A BOTANICAL ASCENT OF DOI INTHANOND

by

R.G. ROBBINS and T. SMITINAND

INTRODUCTION

This paper deals with a botanical excursion to the highest mountain in Thailand, Doi Inthanond, sometimes known as Doi Angka, and which is 2576 m (8452 ft) above sea level. The excursion took place during the cool, dry post-monsoon season and occupied the nine days from October 27th to November 4th, 1962. In the party were Professor M.E.D. POORE, then from the Botany Department, University of Malaya at Kuala Lumpur and now Director of The Nature Conservancy, Great Britain; Dr. R.G. ROBBINS, a plant geographer from the Australian National University, Canberra; and Mr. Tem SMITINAND, Curator of the Herbarium of the Royal Forest Department, Bangkok, and Mr. Chert ATTHYASAIVISUT, Divisional Forest officer at Chiengmai.

The excursion was part of a general botanical visit to Thailand by the first two party members above and was made possible by the kind assistance extended by the Royal Forest Department. Grateful acknowledgement is made here to the Director and all officers.

The party assembled at Chiengmai and left for Chom Thong by a landrover where carriers were engaged, the whole party proceeding to Ban Mae Hoi. See Fig. 2. From here the trek towards the summit is about 35 kms and is made on foot following the valley of the Mae Nam Klang. Camp I was made near to Tat Noi; the second-day camp II at Pha Mawn at the foot of the massive, and by the third day the party was established at camp III which formed a base, just below the prevalent mist level at about 1850 m (5900 ft) on the slopes of Doi Inthanond itself. The next three days were spent botanizing on the mountain including two visits to the summit by way of the track up the northeast slope. In all over 520 numbers were collected and these, deposited in the Forest Herbarium at Bangkok form the basis for the floristic descriptions which follow. Several forest

profiles were drawn and ecological notes made. On November 2nd the party returned to Pha Mawn and the following day reached Ban Mae Hoi, returning to Chiengmai on the morning of November 4th.

PHYSIOGRAPHIC SETTING

Doi Inthanond lies in northwest Thailand in the physiographic province termed the Continental Highlands by PENDELTON (1962) who regarded the region as a southward extension of the Shan Hills of Burma. Fig. 1. Four major tributaries drain the area into the Chaophraya River, flowing through a series of low north-south trending ridges and valleys. Mt. Inthanond is a granitic massive intruded into the range lying some 60 km to the southwest of Chiengmai and forming the divide between the Ping and Chaem Rivers, Fig. 2. Throughout these northern highlands narrow alluvial terraces occupy the bottoms of the small valleys and support agricultural hamlets. In the more elevated and less accessible valleys live the sparse populations of the so-called hill tribes–the Karens, Miaos and Yangs, who, while they cultivate rice along the stream terraces, also practise 'kaingin' or shifting cultivation over the hill and valley slopes. Here they may plant upland rice, maize and maybe a little, now illicit, opium poppies. Thus much of the forested areas have now been converted into woody regrowth or rank grassland. Apart from the valley alluvium, the soils of the northwest highlands are generally poor being shallow, immature, stony and often on steep slopes. The granitic batholiths, of which Doi Inthanond is but one, weather deeply to give coarse sandy loams.

The track followed passes over the three major rock types to be found in the highlands according to PENDELTON's (1962) reconnaissance geologic map. From Ban Mae Hoi to Pha Mawn it traverses the band of gneiss and schist which starts in the northwest with Doi Suthep. This parent material produces the Sithammarat coarse sandy loams which PENDELTON describes as miserably poor and of little agricultural value.

At Pha Mawn there is a narrow pocket of clastic sediments, the Kanchanaburi Series, consisting of shales, saliceous sandstone and

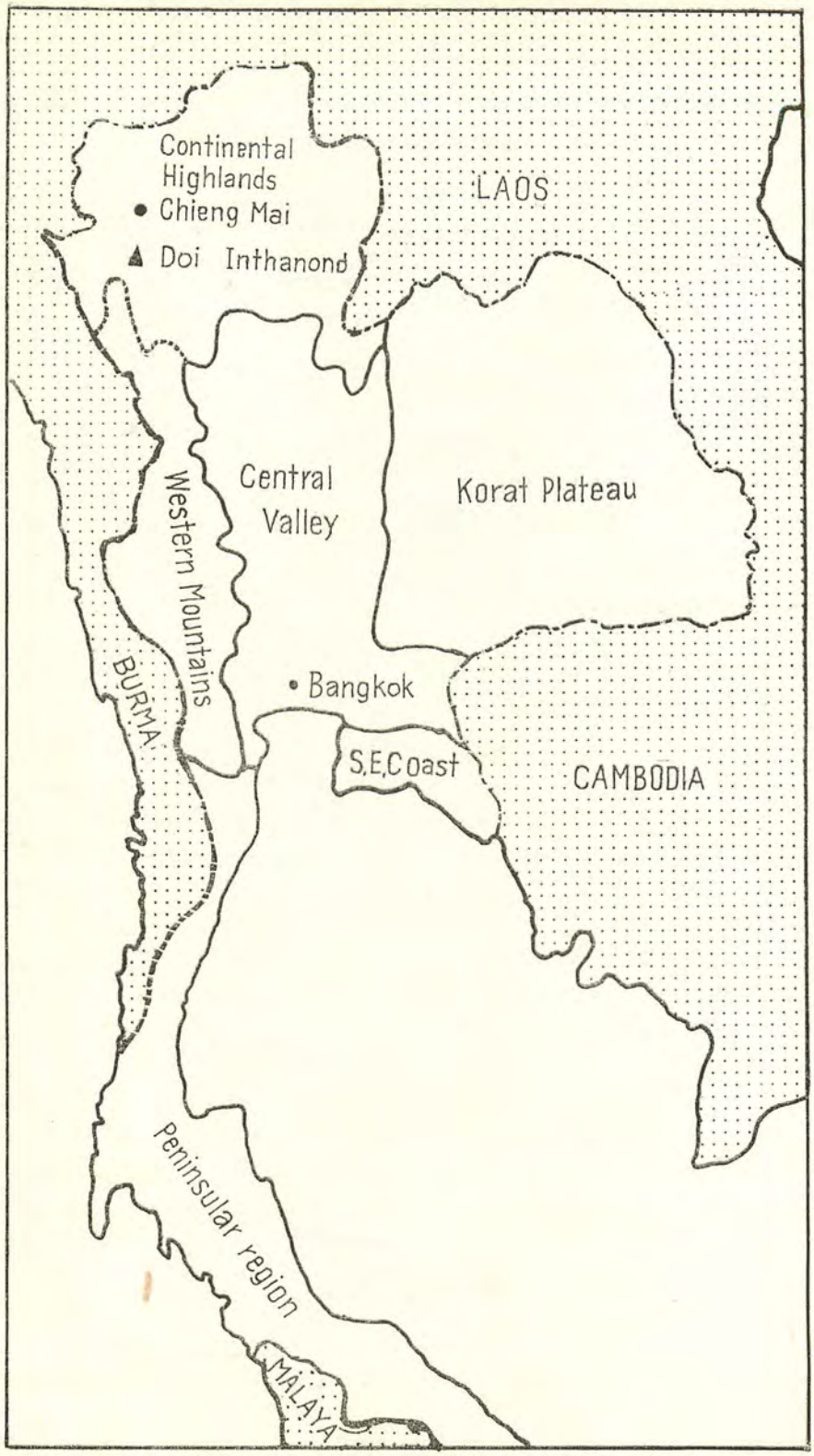

Fig. 1. Sketch map of Thailand Showing Pendleton's six major physiographic regions and the location of Doi Inthanond, 2576m, in the Northeastern Continental Highlands.

