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THE VEGETATION OF DOl KHUNTAN NATIONAL PARK, LAMPHUN-LAMPANG PROVINCES, THAILAND

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ABSTRACT

Doi Khuntan National Park was established in 1975 to protect 255 km^2 of forested hills in the Provinces of Lampang and Lamphun. Very little scientific research has been carried out in the park since its establishment. There has been no systematic survey of the vegetation and although a statement of management has been prepared, it is lacking information about the flora. Hence the methods required to restore natural forest ecosystems to deforested areas (which cover a large part of the park) are unknown. Another problem is commercial collection of plants, especially orchids and ferns, in large numbers. Such activity probably threatens the survival of many species, but with no information available on the status of each species, management options cannot be formulated.

The vascular flora of Doi Khuntan National Park was therefore extensively surveyed from May 1993 until the end of June 1995. Specimens of all species seen were collected and placed in the herbarium of the Biology Department, Chiang Mai University. In addition, taxonomic and ecological data about every species were entered into a computer database for analysis.

The lower areas of the national park, formerly deciduous (mostly teak) forest, have been cleared and cultivated or severely degraded for nearly a century. Deciduous secondary growth in the form of deciduous dipterocarp-oak vegetation is common. Very degraded original growth now has much bamboo. A mixed evergreen + deciduous facies is found from 850–1,000 m above sea level. Above this the forest is evergreen hardwood + pine, the latter far less common as a result of human disturbance. Fire is common throughout the park. The climate is seasonal with a dry period from November to April. At least 165 families and 1,285 species of vascular plants are found there. Four new records for the flora of Thailand were found.

INTRODUCTION

Doi (= mount) Khuntan National Park was established in March 1975, the 14th national park designated in Thailand. It is situated at approximately 18° 40' north latitude, 99° 20' east longitude, and administratively is included in three districts: Mae Tah District, Lamphun Province (NW section of the park), Muang District, Lampang Province (eastern part) and Hang Chat District, Lampang Province (southern part of the park). Almost all of the access roads and tourist facilities, including the park headquarters and park development, are on the NW side. The area of the park is 255 km^2 (0.05% of the total land area of Thailand). The lowest elevation is 325 m and the highest point at the summit of Doi Khuntan is 1363 m[1].

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[1]This is the official height, however the actual elevation is c. 1380 m.

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It was therefore decided to carry out a survey of the flora and vegetation of the park to provide baseline data to improve the management of the park. The project was started in May 1993 and most of the collecting was completed by the end of 1995.

GEOLOGY

The bedrock of the lowland areas, c. 325–800 m elevation, consists of shale (especially the NW part of the park) and talc (east side of the park) of the Kanchanaburi Formation, Tanaosi Group of the Silurian-Devonian geological periods. Shale, a sedimentary rock and originally a fine clay, was deposited in an ancient deep sea, while talc is a soft metamorphic rock of igneous origin. It is locally mined as a raw material for the ceramics industry. These two rocks are estimated to be 350–400 million years old. There is an area on the east side of Doi Tah Goo which has an outcrop of quartzite on top of shale at c. 650 m elevation. All other areas of the national park are composed of granite of the Triassic geological period, originally created by volcanic activity about 200 million years ago (JAVANAPHET, 1969).

Shale on the NW side of the park, that is Tah Goo Station area, extends up to c. 850 m, while in other areas of the park it is found below c. 400 m. Granite, therefore, is found above 400 m elevation on the west side of the park and above c. 550 m elevation on the east side. It is by far the most common and abundant rock in the national park.

HUMAN OCCUPATION

Khuntan Village on the west side of the park is situated on the Bangkok–Chiang Mai railway line where a 1.3 km long tunnel is located. This tunnel, completed in 1918, was cut through solid granite bedrock and during its construction, which started in 1907, the area was exploited by thousands of workers for food, fuel and construction materials. The State Railways of Thailand maintains a small resort facility at 900 m on the west side of the park (Yaw 1) where the oldest and still well-maintained bungalow was built in 1917.

As an inevitable and unfortunate consequence of this railway connection, which provided convenient access to the mountain, almost all of the lowland vegetation up to c. 700 m elevation has been severely and repeatedly degraded by logging and fire, while the middle elevations of 700–1,000 m have experienced slightly less damage. It was not until a few years ago, after the national park was established, that a 18 km long road from Mae Tah (town), passing Khuntan Station, to the national park headquarters was finally completed.

The establishment of many villages around other parts of the park has ensured that all of the lowland and foothill areas of the park are maintained as fields or deciduous scrub vegetation and subjected to annual fires.

CLIMATE

Two sets of meteorological records are available which can be used to indicate approximate rainfall and temperature in the national park. The first set is from the Lamphun Meteorological Station at 296 m above sea level and is about 32 km NW of the center of the national park (Fig. 1). The other information is from the Lampang Meteorological Station at 241 m above sea level and about 30 km to the SE (Fig. 2). These data clearly show that the climate is monsoonal with a distinct and often severe dry season from November to April, during which the lowest (November–January) and highest (March–May) temperatures occur. The rainy season is from May–October. Annual rainfall averages 1004 and 1064 mm at Lamphun and Lampang, respectively.

While the average temperatures will decrease about 0.6°C per 100 m increase in elevation, the actual temperatures on the mountain, especially in areas above 1,000 m, will be considerably less. We have been at the camp at Yaw 3 (1,250 m) during January–February where the temperature at night drops as low as 8°C. The rainfall in the national park, especially in upland areas, is considerably greater than that recorded at the two lowland weather stations.

VEGETATION TYPES

Lowland Vegetation

The boundaries of the park closely follow and encompass most of the mountainous area of the region which is isolated, except on the NE side where it is contiguous with Jae Sawn National Park. All of the original forest cover, except on the NE side, of the lowlands was destroyed decades ago and is now agricultural land. Flat and gently sloping areas from 350-c. 500 m elevation are now used for paddy rice, corn, and other crops as well as fruit tree orchards, e.g. *Dimocarpus longan* Lour. ssp. *longan* var. *longan, Litchi chinensis* Sonn. (both Sapindaceae), and *Mangifera indica* L. (Anacardiaceae), as well as a few *Tectona grandis* L.f. (Verbenaceae, teak) plantations.

