Number of species	57 (72)	12 (19)	21 (34) (39)*
Total basal area ($\text{m}^2 \text{ha}^{-1}$)	30.9 (31.3)	1.4 (1.9)	-

* include herbs

The species number of this forest stand is identified as 57 species of trees and 15 species of lianas while the lower size-classes are correspondingly lower down to 12 and 21 species of trees and 7 and 13 species of lianas with 5 species of

herbs. This forest is fairly rich in floristic composition. Murphy and Lugo²¹ suggested that dry tropics contained a range of species number of 35–90. The species number of this seasonal rain forest is therefore quite well composed closely to the mean of this range.

Correspondingly, total basal area at breast height is estimated at 33.2 m² ha⁻¹ of total woody plants in the 2 upper size-classes (Table 1). The largest size-class alone has the total basal area cover far greater than the 4 stands of dry dipterocarp forest in the vicinity site of the same area reported elsewhere¹² but either lianas combined or tree species alone, total basal area of this forest falls within the range of 17–40 m² ha⁻¹ (dry type) and 20–75 m² ha⁻¹ (wet type) of tropical forest²¹. This basal area cover together with the dense and multilayered crown cover of canopy trees in turn probably determine a low light intensity reaching to ground averaging 1.03 % (geometric mean) of relative illuminance measured in mid cool and dry season (January, 1983) and at 1.2–1.7 % measured in dry and wet season respectively²². However, in an occasional study in this forest type, relative light intensity at ground level in the late rainy season (October, 1992) and late dry season (May, 1993) were at the highest at 1.79 ± 0.631 and 6.08 ± 10.81 %, respectively but significantly observed to be lower than in dry dipterocarp forest, abandoned area and in an *Acacia mangium* plantation of the same locality²⁰ signifying the closed canopy prevailing almost all year round.

Density of trees and lianas of the same size-class as compared with some evergreen and deciduous forest types in Thailand suggest that stand density of Sakaerat seasonal rain forest is greater than the evergreen forest types in Namphrom area^{23,24} and in Khao Chong¹⁹ but lower than the temperate evergreen forest type in Doi Inthanon, northern Thailand¹⁰. The difference in stand density of the same forest type in the same location at Sakaerat is observed to be probably due to the size limit of tree enumeration which they included trees of $D \geq 3.0$ cm while

excluding lianas³. This stand density is also greater than that found in a dry evergreen forest (1,576 stems ha⁻¹) so far reported in southern India which included trees and lianas of GBH \geq 10 cm (approximately \geq 3.16 cm DBH)²⁵. The density of lianas found 124 stems ha⁻¹ is moderately high as compared to the tropical rain forest, southern Thailand¹⁹, the ecotone between the dry evergreen forest and mixed deciduous forest²⁴ but denser than in the similar forest type in Namphrom area, northeastern Thailand²³. A dry evergreen forest in southern India²⁵ seems to be very dense with lianas of 239 stems ha⁻¹. The Sakaerat seasonal rain forest is far denser than some deciduous forest types studied elsewhere in Thailand^{12,19,23}.

Tree density limited to woody plants with D \geq 10 cm is 520 stems ha⁻¹, falls within the range of 245–859 stems ha⁻¹ recorded for various tropical forests^{26,27} and approximately 48 stems (930 m²)⁻¹ within the range of 28–170 stems (930 m²)⁻¹ summarized for several tropical forest types²⁸ but slightly lower than an average of 575 stems ha⁻¹ of trees with GBH \geq 12 in. (approximately \geq 10 cm DBH) in New Guinea tropical rain forest²⁹.

The number of species of trees and lianas, on the other hand, is not only greater than that in the deciduous forest types studied elsewhere in Thailand but also greater than that in a tropical rain forest recorded in southern Thailand¹⁹ and richer than that in a tropical dry evergreen forest of southern India²⁵. Nevertheless, this forest type contains a considerably large number of species as compared to most of tropical dry forest (35–90 species) and slightly above the minimum number of species found in tropical wet forest (50–200 species)²¹.

Stratification

Stratification of trees having $D \geq 4.5$ cm in Sakaerat seasonal rain forest is shown in Figure 1. It is clearly shown that this forest type is arranged vertically in 3 strata in which the third stratum may be subdivided into III_a and III_b by which some of trees in the III_a stratum are partly shaded by the neighboring trees and those in III_b stratum are completely overtopped for more than 90 %. This is in consistence with the similar forest type studied in Namphrom area²³, the dry evergreen/mixed deciduous forest ecotone²⁴ and the tropical rain forest in Khao Chong, southern Thailand¹⁹, suggesting a closed canopy feature of this forest as contrasted to the more open canopy of other forest types in drier habitat such as mixed deciduous and dry dipterocarp forests which are generally found 2–3 layers of stratification^{12,19,23}. Low relative light intensity reaching the ground investigated in various occasions as mentioned earlier confirm that 3 layering features of this seasonal rain forest greatly reduce the light penetrating through the forest. Vertical light intensity observation made on a tower rising over the forest surface³⁰ suggests that 3 layers of this forest stand apparently reflect the infrequent occurrence of tall emergent trees and correspond to high leaf area density in the uppermost and lowermost layers and being relatively low in the middle layer and similar to a warm temperate evergreen oak forest in Japan³¹. This 3 layering results in 69, 163, 284 and 972 trees ha⁻¹ (excluding lianas) in stratum I, II, III_a and III_b, respectively being 14.80, 7.43, 7.41 and 4.57 m² ha⁻¹ of basal area at breast height in each corresponding stratum. The most abundant species dominating in all strata is *Hopea ferrea* followed by *Carallia brachiata* and *Litsea glutinosa* while *Dialium cochinchinense*, one among the main canopy tree species, is found in stratum I, III_a and III_b only and *Terminalia bellerica* is in stratum I, II and III_a. Other sporadic tree species found only in stratum I are *Ficus annulata* and *Peltophorum pterocarpum*. Other subcanopy species dominating in strata II, III_a and III_b are *Memecylon ovatum*, *Hydnocarpus ilicifolius*, *Linociera microstigma*, *Largerstroemia duperreana*, *Memecylon geddesianum*, *Canthium dicoccum*, *Eugenia cumini*, *Pterospermum acerifolium* and *Excoecaria*

cochinchinensis which are arrayed in descending order of abundance. Some subcanopy species which occur sporadically in stratum II are *Cananga latifolia*, *Canarium subulatum*, *Cratoxylum maingayi*, *Dalbergia dongnaiensis*, *Diospyros areolata*, *Erythrina subumbrans*, *Shorea henryana* and *Spondias pinnata*. The rest are those abundantly distributed in the lower strata (see also Table 2). Vertical layering of these species is attributable clearly to their light demanding and shade tolerant characteristics.

