# BOTANICAL EXPLORATION IN THE DOMA PEAKS REGION, NEW GUINEA

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CONTENTS



## 1. INTRODUCTION

The present paper is a report on an expedition held in 1966 and sponsored by the Netherlands Foundation for the Advancement of Tropical Research WOTRO (grant nr. W 929/16). It was a joint undertaking of the Rijksherbarium, Leiden, Netherlands, and the Division of Botany, Department of Forests, Lae, Territory of Papua and New Guinea.

Members of the expedition were the authors of the present paper, and from the Division of Botany Mr A. N. Gillison (during the first part), Mr D. G. Frodin (during the last part), and Mr J. Kaibua (during the whole expedition).

Labourers and carriers were hired from Tigibi, local food could in sufficient quantity be bought from this settlement and from the villages along the Benaria River.

Fig. 1 shows the general situation of the region: east of Tari, in the Southern Highlands District, Territory of Papua and New Guinea.

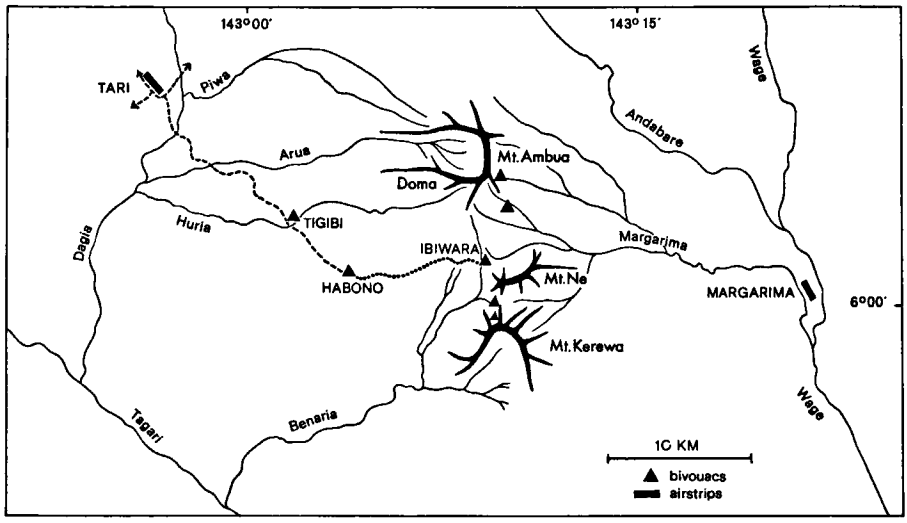


Fig. 1. Map of the Doma Peaks region.

In the title of this paper the area visited is called the 'Doma Peaks region'. The name 'Doma Peaks' is on many maps attached to the mountain that by the local people is called Ambua. The name Doma does exist; however, it does not refer to the whole mountain but to one of the spurs of the horse-shoe-shaped complex.

In some of the older maps Mt Ambua is indicated as 'Mt Rentoul', a name the origin of which we were unable to trace. In the maps in Glasse (1968) the same mountain is called Humphries Range.

Hides was the first explorer to visit this area during a long patrol in the year 1935. His route through the area discussed here, as reconstructed by us from comparison of his description and photograph (Hides, 1936) is shown in map.

The name he used for Mt Kerewa is 'Mt Champion', a name that can be found on many older maps but that has disappeared from the modern ones. The 'Wagi Pass', of which Hides gives such a hair-raising description (l.c., p. 107—109), is the saddle between Mts Kerewa and Ne.

In this report we will, occasionally, use the term Doma Peaks region for the whole of the area visited, but we will call the mountains by their real, local names: Mt Ambua, Mt Kerewa, and Mt Ne. The present notation is in accordance with the second edition of the Australian Geographical Series 1 : 1.000.000, sheet Fly River, SB-54 (1965).

## 2. ITINERARY, BIVOUACS

On the 13th of May, 1966, Kalkman and Vink arrived from Holland at Lae. Together with Gillison and Kaibua they left this town again on May 20th, and after some delay at

Mount Hagen they proceeded to Tari on the 25th of May, and from there to Tigibi on the 27th.

Tigibi lies on the vehicular road which eventually will be the connection between Tari and Margarima, but which at that time ended at about an hours' walking distance from Tigibi near a place called Habono.

The expedition's basecamp (Ibiwara Bivouac, alt. 2700 m) was built in the plain which has Mt Kerewa and Mt Ne on its southern side and Mt Ambua towards the north. For convenience sake this plain will be called 'Ibiwara Plain', although the local name Ibiwara refers only to the place of the Bivouac and the brooklet in its vicinity.

During the transportation of the equipment from Lae to Tari a large part of it got temporarily lost at Mount Hagen. Consequently the collecting work did not proceed very well in the beginning, due to lack of paper and other indispensable equipment.