Isolated patches of deciduous secondary growth are frequently encountered with trees such as *Casearia grewiifolia* Vent. var. *grewiifolia* (Flacourtiaceae), *Fernandoa adenophylla* (Wall. ex G. Don) Steen. (Bignoniaceae), *Ficus hispida* L.f. var. *hispida* and *Broussonetia papyrifera* (L.) Vent. (both Moraceae). Lowland herbaceous weeds are common and rampant. Common Gramineae (grasses) are *Chloris barbata* Sw., *Digitaria setigera* Roth ex Roem. & Schult. var. *setigera, Eleusine Indica* (L.) Gaertn., *Imperata cylindrica* (L.) P. Beauv. var. *major* (Nees) C.E. Hubb. ex Hubb. & Vaugh., *Paspalum conjugatum* Berg., *Pennisetum pedicellatum* Trin., *Rhynchelytrum repens* (Willd.) C.E. Hubb., *Setaria parviflora* (Poir.) Kerg., *Sporobolus indicus* (L.) R. Br. var. *flaccidus* (Roem. & Schult.)

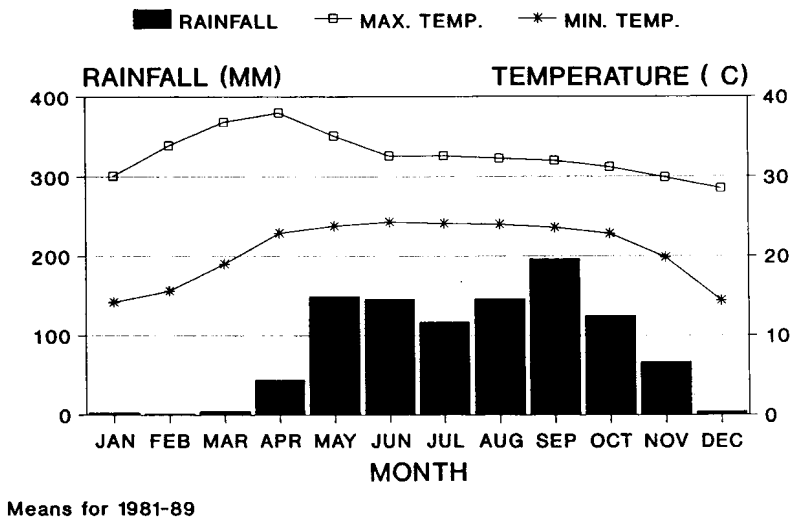

Figure 1. Meteorological data from Lamphun, 296 m elevation.

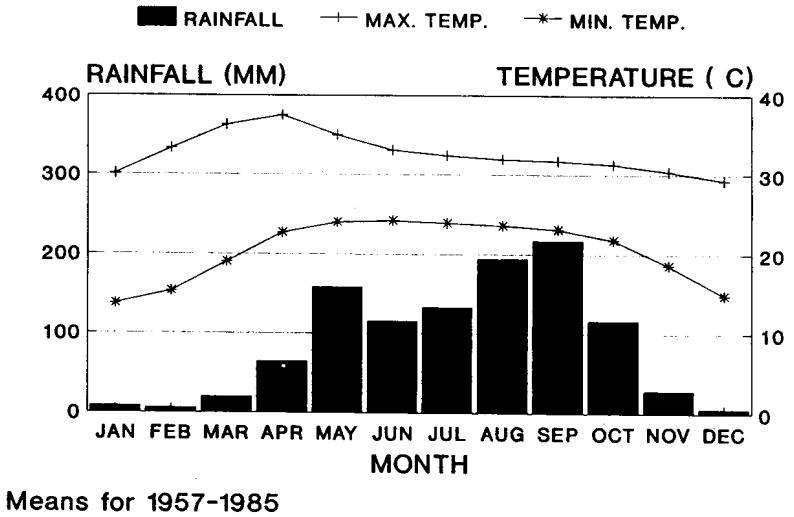

Figure 2. Meteorological data from Lampang, 241 m elevation.

Veldk., and others. Cyperaceae (sedges) are as common as Gramineae with numerous species of *Cyperus,* e.g. *C. compactus* Retz., *C. diffusus* Vahl var. *diffusus, C. distans* L. f., *C. iria* L., *C. nutans* Vahl var. *nutans,* etc. *Fimbristylis* includes several abundant and weedy species, e.g. *F. adenolepis* Kern, *F. dichotoma* (L.) Vahl ssp. *dichotoma,* and *F. littoralis* Gaud. var. *littoralis.*

Dicot weeds are also common and include, for example, *Mollugo pentaphylla* L. (Aizoaceae), *Amaranthus gracilis* Desf. (Amaranthaceae); *Ageratum conyzoides* L., *Conyza sumatrensis* (Retz.) Walk., *Crassocephalum crepidioides* (Bth.) S. Moore, *Eupatorium odoratum* L., *Synedrella nodiflora* (L.) Gaertn., and *Tridax procumbens* L. (all Compositae). *Ipomoea pestigridis* L. and *Merremia vitifolia* (Burm. f.) Hall. f. (both Convolvulaceae); *Euphorbia heterophylla* L., *E. hirta* L., *Phyllanthus amarus* Schumach. & Thonn., *P. urinaria* L. (all Euphorbiaceae); *Hyptis suaveolens* (L.) Poit. (Labiatae); *Mimosa diplotricha* C. Wright ex Suav. var. *diplotricha* and *M. pudica* L. var. *hispida* Bren. (Leguminosae, Mimosoideae); *Crotalaria pallida* Ait., *Desmodium heterocarpon* (L.) DC., and *Zornia gibbosa* Span. (Leguminosae, Papilionoideae); *Sida rhombifolia* L. ssp. *rhombifolia* and *Urena lobata* L. ssp. *lobata* var. *lobata* (both Malvaceae); *Passiflora foetida* L. (Passifloraceae); *Hedyotis corymbosa* (L.) Lmk., *H. diffusa* Willd., and *Mitracarpus villosus* (Sw.) DC. (all Rubiaceae); *Lindernia antipoda* (L.) Alst., *L. crustacea, Scoparia dulcis* L. (all Scrophulariaceae), *Triumfetta rhomboidea* Jacq. (Tiliaceae) and many other species are common.

Deciduous Forest with Bamboo

The original lowland forest, at about 325 to 850 m elevation, was a facies dominated by *Tectona grandis* L. f. (Verbenaceae, teak) which must have been similar to that of the last remaining teak forest in Thailand at Mae Yom National Park, Phrae Province, about 100 km to the N.E. (MAHIDOL UNIVERSITY, 1992). This kind of deciduous forest also includes many other species of commercially valuable hardwood trees, such as *Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) Niels. (Leguminosae, Mimosoideae), *Lagerstroemia cochinchinensis* Gagnep. var. *ovalifolia* Furt. & Mont. (Lythraceae), *Bombax ceiba* L. (Bombacaceae), *Terminalia alata* Roxb. and *Terminalia mucronata* Craib & Hutch., (Combretaceae), *Garuga floribunda* Decne. (Burseraceae), *Cratoxylum formosum* (Jack) Dyer ssp. *pruniflorum* (Kurz) Gog. (Hypericaceae), *Pterocarpus macrocarpus* Kurz (Leguminosae, Papilionoideae), and *Vitex canescens* Kurz (Verbenaceae). *Duabanga grandiflora* (Roxb. ex DC.) Walp. (Sonneratiaceae) and *Irvingia malayana* Oliv. ex Benn. (Irvingiaceae) are tall evergreen species which are also found in this habitat.

