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PLANTSOCIOLOGICAL ANALYSIS OF MONTANE RAINFOREST NEAR TJIBODAS, WEST JAVA

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INTRODUCTION

The forest reserve on the twin volcanoes Mt Gede and Mt Pangerango, West Java, above the botanical garden Tjibodas, ranging from 1400–2900 m and comprising 1200 hectares, is a classical spot of botanical investigations. During more than a century these mountains have been visited by botanists, visitors as well as members of the staff of the Botanical Gardens at Bogor. REINWARDT, BLUME, KORTHALS, JUNGHUHN, ZOLLINGER and TEYSMANN made here investigations on the flora of Java during the first half of the nineteenth century. A more intensive study of the flora and the biology of plants and animals of this nature reserve started during the time of TREUB, who opened in 1891 a guest house and a laboratory.

The forest between Tjibodas and the waterfalls of Tjibeureum was declared to be a nature reserve (see DOCTERS VAN LEEUWEN 1929). This was extended in 1926 to its present boundaries up to the summits of Gede and Pangerango which were especially studied by DOCTERS VAN LEEUWEN (1933). The reserve should be an entirely untouched forest where no felling of trees should be allowed.

F. W. WENT (1945) called this forest a naturalist's paradise, "one of the best protected, best known and richest mountain forests of the tropics", and he wrote further about it: "A biologist's first impression is bewilderment. The forest seems a complete chaos. It takes a rather long and intimate association with a particular forest before the biologist starts to see some order in the arrangement of trees, shrubs, herbs, and epiphytes: then more general rules begin to emerge".

Tjibodas is thus an ideal place for ecological studies. For a botanical bibliography about Tjibodas see VAN STEENIS and VAN STEENIS–KRUSEMAN (1953).

METHOD OF WORK

The present author paid during his stay at Bogor 1952–1954 many visits to the biological station and nature reserve of Tjibodas with the aim to get such an intimate knowledge of the flora of this nature reserve that plantsociological studies could be started.

New collections for the local herbarium, which was destroyed during the war, could be made with the help of the very able plantcollectors NOERTA, HASSAN and ATTING. KOORDERS' Flora of Tjibodas with some unpublished additions by VAN STEENIS (in the library of Herb. Bogoriense) and BACKER's Beknopte Flora van Java (emergency edition)

made it rather easy to name all collections to the species, and training in the field enabled me to recognize many trees from characters of bark and wood.

A new checklist of the flora (unpublished, copies in Herb. Bogoriense and archives of Flora Malesiana) showed the richness of this flora, comprising more than 900 species of phanerogams of which about 870 species are definitely native.

A method of a quadrate survey of one hectare as described by RICHARDS (1952) was used during the first half of 1955 on Mt Sago near Pajakumbuh, W. Sumatra in a montane forest between 1000–1200 m altitude. During August of that year it appeared useful to compare this montane forest which was perhaps not quite undisturbed with analogous but untouched forest in West Java. No better place than the Tjibodas forest could be chosen for that.

In companion with Mr M. JACOBS and the mantris NOERTA and HASSAN we selected a sample plot, a quadrate of one hectare between the forest pathes "Djalan Batu gonggang" and "Djalan Pasarian" at some minutes walking from the mountain garden, at about 1450–1500 m altitude, a flat almost horizontal homogenous part of forest situated between two ravines. Only a part of the plot along the western margin is gently sloping, but influence of this could only be noted in the composition of the groundlayers of herbs where we noticed some species which seemed to be absent in other parts of the quadrate. The sample plot is almost undisturbed by human influence. Only in the south-east corner a gap occurs, about 15 × 30 m wide where a big tree had been blown down in a storm and after sawing had been carried out of the forest. The lower vegetation in this gap will be described separately. The corners of the quadrate are permanently indicated with iron plates.

The whole investigation of one hectare took six days. First we made a quantitative survey of the tree flora noting the name and diameter class of every tree with diameter above 10 cm after making a slash into the bark. The sample plot was investigated walking in four stretches and with each stretch a new list was made. After that we investigated in two corners of the sample quadrate two samples of 10 by 10 m in order to analyze the shrub layers, the herb layer and the trees under 10 cm diameter.

Finally the whole quadrate was searched for other species of herbs, shrubs, and young trees. Epiphytes were left out of consideration because they were already investigated by WENT (1940). The number of their species may be estimated at about 100 (phanerogams and ferns). By collecting from WENT's data those referring to epiphytes on tree species growing in this part of forest we get a detailed picture of the epiphytic flora. The results of our survey are represented in tables I to XI.