Because of these difficulties Vink stayed for some time at Tigibi and it was not before June 16th that the whole party was present in Ibiwara Bivouac.

On June 29th (Kalkman, Gillison) and July 1st (Vink, Kaibua) we moved to a camp (Bamboo Bivouac, alt. 2970 m) on the northern slope of Mt Kerewa. For Gillison these were the last days of the expedition; he returned to Lae on July 3rd.

It proved to be impossible to find a suitable camping place higher up on Mt Kerewa and a temporary camp (Kerewa Bivouac, alt. 3365 m) had to be abandoned again after three nights (Juli 2nd—5th). Further investigation of Mt Kerewa, and that of the southern slope of Mt Ne, was conducted from Bamboo Bivouac. This lasted till July 14th (Vink, Kaibua) and 15th (Kalkman), when we returned to Ibiwara Bivouac.

On July 24th Frodin arrived there too and then we set out to work on Mt Ambua. July 27th Frodin went with Kaibua to Lei Bivouac (alt. 2800 m), set up at the bank of Lei River, a tributary of the Margarima. Kalkman and Vink went (July 25 th, resp. 27 th) to a camp higher on Mt Ambua, Ambua Bivouac (alt. 3280 m). The next shift came on August 17th, when Kalkman and Vink came to Lei Bivouac for a closer investigation of the *Nothofagus* forest, and Frodin and Kaibua moved (via Ibiwara) to Habono Bivouac at the end of the vehicular road.

The exploration came to its close at the end of August (25th Kalkman and Vink to Ibiwara, 29th to Tigibi, 31th Frodin and Kaibua also to Tigibi, whole party back at Tari on Sept. 2nd).

The Ibiwara Plain, and also the northern slope of Mt Ne were investigated during the periods we were living in Ibiwara Bivouac.

After the exploration of this part of the Southern Highlands, Kalkman, Vink, and Frodin went to Telefomin in the Western Sepik District. There were two reasons for this 'appendix'. It seemed worthwhile to do, at relatively little additional costs, some work in a region where only little has been collected, and furthermore it could be considered as a sort of reconnaissance trip in view of the desirability to make a larger expedition into this region in future. The trip was, however, not very successful, since it appeared that the botanically rich areas can only be reached during a well-prepared expedition and maybe not even without air support.

## 3. DESCRIPTION OF THE REGION

The Doma Peaks area is included in a report prepared by a C.S.I.R.O. Land Research team (Perry c.s., 1965). In the following we mainly give our own observations, where necessary referring to that report, in which not only a larger area is described, but where

also the data are placed in a wider geological, geomorphological, vegetational, and climatological context.

### a. Geology and geomorphology

Both Mt Ambua and Mt Kerewa are ruins of Pleistocene volcanoes of which the central parts have been subjected to strong erosion. The deposits of these volcanoes form a large coherent area stretching from Tari to the Andabare River, sloping gently towards the east and slightly steeper towards the Tari Basin.

The incision by the drainage system is deeper on the eastern slope than on the western one. The latter is attacked on its northern, western, and southern margins by retrogressive erosion, but its main surface is relatively smooth.

The marginal remnants of Mt Ambua attain their highest elevation (3567 m according to the triangulation records) on the eastern side (photo 11); the western side is lower and cut by the valley of the Arua River which drains the deeply eroded centre of the volcano (photo 13). In this way a horse-shoe-shaped complex is formed. Judging from the size of the crescent and the dip of the layers on the slopes the original mountain could have overtopped the present summit easily by 250 or 300 metres.

The wide opening of the horse-shoe of Mt Kerewa is directed southwestwards, its highest remnants (3555 m) situated on the northern side (photo 15). Mt Ne and the lower mountains east of it form a crescent around the northern side of Mt Kerewa, with its layers apparently dipping away from the latter. This crescent might represent the ruins of an older phase of the system now dominated by Mt Kerewa.

On Mt Ambua a sulphuric smell was observed in a gentle wind rising from the bottom of the eroded volcano centre.

Evidence of glaciation was not found.

Stone samples were collected on Mt Ambua, on Mt Kerewa, and near Ibiwara Bivouac. These were kindly investigated by Mr G. van der Wegen, and he described them as slightly porous, (light) grey andesites, with the following remarks on petrology. The plagioclase of the phenocrysts is zonal and the anorthite content varies approximately from 35 to 55 %. The dark minerals have been recognized as brown hornblende, augite, olivine, and a little biotite. Magnetite is common and much limotite-hematite has been formed by weathering. Sulphidic minerals are hardly present.