Deciduous trees below the canopy are numerous and include *Schleichera trijuga* Willd. (Sapindaceae), *Spondias pinnata* (L. f.) Kurz (Anacardiaceae), *Millettia brandisiana* Kurz and *Dalbergia fusca* Pierre (both Leguminosae, Papilionoideae), *Vitex limoniifolia* Wall. ex Kurz (Verbenaceae), *Schrebera swietenioides* Roxb. (Oleaceae); *Sterculia ornata* Roxb., *Sterculia stigmarota* Pierre, *Melochia umbellata* (Houtt.) Stapf (Fig. 3) and *Firmiana colorata* Roxb. (all Sterculiaceae) and others. *Strychnos nux-vomica* L. (Loganiaceae, Fig. 4), *Antidesma acidum* Retz. (Euphorbiaceae), and *Bauhinia viridescens* Desv. var. *viridescens* (Leguminosae, Caesalpinioideae) are some examples of deciduous treelet and

trees of the lowest stature in this type of forest.

The ground flora is mostly perennial and deciduous. Thus during the dry season (November–April) the ground as well as the trees are barren. The first herbs to flower are some Zingiberaceae (gingers) e.g. *Kaempferia rotunda* L., *Gagnepainia godefroyi* (Baill.) K. Sch., *Curcuma ecomata* Craib and *C. zedoaria* (Berg.) Rosc., and *Globba nuda* K. Lar., all of which flower during March–May before their leaves appear. With the advent of the rainy season in May, a succession of species begin to flower after their leaves have developed. Some of the early ones are in the Orchidaceae (orchids), e.g. *Peristylus constrictus* (Lindl.) Lindl. and *Eulophia nuda* Lindl. (which flowers before the leaves appear, Fig. 5); Zingiberaceae, e.g. *Globba reflexa* Craib and *G. xantholeuca* Craib, *Hapaline benthamiana* Schott (Araceae, which flowers and fruits before its leaves mature), and others. By about July many other herbs have matured, including many fern allies e.g. *Selaginella ostenfeldii* Hier. (Selaginellaceae), and ferns such as *Aniscocampium cumingianum* Presl and *Kuniwatsakia cuspidata* (Bedd.) Pichi-Ser. (both Athyriaceae), *Dryopteris cochleata* (D. Don) C. Chr. (Dryopteridaceae) and *Nephrolepis delicatula* (Dcne.) Pichi-Ser. (Oleandraceae, which grows on rocks), and *Tectaria immersa* (Fee) Holtt. (Dryopteridaceae) are examples of ferns which become fertile during the latter part of the rainy season.

Some other herbs that typify the deciduous forest are *Oryza meyeriana* (Zoll. & Mor.) Baill. var. *granulata* (Watt) Duist. (Gramineae, wild forest rice), *Barleria strigosa* Willd. (Acanthaceae), and *Hedyotis tenelliflora* Bl. var. *kerrii* (Craib) Fuku. (Rubiaceae).

Disturbed areas in the deciduous forest are often succeeded by several species of bamboos (Gramineae, Bambuseae), the most common being *Bambusa tulda* Roxb., *Dendrocalamus membranaceus* Munro, and *Dendrocalamus nudus* Pilg. Deciduous perennial vines, e.g. *Ampelocissus martini* Pl. and *Cissus hastata* Miq. (both Vitaceae), *Stephania glabra* (Roxb.) Miers (Menispermaceae), *Dioscorea alata* L. (Dioscoreaceae) and *Stemona burkillii* Prain (Stemonaceae) are common. Large deciduous woody climbers (lianas) are also found and include *Tetrastigma obovatum* (Laws.) Gagnep. (Vitaceae), *Entada rheedii* Spreng. (Leguminosae, Mimosoideae), and *Congea tomentosa* Roxb. var. *tomentosa* (Verbenaceae).

Deciduous Dipterocarp–Oak Forest

As a consequence of severe destruction of the deciduous forest, including many places in the national park which were clear–cut, a climax or persistent kind of secondary growth has developed. These disturbed places have lost much of their soil and as a consequence an open, often scrubby, relatively short kind of forest with many Dipterocarpaceae and Fagaceae has developed. The species in this deciduous dipterocarp–oak forest, especially the trees, differ from those found in the deciduous forest which has been replaced. The Dipterocarpaceae dominate this habitat in Doi Khuntan National Park and include *Dipterocarpus obtusifolius* Teijsm. ex Miq. var. *obtusifolius, D. tuberculatus* Roxb. var. *tuberculatus, Shorea siamensis* Miq. var. *siamensis,* and *S. obtusa* Wall. ex Bl. *Quercus kerrii* Craib var. *kerrii* (Fagaceae, an oak) is also found, but is uncommon, among these other trees. It is our opinion that it takes much longer (centuries!) for oaks to develop in these devastated areas than the Dipterocarpaceae. This situation is seen vividly in nearby

Figure 3. *Melochia umbellata* (Houtt.) Stapf (Sterculiaceae). This is a deciduous understorey tree found in mixed bamboo + deciduous forest and is often found in disturbed places. It is found at elevations of 900–1,250 m and flowers in November and December. Photo: V. Anusarnsunthorn, 19 November 1993, 925 m.

Figure 4. *Strychnos nux-vomica* L. (Loganiaceae), a common deciduous treelet or small tree, is found mostly in deciduous dipterocarp–oak forest. It flowers while producing new leaves in March–April and produces ripe fruits from May–August. The seeds contain strychnine, a very poisonous alkaloid. Photo: S. Elliott 3 July 1993, 900 m.

Figure 5. *Eulophia nuda* Lindl. (Orchidaceae) is a deciduous, perennial ground orchid, found in deciduous dipterocarp–oak forest at elevations of 400–900 m where it flowers from April to June. Photo: V. Anusarnsunthorn, 3 June 1993, 850 m.

Figure 6. *Diospyros ehretioides* Wall. ex G. Don (Ebenaceae). This is a presently uncommon deciduous tree in deciduous dipterocarp–oak forest which flowers at the beginning of the hot-dry season (March–April), fruits from July to November and is leafless during February–May. Because of its hard and valuable wood, few large individuals of this species remain in the national park. Photo: V. Anusarnsunthorn, 19 November 1993, 925 m.