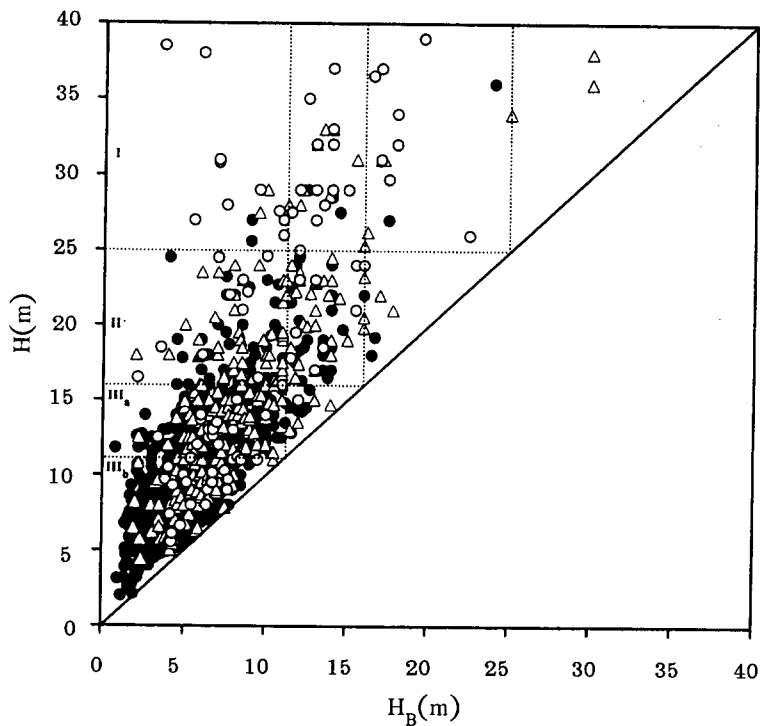


Fig. 1. Stratification by $H-H_B$ relationships¹⁹ of trees ($D \geq 4.5$ cm) in Sakaerat seasonal rain forest

- : tree unshaded by the neighboring tree
- △ : tree partly shaded by the neighboring tree
- : tree completely overtopped by the neighboring tree

Size-structure of the forest

Size-structure of trees and lianas ($D \geq 4.5$ cm) expressing in forms of diameter at breast height distribution is demonstrated by a good fit of the negative power function model ($r^2 = 0.961$) in Figure 2. Frequency distribution of height is shown in Figure 3 by including only trees having $D \geq 4.5$ cm that had been stratified into 3 strata as described above. The diameter distribution following a good fit of the negative power function model is different from the dry dipterocarp forest reported earlier¹² but similar to those studies in the same area within the 2 association types of this forest community³². The diameter distribution of this forest as expressed in forms of negative power function model is different from what is generally found in forms of the classical inversed J-shaped or L-shaped distribution which is best explained by negative exponential function model. However, this present type of distribution is well expected for the uneven-aged forests where density of trees in the smaller size-classes decreases proportionately to the larger ones³³, indicating that mortality of small trees greatly occurs. This is particularly true for this forest stand where the smaller trees are highly abundant in a factor of 10 times of trees in the subsequent larger size-classes as postulated earlier into 3 broad size-classes and correspondingly well to the size-class subdivision of 8 size-classes with 10 cm intervals. Although trees in the intermediate size-classes tend to vary slightly from the expected linear regression line of the negative power function model, they vary considerably if the negative exponential function model is adopted, causing an unsatisfactory fit of the latter model as compared to the first one.

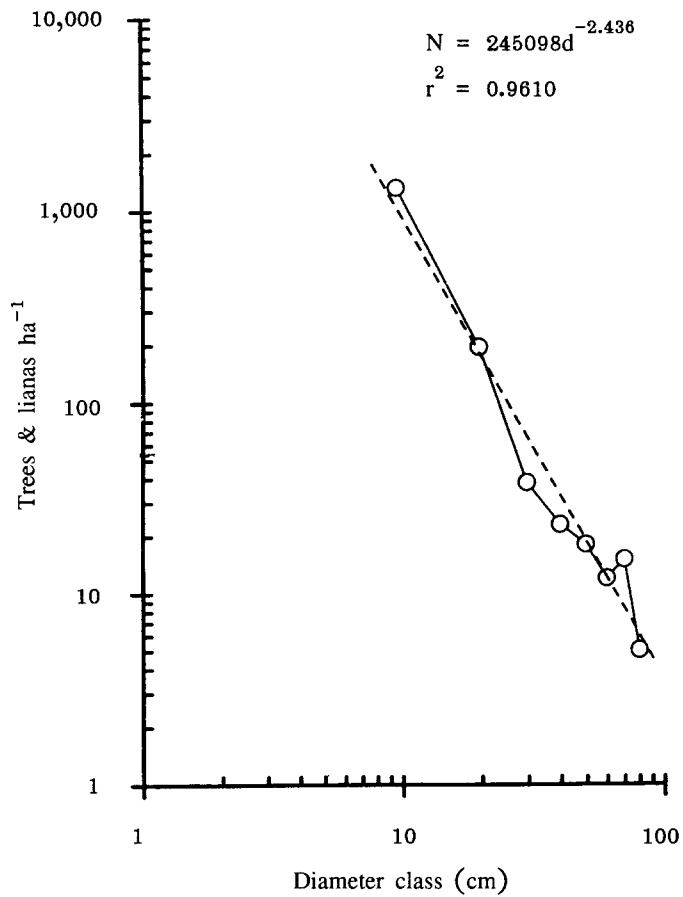


Fig. 2. Size distribution of trees and lianas ($D \geq 4.5$ cm) in Sakaerat seasonal rain forest