DISCUSSION OF THE RESULTS

With this survey at hand we may discuss several aspects of the sociology of this type of forest. In the first place we may focus our attention to the total richness with species. Do we get with such a

TABLE I

The distribution of trees in the diameter classes:

diam. class	no diam.	II 10-20 cm	III 21-30	IV 31-40	V 41-50	VI 51-60	VII 61-70	VIII 71-80	IX 81
number of trees . . .		121	44	39	21	16	20	20	3

TABLE II

Local aggregates of trees

List	1	2	3	4	total
Total trees numbered:	61	47	100	80	288
Villebrunnea rubescens	3	3	27	—	
Saurauia pendula	6	2	17	5	
Antidesma tetrandrum	—	1	—	8	
Viburnum sambucinum	—	—	—	4	
Macropanax dispersum	2	1	—	8	
Ehretia javanica	—	2	2	—	

TABLE III

The tree number/tree species relation (see also Fig. 1).

List	1	2	3	4	total
Total trees numbered in each list . .	61	47	100	80	288
Number of species in first list. . . .	29				29
Number of species added with		14			43
further listing			6		49
				10	59

survey a representative picture of this kind of forest? Which part of the total inventory of the montane forest at this height of the mountain is represented in this survey? Then we may try to get a picture of the structure, the complexity of the forest and the regeneration.

TOTAL INVENTORY OF SPECIES

The area under investigation contains totally about 333 species of phanerogams and ferns. Among these are 78 species of trees, 40 species of shrubs, 30 of climbers, 10 of creepers, about 100 of epiphytes, and 73 of soil herbs, that is one third of the whole flora of the nature reserve which, according to our records, amounts to about 870 phanerogams and about 150 ferns and fern allies. Only 59 species of trees reach a diameter of 10 cm or more at breastheight. Thirteen species of trees able to reach diameters greater than 10 cm were only found as young trees, while six species never reach a diameter of 10 cm (Table V).

Some of these, like species of *Dysoxylum*, are more frequent in parts of the forest at lower altitude on the mountain. *Dysoxylum* rarely occurs higher than 1500 m altitude. *Podocarpus imbricata* does not play a great role in the forest near the garden, this tree being more numerous higher up the mountain. Species which "escaped" our survey and which occur in the same type of forest are nine in number: *Acronodia*

TABLE IV

Number of trees in the diameter classes

class diameter cm	II 10-20	III 21-30	total
Saurauia reinwardtiana	2		2
Eugenia laxiflora	2		2
Itea maxeophylla	3		3
Elaeocarpus pierrei	1		1
Tarenna spec.	2		2
Antidesma tetrandum	9		9
Laportea stimulans	3		3
Cestrum aurantiacum	1		1
Viburnum lutescens	1		1
Polyosma cf. integerrimum	1		1
Wendlandia glabrata	2		2
Acer niveum	2		2
Villebrunnea rubescens	32	1	33
Glochidion cyrtostylum	2	3	5
Acronychia laurifolia		1	1
Ficus ribes	7	2	9
Symplocos costata	1	2	3
Flacourtia rukam	1	1	2
Neolitsea cassiaefolia		1	1
Pygeum latifolium		1	1
Saurauia bracteosa		1	1
„ blumeana		1	1
Eurya cf. glabra		2	2
Turpinia pomifera	2	1	3
Viburnum sambucinum	4	1	5
Lindera polyantha		1	1

TABEL IV *(continuation)*

Number of trees in the diameter classes

class diameter	II cm 10-20	III 21-30	IV 31-40	V 41-50	total
Saurauia pendula	23	6	1		30
Eugenia densiflora			2		2
„ clavimyrtus			1		1
Symplocos fasciculata	1		1		2
Phoebe spec.			1		1
Casearia coriacea			1		1
Ficus alba		2	1		3
Neonauclea obtusa			1		1
Ostodes paniculata	5	5		1	11
Vernonia arborea	1	1	1	1	4
Macropanax dispersum	8	—	2	1	11
Litsea mappacea			1		1
Mischocarpus frutescens			2		2
Quercus (coll. 28)			1		1
Litsea resinosa				1	1
Helicia javanica				1	1
Eugenia operculata		1	1	1	3

TABLE IV *(continuation)*
Number of trees in the diameter classes

class diameter cm	II 10-20	III 21-30	IV 31-40	V 41-50	VI 51-60	VII 61-70	VIII 71-80	IX 81-130	total
Pygeum parvifolium					1				1
Eugenia tenuicuspis		1			1				2
Quercus teysmanniana						1			1
Ficus variegata	1			1		1			3
Quercus pseudomolucca			3	2	1	1			7
Castanea argentea		5	6	4	5	4	1		25
„ javanica		1	1	1	—	1	2	1	7
„ tunggurut			1	1			1	3	6
Quercus induta	1					1		1	3
Ilex pleiobrachiata							1		1
Manglietia glauca							1		1
Ehretia javanica						3		1	4
Machilus rimosa	2	1	3	3	1		1		11
Schima wallichii			1	2	1	3	1	3	11
Altingia excelsa	1	2	7	1	5	5	2	3	26
Engelhardtia spicata								1	1
	121	44	39	21	15	20	10	13	283