Doi Suthep-Pui National Park in which the original deciduous lowland forest was devastated centuries ago and has had a sufficient amount of time to redevelop into an old deciduous dipterocarp-oak facies with plenty of oaks (MAXWELL, 1988). Other deciduous tree species found in this habitat include *Garcinia cowa* Roxb. (Guttiferae), *Buchanania glabra* Wall. ex Hk. f., *B. latifolia* Roxb. (Anacardiaceae), *Eugenia cumini* (L.) Druce (Myrtaceae), *Gardenia erythroclada* Kurz (Rubiaceae), *Dalbergia dongnaiensis* Pierre (Leguminosae, Papilionoideae), *Diospyros ehretioides* Wall. ex G. Don (Ebenaceae) (Fig. 6) and others.

Aganosma marginata (Roxb.) G. Don (Apocynaceae) and *Spatholobus parviflorus* (Roxb.) O.K. (Leguminosae, Papilionoideae) are two common woody climbers, however there is a general lack of vines and woody climbers in this habitat. Smaller deciduous woody species such as *Tristaniopsis burmanica* (Griff.) Wils. & Wat. var. *rufescens* (Hance) J. Parn. & Lug. (Myrtaceae), *Craibiodendron stellatum* (Pierre) W.W. Sm. (Ericaceae), *Catunaregam tomentosa* (Bl. ex. DC.) Tirv. (Rubiaceae), *Ochna integerrima* (Lour.) Merr. (Ochnaceae, Fig. 7), and *Antidesma ghaesembilla* Gaertn. (Euphorbiaceae) as well as the dwarfed *Pavetta fruticosa* Craib (Rubiaceae), *Premna nana* Coll. & Hemsl. (Verbenaceae), and *Phoenix humilis* Roy. var. *humilis* (Palmae) are common.

The deciduous perennial herbaceous ground flora is diverse and in many instances similar to that found in the deciduous forest, especially in areas which grade between these two habitats. Some herbs typical to deciduous dipterocarp-oak areas are *Blumeopsis flava* (DC.) Gagnep. (Compositae), *Euphorbia capillaris* Gagnep. (Euphorbiaceae), *Barleria cristata* L. and *Andrographis laxiflora* (Bl.) Lindau (both Acanthaceae) and *Smilax verticalis* Gagnep. (Smilacaceae). Gramineae (grasses) and Cyperaceae (sedges) are very common and are a serious fire hazard during the dry season. *Arundinella setosa* Trin. var *setosa, Capillipedium parviflorum* (R. Br.) Stapf, *Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult. and *H. triticeus* (R. Br.) Stapf, *Hyparrhenia rufa* (Nees) Stapf var. *siamensis* Clay. and *Sehima nervosum* (Rottl.) Stapf are some of the more common and combustible grasses. *Carex indica* L. var. *microcarpa* T. Koy., *C. speciosa* Kunth, *Rhynchospora rubra* (Lour.) Mak., *Scleria kerrii* Turr., *S. levis* Retz., and *S. lithosperma* (L.) Sw. var. *lithosperma* are among the most common Cyperaceae. Some ground ferns are *Adiantum zollingeri* Mett. ex Kuhn and *Cheilanthes pseudofarinosa* (Ching & S.K. Wu) K. Iw. (both Parkeriaceae). The deciduous dipterocarp-oak forest often has many epiphytic flowering plants, e.g. *Hoya kerrii* Craib (Aslcepiadaceae) and others in Orchidaceae genera *Bulbophyllum, Cymbidium,* and *Eria.* Most of the showy species have been removed from the forest, sold, and mostly died since forest species usually are unable to survive in urban conditions into which most of them have been transplanted.

Pinus merkusii Jungh. & De Vriese (Pinaceae) is found scattered in the upper range of the deciduous dipterocarp-oak forest from c. 800–900 m. Its scarcity in the national park can mainly be attributed to human predation and loss of undisturbed habitat.

Mixed Evergreen + Deciduous Forest

At about 850–1,000 m elevation there is a vegetational change where the lowland deciduous forest and upland evergreen-pine forests mix. There is no specific point or precise elevation where this merging occurs since topography and especially disturbance

are involved.

Large deciduous trees in this habitat are: *Terminalia mucronata* Craib & Hutch. (Combretaceae), *Spondias pinnata* (L. f.) Kurz (Anacardiaceae), *Lagerstroemia cochinchinensis* Gagnep. var. *ovalifolia* Frut. & Mont. (Lythraceae), and others from the deciduous forest (excluding *Tectona grandis* L. f., teak). It should be noted that trees from the deciduous dipterocarp-oak forest are not represented in this "mixed" forest. Areas that have been severely damaged, especially by repeated burning, from 325 m to about 1,200 m, have a deciduous dipterocarp-oak, not "mixed" or evergreen-pine facies.

Some large evergreen trees which are restricted to the "mixed" zone include *Buchanania arborescens* (Bl.) Bl. and *Mangifera caloneura* Kurz (both Anacardiaceae), and *Garcinia hanburyi* Hk. f. (Guttiferae). Smaller evergreen trees, e.g. *Garcinia merguensis* Wight (Guttiferae), *Scleropyrum wallichianum* Arn. var. *siamensis* H. Lec. (Santalaceae) and *Canthium umbellatum* Wight (Rubiaceae) are also mostly restricted to this "mixed" zone.

There is an increase in the number of species and abundance of both evergreen and deciduous woody climbers in this area, however it does not seem that any of them are restricted to this "mixed" zone. *Combretum latifolium* Bl. (Combretaceae), which is deciduous and *Hiptage benghalensis* (L.) Kurz (Malpighiaceae), an evergreen woody climber, for example, are found in this "mixed" area, but are also known to grow in deciduous and evergreen-pine habitats elsewhere.

The ground flora is a mixture of deciduous perennial and evergreen species. *Amorphophallus krausei* Engl. (Araceae), which never has inflorescences/infructescences and leaves simultaneously on the same plant, *Arisaema cuspidatum* (Roxb.) Engl. (Araceae), and *Zingiber kerrii* Craib (Zingiberaceae) are some deciduous perennial herbs which are most common in the "mixed" zone. Evergreen counterparts are *Hedyotis oligocephala* (Kurz) Craib (Rubiaceae), *Pteris decrescens* Christ (Pteridaceae) and *Bolbitis hookeriana* K. Iw. (Lomariopsidaceae) (both ferns).

Evergreen + Pine Forest

Pinus kesiya Roy. ex Gord. (Pinaceae), being far more common than *P. merkusii* Jungh. & De Vriese, which is restricted to a level of 800–900 m elevation in deciduous dipterocarp-oak areas, is the only other native pine in the national park (both are the only two in Thailand). Again, due to exploitation, *Pinus kesiya* is certainly not as common as it used to be, however, it is still common on ridges from about 1,000–1,350 m. The area around Yaw 3, 1,250–1,300 m, was planted with *P. kesiya* about 60 years ago which are now very mature and among the largest individuals of this species in the national park. Since the summit ridge of Doi Khuntan has been severely disturbed, it seems that *P. kesiya* would have grown on the top since its elevation range in nearby forests (e.g. Mae Soi Ridge, Doi Suthep–Pui, etc.) surpasses this point (c. 1,380 m).