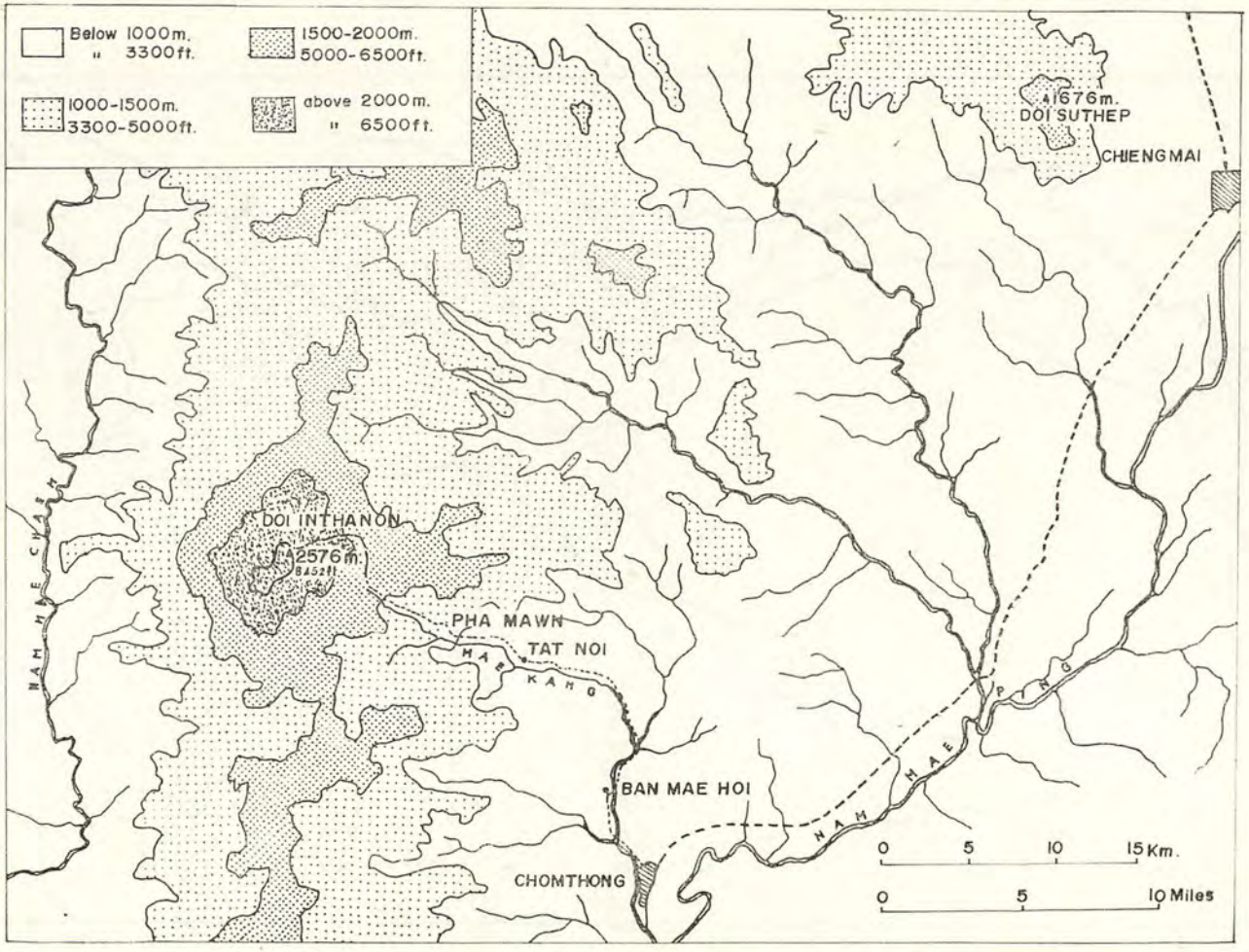

Fig. 2. Map of Doi Inthanond and its environs showing the route taken from Ban Mae Hoi to the summit.

in places, quartzites and slates. These develop poor soils, shallow and stony and of scant agricultural value.

Doi Inthanond itself is a granitic massive giving rise to the Kuantan sandy loams of shallow coarse and stony soils generally. Over the rough mountainous terrain this soil type supports mixed forests except where the hill tribes kaingin the slopes for maize cropping.

The climate of the area is monsoonal with a strong alternation of wet and dry seasons. STERNSTEIN (1962) on the basis of this seasonality, recognised seven rainfall regions for Thailand. Doi Inthanond falls in the centre of the North Region. This has a uniform monsoon climate with heaviest rain coinciding with the wet-carrying northwest monsoon during Aug./Sept. and the driest month, which is December, coinciding with the dry northeast monsoon. The average annual rainfall for the North Region is 1500 mm. (59 inches) which compares with 1195 mm. (47 inches) for the driest region in Thailand and 3735 mm. (147 inches) for the wettest. A more detailed account of the climate of Doi Inthanond is not available, the only local figures being from lowland stations where deciduous monsoon forest vegetation prevails. Chiengmai, the nearest station has an annual total (for 1960) of 1344 mm. (53 inches) rainfall of which only about 248 mm. (7 inches) falls during the six months dry season. There is no doubt that Doi Inthanond, especially at altitudes above 1000 m, has a higher and more evenly distributed rainfall of at least 2000 mm. (80 inches), to which must be added the other factors important to moist forest—cooler temperatures, lower humidities, prevalent mists and a deeper moisture-retaining soil.

FOREST CLASSIFICATION

The forest vegetation types of Thailand first proposed by CREDNER (1936) have been adopted by the ROYAL FOREST DEPARTMENT (1962).

There are six broad categories:—

Lowland

1. Mixed deciduous (teak) forests
2. Dipterocarp deciduous forests
3. Mangrove evergreen forests
4. Tropical evergreen forests

Lower Montane

5. Hill evergreen forests
6. Coniferous forests

Some writers (PENDELTON, 1962), have described floristic and physiognomic subcategories and there is no doubt that future study will delimit many distinct associations within these major formations. Mangroves excepted all are to be found in the northwest highlands forming a mosaic pattern in response to local climatic and edaphic conditions.

The forest types of Doi Inthanond have been further described by OGAWA, YODA and KIRA (1961), who visited the area in the dry month of January 1958. They have outlined the main forest types of NW Thailand as follows:–

1. Tall deciduous or monsoon forest (= Mixed deciduous)
2. Savanna forest (= Dipterocarp forest)
3. Evergreen gallery (= aspect of Tropical evergreen)
4. Subtropical evergreen (= an ecotone)
5. Temperate evergreen (= Hill evergreen forest)

The equivalent types as recognised in the present paper are given in brackets. Mixed deciduous forest, usually characterised by teak, is absent along the track followed to Doi Inthanond. In their savanna forest OGAWA *et alia* recognised a dry dipterocarp aspect and a more mesic mixed dipterocarp aspect. Both aspects are continuous with each other and while the dry one predominates over the lower foothills around Doi Inthanond, the mixed aspect is present in depressions here and over the eastern slopes.

Evergreen gallery forest is a tall stream-terrace type belonging to lowland tropical evergreen forest category. The subtropical evergreen forest of OGAWA *et al.* is recognised by them as a transitional altitudinal ecotone between the lowland and the temperate (lower montane) forest.

Temperate evergreen forest is certainly synonymous with Hill evergreen forest which in the present paper is recognised as a lower montane formation. It occurs at altitudes above 1000 m and apart from being characterised by a shift in species composition from the

adjacent lowland formation it is defined on structure having two, instead of three tree layers in optimum development. An application of this approach is seen in ROBBINS & WYATT SMITH (1962) on the forests of the Malayan Peninsular. In this classification system tropical lowland forest has an optimum development showing three tree height groupings or layers. The series passes to a lower montane zone, uniformly commencing at 1000 m in the tropics, and occupied by the lower montane forest formation. Here the optimum is a two tree-layered forest structure. True montane forest is not expressed until a still higher altitude where the maximum development is a single-layered forest.

While the floristic associations making up the formation are usually characteristic and hence diagnostic, the basis of formation definition is on the physiognomy, that is, its appearance features and upon structure. Physiognomy and structure are studied by means of forest profile diagrams and the method has been reviewed by ROBBINS (1959). The profile is a scale drawing of an actual strip of forest from a selected site.