punctata, *Litsea angulata*, *Litsea mappacea*, *Litsea noronhae*, *Glochidion macrocarpon*, *Neolitsea javanica*, *Sloanea zigun*, *Toona sureni* and *Ficus involucrata*. The three last mentioned species are rare at 1500 m as they reach their upper limit about this altitude. This makes a total list of about 87 species of trees in the forest between 1400 and 1500 m altitude. The bulk of this flora is thus represented within a sample plot of one hectare. The sample may serve as a qualitative one, fairly representative for the forest at this altitude (fig. 1 and Table III). If we take into consideration that KOORDERS' flora of 1914 contained 165 species of trees (among 575 phanerogams) and the total number of trees represented in our checklist of Tjibodas is about 172 (among about 870 of native not introduced phanerogams) we may assume that about half of the tree flora of the Mount Gede is represented in our survey.

Along the road to Air Panas (2000 m) the forest changes gradually in composition. *Schima* becomes more abundant. *Altingia* disappears at about 1700 m. Several species occur above 2000 m altitude which are absent at lower levels: *Quercus pallida*, *Castanea (Castanopsis) acuminatissima*, *Polyosma ilicifolia*, *Weinmannia blumei*, *Rapanea avenis*, *Elaeocarpus acronodia*, *Leptospermum flavescens*, *Eurya acuminata*, *Podocarpus neriifolia*, *Podocarpus amara*, *Acer niveum*, *Albizzia lophantha* and higher up several arboreus species of *Vaccinium* (DOCTERS VAN LEEUWEN 1933, MEIJER 1954).

HOMOGENITY OF THE SAMPLE PLOT

VAN STEENIS (1958) pointed to spot-wise regeneration in rainforest as was earlier described by KRAMER (1926) in a study of natural regeneration of montane forest in W. Java. The result of regeneration

in large gaps in the forest should be a group or aggregate of individuals of one species by mere chance regeneration thus causing "local" dominance. Though this phenomenon may occur I think that it is rather overestimated and means no objection to apply "temperate" methods of analysis to tropical vegetation types as VAN STEENIS suggested.

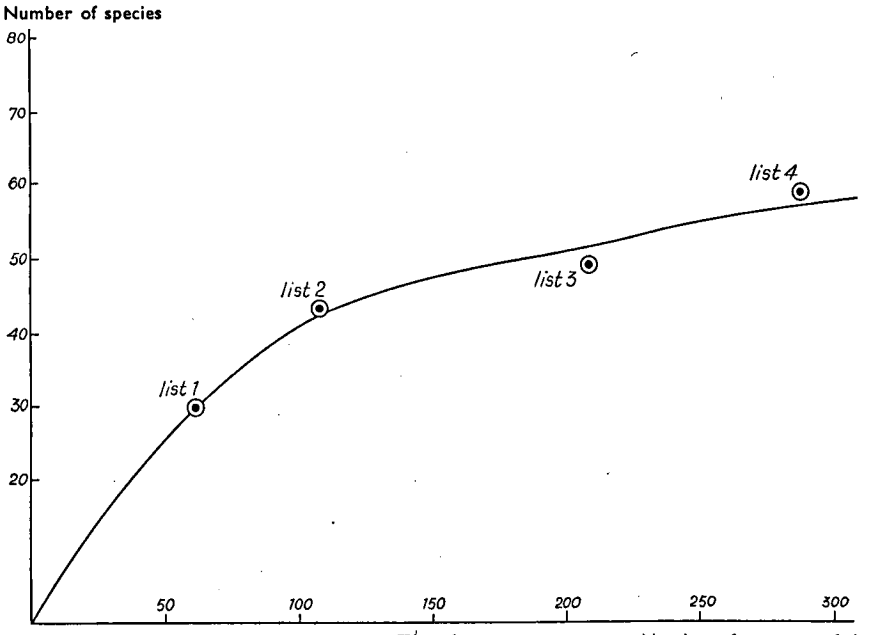

Fig. 1.

Within our sample plot some low storey trees showed gregarious occurrence. Theoretically it may be possible that such aggregates among the high storey trees escape surveys of only 1 hectare. That remains a point for future investigations.