Since the entire upland area above 1,000 m elevation is composed of mostly evergreen hardwood trees and a minority of *Pinus kesiya,* we have designated this kind of forest as evergreen-pine. There are some large canopy trees, all of which are scattered and deciduous, in the evergreen-pine forest. These include some of the tallest (40+m) trees in the national park, viz. *Hovenia dulcis* Thunb. (Rhamnaceae), which was not previously recorded in Thailand (MAXWELL, 1994); *Acrocarpus fraxinifolius* Wight & Arn. (Leguminosae,

Caesalpinioideae), *Pterocymbium laoticum* Tard. (Sterculiaceae), which is only recently known from Thailand (MAXWELL, 1989), and two Meliaceae trees: *Melia toosendan* Sieb. & Zucc. and *Toona microcarpa* (C. DC.) Harms. *Tetrameles nudiflora* R. Br. ex Benn. (Datiscaceae), with its enormous plank buttresses, is also noted, however it is uncommon. *Erythrina subumbrans* (Hassk.) Merr. (Leguminosae, Papilionoideae), although uncommon, is very conspicuous in upper water catchment valleys in December–January when it flowers while leafless. *Erythrina stricta* Roxb. is more common and is found on ridges and slopes from about 925–1,200 m. It flowers, also when leafless, from late January to early March.

Evergreen canopy tree species include *Sapium baccatum* Roxb. (Euphoribaceae), *Michelia champaca* L. and *Paramichelia baillonii* (Pierre) Hu (both Magnoliaceae), *Actinodaphine henryi* Gamb. (Lauraceae), *Betula alnoides* B.-H. (Betulaceae, which because of denaturing properties for alcohol has nearly been extirpated from the area), *Artocarpus lanceolata* Trec. and *Ficus altissima* Bl. (both Moraceae), as well as many Fagaceae which, in areas associated with fire and *Pinus kesiya,* are very common. Some of these Fagaceae are *Castanopsis calathiformis* (Skan) Rehd. & Wils., *C. diversifolia* King ex Hk. f., *Lithocarpus elegans* (Bl.) Hatus. ex Soep. and *L. fenestratus* (Roxb.) Rehd., and *Quercus vestita* Rehd. & Wils.

The understorey is composed mainly of evergreen trees, 10–30 m tall, e.g. *Schima wallichii* (DC.) Korth. (Theaceae), *Ostodes paniculata* Bl. and *Antidesma bunius* (L.) Spreng. (Fig. 8) (both Euphorbiaceae), *Cinnamomum iners* Reinw. ex Bl. and *Litsea monopetala* (Roxb.) Pers. (both Lauraceae), *Sarcosperma arboreum* Bth. (Sapotaceae), *Eugenia albiflora* Duth. ex Kurz (Myrtaceae), and *Dysoxylum procerum* Wall. ex Hiern (Meliaceae). Some deciduous counterparts are *Engelhardia spicata* Lechen. ex Bl. var. *spicata* and var. *colebrookeana* (Lindl. ex Wall.) O.K. (Juglandaceae). *Memecylon plebejum* Kurz (Melastomataceae), *Baccaurea ramiflora* Lour. (Euphorbiaceae), and *Turpinia pomifera* (Roxb.) Wall. ex DC. (Staphyleaceae) are examples of common evergreen trees up to 10 m tall in the upland forest. Slightly disturbed areas, especially with *Pinus kesiya* and/or periodic fire have *Vaccinium sprengelii* (D. Don) Sleum. (Ericaceae), *Helicia nilagirica* Bedd. (Proteaceae), and *Styrax benzoides* Craib (Staphyleaceae).

Woody climbers are abundant and include *Rourea minor* (Gaertn.) Leenh. ssp. *minor* (Connaraceae), *Spatholobus spirei* Gagnep. and *Mucuna macrocarpa* Wall. (both Leguminosae, Papilionoideae), *Bauhinia ornata* Kurz var. *kerrii* (Gagnep.) K. & S.S. Lar. (Leguminosae, Caesalpinioideae), *Tetrastigma laoticum* Gagnep. (Vitaceae), and *Erycibe subspicata* Wall. ex G. Don (Convolvulaceae). All areas of the forest also include a profusion of seedlings, saplings, and immature climbers and trees. Shrubs and treelets include *Euodia triphylla* DC. (Rutaceae), *Leea indica* (Burm. f.) Merr. (Leeaceae), *Prismatomeris tetrandra* (Roxb.) K. Sch. spp. *tetrandra* (Rubiaceae), *Ardisia corymbifera* Mez and *Maesa montana* A. DC. (both Myrsinaceae).

The herbaceous ground flora is mostly evergreen and is most diverse in upper water catchment valleys with constant stream flow throughout the year which extend up to c. 1,300 m elevation. The fern flora is especially abundant in the valleys where *Pinus kesiya* is absent and includes both ground and epiphytic/epilithic species. Some of the ground ferns are *Pteris longipes* D. Don (Pteridaceae); *Amphineuron terminans* (Hk.) Holtt., *Thelypteris truncata* (Poir.) K. Iw., and *Christella cylindrothrix* (Roesenst.) Holtt. (all

Thelypteridaceae); *Diplazium leptophyllum* Christ and *Kuniwatsukia cuspidata* (Bedd.) Pichi-Ser. (both Athyriaceae), and *Angiopteris evecta* (Forst.) Hoffm. (Marattiaceae), which grows along streams. Epiphytic and epilithic ferns are common and include the massive *Asplenium nidus* L. var. *nidus* and the smaller *A. obscurum* Bl. (Aspleniaceae), *Vittaria flexuosa* Fee (Vittariaceae), and several Polypodiaceae, e.g. *Crypsinus ebinipes* (Hk.) Copel., *Lepisorus scolopendrium* (Ham. ex D. Don) Tag., and *Pyrrosia mollis* (O.K.) Ching.

Epiphytic flowering plants are mostly Orchidaceae with *Bulbophyllum morphologorum* Krzl., *Coelogyne trinervis* Lindl., *Dendrobium crystallinum* Rchb. f., *D. signatum* Rchb. f., *Eria amica* Rchb. f., *E. bractescens* Lindl. var. *bractescens,* etc. Ground Orchidaceae are numerous, but the number of individuals is much less than the epiphytic ones. Some of the more common ground Orchidaceae include: *Habenaria corymbosa* Par. & Rchb. f., *Malaxis acuminata* D. Don, *Nervilia aragoana* Gaud., and *Peristylus constrictus* (Lindl.) Lindl. Saprophytic/parasitic ground Orchidaceae are rare and include *Epipogium roseum* (D. Don) Lindl., *Aphyllorchis montana* Rchb. f., and *Gastrodia siamensis* Rol. ex Dow.