On the slopes of Doi Inthanond a two-layered lower montane forest was recognised from about 1000 m and extending to the summit at 2576 m. The upper aspects from 1850 m are frequently misted and only the lower aspects are utilised for shifting agriculture, ROBBINS (1964). Due to the prevalent cloud cover the summit forest is heavily mossed and the trees gnarled, reduced in stature and umbrella-crowned but profile analysis still shows a two-layered structure. The summit of Doi Inthanond has then, a depressed lower montane forest which approaches but does not constitute a true montane forest for Thailand. It supports the contention that such true montane forest in tropical areas is not found below 2750 m (9,000 ft).

VEGETATION DESCRIPTION

Lowland dipterocarp deciduous forest From Ban Mae Hoi, from where one starts the foot track approach to Doi Inthanond, the path follows the gorge of the Klang River. The dry stony terrain and steep hill slopes are covered with a low open deciduous dipterocarp forest. It

is the post-monsoon season (November) and the trees are newly leafy and green, the atmosphere cool. The forest is made up of small-boled trees about 12 metres high which are dense enough in places to give the appearance of a thicket. Usually, however, spacing is open with a few associated shrubs and a sparse ground layer of grasses and herbs. Throughout the red-brown soil is dry, poor in nutrients and full of coarse angular gravel and forms but a shallow cover over the parent rock of granites, schists and shales. In the dry season the forest floor is almost inevitably burnt off by fire which clears the heavy leaf litter of the previous season. In addition many trees are cut for use as fuel. The dominant trees are *Pentacme suavis,* which may constitute up to 50% of the cover and *Shorea obtusa. Dipterocarpus tuberculatus* and *D. obtusifolius* co-dominate in places. Generally floristic composition reflects local variations in moisture and other trees which may be found in this community are:– *Mangifera caloneura, Terminalia* spp., *Elaeocarpus lacunosus, Garuga pinnata, Vitex limonifolia, Spondias pinnata Phyllanthus emblica, Parinari annamense, Melanorrhea usitata, Schoepfia fragrans, Quercus kingiana, Q. mespilifolioides, Q. brandisiana, Lithocarpus polystachyus, L. spicatus, L. microsperma, Castanopsis indica, C. echinocarpa, Chukrasia velutina* and *Premna latifolia* var. *mucronata.*

On the ground are such herbs as *Desmodium gangeticum, Pygmaeopremna herbacea* var. *thailandica, Ophiopogon brevipes, Barleria siamensis, Plectranthus striatus, Cycas siamensis, Carex continua* and *C. doisutepensis,* the dry fern, *Cheilanthes farinosa* together with the grasses *Echinochloa colonum, Themeda triandra, Sorghum nitidum, Heteropogan triticeus* and *Hyparrhenia rufa,* and the bamboo *Gigantochloa albociliata.*

Epiphytic ferns here are *Aglaomorpha coronans* and *Drynaria rigidula* with *Mucuna pruriens, Thunbergia hossei, Dunbaria longeracemosa* and *Argyreia* sp., as climbers. Shrubs are sparse but include *Strychnos nux-vomica, Zizyphus incurva, Cratoxylon pruniflorum, Gardenia erythroclada, Crotalaria alata, C. ferruginea* and *Croton oblongifolius.*

Here and there along open stream banks and in clearings, a scrubby regrowth occurs in which *Erythroxylum cuneatum, Reinwardtia*

trigyna, Blumea fistulosa and *Glochidion assamicum* can be found. As the track climbs upward, the narrow gorge of the lower reaches of the Klang River widens out and a low river terrace is present supporting a tall evergreen riverine or gallery forest. Here in the north of Thailand it is apparently the nearest equivalent to the wet lowland evergreen rainforest of the south. The canopy, which is dominated by *Dipterocarpus turbinatus,* is 30 m (100 ft), high and includes also *Dipterocarpus alatus, Hopea odorata, Shorea obtusa, Terminalia mucronata, Pterocarpus macrocarpus, Eugenia siamensis, Garcinia merguensis, Quercus fleuryii, Lithocarpus truncatus, Castanopsis argyrophylla, Carpinus viminea, Salix tetrasperma,* and *Ficus maclellandii.* Stratification is poorly developed but there is a fairly dense ground cover of bushes and herbs among which were recorded *Desmodium velutinum, Lysimachia pilosa, Symplocos caudata, Sladenia celastrifolia, Celastrus paniculatus, Phyllanthodendron roseum, Aporosa wallichii, Alternanthera sessilis, Elaeagnus latifolia, Cycas pectinata, C. micholitzii* var., *Pandanus furcatus, Bambusa tulda* and the clubmoss *Selaginella ostenfeldii* with the ferns *Lygodium microphyllum* and *Osmunda vachelii.* Terrestrial by the streamside is *Equisetum debile, Pogonatherum crinitum, Pseudopogonatherum contortum, Itea riparia, Ficus ishnopoda, F. virens, Photinia mollis,* and *Homonoia riparia.*

In the gallery forest many of the larger *Dipterocarpus turbinatus* trees are disfigured by small blackened hollows where local inhabitants have cut into the big trunks to get wood oil, setting fire to the residue to stimulate further exudation.

At Tat Noi, a small Karen hamlet where the valley widens enough for alluvial ricefields, the first *Pinus insularis* (syn. *P. khasya*), are encountered. The track now leaves the river and passes over a spur reaching 1250 m (4000 ft), as it does so. At first the evergreen terrace forest and the deciduous *Pentacme-Shorea* forest of the slopes above merge into a semi-evergreen transition belt dominated by *Dipterocarpus obtusifolius* and here at 900 m (2590 ft) under cooler moister conditions epiphytic *Psilotum triquetrum* was collected. A little higher, at about 1000 m (3,300 ft), the first zone of the lower montane forest is reached. This formation has been variously termed as "hill evergreen", "temperate evergreen", and "montane subtropical" forest in

the literature. Characteristic dominants are the oaks among which are *Castanopsis acuminatissima, C. tribuloides, Quercus kingiana, Q. brandisiana* and *Lithocarpus leucostachys* while *Pinus insularis* which also occurs at lower altitudes, here forms small groves of pine forest. Such stands predominate on the ridge crests and the track passes through one. The trees are up to 25 m (80 ft) tall in fairly dense pure stands in which undergrowth is lacking and the floor strewn with needle litter. A second species of pines in Thailand, *Pinus merkusii,* is a lowland component. There seems little doubt that the pine forests of northern Thailand represent a relic wedge from a past migration southwards from the Sino-Himalayan region. As such they occupy a cool mid-mountain zone but may overlap into lowland sites. They should not be regarded as just another forest type within the evergreen lower montane formation. As in Luzon in the northern Philippines they do not conform to any local altitudinal formation and can only be recognised as a temperate-subtropical formation now intruded into a tropical region.

Once more the track descends to emerge quite suddenly into the valley of Pha Mawn, Photo 1. Here is another Karen village, larger this time and reflecting the fairly extensive terraced paddy fields of rice occupying the valley floor. Here in the ricefields and other wet swampy sites are a host of herbs among which are:– *Lobelia angulata, Torenia reptans, Lindernia nummularifolia, Monochoria vaginalis, Xyris lobbii, Rotala rotundifolia, Inula eupatorioides, Lactuca siamensis, Asclepias curassavica, Marsilea* sp., *Cyperus kyllinga, C. cyperoides, Juncus prismatocarpus, Eragrostis atrovirens, Isachne pulchellum, Eranthemum tetragonum, Elsholtzia winitii, Eurysolen gracilis, Dysophylla auricularia, D. pentagona, Biophytum apodiscias, Polygonum odoratum, P. plebejum* and *P. strigosum* and *Acorus gramineus.*

Along the edge of the swampy area secondary vegetation of 8-10 m. high forms up thickets of small trees, shrubs and climbers. Trees species are *Adinandra phlebophylla, Acronychia pedunculata, Eugenia oblata, E. winitii* var. *terminalis, Styxax polyspermus, Linociera ferruginea, Callicarpa macrophylla, Litsea garrettii, Trema angustifolia,* and *Villebrunnea frutescens;* the followings are shrubs and perennial herbs:– *Polygala tricholopha, Epilobium trichoneuron, Decaspermum*