In the above-mentioned C.S.I.R.O. report, Perry c.s. classified Mt Ambua, Mt Ne, and Mt Kerewa in their Ialibu land system, but the dissected western part of Mt Ambua and the southern part of Mt Kerewa in the Doma land system. The plain between Mts Ambua and Ne, together with its long gentle eastern and western slopes, falls in the Nemarep land system, interspersed with Dibibi land system for the eastern slope and with Birap land system for the western slope, a.o. Wauwe Hill.

### b. Climate

Climatological data are available for Tari (*c.* 1570 m alt.), but these are of very limited value for the expedition area itself. Tari has an everwet climate (281 rainy days annually, mean annual rainfall 2448 mm), without a distinct dry spell, the driest month (June) having a mean of 142 mm. From the preliminary isohyetal map published by Fitzpatrick (in Perry c.s., 1965) it may be inferred that the mountainous expedition area has an annual rainfall of *c.* 3750 mm. In fact, out of 77 expedition days, 53 had rain, mostly starting between noon and 4 p.m.; 29 days were foggy during early morning or late afternoon and evening; 4 days of our stay at Ambua Bivouac (3280 m alt.) had hail.

The mean annual temperature at Tari is 18.7 °C (mean maximum 24.2°, mean mini-

mum 13.3°), but of course at higher altitudes the temperature is lower. During the expedition only minimum temperatures were recorded, since the measuring of maximums requires provisions we were unable to meet. In fig. 2 the measurements are related to the altitude and compared with records from the Kubor Range (Vink, unpublished).

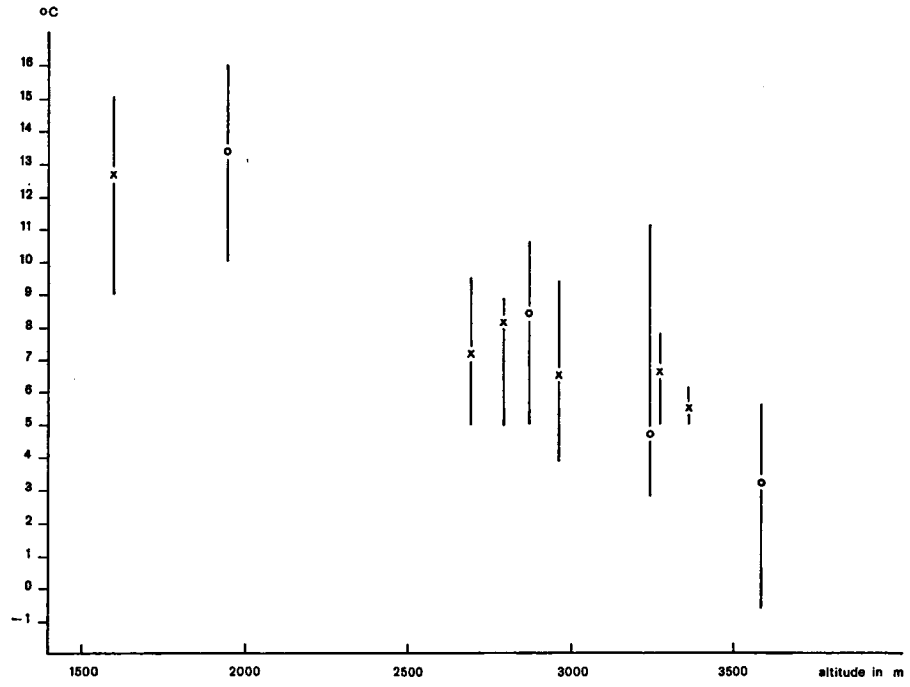


Fig. 2. Means (x, o) and ranges (—) of the minimum temperatures measured in the Doma Peaks region (x) in 1966 and on the Kubor Range (o) in 1963.

It appears that the position of the means for the Kubor Range is much more normal than that for the Doma Peaks region. On one hand this may be due to the smaller number of measurements, on the other hand also to the fact that the localities on the Kubor Range were all situated on one spur, those in the Doma Peaks region on two different mountains and the plain in between.

Neither temperatures below zero at 1 m above ground level, nor frost at ground level were observed in or near the bivouacs we occupied. In the Kubor Range, however, nightly temperature dropped once to —0.6 °C (1 m above ground level, at 3590 m alt.) and frost at ground level was several times observed (once at 3250 m, four times at 3590 m).

### c. Vegetation

As can be seen from photograph 2 and from the map which was prepared on the base of the aerial photographs, the region shows the pattern which is usual in this part of the world: forest alternating with grassland. The former has undergone a stronger or weaker human influence, the latter is here entirely man-made by the old renowned method of repeated burning.

In the following chapters attention will be given to the forest in the plain (i.a. to the *Nothofagus* clumps that are common here), to the forest on the mountain slopes, to the shrubberies and low vegetation above the forest, and to the grassland in the plain.