Some examples of other flowering ground flora herbs are: *Lepidagathis incurva* Ham. ex D. Don and *Justicia procumbens* L. (both Acanthaceae), *Anisomeles indica* (L.) O.K. and *Gomphostemma lucidum* Wall. ex Bth. (both Labiatae), *Aerva sanguinolenta* (L.) O.K. (Amaranthaceae), *Argyreia henryi* (Craib) Craib (Convolvulaceae) (Fig. 9) and *Impatiens violaeflora* Hk. f. (Balsaminaceae) (Fig. 10), which are all dicots. Some common monocots are *Peliosanthes teta* Andr. spp. *humilis* (Andr.) Jess. and *Asparagus filicinus* Ham. ex D. Don (both of which are deciduous), plus *Dianella ensifolia* (L.) DC. and *Paris polyphylla* J.E. Sm. (both evergreen) (all Liliaceae); *Amorphophallus yunnanensis* Engl. and *Colocasia fallax* Schott (both Araceae), *Boesenbergia rotunda* (L.) Mansf. and *Zingiber smilesianum* Craib (Zingiberaceae). Other monocots include *Carex baccans* Nees and *C. continua* Cl. (Cyperaceae), and Gramineae such as *Cyrtococcum accrescens* (Trin.) Stapf, *Panicum notatum* Retz., with *Microstegium vagans* (Nees ex Steud.) A. Camus being very common in open places where it is a fire hazard. *Musa acuminata* Colla (Musaceae, wild banana) is common in wet, upper water catchment valleys.

Secondary Growth

Cultivated and severely degraded lowland areas have many weeds and deciduous secondary growth species which have been mentioned previously. Many of the weeds are also found at higher elevations. The summit of Doi Khuntan has been cleared for decades and in addition to numerous weeds, it also has dense growth of *Pteridium aquilinum* (L.) Kunth spp. *aquilinum* var. *wightianum* (Ag.) Try. (Denstaedtiaceae). *Thysanolaena latifolia* (Roxb. ex Horn.) Honda (Gramineae), as coarse and fire-resistant as *Pteridium,* is also common in very disturbed areas. Secondary growth trees include *Callicarpa arborea* Roxb. var. *arborea* (Verbenaceae) and *Macaranga denticulata* (Bl.) M.-A. (Euphorbiaceae).

Figure 7. *Ochna intergerrima* (Lour.) Merr. (Ochnaceae) is a common deciduous treelet or small tree found in deciduous dipterocarp–oak and mixed bamboo + deciduous forest from 350–900 m. It flowers usually while leafless from February to May and produces black berries on a red receptacle which is subtended by dark red sepals. It is leafless from January to April. Photo: V. Anusarnsunthorn, 2 April 1994, 500 m.

Figure 8. *Antidesma bunius* (L.) Spreng. (Euphorbiaceae). The fruits of this evergreen understorey tree are relished by many animals. It is found in evergreen hardwood forested areas from 1,050–1,250 m. The flowering period is from March–May while it fruits during July and August. Photo: V. Anusarnsunthorn, 15 July 1993, 1,200 m.

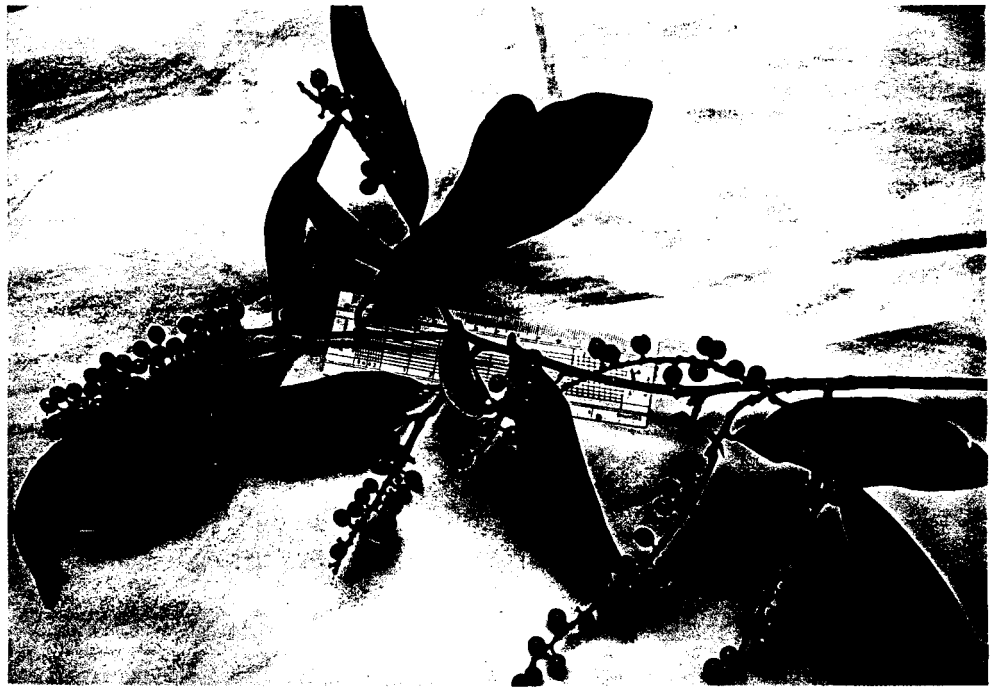

Figure 9. *Argyreia henryi* (Craib) Craib (Convolvulaceae). This evergreen vine is found in open mixed bamboo + deciduous forest and evergreen hardwood + pine forest from 900–1,200 m. Flowers are produced from October to December and fruits during December to February. Photo: V. Anusarnsunthorn, 19 November 1993, 925 m.

Figure 10. *Impatiens violaeflora* Hk. f. (Balsaminaceae). This is one of the most common and conspicuous annual ground herbs found mostly in evergreen hardwood + pine areas at elevations mostly above 1,000 m. While it flowers from May to December, its peak is from August to November. Photo: S. Elliott, 17 August 1994, 1,250 m.