Table II gives an impression how in certain stretches of forest within one hectare some species of trees were more frequent than others. We noted that *Macropanax dispersum* occurred especially in the south-west part of the quadrate and *Ehretia javanica* in the eastern part. *Villebrunnea rubescens* was the most frequent in the centre as well as *Saurauia pendula*. *Viburnum sambucinum* occurred in the western part. Among these species only *Ehretia* belongs to the higher storey trees. Young trees of this species were not noted within the quadrate. The other species are all lower storey trees. The same phenomenon of local gatherings was noted in the forest on Mt Sago and on Mt Kerinchi. Chance factors and the way of distribution of the species may play a part in this and local gaps always occur here and there in the forest after storms have blown down old heavy trees.

The average species composition is not so much affected by this

TABLE V

Treelets of diameter below 10 cm, occurring among the shrub layers.

A. Treelets belonging to the lowest diam. class (0–10 cm)

Talauma candolleana	Allophyllus cobbe
Orophea hexandra	Polyalthia
Glochidion rubrum	Pithecellobium montanum

B. Young trees of species which are outside the quadrate represented in the higher classes:

Hypobathrum	Cryptocarya tomentosa
Litsea tomentosa	Podocarpus imbricata
Pyrenaria serrata	Endiandra javanica
Decaspermum fruticosum	Michelia montana
Dysoxylum excelsum	Alangium rotundifolium
,, nutans	Macaranga rhizinoides
,, alliaceum	(in forest gap)

TABLE VI

The frequency of the tree species, demonstrated by the number of species represented by 1, 2–5, . . . individuals.

	number of individuals					
	1	2–5	6–10	11–20	21–30	31–40
number of species	23	26	4	4	3	1

TABLE VII

The shrub layer

A. *Treeferns, palms, bamboos and bananas*

Cyathea latebrosa	Pandanus furcatus
,, cf. junghuhniana	Pinanga cf. javanica
Gigantochloa apus	,, kuhlii
Musa acuminata	

B. *Real shrubs*

Ardisia fuliginosa	Leea indica
,, vestita	Maoutia diversifolia
Brassaiopsis glomerulata	Melastoma setigerum
Breynia laevigata	Mussaenda frondosa
Claoxylon glabrifolium	Mycetia lateriflora
Clerodendron disparifolium	Olea javanica
Dichroa febrifuga	Piper nigrescens
Evonymus javanica	Psychotria divergens
Ficus cuspidata	Rapania spec
,, cf. laevis	Rubus elongatus
,, montana	,, fraxinifolius
,, pisifera	,, moluccanus
,, cf. tricolor	Saprosma dichotomum
Lasianthus bracteolatus	Schefflera rigida
,, glaber	Trevesia sundaica
,, purpureus	Urophyllum corymbosum
,, cf. stercorarius	

Most prominent: members of *Araliaceae*, *Rubiaceae*, *Ardisia* and *Rubus*.
Total number: 40.
Two species *(Ficus pisifera* and *Schefflera rigida)* occur also as strangler and one *(F. laevis)* as a climber.

phenomenon in case we make our samplings at least 1 ha, or about 1,5 ha as suggested by RICHARDS (1952).

THE COMPLEXITY OF THE FOREST

This is illustrated by the high number of species in comparison with the number of their individuals, the frequency of the species, the number of different life forms sometimes even within one genus, for example in the genus *Ficus*, and by the stratification of the forest. Among 285 trees with diameters above 10 cm, 59 species occur.

Table IV gives an impression of the frequency of trees in different layers.

One species, *Villebrunnea rubescens*, is with 33 trees (11 %) the most frequent tree in this forest. It is a low storey tree, with diameters below 20 cm and according to BAAS BECKING (1948) never higher than 20 m.

TABLE VIII

Woody climbers	
Calamus spec	Plectocomia elongata
Celastrus hindsii	Psychotria sarmentosa
Daemonorops spec.	Sageratia ramosa
Dissochaeta bibracteatum	Tetrastigma dichotomum
Elaeagnus latifolia	,, cf. glabratum
Embelia coriacea	,, papillosa
,, ribes	Toddalia asiatica
,, viridifolia	Tournefortia tetrandra
(Ficus laevis) [1]	Uncaria spec.
Kadsura scandens	Urceolaria javanica
Luvunga eleutherandra	

[1] Species already mentioned in other life-form class.

TABLE IX

Non-woody climbers	
Cissus vitigenea	Smilax celebica
Clematis leschenaultii	,, macrocarpa
Melodinus spec.	Stephania capitata
Passiflora spec.	Trichosanthes palmata
Rubia cordifolia	
Stranglers	
Fagraea obvata	Schefflera rigida [1]
Ficus pisifera [1]	
Woody creepers	
Conocephalus suaveolens	Piper spec
Ficus disticha	Randia corymbosa
Piper baccata	
Non-woody creepers	
Agalmyla parasitica	Rhaphidophora silvestris
Ficus spec.	Scindapsus hederaceus
Freycinetia insignis	
Hemi-parasite	
Scurrula korthalsii	

[1] Already mentioned in the shrublayer.