### d. Population

The actual expedition area is entirely uninhabited, as the altitude is unsuitable for growing sweet potato. However, the plains between the mountains show a dense network of trails connecting the populated Tari Basin and the lower Benaria Valley in the west, and the Margarima area in the east. These trails also give access to the hunting grounds (possums and wallabies) and to the pandanus groves. The latter are natural occurrences, which are in a haphazard way encouraged by clearing the undergrowth during the harvest of the pandanus nuts.

Although, as said above, the expedition area itself is not populated, it may be appropriate to add a few words about the people this land belongs to. This tribe, inhabiting the valleys of the Tagari River and its tributaries, is called the Huli. According to Glasse (1968), there are *c.* 30.000 of them, scattered over an area of almost 2000 sq.km, and mainly concentrated on the basin floor. They are more or less settled sweet-potato-growers, having their own difficulties on the road to westernized civilization, like the lack of paying labour and the reluctance of the older, richer men to give up polygamism.

Three points may briefly be mentioned as qualities that strike the non-anthropologist traveller as peculiar to this group. The large wigs, made of human hair and adorned with a.o. the yellow flowerheads of *Helichrysum bracteatum*, and worn by the men on special occasions (like a farewell party for three botanists!) have from the first contact with these people attracted the attention (see Hides, 1936). All the fantasy they have — and we believe them to be very matter-of-fact people — goes into the wig.

Characteristic is secondly the very subordinate place that the girls and women are referred to. In this aspect there seems to be a worldwide difference between the Huli and e.g. the Kuma people.

The third quality that will always be remembered by anyone who lived with Huli men in one bivouac, is their capacity for endless and almost tuneless chanting at night. Part of the chants are improvisations to record the adventures of the day and we often wanted to be able to understand what they were singing about those 'waitmen bilong Holland ol-i go lukaut long plaua'.

In the neighbourhood of Tari many artifacts (mortars and pestles, sculptings, etc.) have been found buried in the soil. These must be considered to be artifacts made by a population antedating the present one, the Huli certainly not knowing how to make these objects. The Huli tell about a big flood that extinguished the people that made them. That flood — if it really happened — might be the bursting of the western craterwall of Mt Ambua and the emptying of its crater-lake into the Tari Basin, but of course there should be made a thorough geological and archeological investigation before this can be more than a speculation.

## 4. METHODS OF INVENTARISATION

The primary object of the exploration was to collect herbarium specimens, in the first place of the Vascular Plants of the region. To acquire a more differentiated collection and to make possible floristic comparisons, the three mountains visited and the plain between them were treated as separate entities. In each of these entities we aimed at com-

pleteness of collecting. The whole collection from the Doma Peaks region numbers 2086 specimens, of which 716 numbered in the N.G.F. series.

Apart from the collecting, however, we also tried to do some semi-quantitative work. It is evident that profound ecological work on forest types, grassland mosaics, fire-succession, etc., is hardly possible during a short expedition, part of which has to be spent on purely floristic work, and on getting acquainted with the regional flora. Only a high degree of specialisation could make this possible. It is not impossible, however, to give a more quantitative accent to descriptions of some of the vegetation types than is usually done. That is why we made a few line-surveys in the forest, hoping that the picture rising from the figures will be more significant to the reader (significant in a general way, not in any statistical sense) than a verbal description could be.

The delay in arriving of the equipment, mentioned above, did not result in lost working days, because during that time we could start with the survey at Ibiwara.

It goes without saying that only part of the plants could be identified as to species. To facilitate comparison of the floras from different collecting-sites, we sorted our material into 'species' (better: groups of conspecific specimens) and refer to them by letter. The appendix gives a list of all such species mentioned in the present paper, with the pertinent collection numbers.

In addition to the botanical work, some collections of insects, crustaceans, frogs, and fishes were made; these were sent to the Rijksmuseum van Natuurlijke Historie, Leiden (see a.o. Holthuis, 1968). Some freshwater plankton samples were sent to Dr K. Thomasson at Uppsala.

## 5. SUMMARY OF VEGETATION TYPES

In the present paper reference is made to, or a more extensive treatment is given of several types of vegetation. They will be presented in the following order: forests of slopes and plain, shrubberies and forest margins, grasslands in the plain and on the mountains.

For convenience sake the vegetation-types are tabulated once more below, but then grouped in another way.

Saunders, and also Robbins and Pullen, both in Perry c.s. (1965), use a slightly different terminology and classification. As far as appropriate, their terms have been mentioned between brackets.