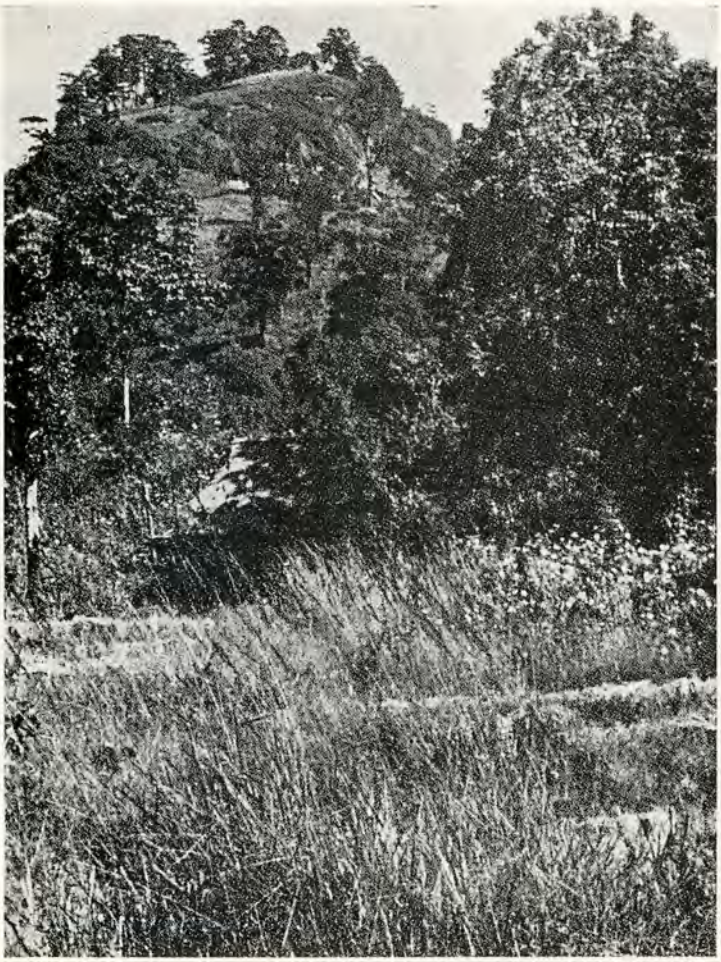

Photo 1. The Shoulder of Pha Mawn showing the granitic boulders. (Photo DICKINSON)

Photo 2. Eastern slopes of Doi Inthanond clothed with mist. (Photo DICKINSON)

fruticosum, Osbeckia garrettii, Viburnum garrettii, Aralia pseudoginseng var. *angustifolia, Senecio nagensium* var. *lobbii, Buddleia asiatica, Fagraea obovata, Callicarpa rubella* and *Clerodendrum serratum.* A number of climbers are abounded, such as *Rosa gigantea, Rubus angkae, Tylophora sootepensis, Lonicera robustum, Trachylospermum siamensis, Chonemorpha macrantha, Alyxia siamensis* and *Lettsomia henryi.*

Ahead, Photo 2, rise the eastern slopes of Doi Inthanond, the summit clothed with mist down to a level of 1850 m (6,000 ft). The foothills and slopes of the mountain surrounding the valley have been cleared except for small patches of remaining forest, by the shifting agriculture of the Karens. Much has now been converted to a dis-climax grassland. In these hill garden plots maize, bananas, upland rice and *Cannabis sativa* may be grown. The grasslands are of tall *Themeda arundinacea, Setaria pallide-fusca, Imperata cylindrica, Capilli-pedium assimile, Sporobolus indicus, Thysanolaena maxima* and *Oryza granulata* together with the sedges *Carex baccans, Fimbristylis miliacea,* and *Rhynchospora* sp. and the ferns *Pteridium aquilinum* and *Dicranop-teris linearis.* Common herbs are *Desmodium renifolium, Codonopsis javanica, Gerbera piloselloides, Perilepta siamensis, Leonotis nepaetifolia, Plectranthus ternifolius, P. garrettii, Scutellaria discolor* and *Eriocaulon orysetorum. Castanopsis* is common as scattered trees throughout, and it is apparent that forest regeneration has proceeded in places. One slope had clearly discernable rectangular patterns, both *Castanopsis* and *Pinus* in pure stands fairly obviously secondary forest on long since abandoned garden plots. The grassland continues up the slopes forming an irregular boundary with the virgin forest but there are cleared patches at even higher levels within the forest. At about 1800 m (6,000 ft) at the lowermost levels of the persistent mists such activities cease.

Lower montane forest on Doi Inthanond and the surrounding hills begins at about 1000 metres (3,300 ft) and extends to the summit of the mountain at 2576 m (8,452 ft.). It is a mixed forest among which a number of temperate families predominate such as *Fagaceae* (represented by oaks), *Magnoliaceae, Theaceae* and *Ericaceae* while *Lauraceae* is also notable. The gymnosperm element is seen in *Podo-carpus, Cephalotaxus* and *Gnetum.* The lower montane forest presents

several aspects on the slopes of Doi Inthanond due to such factors as disturbance by fire, soil moisture and depth, and increasing altitude coupled with mistiness. In the moister, more fertile basins and gullies and particularly below the mist levels is found a tall mixed forest, luxuriant and rich in species. On drier ridges and more exposed shoulders throughout a typical oak-laurel aspect is found in which *Castanopsis acuminatissima* is characteristically the dominant. The summit area has a rather reduced and mossy aspect where *Schima* is common. A small sphagnum moss bog here is surrounded by *Ericaceae,* notably *Rhododendron* species and is the nearest approach to true montane forest in Thailand.

Soil type on the massive appears to be much the same throughout and derived from granite. Two and a half centimeters (1 inch) or more leaf litter is followed by about 7½ cm. (3 inches) of red-brown humus with a pH of 5.1 and then 60 cm. (2 ft) of orange-red loam forming a B horizon with a pH of 5.4.

By the time the actual slopes of the mountain are reached one has already traversed the lower aspects of the lower montane forest. Groves of *Pinus insularis* are left behind at 1200 m (4,000 ft) and are not found on the forested eastern slopes of Doi Inthanond. We enter the tall mixed lower montane forest from the now open valley of Pha Mawn at 1500 m (5,000 ft). Here the larger trees are over 35 m (100 ft) tall and form a dense undulating canopy. Figure 3 illustrates an actual profile strip within this forest, the two tree-layered structure confirming that this forest belongs to the lower montane formation.

The upper canopy layer is made up of relatively few trees with boles up to 6 m (19½ ft) diameter. Recorded here are *Sapium baccatum, Quercus rex, Canarium? subulatum, Cepholotaxus? fortunei, Nyssa javanica, Pterospermum? grande, Calophyllum? polyanthum, Poupartia axillaris* and *Cedrela toona* as well as *Sloanea tomentosa, Castanopsis acuminatissima, C. purpurea, C. tribuloides, C. brevispinula, C. calathiformis, C. ferox, Lithocarpus oxycarpus, L. aggregatus, L. auriculatus, L. magnificus, Quercus glabricupula, Q. chapensis, Q. dussaudii,* and *Q. oidocarpus.*