----- = linear regression line of the negative
power function model: $N = \alpha d^{-\beta}$

where N = number of trees and lianas (ha^{-1})

d = mid-point of diameter at breast
height class (cm)

α and β = constants

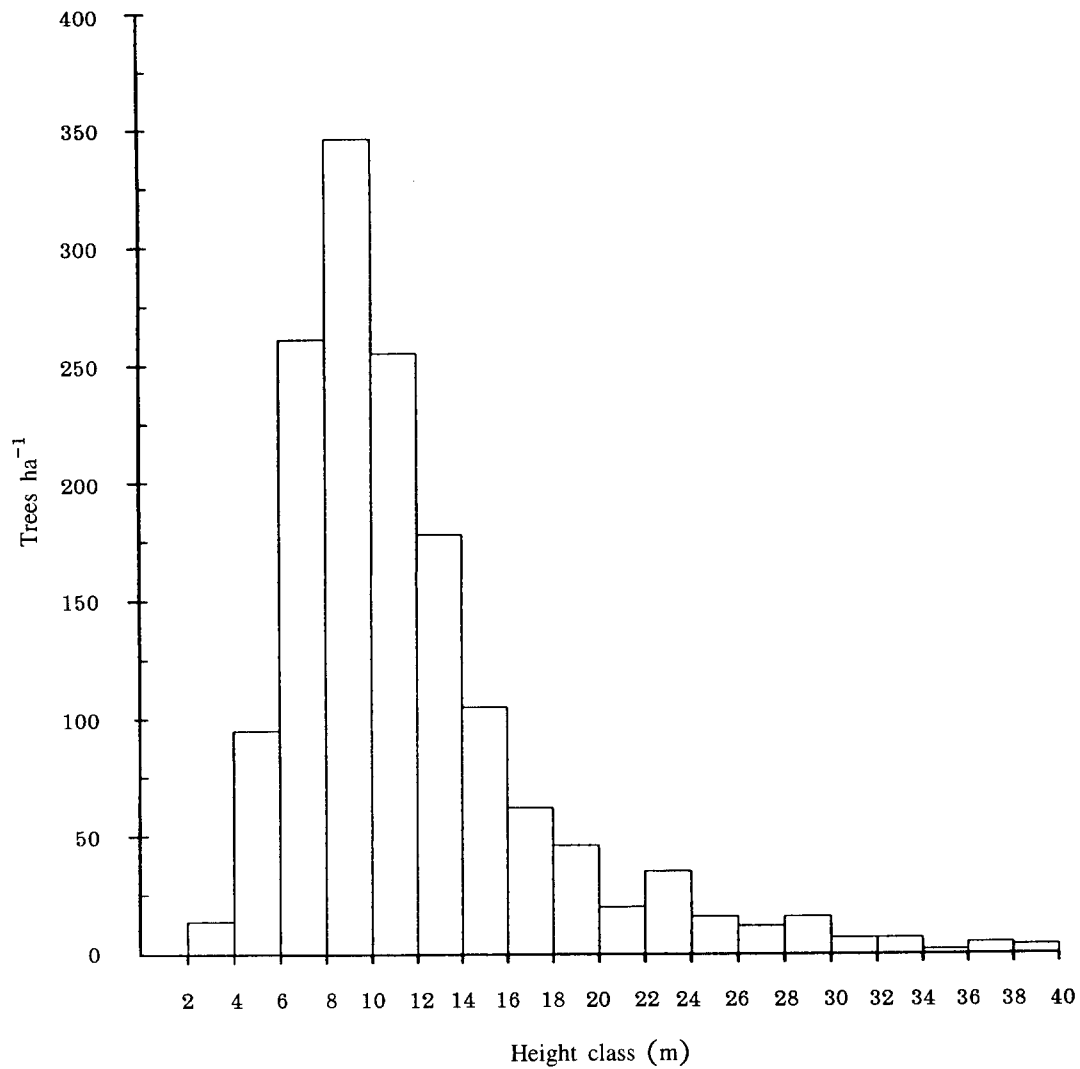


Fig. 3. Height distribution of trees ($D \geq 4.5$ cm) in Sakaerat seasonal rain forest

Generally, frequency distribution of trees by size-class is adopted for explaining age distribution of the population in any tree community representing survivorship curves of the long lived species³⁴⁻³⁷. It is unapplicable to most natural grown tropical tree species which age determination is scarcely done to get the reliable and substantial relationships between size and age of trees. However,

this distribution pattern (Figure 2) characterizes the mixed-aged stand of this forest type where overall natural regeneration of stand is expected to occur steadily resulting in a balanced uneven-aged stand. With respect to species level, frequency distribution of diameter at breast height is of 2 types: L-shaped and B-shaped (bell-shaped) distributions. Within 1 ha plot, those species having a potential of well natural regeneration characterized by L-shaped distribution are *Hopea ferrea*, *Memecylon ovatum*, *Hydnocarpus ilicifolius*, *Walsura trichostemon*, *Aglaia pirifera*, *Linociera microstigma*, *Memecylon geddesianum*, *Canthium dicoccum* and *Carallia brachiata*. Those species characterized by B-shaped distribution, on the other hand, and believed to be shade-intolerant species of young trees are *Dialium cochinchinense*, *Eugenia cumini*, *Lagerstroemia duperreana* and *Terminalia bellerica*. The rest, characterized by the lack of large-sized trees and only small-sized stature showing abundant occurrence only in lowest size-class, are considered to be shade-tolerant species associated with the abundant canopy and subcanopy species. Kanzaki and his co-workers reported species possibly regenerate in each phase of the mosaic structure of this forest³.