1. Between *c.* 2650 and 2800 m alt., in the plains.
   a. Mixed forest (Saunders: Lower montane mixed forest and also Mixed-Beech forest; Robbins & Pullen: Lower montane mixed forest). Mainly Dicots with (mostly near the margins) *Pandanus*, and with a low frequency of Conifers. Mono- of bispecific stands may be formed by means of selective cutting.
   b. Coniferous-Mixed forest. As the former but with high frequencies for Conifers. *Libocedrus papuana* often emergent.
   c. *Nothofagus* groves occurring in both of the above-mentioned forest types.
   d. Pyrogenic grasslands, with a wide variation of subtypes.
   e. Forest margins with light-demanding species, many of the latter also occurring above the mossy forest in the scrub.

2. Between *c.* 2800 and 3565 m alt., on mountain-slopes.
   a. Mixed forest (Robbins & Pullen: Lower montane mixed forest; Saunders: ibid.,

also Montane forest). The Conifers with only slightly higher frequencies than in the Mixed forest of the plains (1a). *Weinmannia* often with high frequencies. In its lower parts, where disturbed, with the climbing bamboo *Nastus*. Upslope reduction of number of species. May be pyrogenously degraded.

b. Mossy forest, a mossy aspect of the above-mentioned forest type (Robbins & Pullen: Montane rain forest; Saunders: Montane forest). The location of this zone on the slope and thus its species contents, dictated by local cloud settlement.
c. Scrub above the mossy forest (Saunders: included in the Montane forest). A collection of light-demanding species and forest species able to thrive outside the forest as well. In the higher altitudes with fewer trees of the latter category.
d. Grasslands, with a wide variation of subtypes.
e. Boggy herb-vegetation with cushion-plants (Robbins & Pullen: Alpine peat bogs).

## 6. THE FOREST ON THE MOUNTAIN SLOPES (2800—3365 m alt.)

The forest that covers the mountain slopes has — more or less intensively — been studied on Mts Kerewa, Ne, and Ambua. In the following sections the acquired data will be presented, partly only descriptive, partly also comparative.

### a. Mt Kerewa

Our 'Bamboo Bivouac' was situated near the lower limit of a forest of an undoubtedly secondary nature. It is a low forest with the canopy not closed, the crowntops rarely higher than 15 m. Many dead trees emerge from the forest (photo 10). In the tales of the Tigibi people there remains the memory of a time when there had been so little rain that the crops died. A man (from another village, they say, of course) went hunting on Kerewa, made a fire and could not prevent it from spreading. The result was that 'the whole mountain burned down'. It certainly must have been an extensive and devastating fire.

The composition of the forest was not studied by means of a transect, and the information compiled in the list is not more than an approximation. The very steep and deep valleys to the left and right of the track to the topregion were not studied and the list refers only to the forest on the spur.

The most common species of the forest on Mt Kerewa, near and above Bamboo Bivouac, between *c.* 2900 and 3100 m alt.[1])

Species of the upper tree layer

| | | | |
|---|---|---|---|
| *Act.* | *Saurauia (c)* | *Ochn.* | *Schuurmansia henningsii* |
| *Cun.* | *Weinmannia (a)* | *Pitt.* | *Pittosporum ramiflorum* |
| *Cupr.* | *Libocedrus papuana* | *Pod.* | *Dacrycarpus cinctus* |
| *El.* | *Elaeocarpus (b), (h), (i)* | *Rub.* | *Timonius belensis* |
| | *Sericolea (b)* | *Sax.* | *Quintinia (a)* |
| *Euph.* | *Macaranga (a)* | *Sphen.* | *Sphenostemon arfakensis* |
| *Laur.* | *Cryptocarya minutifolia* | | *S. papuanum* |
| *Myrs.* | *Rapanea (e)* | *Wint.* | *Bubbia (a)* |
| *Myrt.* | *Syzygium ?adelphicum* | | *Drimys piperita ('coriacea')* |
| | *S. vaccinioides* | | |

[1]) Throughout this paper letters between brackets after the genus name replace epithets of unidentified species. See Appendix.

Undergrowth

a) treelets and shrubs

*Act.* *Saurauia (a)*
*Aral.* *Harmsiopanax aculeata*
*Comp.* *Olearia spec.*
*Senecio spec.*
*El.* *Sericolea (c)*
*Sloanea spec.*
*Euph.* *Breynia cernua*
*Claoxylon (a)*
*Glochidion (a)*
*Omalanthus (a)*
*Monim.* *Kibara (a)*
*Mor.* *Streblus urophyllus* var. *salicifolius*
*Myrs.* *Rapanea (a)*
*Myrt.* *Xanthomyrtus papuana*
*Pand.* *Pandanus*
*Pip.* *Piper (b)*
*Pod.* *Podocarpus archboldii* var. *crassiramosus*
*Pter.* *Cyathea aeneifolia*
*Dicksonia hieronymi*
*Rub.* *Amaracarpus (a)*
*Rut.* *Evodia (a)*
*Sympl.* *Symplocos (c)* and *(j)*
*Theac.* *Eurya (a)*