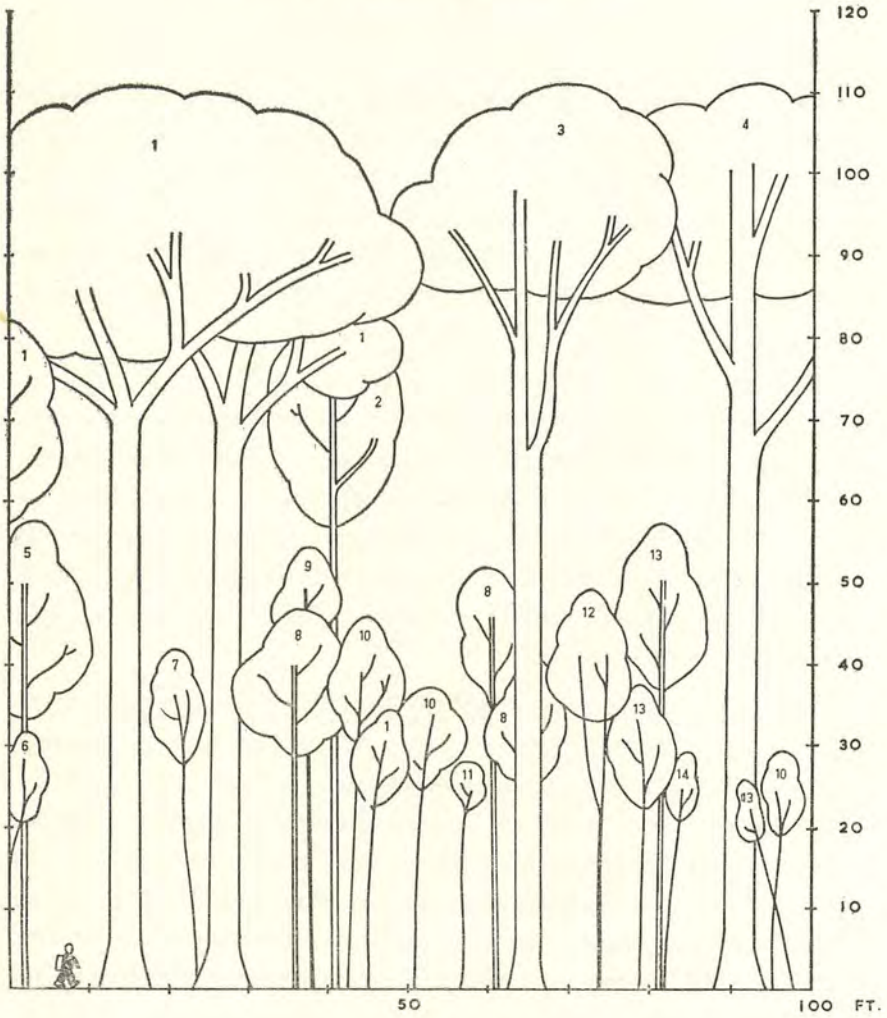

Fig. 3

Mixed lower montane forest on the lower slopes of Doi Inthanond. The profile diagram represents an actual strip of forest 30.5 m (100 ft) long by 7.6 m (25 ft), wide at 1600 m (5300 ft) above sea level. Note the scale figure. Ground and shrub vegetation below 6 m (20 ft) is not depicted and the forest shows to tree layers. For full description and discussion see text.

1 = *Quercus rex* 2 = *Canarium* 3 = *Pterospermum*
4 = *Calophyllum* 5 = *Michelia* 6 = *Aquilaria*
7 = *unidentified* 8 = *Diospyros* 9 = *Cinnamomum*
10 = *Mallotus* 11 = *Cedrela* 13 = *Helicia*
14 = *Symploccos*

The second layer is composed of small trees between 10 to 17 m (30-50 ft) high forming a distinct stratum. It is rich in species including *Celtis tetrandra, Cinnamomum siamense, Garcinia speciosa, Camellia connata, Polyosma elongata, Alseodaphne* sp., *Nothaphoebe* sp., *Diospyros viridus, Engelhardia spicata, Diospyros? castanea, Michelia rajaniana, Mallotus* spp., *Helicia formosana, H. terminalis, H. nilagirica, Meliosma microcarpa, Macropanax oreophilum, Eriobotrya bengalensis, Abarema glomeriflora, Linociera sutepensis,* and *Symplocos hookeri, S. henschelii, S. laurina, S. magnifica,* and *S. yunnanensis.*

The shrub layer, which is not depicted on the profile drawing, is nowhere very dense but many species are represented here among them being *Schefflera bengalensis, Schoepfia acuminata, Euonymus colonoides, Hiptage candicans, Canthium parvifolium, Ardisia* sp., *Pouzolzia* spp., *Piper boehmeriaefolium, Mussaenda garrettii, Ixora kerrii, Pavetta petiolaris, Psychotria monticola, P. lineolata, Lasianthus tubiferus, Maesa montana, M. permollis, Antidesma velutinum, Baliospermum siamensis* and *Sauropus garrettii.*

A ground layer with rotting logs and ample leaf litter and humus is well developed. Here there are seedlings of the main trees already mentioned as well as *Acer oblonga* and *Podocarpus neriifolius,* with ground herbs such as *Viola betonicaefolia, Begonia lacinlata, Boeninghausenia albiflora, Elatostemma, Pilea,* the ginger plants, *Catymbium, Globba* and *Hedychium,* as well as *Forrestia glabrata, Brandisia discolor, Pedicularis* sp., *Dracaena, Musa, Impatiens chinensis, I. garrettii* and *I. jurpia, Peperomia* spp., *Lycianthes macrodon, Ophiorhiziphyllon hypoleucum* and the Rubiaceous herbs, *Argostemma laxum, Hedyotis garrettii, Anotis calycina, A. quadrilocularis, Ophiorrhiza angkae.* Also recorded here are *Corallodiscus patens, Chirita macrophylla, C. pumila, Cyrtandromoea acuminata, C. grandiflora, Tacca garrettii, Gentiana napulifera, Amorphophallus* sp., *Remusatia vivipara, Dianella ensifolia* and the root parasites *Balanophora globosa, Aeginetiá indica* and *Sapria himalayana,* This last, a representative of the *Rafflesiaceae* making a striking splash of orange colour with its yellow-flecked starlike inflorecences.

Ground ferns are *Colysis elliptica, Crypsinus* sp., *Asplenium* spp., *Sphenomeris chusana, Microlepia strigosa, Polypodium garrettii,* and *Bolbitis sinensis* on roots together with mosses.

Lianes and climbers include *Gnetum montanum, Calamus* spp., *Smilax corbularia, S. lanceaefolia, Pothos* sp., *Dittoceras garrettii, Lonicera ferruginea, Thunbergia coccinea, T. similis, Hedera himalaica, Tetrastigma garrettii* and the *Cucurbitaceae, Trichosanthes himalensis, Thaladiantha hookeri, Melothria maderaspatana* var. *gracilis, M. perpusilla* and *Gymnostemma siamica.*

Epiphytes are *Hoya engleriana, H. fusca, H. longifolia, Aeschynanthus hilldebrandii, A. hosseusii, A. lineatus, A. superbus* and *Lysionotus serratus* with numerous orchids which are listed separately in the appendix. An interesting feature is that both here and at higher levels there is an absence of treeferns. Filmy ferns are almost restricted to the upper misted levels. No *Pandanus* were recorded in the lower montane zone but both rattans and *Areca* palms occur.

Passing through the mixed forest of the lower slopes the track now ascends the east ridge and here the dominance of oaks, in particular *Castanopsis,* reflects the steeper slopes and drier soils. The large trees of the lower basin – *Cedrela, Calophyllum, Pterospermum* and *Canarium* are no longer present. This elimination of genera with lowland affinities, together with a general lower stature and changed physiognomy of the forest also coincides with the lower limits of the frequent mists. Fig. 4 shows a forest profile made on a spur shoulder at 2350 m. (7,650 ft). The general canopy is reduced to under 30 m. (100 ft) in height and is more uniform being made up of many small-boled trees with fairly compact crowns. Common here are *Castanopsis acuminatissima, Lithocarpus aggregatus, Quercus glabricupula, Michelia rajaniana, Manglietia garrettiana, Helicia* spp., and *Adinandra* sp. The second tree layer is still proportionally dense and remains at 10-17 m. (30-50 ft) but due to a lowering of the upper stratum it is brought closer to the canopy. Here are *Turpinia nepalensis, Rhododendron moulmeinense, Betula alnoides* var. *cylindrostachya, Symingtonia populnea, Litsea* spp., *Dendropanax, Anneslea fragrans, Aquilaria* and *Vaccinium.*