The height distribution, on the other hand, shows an approximate normal distribution with a slight skew to the lower height-classes with a maximum density at around 8–10 m height-class followed by an exponential decreasing trend of tree density throughout the height-class ranges in the subsequent classes (Figure 3). This is in consistence with the vertical arrangement of trees, showing that the emergent trees in the first stratum of this forest type are not prominent and clearly separated from the subsequent lower strata (Figure 1). The vertical arrangement of trees in this forest stand suggests three mosaic structure as representing the trees in the gap phase ($H \leq 10$ m), building phase ($H \geq 10-20$ m) and mature phase ($H \geq 20$ m) according to the phase discrimination proposed generally by Whitmore² and particularly for this forest type by Kanzaki and his co-workers³. This study did not attempt to identify the mosaic structure but all trees are included in all phases. However, not all species are being regenerated and become mature since some species are only small-sized trees or shrubs, especially those having $D \geq 4.5$ cm in this studied stand.

Among the 10 most abundant species showing successful performance in this forest stand, *Hopea ferrea* is notably found in all height-classes while *Canthium dicoccum*, *Hydnocarpus ilicifolius*, *Memecylon ovatum* and *Lagerstroemia dupperreana* are found in the lowest height-class up to 22–24 m height-class. *Aglaia pirifera*, *Carallia brachiata*, *Linociera microstigma*, *Memecylon geddesianum* and *Walsura trichostemon* are found in all height-classes up to 16–20 m height-class. The rest are species occurring irregularly and are not remarkable in any specific height-class, showing their occurrence differently only in some particular height-classes.

Families, genera and species organization

Species composition of this seasonal rain forest classified into 3 diameter and height size-class categories are shown in Tables 2–4. This forest is composed of 30 families of trees and 13 families of lianas of $D \geq 4.5$ cm (Table 2), 10 families of trees and 7 families of lianas of $D \leq 4.5$ cm, $H \geq 1.30$ m (Table 3) and 15 families of trees, 11 families of lianas ($H \leq 1.30$ m) and 5 families of herbs (Table 4). Most studies on species composition of various forest types in Thailand did not include the identification of floristic family, making it impossible to detect the similarity and difference among the forest types; however, a study in southern India's dry evergreen forest²⁵ is comparable to the present study. Most families of trees and lianas are similar among the seasonal rain forest in northeast Thailand and the dry evergreen forest in southern India but about 11 genera are identical with one species being closely identified, *Canthium dicoccum*. General feature of the forest may be quite similar in the 2 geographic regions as both locations are $12^{\circ} 03'$ N for the forest stand in India and $14^{\circ} 30'$ N for the present study site in Thailand with similar climatic conditions of mean annual rainfall of about 1,258 and 1,240 mm yr⁻¹, respectively for the 2 locations with the definite dry and wet seasons and on a similar sandy loam soil type.

Within 30 families of trees and 13 families of lianas of $D \geq 4.5$ cm, there are 49 and 13 genera, 57 and 15 species of trees and lianas, respectively (Table 2) while the second size-class category ($D \leq 4.5$ cm, $H \geq 1.30$ m) contains 10

families with 11 genera and 10 species of trees and 7 families with 7 genera and 7 species of lianas (Table 3). Three families of trees and lianas in this category are not found in the first size-class category (Stilaginaceae, Capparidaceae and Rubiaceae). At the generic level, 2 genera of trees (*Capparis* and *Calophyllum*) and 1 genus of liana (*Randia*) are not found in the first category representing the rarity of these floras as this criterion is taken into consideration. The smallest size-class ($H \leq 1.30$ m) is composed of 15 families with 19 genera and 21 species of trees, 11 families with 13 genera and 13 species of lianas and 5 families with 5 genera and 5 species of herbs (Table 4). Of these genera, 6 genera of trees and 6 genera of lianas are not present in the first category, 4 genera of trees and 2 genera of lianas are present in the first category but not in the second category. One genus of trees and 1 genus of lianas are found only in the first and third categories only.

The overall species richness consists of trees belonging to Euphorbiaceae and Ebenaceae families with 6 species, Rubiaceae with 4 species, Mimosaceae and Meliaceae with 3 species each, and the remaining 10 and 15 families are 2 and 1 species containing families respectively. There are only 2 families of lianas consisting of 2 species, i.e. Strychnaceae and Vitidaceae. Only 4 genera of trees in the first category have 2 species except 1 genus (*Diospyros*) which has 6 species; the rest are single species for each genus. Two genera of lianas have 2 species (*Cissus* and *Strychnose*) and the other 11 genera have single species. Only 1 genus of trees in the second category has 2 species (*Aglaia*), other genera of both trees and lianas have single species only. In the lowest size-class, 2 genera of trees have 2 species (*Aglaia* and *Memecylon*), other genera of both trees and lianas have single species and also 5 genera of herb each has 1 species only. Maintaining of the floras found only in the second and third categories is believed to respond to the low light intensity and adapt well to grow underneath the shading of large-size floras in the 2 upper size-classes, making up the floristic abundance and high density of this forest.