b) straggling, climbing, and epiphytic plants

*Apoc.* *Alyxia spec.*
*Eric.* *Dimorphanthera cornuta* var. *cornuta*
*Good.* *Scaevola oppositifolia*
*Gram.* *Nastus spec.*
*Lyc.* *Lycopodium (d)* and *(g)*
*Myrs.* *Rapanea (f)*
*Pter.* *Gleichenia brassii*
*Ros.* *Rubus ledermannii* var. *ledermannii*
*R. tsiri*

c) herbs

*Halor.* *Gunnera macrophylla*
*Pter.* *Pteris (a)*
*Zing.* *Alpinia (a)* and *(c)*

The tree species which is most dominant is probably *Weinmannia*, but so many other species are common in the upper tree layers that it would be deceiving to describe the forest as a *Weinmannia* forest.

The undergrowth is dense and consists of shrubs and treelets, few herbs, and some climbers among which the omnipresent climbing bamboo *Nastus*. The two *Lycopodiums (d)* and *(g)* are also scrambling plants.

The forest is very rich in epiphytic mosses and must have been a mossy forest like on Mt Ne (see below). Its secondary nature, however, giving the uneven, open canopy, causes it to dry out rapidly when the weather permits. Consequently, from 20 till 25 June it was dripping wet in Bamboo Bivouac, but later on (5—14 August) it became crackling dry.

## b. Mt Ne

Working from Bamboo Bivouac, we could also explore the southern slope of Mt Ne, which is not disturbed by fire like the overlying slope of Mt Kerewa.

At an altitude of *c.* 3140 m one enters above the mixed forest, which is dominated by *Weinmannia*, *Timonius*, and *Quintinia*, a mossy forest of quite typical aspect (photo 20). It is a rather dense and tall forest with thick moss layers covering all stems, branches, and roots, and also the floor (causing many pitfalls). After a few days of rain and low clouds, one can hardly imagine that a forest of this type, 'waterlogged' as it is, could ever be set afire. On the other hand, after a prolonged dry period the thick moss layers must be extremely vulnerable to fire.

In the forest on this slope, a transect was laid of 125 m long and 4 m wide, the long axis of the transect going upslope, and with an altitudinal difference of *c.* 50 m between beginning and end.

In the transect all trees with a diameter of 5 cm or more (breast high) were noted, measured, and identified (if necessary after being cut and collected). An enumeration of the most common tree species is given in table A, the complete list of all species which were seen in the transect can be found in tabel F, at the end of the paper.

The transect started just above the limit of a secondary climbing-bamboo forest, at an

altitude of 3140 m. Going upwards it became rapidly more mossy. The only significant change in composition was the disappearance of *Weinmannia* and *Timonius belensis* (table B). For a further discussion and a comparison with the mossy forest on Mt Ambua, see p. 97.

Table A. The most common tree species in the 500 sq.m transect on Mt Ne (c. 3150 m), divided into diameter classes

| | number of trees 5 cm → | diameter classes | | |
|---|---|---|---|---|
| | | 5–14 cm | 15–24 cm | 25 cm → |
| Sax. Quintinia (a) | 25 | 4 | 15 | 6 |
| Aq. Ilex (a) | 15 | 7 | 7 | 1 |
| Myrs. Rapanea (d) | 14 | 12 | 2 | - |
| Myrt. Syzygium vaccinioides | 12 | 6 | 4 | 2 |
| Myrt. Xanthomyrtus papuana | 11 | 9 | 2 | - |
| El. Elaeocarpus (h) | 7 | - | 6 | 1 |
| El. Sericolea (a) | 7 | 7 | - | - |
| Cun. Weinmannia (a) | 7 | 3 | 3 | 1 |
| Rub. Timonius belensis | 6 | - | 3 | 3 |
| Pter. Dicksonia hieronymi | 11 | 11 | - | - |
| Other species (10 in all) | 16 | 13 | 1 | 2[1]) |