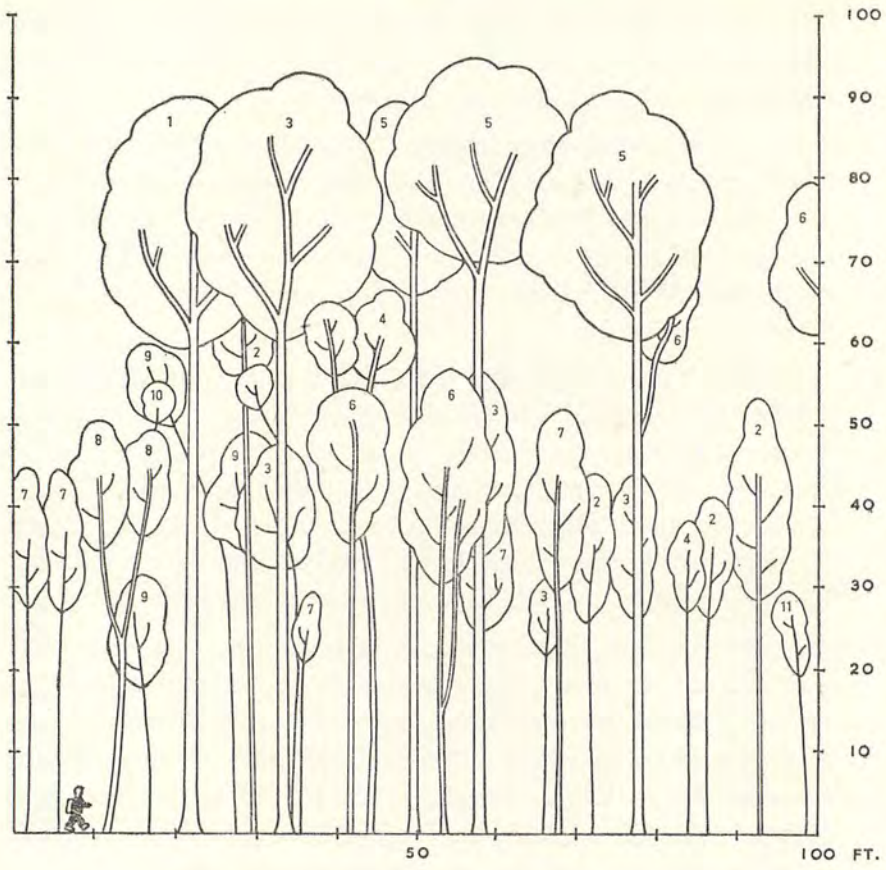

Fig. 4
Oak lower montane forest at 2350 m (7650 ft) on Doi Inthanond. Many of the larger trees have been eliminated at this level due to persistent mists, however two tree layers are still represented.

1 = *Michelia*	2 = *Lauraceae*	3 = *Quercus glabricupula*
4 = *Helicia* sp.	5 = *Adinandra*	6 = *Helicia* sp. (2)
7 = *Aquilaria*	8 = *Vaccinium*	9 = *Olea*
10 = *Dendropanax*	11 = *Symplocos*	

The shrub layer is also dense and includes, apart from many oak saplings, *Sambucus javanica, Viburnum cylindricum, Dichroa febrifuga, Cornus oblonga, Ardisia, Mycetia rivicola, Craibiodendron henryi, Acer garrettii, Lindera* spp., *Lasianthus lucidus* and *Wikstroemia indica.* The ground herbs are *Begonia garrettii, B. yunnanensis, Valeriana hardwickii, Sonerila violaefolia, Rubia garrettii, Galium asperifolium,*

G. punduanum, Goldfussia rex, Strobilanthes anfractuosus, S. hossei, Lysimachia garrettii, L. pilosa, Elsholtzia blanda, Ophiopogon and many ground ferns. Small vines and epiphytes are *Tetrastigma serrulatum, Smilax china, Wightia speciossisima Rhododendron veitchianum,* and *Hymenopogon parasiticus,* orchids and the ferns *Microsorium, Phymatodes* and *Gymnogramitis dareiformis.* Locally small clumps of bamboo occur. Much of the oak-dominated forest occurs on steep slopes and where charcoal in the soil indicates fires in past dry seasons. In the more open spaces which evidently mark regeneration phases are found *Glochidion velutinum, Euphorbia hirta, Trema* sp., *Boehmeria* sp., *Cissus discolor, Prunus punctata, Rubus efferatus, Girardinia heterophylla, Burmannia coelestis, Asparagus filicinus, Saussurea deltoidea, Lactuca garrettii, Myriactis nepalensis, Cyperus condensata* and *C. cruciata.*

Just before attaining the summit, the track crosses over to the northern slope and here there is a transition from oak dominated lower montane forest to the *Schima* dominated lower montane summit forest. This is seen in Fig. 5, which is at an altitude of 2,500 m. (8,250 ft). Except for the few emergent *Quercus glabricupula* the upper layer is now more dense and uniform and reduced to about 25m (80 ft) in height while the second layer, quite sparse here is centred at 15 m. (45 ft). By the time the summit ridge is reached oaks are no longer present and *Schima wallichii* and other species are the tree dominants. The canopy, now at 22m (70 ft) is a dense uniform layer of twiggy, flattened crowns beneath which is a sparse second layer as seen in Fig. 6.

The forest is still within the lower montane category but shows features anticipating a higher true montane formation not quite attained at this altitude. Many of the trees are coppiced and the flat shallow crowns are supported by several slender boles. Recorded here are *Schima wallichii, Pyrenaria* sp., *Anneslea fragrans, Lindera bifaria, L. pulcherrima, Litsea garrettii, Pygeum* sp., *Helicia* spp., *Olea* and *Ternstroemiaceae.*

The poorly developed second layer has *Myrsine semiserrata, Embelia subcoriacea, Maesa ramentacea* and *M. indica,* all in the *Myrsinaceae,* as well as *Myrica farguhariana, Gordonia dalglieshiana,*

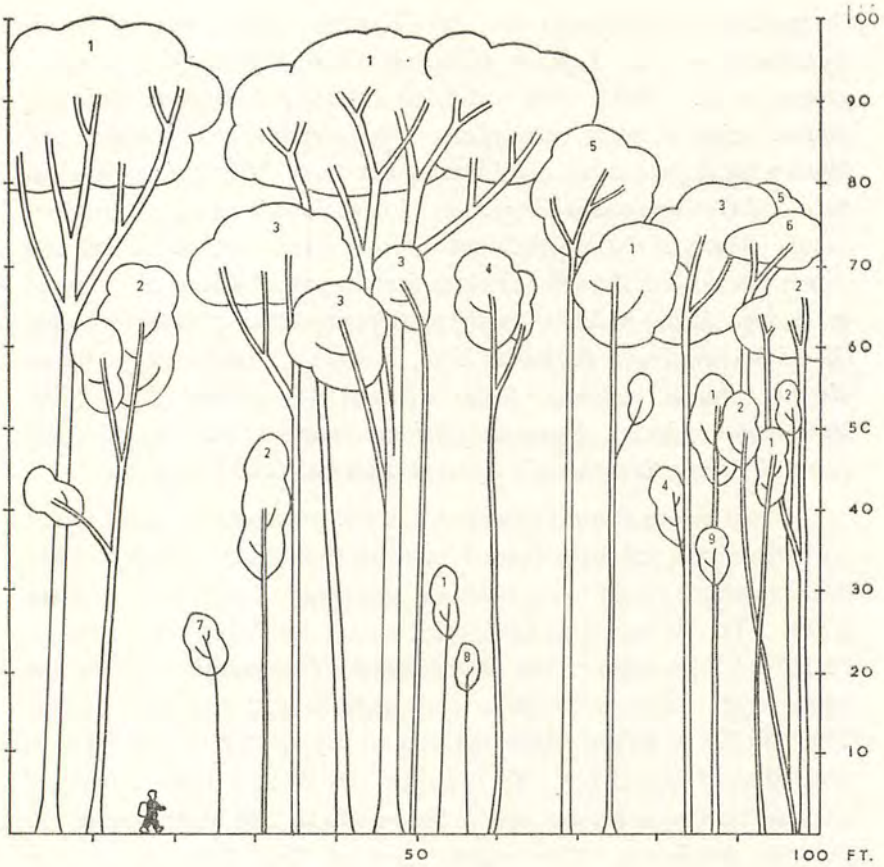

Fig. 5
Lower montane forest on Doi Inthanond at 2500 m (8250 ft). The profile represents a transition from the oak-dominated aspects to *Schima* dominated forest near the summit. See also Fig. 6.

1 = *Quercus glabricupula* 2 = *Olea* 3 = *Eurya* 4 = *Lauraceae*
5 = *Helicia* sp. 6 = *Schima wallachii* 7 = *Myrsinaceae*
8 = *Lindera* 9 = *Helicia* sp. (2)

Michelia kerrii, ***Wikstroemia indica***, ***Vaccinium garrettii***, ***Symploccos siamensis***, and ***Eurya japonica*** var. ***nitida***.