CONSERVATION

Doi Khuntan National Park, especially below 1,000 m elevation, has been ravaged by uncontrolled cutting, burning, and extraction of many ferns and orchids which are sold at Khuntan railway station. Upland areas have also been plundered to the extent that several streams which formerly provided water to the houses at Yaw 2 (1,025 m) have recently become dry. This is due to the destruction of water catchment valleys to ensure the "cleanliness" of the water and also for mosquito, etc. control. Many other areas above this level have been deliberately burned, thus destroying much of the original vegetation as well as reducing the water storage capabilities of the soil. Hunters arrogantly roam throughout the national park unrestrained resulting in the elimination of many animal species. This has and will continue to have adverse effects on the vegetation and overall biodiversity of the area. Fire control and refuse/sewage disposal are other problems which have yet to be solved there. Tourism has dropped from 25,018 visitors in 1977 to 11,073 in 1993. This is partly due to other forested areas becoming national parks, but also due to the fact that Doi Khuntan is not as scenic or interesting as it used to be. In recent years the major emphasis has been to lure rich visitors to the elegant resort-style bungalows there at the expense of conservation and nature education in the national park. If the national park is to survive as a viable forested area then the priorities and management of Doi Khuntan National Park require urgent rectification.

A BRIEF ANALYSIS OF THE FLORA

A data record for every species observed was entered into a computer database, using the FoxPro package. Data include botanical name, family, habit, abundance, habitat, altitude range and time of flowering, fruiting and leafing and other notes. The database can be used to generate statistics to determine the conservation value of different habitats or ranges of altitude and answer more specific questions to help plan management of the park. The database now covers 1,285 plant species, including 297 trees, 136 treelets, 92 lianas, 52 shrubs, 146 vines and 562 herbs. For a taxonomic breakdown of the flora, see Table 1.

Table 1. Summary of collection as of 30th June 1995.

	FAMILIES	SP., SPP., VAR.	TOPOTYPES	NEW RECORDS
ANGIOSPERMS				
Dicots	121	934	1	4
Monocots	19	267		
GYMNOSPERMS	3	4		
FERNS & ALLIES	22	80		
TOTAL	165	1,285	1	4

The new records are:

Hovenia dulcis Thunb. (Rhamnaceae; Maxwell, 1994)
Ventilago laotica (Tard.) Maxw. (Rhamnaceae; Maxwell, 1994)
Desmodium laxiflorum DC. ssp. lacei (Schidl.) Oha.
(Leguminosae, Papilionoideae; Maxwell, 1994)
Phyllanthus debilis Klein ex Willd. (Euphorbiaceae; Maxwell, 1992)

Table 2. Number of species and percentage of habitat's total flora restricted to a single habitat or close to extirpation from Doi Khuntan National Park

Habitat	Habitat-restricted		Close to extirpation	
	No. spp.	%	No. spp.	%
Deciduous dipterocarp-oak forest	120	37	3	1
Bamboo + deciduous forest	109	19	16	3
Mixed deciduous + evergreen forest	31	8	1	0
Evergreen + pine forest	172	29	7	1
Disturbed areas and secondary growth	14	6	1	1

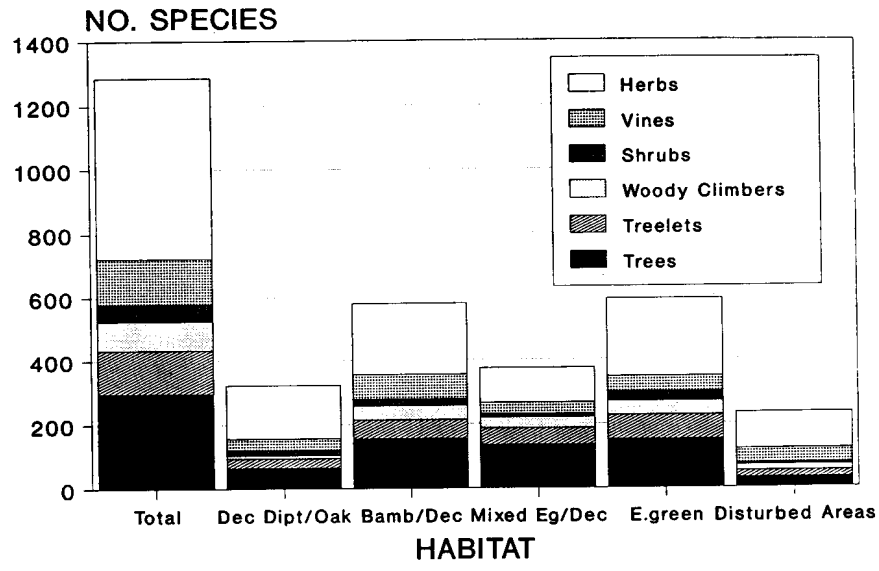

Figure 11. Vascular plant species by habit and habitat on Doi Khuntan.

A preliminary analysis of the database (Fig. 11) indicates that evergreen + pine forest has the highest species richness (591 species or 45.9% of the park's flora) and bamboo + deciduous forest is also exceedingly rich (579 species, 45.0% of the park's flora). Secondary growth or disturbed areas support only 233 species (18.1% of the park's flora). Clearly further conversion of forest into disturbed areas would lead to a great decrease in the botanical diversity of the park.

Evergreen + pine forest also has the highest degree of habitat endemism (defined as the total number of species restricted to a single habitat type), followed by deciduous dipterocarp-oak forest, with secondary growth and disturbed areas being least important (Table 2). However, bamboo + deciduous forest is most important for plant species which are recorded as down to a few individuals or close to extirpation from the park. Such analyses help to prioritize conservation activities, especially when manpower and financial resources are limiting. It is clear that increased protection of the evergreen + pine forest areas would do most to maintain the biodiversity of the park.

The database can also provide interesting insights into the functioning of different forest ecosystems or different types of plants according to their habit. Understanding how complex ecosystems function can help to develop effective methods to restore degraded areas. For example, a comparison of the seasonality of flowering of trees and herbs between the driest habitat (deciduous dipterocarp-oak forest) and the wettest (evergreen + pine forest) is shown in Figs. 12 & 13, respectively. The seasonal patterns in both habitats were remarkably similar. Flowering of trees peaked in March at the hottest, driest time of the year and reached a minimum in August in deciduous dipterocarp-oak forest and in November in evergreen forest, i.e. the end of the rainy season to the beginning of the cool, dry season. Non-epiphytic herbs reached their peak of flowering when tree flowering was minimal, i.e. September–October. There were too few epiphytic herbs flowering in each month to permit meaningful analysis of the data for deciduous dipterocarp-oak forest, but in evergreen + pine forest flowering of epiphytic herbs showed two peaks, one coinciding with the flowering peak of ground herbs and another co-inciding with the flowering peak of trees.

Figures 14 & 15 show the same analysis for fruiting seasonality. For trees in deciduous dipterocarp-oak forest there was a fairly constant, but low number of species fruiting in all months, whereas in evergreen + pine forest a broad peak occurred at the beginning of the rainy season. Tree seedlings from seeds germinating at that time would have the maximum amount of time during the rainy season to accumulate food reserves before the onset of less optimal conditions in the cool season and dry season. Herbs showed a different strategy, with peak numbers of species fruiting in October (the end of the rainy season) in both habitats. This would have included many annual herbs which survive as seeds during the cool season and dry season, germinate at the start of the rainy season, during which they accumulate food reserves for flowering and fruiting before the weather turns cold and dry in November–December.