[1]) One Evodia (e) and one dead tree

Table B. Comparison of the lower 200 sq.m and the upper 200 sq.m, the latter distinctly more mossy

| species (see table A for full name) | lower part | | | | upper part | | | |
|---|---|---|---|---|---|---|---|---|
| | diam.classes, cm | | | total 5 → | diam.classes, cm | | | total 5 → |
| | 5–14 | 15–24 | 25 → | | 5–14 | 15–24 | 25 → | |
| Quintinia (a) | 2 | 6 | 1 | 9 | 2 | 6 | 3 | 11 |
| Ilex (a) | 1 | 1 | 1 | 3 | 4 | 3 | - | 7 |
| Rapanea (d) | 4 | - | - | 4 | 4 | 2 | - | 6 |
| Syz.vaccin. | 4 | 2 | - | 6 | 3 | 2 | 1 | 6 |
| Xanth.pap. | 3 | 2 | - | 5 | 5 | - | - | 5 |
| Elaeoc. (h) | - | 2 | - | 2 | - | 3 | 1 | 4 |
| Sericolea (a) | 4 | - | - | 4 | 3 | - | - | 3 |
| Weinmannia (a) | 3 | 2 | 1 | 6 | - | - | - | - |
| Timonius bel. | - | 3 | 3 | 6 | - | - | - | - |
| Dicks.hier. | 7 | - | - | 7 | 4 | - | - | 4 |
| Totals | 28 | 18 | 6 | 52 | 25 | 16 | 5 | 46 |

### c. Mt Ambua

Of the three mountains, Mt Ambua was the most thoroughly investigated. Frodin collected (from Lei Bivouac) in the forest on the lower part of the slope, Vink and Kalkman worked from Ambua Bivouac and sampled the forest above *c.* 3150 m altitude, including the mossy forest.

The slope of Mt Ambua is covered with a mixed forest which in its upper part is distinctly mossy (although not as beautifully as Mt Ne). The forest has not been disturbed by fire. Near its lower margin there may have been a slight effect of selective cutting (Conifer bark for roofing during the pandan harvesting season, *cf.* p. 120). The recent influence of hunters going up and down may be neglected: the track upwards had to be cut.

In table E (at the end of this paper) have been brought together the data from three collecting-sites, viz.:

a) a short transect at an altitude of 3150 m and its immediate vicinity;
b) the forest around Ambua Bivouac, 3250—3300 m alt.;
c) the mossy forest, altitude 3300—3365 m.

From the table the following appears:

a) a considerable proportion (25 species) is found from 3150 m upwards into the mossy forest (and sometimes also in the scrub above that);
b) several species (more than 20) disappear somewhere between the transect and the mossy forest, usually around 3200 m altitude;
c) a few species were seen at the higher altitudes only, not at 3150 m. This group consists of light-demanding smaller plants, growing also in the shrubberies and in the grassfields of the topregion, some of them also in the open vegetations at lower altitude.

Summarizing, the disappearance of species before the mossy forest begins is not counterbalanced by the appearance of some high-altitude light-demanding plants which do not descend beyond the lower limits of the mossy forest. Consequently, it may be said that the mossy forest here is essentially a depauperated montane forest.

The composition of the mixed montane forest, as taken from our transect at 3150 m alt. (375 sq.m, length 75 m) is summarized in table C, in which the more common tree species are recorded with their diameters.

We now are able to make two comparisons, that between the mossy forests on Mt Ne and on Mt Ambua, and that between the mossy forest on Mt Ne and the forest of the transect of Mt Ambua. The former comparison is one between two forests of the same aspect, but on different altitudes, the latter comparison is one between forests at the same altitude but of different aspect.

On Mt Ambua the mossy aspect starts at *c.* 3300 m altitude, and the upper limit (scrub) is at *c.* 3365 m, whereas on Mt Ne beginning and end of the mossy forest are at *c.* 3140 and *c.* 3210 m, respectively. The vertical extension of the mossy aspect being the same, viz. only about 70 metres, it appears that on Mt Ambua it is situated some 160 metres higher than on Mt Ne. This of course must be related to the topography and to the place where the cloud-layers normally settle.

The comparison has been tabulated (table F, at the end of this paper). From the table it can be seen that the agreement between forests at the same altitude but of different aspect, is of the same order as that between forests of the same aspects but at different altitudes. This stresses again that 'mossy forest' cannot be considered as an independent community but that it is only a variant of the mixed montane forest, differing more in physiognomy than in composition.

Table C. The most common tree species in the 375 sq.m transect on Mt Ambua, 3150 m alt.

| | number of trees 5 cm → | diameter classes | | |
|---|---|---|---|---|
| | | 5–14 cm | 15–24 cm | 25 cm → |
| Sax. Polyosma (d) | 5 | 5 | - | - |
| Wint. Bubbia (a) | 4 | 3 | - | 1 |
| Wint. Drimys piperita ('heteromera') | 4 | 4 | - | - |
| Aquif. Ilex (a) | 3 | 1 | 2 | - |
| Monim. Levieria parvifolia | 3 | 2 | 1 | - |
| Myrs. Rapanea (d) | 3 | 3 | - | - |
| Rut. Evodia (b) | 3 | 3 | - | - |
| Sax. Polyosma (b) | 3 | 1 | 1 | 1 |
| Symp. Symplocos (b) | 3 | 2 | 1 | - |
| El. Elaeocarpus (h) | 2 | 1 | - | 1 |
| Myrs. Rapanea (b) | 2 | 2 | - | - |
| Rub. Timonius belensis | 2 | - | - | 2 |
| Rut. Evodia (f) | 2 | 2 | - | - |
| Theac. Eurya ?tigang | 2 | 1 | 1 | - |
| Pter. Cyathea aeneifolia | 10 | 10 | - | - |
| Pter. Dicksonia hieronymi | 13 | 13 | - | - |
| Other species (6 in all) | 6 | 4 | 2 | - |