TABLE X
The herb layer

A. *Ferns* (det. teste Prof. Dr. R. E. HOLTTUM)

Angiopteris evecta
Asplenium belangeri
„ cf. caudatum
„ robustum
Athyrium boryanum
Cyclosorus callosus
„ heterocarpus
„ megaphyllus
Diplazium bantamense
„ pallidum
Diplazium repandum
„ spec.
Dryopteris hirtipes
Lindsaya spec.
Marattia sambucina
Microlepia spec.
Nephrolepis acuminata
Polypodium persicifolium
Pteris spec.
Selaginella cf. opaca

B. *High herb layer*

Amomum coccineum
„ hochreuteneri
Blumea balsamifera
Coleus galeatus
Lycianthus laevis
Polygala venenosa
Strobilanthes cernuus
Zingiber odoriferum

C. *Lower herb layer*

Achyranthus spec.
Anotis hirsuta
Argostemma montana
Begonia robusta
Carex baccans
„ cf. neoguinensis
Commelina cf. obliqua
Corymborchis veratrifolia
Curculigo spec.
Cyrtandra arborescens
„ cuneata
„ picta
„ sandei
Cystorchis aphylla
Desmodium scalpe
„ spec.
Dianella montana
Disporum chinense
Elatostema cuneatum
„ macrophyllum
Elatostema sesquifolium
Eupatorium riparium
Forrestia glabrata
Impatiens platypetala
Medinilla cf. verrucosa
Ophiopogon caulescens
Ophiorrhiza cf. sanguinea
Oplismenus compositus
Paraphlomis oblongifolia
Peperomia laevifolia
Peristrophe bivalvis
Pilea angulata
Polygonum chinense
Pratia nummularoides
Procris frutescens
Sanicula europaea
Schismatoglottis spec.
Scleria spec.
Tropidia curculigoides

D. *Herbs* noted only in *forest gap*

Adenostemma macrophyllum
Eupatorium pallescens
Gynura crepidioides
Gynura sarmentosa
Pilea smilacifolia
Solanum ferox

Dominance in the herb layer

The dominant species in the higher herb layer is *Strobilanthes cernuus* (locally) while *Coleus galeatus* is rather frequent. Abundant in the lower herb layer are: *Cyrtandra picta, C. arborescens*, species of *Cyclosorus* and *Elatostema sesquifolium.*

The next frequent species are *Saurauia pendula* with 30 trees (max. height 20 m), *Castanea argentea* 25 trees (max. height 45,5 m), and *Altingia excelsa* 26 trees (max. height 60 m). Less frequent (between 11–20 individuals) are *Macropanax dispersum* (11 trees, max. height 33 m), *Ostodes paniculatum* (11 trees, most common in the lower storeys), *Machilus rimosa* (11 trees, max. height 31,5–40 m), and *Schima wallichii*

(11 ex., max height 43,5 m). In the frequency class of 6–10 occur in the lower storeys: *Antidesma tetrandrum* (9 trees), *Ficus ribes* (9 trees), and, in the medium storeys *Castanea tunggurut* (6 trees, max. height 43 m) and *Castanea javanica* (7 trees, max. height 58 m).

Fifteen species of trees occur in the diameter classes below 41 cm. They would not be taken into consideration by the sampling methods of the indonesian forest service in which only trees with diameters above 40 cm are included.

It is quite logical that stratification of the forest goes generally parallel with the diameter classes but every forester knows that each tree species has its own mode of growth and that we are not allowed to assume that two trees of different species with the same diameter possess the same height. From the measurements made by BAAS BECKING (1948) it appears that for example *Machilus rimosa* and *Engelhardtia spicata*, trees with maximal diameters between 70–90 cm, are generally shorter than trees of *Altingia excelsa* of the same diameter while at the other side trees like *Ilex pleiobrachiata*, *Acronychia laurifolia* and *Helicia serrata* possess a relative small diameter with a great height. We may thus distinguish 'plump' and 'tall' trees.

Altingia is the highest tree in this forest, the highest measuring according to BAAS BECKING (1948) 62 m. It is an emergent tree. (Fig. 2). Next comes *Castanea javanica* (58 m). Below this reach till about 45 m the rather frequent *Castanea argentea* and *Schima wallichii* and the less frequent *Quercus induta*, *Quercus pseudomoluccana* and the here rather rare *Engelhardtia spicata*.

Below this we meet between 20–40 m rather sparingly *Macropanax dispersum* and *Ostodes paniculata* and less frequently species of *Eugenia*, *Symplocos*, *Lauraceae*, *Ficus ribes*, *Ficus alba*, *Flacourtia rukam*, *Casearia*, *Vernonia arborea*, and very sparingly several other species.