Shrubs include ***Capparis acutifolia***, ***Osmanthus fragrans***, ***Lasianthus lucidus***, ***Viburnum kerrii***, ***Photinia integrifolia*** and a dense growth of ***Strobilanthes hossei*** in the *Acanthaceae*, a soft woody herb up to 3 m (10 ft) or more in height.

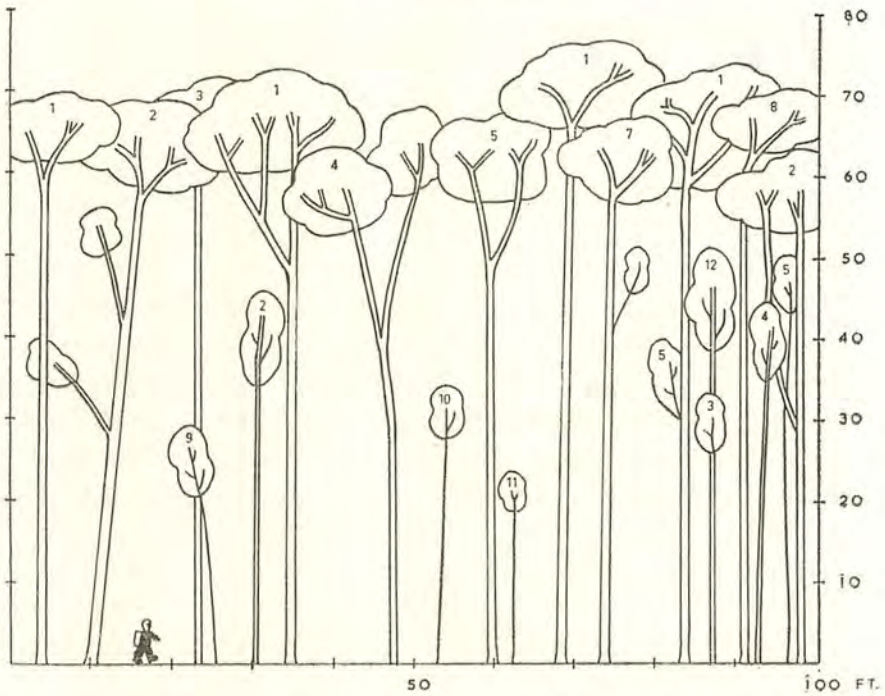

Fig. 6

Lower montane forest at 2560 m (8400 ft) on the summit area of Doi Inthanond, highest point in Thailand. This composite profile shows the reduced *Schima* dominated aspect, see also Fig. 5. The canopy layer is uniform at 22 m (70 ft) with a sparse second tree layer and there is an approach to the true montane forest which, however is not quite attained in Thailand.

1 = *Schima wallichii*	2 = *Olea*	3 = *Helicia* sp.	4 = *Eurya*
5 = *Lauraceae*	7 = *Pygeum*	8 = *Anneslea*	9 = *Ardisia*
10 = *Pyrenaria*	11 = *Lindera*	12 = *Adinandra*	

Ground herbs included *Impatiens longiloba*, *I. racemosa*, *Elatostemma*, *Ophiopogon*, *Lecanthus*, *Begonia cathcartii*, *Lysimachia ramosa*, *Lobelia nicotaenifolia*, *Ophiorrhiza ripicola*, *Mercurialis leiocarpus*, *Polygonum runcinatum*, *P. molle* and *P. chinense* together with the bulbinous *Liliaceae*, *Disporum coloratum*, *D. pullum* and *Disporopsis* sp., the bamboo *Teinostachys* sp., and the ferns *Athyrium* and *Polystichum*. Large woody lianes are absent but climbing vines of *Smilax china*, *Stephania glabra*, *Streptolirion volubile*, *Jasminum dispermum* and *Clematis* are common. Epiphytes now include a range of filmy ferns of the *Hymenophyllaceae* and representatives of the *Gesneriaceae* such

as *Aeschynanthus garrettii* with bright orange flowers as well as *Loranthus, Agapetes, Vaccinium* and *Rhododendron* species. Small orchids, ferns, bryophytes and lichens also all contribute to the epiphytes.

The soil here is a crumbly red-brown loam some 60 cm. (2 ft) deep, derived from granite and with a pH of just over 5.

On a southern spur just below the summit there is a small open sphagnum moss bog in which there are growing *Hypericum garrettii, H. nepaulensis, Astilbe speciosa, Carex oedorrhampha, C. speciosa, Leersia* sp., *Setaria pallide-fusca, Polygonum chinense, Impatiens racemosa, Gymnostemma pedata, Hydrocotyle javanica, Heracleum siamicum, Viola serpens, V. angkae, Polygala karensium, P. kerrii* and *P. arillata, Rubus ferreus, Sarcopyramis nepalensis, Anaphalis margaritacea, Ainsliaea pteropoda, Gentiana crassa, Botrychium virginianum, Stellaria saxatilis, Xyris pauciflorus, Drosera peltata, Juncus prismatocarpus, Lycopodium clavatum* and the fern, *Plagiogyria* sp. Around the periphery of the bog are gnarled and mossed *Rhododendron delaveyi, R. microphyton* and *R. veitchianum, Vaccinium garrettii, V. sprengelii, Agapetes hosseana,* and *Lyonia ovalifolia,* a species list which here has a distinct montane flavour.

DISCUSSION

There is little doubt that the contour of 1000 m. could be used in Thailand to map out the "hill evergreen forest" or lower montane forest formation, hitherto incorporated with "lowland evergreen forests" in the maps produced to date. For example the shaded area in Fig. 2 represents lower montane forest with the exception of pine forests. These should be separated as subtropical intrusions from the north and are easily delimited by the use of aerial photomapping which may also further define the floristic associations of the lower montane forests. Doi Inthanond is not only important as being the highest peak in Thailand but also apparently lies on the boundary of the tropical-subtropical rainforest phytoclimatic zones but belonging to the first. Hence a tropical lower montane forest formation clothes the mountain to its summit and the tropical montane forest formation

is not represented in Thailand. It is developed only above 2750 m. (9,000 ft) in the tropics as defined in this paper. Allowing for increasing latitudes, i.e. entering the subtropical phytoclimatic zone and for the increasingly large areas occupied by gymnosperm forests (See HUNDLEY 1961), it should be possible to trace these observations into Burma through the adjacent Shan Hills. While higher altitudes attain here, it should be noted that the subtropical formations have a whole new set of altitudinal levels and cannot be directly compared with those of tropical Thailand.

APPENDIX

List of Doi Inthanond Orchids

Acriopsis indica WIGHT. 1000-1300 m., epiphytic in oak & pine forest.
Aerides crassifolium PAR. & RCHB. F. 1300 m. epiphytic in grassy slopes.
Anoectochilus clarkei (HK. F.) SEID. & SMIT. 1400 m. terrestrial.
A. elwesii (C.B. GLARKE) KING & PANTL. 1430 m. terrestrial.
A. grandiflorus LINDL. 1500 m. terrestrial.
A. siamensis SCHLTR. 1500 m. terrestrial.
A. tortus KING & PANTL. 1560 m. terrestrial.
Anthogonium gracile LINDL. 800 m. terrestrial in old clearings.
Armodorum siamense SCHLTR. 1420-1730 m. on trees in evergreen forest.
Bulbophyllum collettii KING & PANTL. 1500 m. epiphytic in evergreen forest.
B. craibianum KERR. 1400 m. epiphytic in evergreen forest.
B. hymenanthum HK. F. 1400 m. epiphytic.
B. refractum RCHB. F. 1420 m. epiphytic in open grassy slopes.
Calanthe biloba LINDL. 1550 m. terrestrial in evergreen forest.
Cheirostylis macrantha SCHLTR. 1400 m. on rocks.
Coelogyne fuscescens LINDL. 1550 m. epiphytic in evergreen forest.
C. huettneriana RCHB. F. Epiphytic in evergreen forest.
C. nitida (ROXB.) HK. F. 2500 m. epiphytic in evergreen forest.
Cymbidium kerrii ROLFE ex DOWNIE. 1560 m. terrestrial in evergreen forest.
Cymbidium grandiflorum GRIFF. 1500-1800 m. epiphytic in evergreen forest.
Cymbidium lowianum RCHB. F. 1300-2000 m. epiphytic in evergreen forest.
Cymbidium macrorhizon LINDL. 1300 m terrestrial in evergreen forest.
Cymbidium simulans ROLFE. 1500 m. epiphytic in evergreen forest.
Cymbidium traceyanum HORT. ex O'BRIEN. 1550 m. epiphytic in evergreen forest.
Dendrobium acinaciforme ROXB. 2100 m. epiphytic in evergreen forest.
Dendrobium bellatulum ROLFE. Epiphytic in oak forest.
Dendrobium binoculare RCHB. F. Epiphytic in mixed deciduous forest.