Table 2. Species composition, status in stand stratification, size-structure type and importance value index (IVI) of trees and lianas ($D \geq 4.5$ cm) in a seasonal rain forest, Sakaerat, northeast Thailand

Species	Status in stand stratification ¹	Family	Size-structure type ²	IVI (%)
Trees				
<i>Acacia pennata</i> Willd.	i	Mimosaceae	-	2.73
<i>Adenantha pavoniana</i> Linn.	i	Mimosaceae	-	1.16
<i>Aglaiia pirifera</i> Hance	i	Meliaceae	L	10.48
<i>Amoora cucullata</i> Roxb.	j	Meliaceae	-	0.23
<i>Anogeissus acuminata</i> Wall.	h	Combretaceae	-	0.34
<i>Antidesma laurifolium</i> Airy Shaw	j	Stilaginaceae	-	0.23
<i>Arfeuillea arborescens</i> Pierre	j	Sapindaceae	-	1.98
<i>Cananga latifolia</i> Finet & Gagnep.	e	Annonaceae	-	0.32
<i>Canarium subulatum</i> Guill.	e	Burseraceae	-	0.39
<i>Canthium dicoccum</i> Merr.	fg	Rubiaceae	L	7.09
<i>Carallia brachiata</i> Merr.	bcd	Rhizophoraceae	-	7.82
<i>Cestrum nocturnum</i> Linn.	j	Solanaceae	-	0.24
<i>Cleidion spiciflorum</i> Merr.	h	Euphorbiaceae	-	0.26
<i>Cleistanthus gracilis</i> Hook. f.	j	Euphorbiaceae	-	1.90
<i>Cleistanthus siamensis</i> Craib	j	Euphorbiaceae	-	0.47
<i>Cratoxylum maingayi</i> Dyer	e	Guttiferae	-	0.25
<i>Dalbergia dongnaiensis</i> Pierre	e	Papilionaceae	-	0.59
<i>Dialium cochinchinense</i> Pierre	cd	Caesalpinaceae	B	2.37

Table 2. (Continued)

Species	Status in stand stratification ¹	Family	Size-structure type ²	IVI (%)
<i>Diosyros areolata</i> King & Gamble	e	Ebenaceae	-	0.27
<i>Diospyros gracilis</i> Fletch.	h	Ebenaceae	-	0.25
<i>Diospyros mollis</i> Griff.	j	Ebenaceae	-	0.25
<i>Diospyros montana</i> Roxb.	j	Ebenaceae	-	0.55
<i>Diospyros oblonga</i> Miq.	j	Ebenaceae	-	0.44
<i>Diospyros rhodocalyx</i> Kurz	h	Ebenaceae	-	0.24
<i>Erythrina subumbrans</i> Merr.	f	Papilionaceae	-	1.03
<i>Eugenia aequa</i> Burm. f.	j	Myrtaceae	-	0.24
<i>Eugenia cumini</i> Douce	fg	Myrtaceae	B	3.88
<i>Excoecaria cochinchinensis</i> Lour.	fg	Euphorbiaceae	-	2.66
<i>Ficus annulata</i> Bl.	a	Moraceae	-	0.31
<i>Garcinia cowa</i> Roxb.	j	Guttiferae	-	0.46
<i>Grewia paniculata</i> Roxb.	i	Tiliaceae	-	0.64
<i>Hopea ferrea</i> Pierre	bcd	Dipterocarpaceae	L	97.16
<i>Hydnocarpus castaneus</i> Hook. f. & Th.	i	Flacourtiaceae	-	1.02
<i>Hydnocarpus ilicifolius</i> King	fg	Flacourtiaceae	L	27.04
<i>Ixora ebarbata</i> Craib	i	Rubiaceae	-	1.62
<i>Lagerstroemia duperreana</i> Pierre	fg	Lythraceae	B	12.18
<i>Linociera microstigma</i> Gagnep.	fg	Oleaceae	L	12.48
<i>Litsea glutinosa</i> C.B. Robinson	bcd	Lauraceae	L	7.11
<i>Memecylon geddesianum</i> Craib	fg	Memecylaceae	L	6.82
<i>Memecylon ovatum</i> J.E. Smith	fg	Memecylaceae	L	51.91

Table 2. (Continued)

Species	Status in stand stratification ¹	Family	Size-structure type ²	IVI (%)
<i>Metadenia trichotoma</i> Bakh. f.	j	Rubiaceae	-	0.68
<i>Nephelium hypoleucum</i> Kurz	j	Sapindaceae	-	0.32
<i>Parkia speciosa</i> Hassk.	j	Mimosaceae	-	0.25
<i>Peltophorum pterocarpum</i> Back. ex Heyne	a	Caesalpinaceae	-	0.72
<i>Planchonella siamensis</i> Fletch.	j	Sapotaceae	-	0.26
<i>Pterospermum acerifolium</i> Willd.	fg	Sterculiaceae	-	2.47
<i>Randia wittii</i> Craib	j	Rubiaceae	-	0.23
<i>Sapium insigne</i> Benth.	j	Euphorbiaceae	-	0.24
<i>Shorea henryana</i> Pierre	e	Dipterocarpaceae	-	0.44
<i>Spondias pinnata</i> Kurz	g	Anacardiaceae	-	1.03
<i>Sterculia guttata</i> Roxb.	h	Sterculiaceae	-	0.24
<i>Suregada multiflorum</i> Baill.	fg	Euphorbiaceae	-	0.79
<i>Terminalia bellerica</i> Roxb.	bc	Combretaceae	B	1.28
<i>Tetrameles nudiflora</i> R. Br.	h	Tetramelaceae	-	0.24
<i>Vitex canescens</i> Kurz	j	Verbenaceae	-	0.24
<i>Walsura trichostemon</i> Miq.	i	Meliaceae	L	22.73
<i>Wrightia tomentosa</i> Roem. & Schult.	i	Apocynaceae	-	0.49
		Total		300.00
Lianas				
<i>Acacia comosa</i> Gagnep.	-	Mimosaceae	-	16.13
<i>Ancistrocladus tectorius</i> Merr.	-	Ancistrocladaceae	-	95.83
<i>Celastrus paniculata</i> Willd.	-	Celastraceae	-	10.99

Table 2. (Continued)