These trees are generally low enough to name them with Field glasses on characters of leaves and phyllotaxy or to climb them in case of doubt. The higher trees have to be known by their bark and slash characters, species of the genus *Quercus* with its fissures of bark rays on its cambium, *Castanea* with a violet flush on its freshly cut cambium, *Schima* with a reddish inner bark with white needle-like fibers and a

TABLE XI

Total species in the life form classes

	number of species
trees	78
shrubs	40
woody climbers	20
non-woody climbers	10
stranglers	1
creepers	10
semi-parasites	1
soil herbs	73
epiphytes (WENT 1940) ca	100
total	333

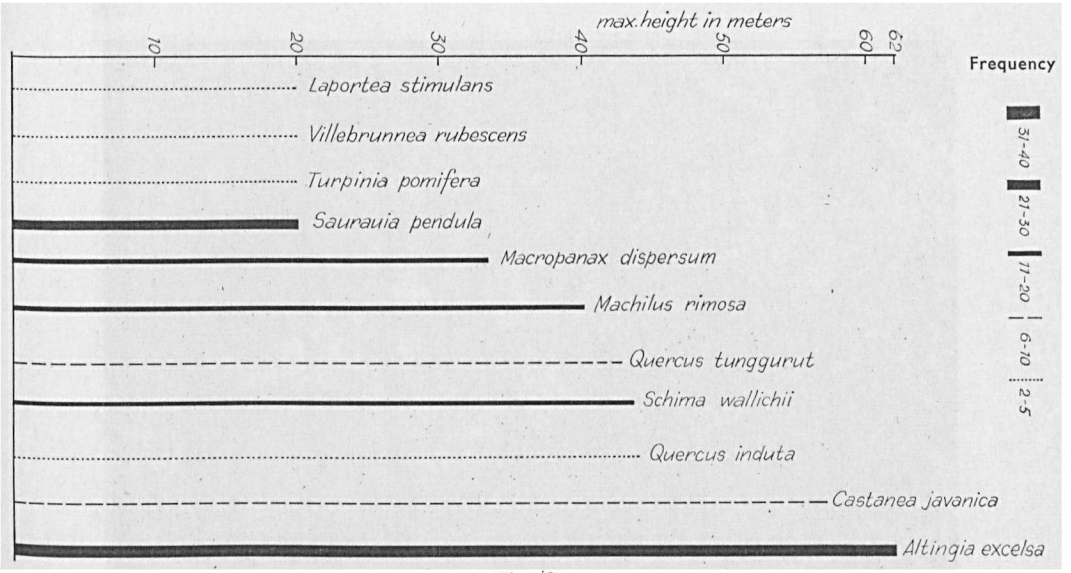

Fig. 2.

very rough fissured outer bark, *Altingia* with rather smooth scale-like bark and a distinct smell.

In forest gaps we get an impression of the stratification. In the gap in our quadrate as seen from the East we note in the foreground some treelets of *Villebrunnea*, *Saurauia pendula*, *Symplocos fasciculata* and *Ostodes paniculata* together with a young *Quercus*. Rising above this lowest storey we note a single tree of *Pygeum parvifolium* only once noticed in the whole quadrate and one of *Ehretia* of which only four occur in our hectare. Higher up in the centre we see the rather ragged crown of an old *Quercus induta*, a tree which may reach heights of 44 m, overgrown with the woody climbers *Embelia ribes*, *Randia corymbosa* and a species of *Tetrastigma*. In the background we see high trees of *Castanea argentea*. Emerging above this forest are several pillars of *Altingia excelsa*.

Fig. 2 gives an impression of the relative height of the trees and their frequency.

Rejuvenation of the forest

Our analysis gives the impression that almost all tree species noted in our survey are still rejuvenating themselves (see Table IV). Helped by the keen eyes of our local tree namers it was possible to find young plants of practically every tree species in the herb and shrub layer. A superficial first investigation of this forest would suggest that several trees occur only at the adult stage but after a thorough investigation we find very dispersed seedlings and young trees. Not a single species however has been noted with abundant seedlings. Our detailed surveys gave the following lists of young trees:

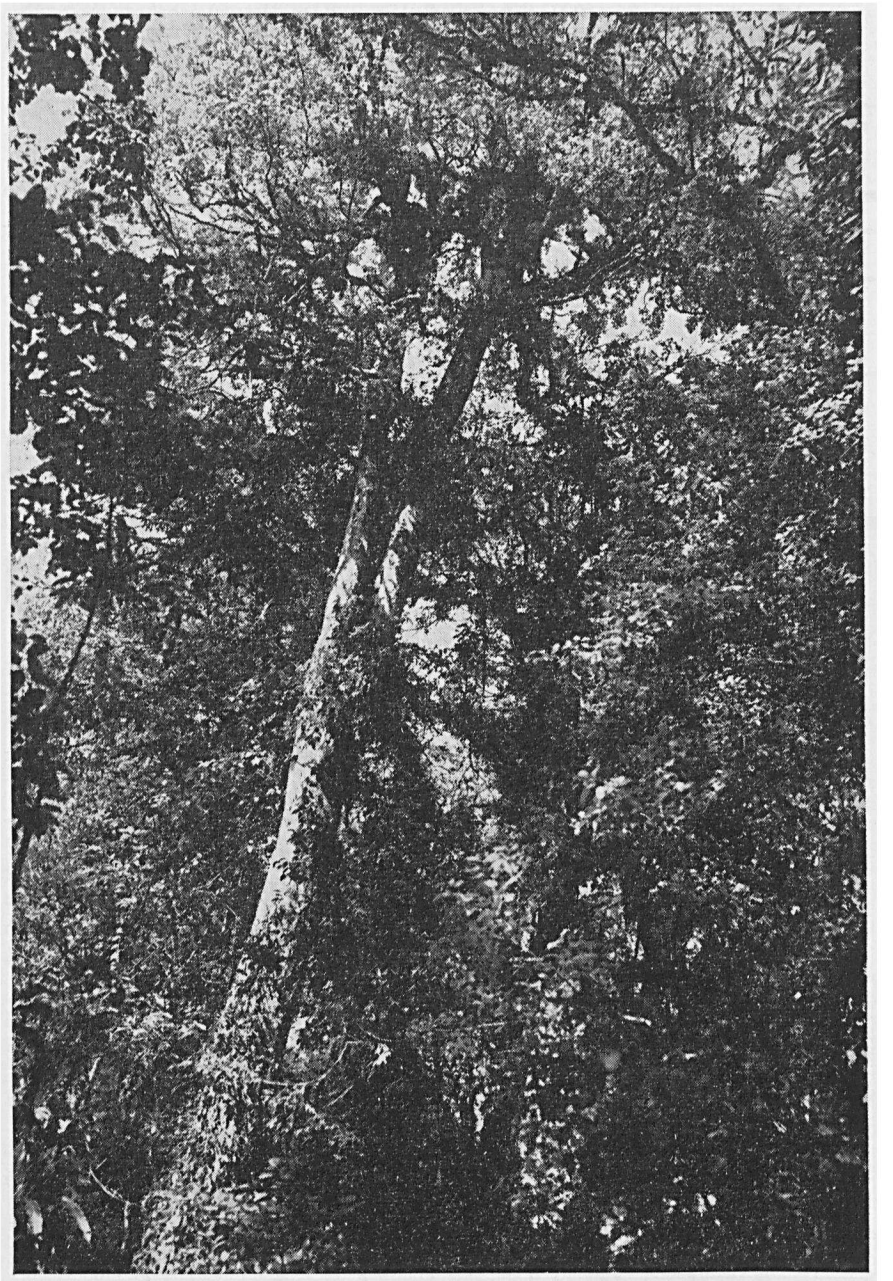

Fig. 3.
Altingia excelsa in the Tribolas Fosen (1450 m. altitude).

Plot 1

Litsea mappacea	0.5	m	height
Castanea javanica	0.5	,,	,,
Wendlandia glabrata	2.5	,,	,,
Olea javanica	1	,,	,,
Ficus cuspidata	2	,,	,,
Litsea tomentosa	2	,,	,,
Castanea argentea	3.5	,,	,,
Quercus spec.	2	m	height
Pyrenaria serrata	3	,,	,,
Symplocos fasciculata	1.5	,,	,,
Quercus induta	2	,,	,,
Glochidion cyrtostylum	2	,,	,,
Viburnum lutescens	4	,,	,,
Ficus pisifera	2	,,	,,
Turpinia pomifera	2	,,	,,

Plot 2

Symplocos costata	2	m	height
Mischocarpus	3	,,	,,
Villebrunnea	2	,,	,,
Eugenia densiflora	0.5	,,	,,
Macropanax dispersum	2	,,	,,
Pyrenaria serrata	1	m	height
Saurauia pendula	2	,,	,,
Ficus cuspidata	2	,,	,,
Castanea tunggurut	1	,,	,,
Vernonia arborea	2	,,	,,

Outside these 10 × 10 m sample plots the following young trees were noted:

Altingia excelsa	1	m	height
,, ,,	0.03	,,	,,
Schima wallichii	0.5	,,	,,
Casearia coriacea	1	,,	,,
Helicia serrata	1	m	height
Podocarpus imbricatus	0.05	,,	,,
Glochidion rubrum	2	,,	,,
Dysoxylum alliaceum	2	,,	,,