Dendrobium delacourii GUILL. 700 m. epiphytic in mixed deciduous forest.
Dendrobium devonianum PAXT. 1520 m. epiphytic in evergreen forest.
Dendrobium draconis RCHB. F. 600-700 m. epiphytic in mixed deciduous forest.
Dendrobium eriaeflorum GRIFF. Epiphytic in oak forest.
Dendrobium fimbriatum LINDL. Epiphytic in mixed deciduous forest.
Dendrobium formosum LINDL. Epiphytic in evergreen forest.
Dendrobium scabrilinque LINDL. Epiphytic in oak forest.
Dendrobium sutepense ROLFE ex DOWNIE. 1640 m. epiphytic in oak forest.
Dendrobium thyrsiflorum RCHB. F. 1530 m. epiphytic in evergreen forest.
Dendrobium trigonopus RCHB. F. 1200 m. epiphytic in oak and pine forest.
Dendrobium wattii (HK. F.) RCHB. F. Epiphytic in evergreen forest.
Epipogium roseum (DON.) LINDL. 1580 m. terrestrial in evergreen forest.
Eria dasyphylla PAR. ex RCHB. F. 1300-1500 m. epiphytic in oak forest.
Eria muscicola LINDL. 1500 m. epiphytic in evergreen forest.
Eria pannea LINDL. 1000 m. epiphytic in open oak forest.
Eria pubescens WIGHT. 1430 m. epiphytic in grassy slopes.
Eria spicata (D. DON.) HAND.-MAZZ. Epiphytic in evergreen forest.
Eria stricta LINDL. 1900 m. epiphytic in evergreen forest.
Eria tomentosa (RETZ.) HK. F. 1000-1300 m. epiphytic in open oak forest.
Eria truncata LINDL. 1500 m. epiphytic in evergreen forest.
Eulophia burkei ROLFE ex DOWNIE. 2100 m. terrestrial in evergreen forest.
Galeola kerrii ROLFE ex DOWNIE. Terrestrial in evergreen forest.
Gastrochilus bellinus (RCHB. F.) O. KTZE. 1500 m. epiphytic in evergreen forest.
Goodyera procera HK. F. 700 m. terrestrial in wet locality.
Habenaria acuifera WALL. 1200 m. terrestrial in old clearings.
Habenaria andamanica HK. F. 1390-1430 m. terrestrial in grassy slopes.
Habenaria aurantiaca ROLFE ex DOWNIE. 1100-1200 m. terrestrial in rice field.
Habenaria dentata (SUR.) SCHLTR. 1300 m. terrestrial in grassy slopes.
Habenaria garrettii ROLFE ex DOWNIE. 1100 m. terrestrial in grassy spots.
Habenaria malintana MERR. 2100 m. epiphytic in evergreen forest.
Habenaria siamensis SCHLTR. 1200-2000 m. terrestrial in evergreen forest.
Herminium angustifolium BENTH. 1570 m. terrestrial in open slopes.
Herpysma longicaulis LINDL. 1560 m. terrestrial by stream.
Ione scariosa KING & PANTL. 1300 m. epiphytic in grassy slopes.
Liparis angkae KERR. 2100 m. terrestrial in evergreen forest.
Liparis bootanensis GRIFF. 1900 m. epiphytic in evergreen forest.
Liparis caespitosa (THOU.) LINDL. 1500 m. epiphytic in evergreen forest.
Liparis viridiflora (BL.) LINDL. 1450 m. epiphytic in oak forest.
Malaxis orbicularis W.W.SM. 1660 m. terrestrial in evergreen forest.
Malaxis siamensis (ROLFE ex DOWNIE) SEID. & SMIT. 1770 m. terrestrial in evergreen forest.
Malaxis sp. 2300 m. terrestrial in evergreen forest.

Neogyne gardneriana (LINDL.) RCHB. F. 1560-1590 m. epiphytic in evergreen forest.

Oberonia flava RIDL. Epiphytic in evergreen forest.

Oberonia hosseusii SCHLTR. 2160 m. epiphytic in evergreen forest.

Oberonia iridifolia LINDL. 1600 m. epiphytic in evergreen forest.

Otochilus alba LINDL. 2300-2500 m. epiphytic in evergreen forest.

Ornithochilus fuscus WALL. 1600 m. epiphytic in evergreen forest.

Pachystoma senile (LINDL.) RCHB. F. 1580 m. terrestrial in grassy slopes.

Panisea uniflora LINDL. Epiphytic in evergreen forest.

Paphiopedilum callosum (RCHB. F.) PFITZ. 900 m. terrestrial in wet situation.

Paphiopedilum villosum (LINDL.) PFITZ. 1500-1700 m. epiphytic in evergreen forest.

Phajus tankervilliae (AIT.) BL. 2000 m. terrestrial in evergreen forest.

Pholidota articulata LINDL. 1740 m. epiphytic in evergreen forest.

Pholidota convallariae RCHB. F. & HK. F. 1000-1730 m. epiphytic in oak and evergreen forest.

Pholidota pallida LINDL. 1000-1200 m. epiphytic in oak and evergreen forest.

Pleione maculata LINDL. 1490 m. epiphytic in evergreen forest.

Pleione praecox (SM.) D.DON. 2500 m. epiphytic in evergreen forest.

Polystachya flavescens (BL.) J.J.S. 1500 m. epiphytic in evergreen forest.

Porpax jerdoniana (WIGHT) RCHB. F. Epiphytic in evergreen forest.

Spiranthes lancea (THUNB.) B.B. & S. 750 m. terrestrial in wet situation.

Stereosandra javanica BL. Terrestrial in wet situation.

Tainia viridifusca BENTH. 1600 m. terrestrial in evergreen forest.

Thelasis khasiana HK. F. 1500 m. epiphytic in evergreen forest.

Thunia alba RCHB. F. 1700 m. epiphytic in evergreen forest.

Vanda watsoni ROLFE. 1560 m. epiphytic in evergreen forest.

Zeuxine pumila KING & PANTL. 2320 m. terrestrial in evergreen forest.

REFERENCES

CREDNER, A.S. 1935 : Siam, das Land der Thai.

HUNDLEY, H.G. 1961 : The forest types of Burma. ***Tropical Ecology*** **2**:48-76.

OGAWA, H., K. YODA & T. KIRA 1961 : A preliminary survey of the vegetation of Thailand. ***Nature & Life in South-East Asia*** 1 : 22-157.

PENDELTON, R.L. 1962 : Thailand, aspects of landscape and life. Am. Geogr. Soc. Handbook. New York 1962.

ROYAL FOREST DEPARTMENT 1962 : Types of forests of Thailand. ***Bulletin R 44.***

STERNSTEIN, L. 1962 : The rainfall of Thailand. Mongr. Indianna Univ. Res. Div.

ROBBINS, R.G. 1959 : The use of the profile diagram in rainforest ecology. ***J. Biological Sc.*** (Bombay) **2** : 54-63.

_____. 1964 : The montane habitat in the tropics. Proc. IUCN 9th Tech. Meeting in Nairobi, 1963. ***IUCN Pub. No. 4 n.s.*** 163-171.

_____. & J. WYATT-SMITH 1964 : Forest formations and forest types in the Malayan Peninsular. ***Malayan Forester*** **27** : 188-216.