The database is open to anyone who wishes to use it for research or conservation management. Those wishing to access the facility should contact the authors.

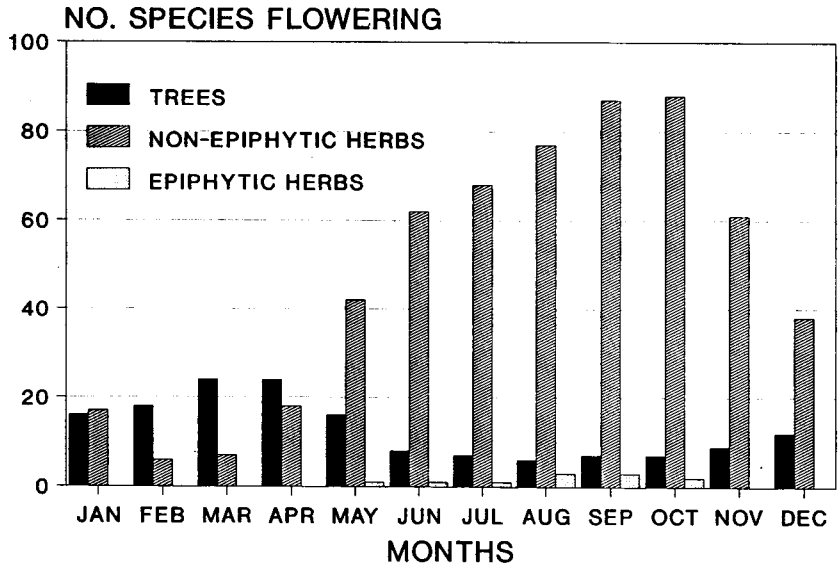

Figure 12. The seasonality of flowering in deciduous dipterocarp–oak forest.

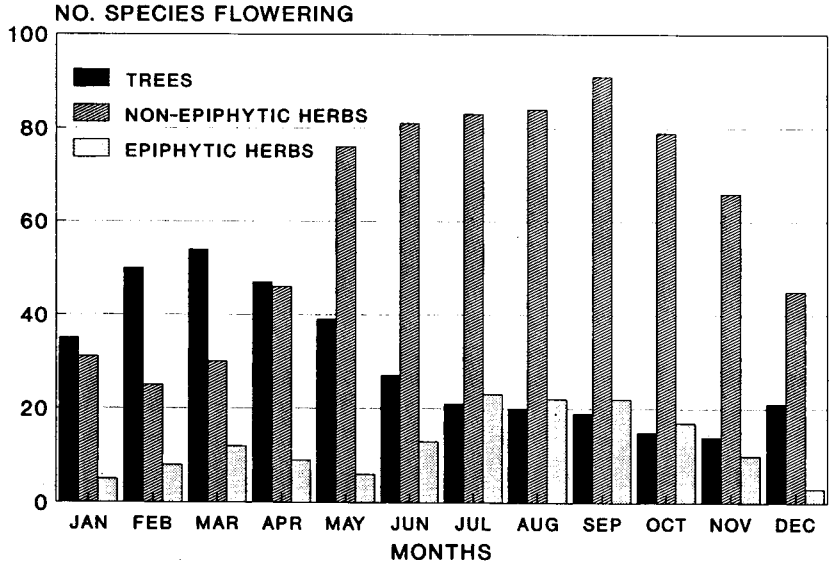

Figure 13. The seasonality of flowering in evergreen + pine forest.

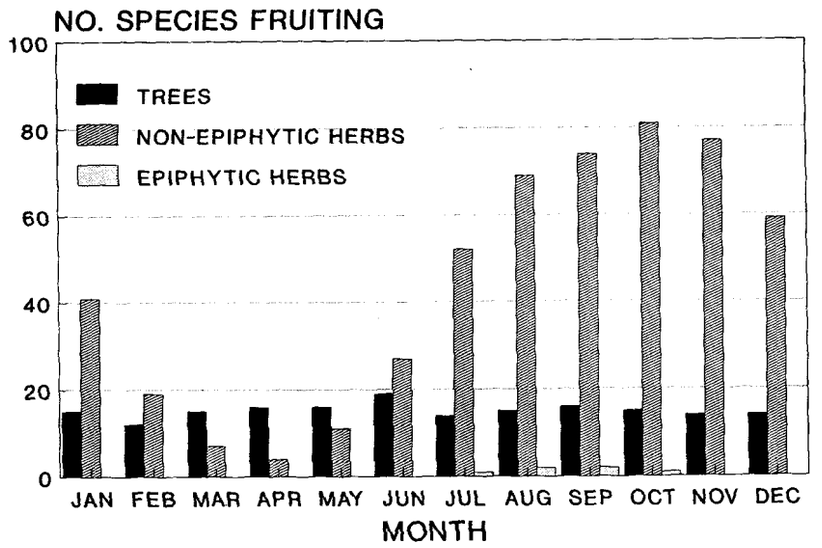

Figure 14. The seasonality of fruiting in deciduous dipterocarp–oak forest.

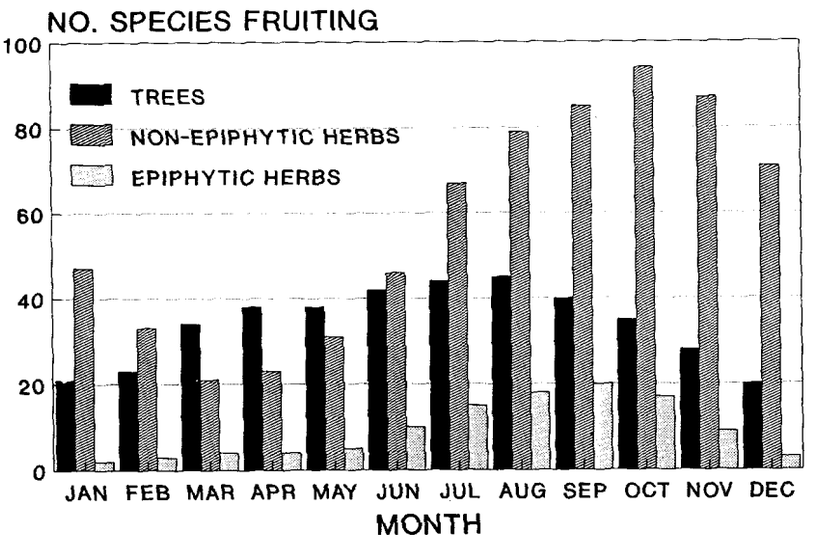

Figure 15. The seasonality of fruiting in evergreen + pine forest.

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