Species	Status in stand stratification ¹	Family	Size-structure type ²	IVI (%)
<i>Cissus repanda</i> Vahl	-	Vitidaceae	-	2.24
<i>Cissus rheifolia</i> Planch.	-	Vitidaceae	-	3.87
<i>Ficus pubilimba</i> Merr.	-	Moraceae	-	5.18
<i>Gnetum latifolium</i> Bl. var. <i>funiculare</i> Markgr.	-	Gnetaceae	-	18.81
<i>Hoya pachyclada</i> Kerr	-	Asclepiadaceae	-	3.46
<i>Hymenopyramis brachiata</i> Wall.	-	Verbenaceae	-	26.37
<i>Myriopteron extensum</i> Schum.	-	Periplocaceae	-	11.39
<i>Strychnos kerrii</i> A.W. Hill	-	Strychnaceae	-	28.91
<i>Strychnos thorelii</i> Pierre	-	Strychnaceae	-	2.73
<i>Tournefortia intonsa</i> Kerr	-	Boraginaceae	-	27.30
<i>Ventilago harmandiana</i> Pierre	-	Rhamnaceae	-	30.69
<i>Willughbeia cochinchinensis</i> Pierre	-	Apocynaceae	-	16.22
		Total		300.00

¹ Species presence in the successive stratum are a=I; b=I, II; c=I, III_a; d=I, III_b; e=II; f=II, III_a; g=II, III_b; h=III_a; i=III_a, III_b; j=III_b. Stratum classification follows Figure 1 (excl. lianas).

² Size-structure types are: L=L-shaped distribution, B=B-shaped distribution, -=undetected distribution pattern.

Table 3. Species composition, its presence/absence in the preceding size-class and IVI of trees and lianas ($D \leq 4.5$ cm, $H \geq 1.30$ m) in a seasonal rain forest, Sakaerat, northeast Thailand

Species	Presence/absence in preceding size-class ¹	Family	IVI (%)
Trees			
<i>Aglaia pirifera</i> Hance	p	Meliaceae	23.22
<i>Aglaia</i> sp.	a	Meliaceae	7.98
<i>Antidesma laurifolium</i> Airy Shaw	p	Stilaginaceae	8.00
<i>Calophyllum dryobalanoides</i> Pierre	a	Guttiferae	16.05
<i>Capparis siamensis</i> Kurz	a	Capparidaceae	9.68
<i>Carallia brachiata</i> Merr.	p	Rhizophoraceae	49.44
<i>Cleistanthus gracilis</i> Hook. f.	p	Euphorbiaceae	21.99
<i>Excoecaria cochinchinensis</i> Lour.	p	Euphorbiaceae	27.98
<i>Hopea ferrea</i> Pierre	p	Dipterocarpaceae	65.20
<i>Linociera microstigma</i> Gagnep.	p	Oleaceae	15.39
<i>Memecylon ovatum</i> J.E. Smith	p	Memecylaceae	23.32
<i>Metadenia trichotoma</i> Bakh. f.	p	Rubiaceae	31.74
		Total	300.00
Lianas			
<i>Acacia comosa</i> Gagnep.	p	Mimosaceae	20.77
<i>Ancistrocladus tectorius</i> Merr.	p	Ancistrocladaceae	84.61
<i>Gnetum latifolium</i> Bl. var. <i>funiculare</i> Markgr.	p	Gnetaceae	15.44
<i>Myriopteron extensum</i> Schum.	p	Periplocaceae	31.56
<i>Randia siamensis</i> Craib	p	Rubiaceae	83.43
<i>Strychnos kerrii</i> A.W. Hill	p	Strychnaceae	31.31
<i>Ventilago harmandiana</i> Pierre	p	Rhamnaceae	32.88
		Total	300.00

¹ p = presence, a = absence

Table 4. Species composition, its presence/absence in the two preceding size-classes and IVI of trees, lianas ($D \leq 4.5$ cm, $H \leq 1.30$ cm) and herbs in the same stand of a seasonal rain forest, Sakaerat, northeast Thailand

Species	Presence/absence in preceding size-class ¹	Family	IVI (%)
Trees			
<i>Aglaia pirifera</i> Hance	p	Meliaceae	4.45
<i>Aglaia</i> sp.	p**	Meliaceae	11.13
<i>Antiaria toxicaria</i> Lesch.	a	Moraceae	2.22
<i>Antidesma laurifolium</i> Airy Shaw	p	Stilaginaceae	2.22
<i>Calophyllum dryobalanoides</i> Pierre	p**	Guttiferae	6.98
<i>Carallia brachiata</i> Merr.	p	Rhizophoraceae	2.22
<i>Casearia grewiaefolia</i> Vent.	a	Flacourtiaceae	2.22
<i>Cleistanthus gracilis</i> Hook. f.	p	Euphorbiaceae	2.22
<i>Colona auriculata</i> Craib	a	Tiliaceae	4.76
<i>Dialium cochinchinense</i> Pierre	p*	Caesalpiniaceae	2.22
<i>Excoecaria cochinchinensis</i> Lour.	p	Euphorbiaceae	6.98
<i>Hopea ferrea</i> Pierre	p	Dipterocarpaceae	94.84
<i>Hydnocarpus ilicifolius</i> King	p*	Flacourtiaceae	2.83
<i>Ixora ebarbata</i> Craib	p*	Rubiaceae	4.45
<i>Knema furfuracea</i> Warb.	a	Myristicaceae	2.52
<i>Lepisanthes rubiginosa</i> Leenh.	a	Sapindaceae	2.22
<i>Meladorum fruticosum</i> Lour.	a	Annonaceae	2.22
<i>Memecylon geddesianum</i> Craib	p*	Memecylaceae	21.01
<i>Memecylon ovatum</i> J. E. Smith	p	Memecylaceae	2.22
<i>Metadenia trichotoma</i> Bakh. f.	p	Rubiaceae	17.80
<i>Walsura trichostemon</i> Miq.	p*	Meliaceae	2.22
		Total	200.00

Table 4. (Continued)