From the studies made by KRAMER (1926) on the forest rejuvenation of Mt. Gede outside the nature reserve we may conclude that seedlings and young trees develop much more numerously when gaps occur in the forest. Moreover species of *Strobilanthus*, *Zingiberaceae*, *Cyrtandra* and *Elatostema* get a better chance to form dense vegetations. When these gaps become big, however, tree species typical for secondary forests become dominant. The only distinct example of such a tree in our sample is *Macaranga rhizinoides* in the above mentioned forest gap. The biggest changes after tree felling occur in the herb layers where species like *Gynura crepidioides*, *G. sarmentosa*, *Eupatorium pallescens*, *Adenostemma macrophyllum* and *Blumea balsamifera* become abundant (Table X). Such vegetations are possibly to be compared with "Hochstaudenflur" of temperate forest gaps. The occurrence of these species possibly depends not only on a change in the light factor but also on microbiological activities in the soil connected with greater humus decomposition. Concurrency for young trees seems to be difficult in cases where a dense "secondary" herb layer is developed.

AGE, DEGRADATION AND RENEWED SUCCESSION

As a result of tree measuring executed by KOORDERS (1914), BRUGGEMAN (1927) and BAAS BECKING (1948) extending over a period of 34 years, BAAS BECKING (1948) estimates the maximum age of trees in the Tjibodas forest to be between 200–250 years, the mean average of the measured trees 130 years, the mortality 0,77–0,83 % in each year. The last figure is important in order to know how much "harvest" such a forest can stand without almost any change in composition when only fallen trees or quite dispersed very old trees are removed.

When indiscriminate exploitation takes place the growth of the young tree generations is accelerated and accordingly the opportunity for a

greater harvest (KRAMER 1926); when the exploitation is carried out according to a wise policy of very dispersed tree felling the forest structure is left intact.

In the case of a harvest which is too big the rejuvenation is hampered and the quality of the forest decreases because its character is changing into the direction of secondary forest with many tree species with very soft wood. A detailed understanding of these processes are highly useful in forestry practice. A long experience with tree species and forest composition is necessary before a forester is able to handle the forest in the wisest way possible.

ECOLOGICAL REMARKS

The ecological character of the forest in this sample plot appears most clearly from a study of the spectrum of the life forms (Table XI). This montane forest has a cool wet climate with average temperature 17.7° C (extremes 12–27° C), rainfall 3400 mm, relative humidity 80–90 % [1]) and a maximal dry period of three weeks (WENT 1940). This climate is reflected by the rich development of epiphytes, the relative poorness of woody climbers and the rich vegetation of soil herbs. Lowland rain forests are known for their poor terrestrial flora and the lack of a well developed humus layer (MOHR and VAN BAREN 1954), epiphytes are generally also less luxuriently represented in the lowlands, except near rivers. The soil in our sample plot is formed by the deposits of the volcano, Mt. Gede. A soil profile showed us that the layers which are rich in humus reach a depth of about 20–30 cm and that the hard rocks lay at about 70–80 cm below the surface.

Several soil herbs like members of the genera *Cyrtandra*, *Elatostema*, *Begonia* and *Strobilanthes* (sensu lato) which are rather abundant in our sample plot may be considered indicators of a rich soil, not deficient of mineral salts. To my experience in forests in Borneo and Sumatra they are always lacking on poor sandy acid soils, and less abundant on old or originally more acid than on young rich volcanic soils.

SUMMARY

After three years of continued botanical study of the flora in the nature reserve of Tjibodas, Mt. Gede, W. Java it appeared technically possible to make a total inventary of a homogenous part of the mountain forest at about 1500 m. altitude in which all trees with diameters above 10 cm at breathheight were named and counted. It appeared that such an intensive study of a relative small part of the forest of Mt Gede comprises the bulk (about three quarter) of the flora of the montane region (1400–1700 m. alt.). The higher layers of the forest are chiefly composed by oaks, chestnuts, *Altingia* and *Schima* while especially *Lauraceae* and species of *Eugenia* come to the fore in the lower storeys. Half of the tree species represented in the sample plot occurred only once. About 13 tree species were only found in juvenile state. The more common species are represented by younger stages in all size (age) classes. Some species show local gatherings which possibly depend on their way of distribution. The total inventary of the flora on one hectare comprises about 333 species of phanerogams and ferns, including 78 species of trees,

[1]) My own measurements on 2 August 1955 were 10 a.m. in halfshade in forest: temperature 17° C, relative humidity 90 %, during one day and night in rest house max. temp. 27° C – min. 13° C.

40 species of shrubs, 73 species of soil herbs and about 100 species of epiphytes. The latter groups especially reflect the montane character of this forest and among the soil herbs occur species which might be considered as indicators of the fertility.

The study must be considered as a first attempt to apply modern methods of plantsociological analysis in the mountain forests of Java.

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