Species	Presence/absence in preceding size-class ¹	Family	IVI (%)
Lianas			
<i>Acacia comosa</i> Gagnep.	p	Mimosaceae	35.00
<i>Cissus repanda</i> Vahl	p*	Vitidaceae	12.36
<i>Congea tomentosa</i> Roxb.	a	Symphoremataceae	6.80
<i>Dioscorea pierrei</i> Prain & Burk.	a	Dioscoreaceae	9.58
<i>Entada glandulosa</i> Pierre ex Gagnep.	a	Mimosaceae	9.58
<i>Jasminum anodontum</i> Gagnep.	a	Oleaceae	6.80
<i>Myriopteron extensum</i> Schum.	p	Periplocaceae	35.00
<i>Oxystelma esculentum</i> R. Br.	a	Asclepiadaceae	9.58
<i>Randia siamensis</i> Craib	p**	Rubiaceae	6.81
<i>Strychnos kerrii</i> A.W. Hill	p	Strychnaceae	19.91
<i>Tournefortia intonsa</i> Kerr	p	Boraginaceae	24.66
<i>Toxocarpus villosus</i> Decne.	a	Asclepiadaceae	6.80
<i>Ventilago harmandiana</i> Pierre	p	Rhamnaceae	17.13
		Total	200.00
Herbs			
<i>Fimbristylis dipsacea</i> Clarke	u	Cyperaceae	83.75
<i>Knoxia brachycarpa</i> R. Br.	u	Rubiaceae	16.50
<i>Rhaphidophora peepla</i> Schott	u	Araceae	71.25
<i>Vernonia elliptica</i> DC.	u	Compositae	18.25
<i>Zingiber zerumbet</i> Smith	u	Zingiberaceae	10.25
		Total	200.00

¹ p = presence in preceding 2 size-classes

* presence in the first but not in the second size-class

** presence in the second size-class but not in the first size-class

a = absence in preceding size-classes, u = undergrowth

Species-area relationships

Species-area curve of trees and lianas of the first size-class category is shown in Figure 4. The curve represents a positive power function model: $S = kA^z$, where S is cumulative number of species of trees and lianas and A is area of the sample plot (m^2) determined in an increasing area of the square plot of 10×10 , 20×20 m up to 100×100 m and k and z are constants specific to the stand study. The good fit of the model with $r^2 = 0.9864$ confirms the increase of the number of species in this seasonal rain forest following the enlargement of the area in a geometric progression manner and is in consistence with that postulated by Kilburn³⁸.

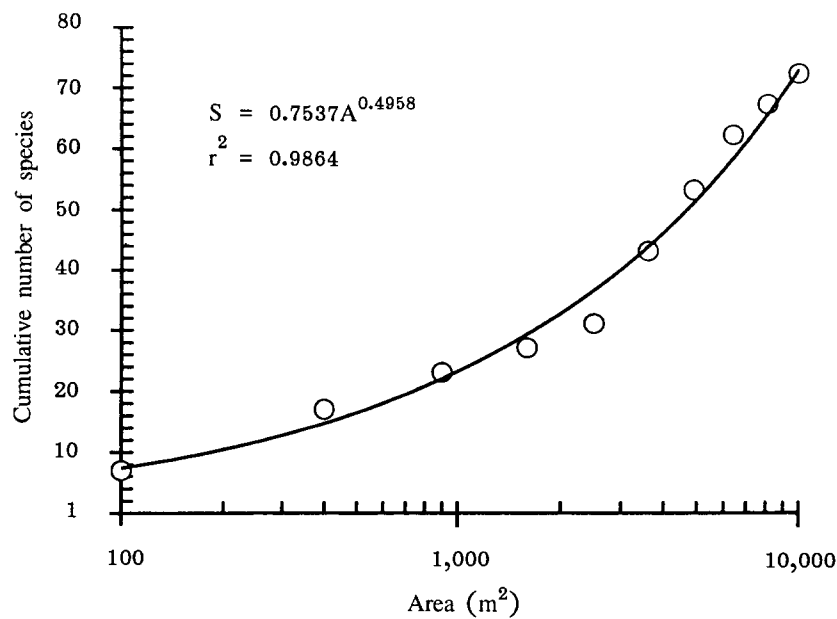


Fig. 4. Species-area relations of trees and lianas ($D \geq 4.5$ cm) fitted to a positive power function model: $S = kA^z$

where S = cumulative number of species in the corresponding quadrat size

A = quadrat area (m^2)

k and z = constants

Note that quadrat area is plotted on a logarithmic scale.

Previous study on a comparison among 4 stands of dry dipterocarp forest and 1 stand of dry evergreen forest in the same site at Sakaerat³⁹ found that species–area relationships of dry dipterocarp forest could be well fitted by both power and exponential function models. On the other hand, for the seasonal rain forest in this study, it is likely that power function model is better fit to the observed data than does the exponential function model.

Species–area curve of trees and lianas of this forest seems to flatten out at an area of 6,400 m² onward although the first steep slope rises up from the quadrat size of 100 to 2,500 m² and again rises up gradually in the quadrat size thereafter with a moderate slope. This phenomenon may mislead to cause the sampling error for the number of species count if the plot area is just only limited to lower than 2,500 m² and then extrapolate to the larger plot size. Species number will be considerably underestimated in this forest type. The plot size beyond 3,600 m² to 1 ha seems to be reasonable for detecting the number of species of trees and lianas of this size–class ($D \geq 4.5$ cm) in the present study forest stand. This is partly due to the distribution of some tree species, especially the lianas are always in clumped pattern, not evenly or randomly distributed as in most cases found in some forest types of Thailand^{10, 12} and in some temperate forests such as those reported elsewhere⁴⁰. However, studies on species–area curves of the tropical rain forest stands on BCI and in New Guinea suggested that there were some plateauing of the curves after the area of the sample plots reaching about 1.5 ha^{29, 41}. For tree species with $D \geq 10$ cm in tropical rain forest in Gunung Silam, Sabah, Malaysia⁴², Gunung National Park, Sarawak⁴³, lowland rain forest on Maraca Island, Brazil⁴⁴, a tropical rain forest along the altitude of Volcan Barva, Costa Rica⁴⁵ and a montane rain forest, Jamaica⁴⁶, the similar relationship curves suggested that plateauing of the number of species is generally found in area of plots ranging from 1,000 m² to 1 ha. Thus, it means that the number of species may be found at the maximum level variably depending on types and locations of the evergreen forests and no specific area size can be generalized as a standard for detecting the number of species of each forest.

Importance value indices and association type

Floristically, this forest type represents considerable richness in species of trees and lianas in all 3 size-class categories but few herbs. The importance value indices of the first category of plants (Table 2) suggest that this forest is a *Hopea ferrea*-*Memecylon ovatum* association type showing the 2 highest values belonging to the *Hopea ferrea* subcommunity type, particularly in this area as suggested by Bunyavejchewin³² although the similar forest type, particularly in the Namphrom area²³, these tree species are not as dominant as other species, i.e. *Quercus* sp., *Pterospermum semisagittatum* and *Croton oblongifolius*. *Hopea ferrea* is ranked fourth among these 3 leading dominant species in the Namphrom area²³. The dominance of *Hopea ferrea* may be partly due to the topographic condition of the site at Sakaerat where it is on a lower slope, gentle terrain and lower altitude as compared to the Namphrom area where it is located on a quite high altitude and along the flat slope of depression near the small stream which is likely to promote the abundance of a single tree species in Sakaerat seasonal rain forest to be more notable than in the Namphrom site. Bunyavejchewin³² reported that *Hopea ferrea* preferred to grow well on soil rich in organic matter, high percentage of silt + clay and low pH as compared to other leading dominant species in Sakaerat tropical semi-evergreen forest. The abundance of *Hopea ferrea* in all 3 size-class categories (Tables 2-4) suggests that this forest is a monodominant forest community in which its own young saplings and seedlings are also well grown and tolerable to shading by the top canopy species and densely fill up the canopy gap of this forest. This finding supports the assumption postulated by Kanzaki and his co-workers³ that the maintenance of the monodominance of this forest is due to the high shade tolerance of *Hopea ferrea* saplings and seedlings.

The most significant feature of the Sakaerat seasonal rain forest is the abundance of woody lianas showing a considerably large number of species and moderate number of individuals having top 3 IVI by *Ancistrocladus tectorius*, *Ventilago harmandiana* and *Strychnos kerrii* in the first size-class category (Table 2) although the small-sized lianas of the same species in the second and third size-class

categories are not frequently found (Tables 3 and 4) but IVI of *Ventilago harmandiana* and *Strychnos kerrii* are high and rank among the top 5 liana species, being abundant next to *Myriopteron extensum*, *Acacia comosa* and *Tournefortia intonsa*. Species composition of lianas in this forest is somewhat similar to that found in the Namphrom dry evergreen forest²³ and in an ecotone between the mixed deciduous and dry evergreen forests²⁴, especially *Ventilago harmandiana* is the most abundant liana species in these 2 forest types. However, the liana species found in this seasonal rain forest are different from that found in the monsoon forest in the northern region and in a wetter site in the tropical rain forest in southern Thailand¹⁹ and less abundant than those in a primary dipterocarp forest in Lambir National Park, Sarawak⁴⁷, in a lowland tropical rain forest, Gunung Mulu National Park, Sarawak⁴³ and in a neotropical forest, Barro Colorado Island, Panama⁴⁸. There are only 2 genera of lianas, *Strychnos* and *Ventilago*, similarly found in Sakaerat seasonal rain forest and in a dry evergreen forest in southern India²⁵, and 2 genera, *Strychnos* and *Gnetum*, are the same as in a tropical rain forest in Sarawak⁴⁷. However, the presence of lianas in this forest stand contributes a remarkable feature to the forest structure as their basal area cover is as large as about 1 m² ha⁻¹ in both size-class categories combined together (Table 1). It is expected that the abundance of lianas may also contribute more or less to the species diversity of this species-rich forest.

CONCLUSION

Sakaerat seasonal rain forest is relatively rich in species composition being dominated by *Hopea ferrea* and the stand is well recognized as a *Hopea ferrea*-*Memecylon ovatum* association type. Lianas of *Ancistrocladus tectorius* and *Ventilago harmandiana* are remarkably abundant. The stand is considered to be a monodominant plant community type as *Hopea ferrea* is the most abundant species having highest IVI in all 3 size-class categories. The vertical structuring of this

forest mainly consists of 3 strata by which the lowest stratum is likely to be divided further into 2 substrata of plants almost being fully overtopped and those mostly shaded by neighboring plants of about 90 %.

Stand density of this forest is fairly high as compared to other deciduous and evergreen forest types in Thailand but lower than those found for the hill evergreen or temperate evergreen forest and being within the range of several forest types in other tropical regions. As the density of the canopy and subcanopy plants are quite high, the forest is considered a close forest having low species abundance but high density of shade tolerant of regenerating trees and undergrowth.

Tree-size structure as determined by D distribution is well fitted to the negative power function model suggesting a characteristic of uneven-aged stand and fairly high mortality may be likely to occur in most small-sized plants. Height distribution of trees is approximately a bell-shaped curve as the stand includes trees of small size lower than 10 m high in the analysis and if only trees of above this height class are incorporated, this height distribution pattern may suggest a negative exponential decreasing trend.

Plant composition at the family, generic and species levels demonstrates that this forest type is remarkably rich in this taxonomic classification and notably resembles dry evergreen forest type located in similar latitude, climatic and soil conditions in other geographical regions of the tropical zone of Asian.

Species-area relationships of the stand are well explained by a positive power function model in which the total number of species is likely to flatten out at an area of 6,400 m². It is suggested that plot size study should be as large as 3,600 m² to 1 ha for a reliable detecting of the total number of woody plant species including lianas of the specific size ($D \geq 4.5$ cm) of this species-rich forest type.

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