A few of the more striking differences between the two mountains may be commented upon.

a) *Weinmannia* was on Mt Ambua not found above *c.* 3000 m, on Mt Ne, however, it was seen up to an altitude of almost 3150 m. This is not a sign of different zonation on the two mountains, because e.g. *Timonius belensis*, on Mt Ne disappearing at *c.* 3150 m, goes on Mt Ambua up to *c.* 3350 m altitude.

b) *Daphniphyllum gracile*, a common tree on the mountains of Ambua and Kerewa and also in the plain, was not seen on Mt Ne, neither in the forest, nor in the shrubberies around the summit. We cannot offer an explanation for this absence.

c) *Drimys piperita ('heteromera')* was strikingly absent from Mt Ne and from Mt Kerewa, although it occurred in the plains and in the pass between the two mountains mentioned. On Mt Ambua it was present from the base up into the topregion.

d) The treeferns *Cyathea aeneifolia* and *Dicksonia hieronymi* were absent in the mossy forest on Mt Ambua. The former, however, returned in the scrub immediately above the forest.

## 7. THE FORESTS IN THE IBIWARA PLAIN (2650—2800 m alt.)

### a. Mixed forest near Ibiwara Bivouac

The forest around the basecamp Ibiwara is limited to rather small pockets within the

grassland area. Its canopy is rather low (12—20 m), without distinct emergents; the undergrowth is very dense.

In this forest a plot of 45 m long and 10 m wide was laid out, starting just within the forest border (photo 5) and perpendicular to it. The important components can be found in table D, where the most common tree species are listed.

Table D. The most common and/or most important tree species in the 450 sq.m transect in the forest near Ibiwara Bivouac

| | | number of trees 5 cm → | diameter classes 5–14 cm | 15–24 cm | 25 cm → |
|---|---|---|---|---|---|
| Laur. | Litsea exsudens | 4 | - | - | 4 |
| Rub. | Timonius belensis | 4 | - | - | 4 |
| Ros. | Prunus grisea var. grisea | 3 | 2 | 1 | - |
| Aral. | Schefflera (e) | 2 | 2 | - | - |
| El. | Elaeocarpus (b) | 2 | 2 | - | - |
| Mon. | Kibara (a) | 2 | 2 | - | - |
| Mon. | Levieria parvifolia | 2 | 2 | - | - |
| Rut. | Evodiella (a) | 2 | 1 | 1 | - |
| Sax. | Polyosma (b) | 2 | 2 | - | - |
| Sax. | Polyosma (d) | 2 | 2 | - | - |
| Aq. | Ilex (a) | 1 | 1 | - | - |
| Laur. | Cryptocarya ledermannii | 1 | 1 | - | - |
| Log. | Fagraea salticola | 1 | - | - | 1 |
| Myrt. | Syzygium ?adelphicum | 1 | 1 | - | - |
| Myrt. | Syzygium (a) | 1 | - | 1 | - |
| Sax. | Quintinia (a) | ') | | | |
| Pand. | Pandanus | 12 | 7 | 5 | - |
| Pter. | Dicksonia hieronymi | 29 | 29 | - | - |
| Pter. | Cyathea rigens | 25 | 25 | - | - |
| Pter. | C. aeneifolia | 6 | 6 | - | - |
| Other species (8 in all) | | 8 | 8 | - | - |

') Not in the plot itself, but very close to it

The table above gives a fairly good picture of the forest: mixed, but rather poor in number of tree species. Outside the plot Conifers *(Phyllocladus hypophyllus, Dacrycarpus cinctus, Podocarpus bracteatus)* were present though rare; *Quintinia* was locally common. *Pandanus* grows mainly near the margins of the forest, its numbers decrease markedly away from the forest border. The largest trees in the plot were a *Fagraea salticola* of 100 cm d.b.h., and the four specimens of *Timonius belensis*, measuring 40 to 70 cm d.b.h.

The undergrowth is very dense. As can be seen from the table, many treeferns were present. Also common were *Cyrtandra* and *Alpinia* species, and in general the under-

growth is not different from that in the *Nothofagus* forest which can be found summarized in table G at the end of this paper. Under the lianas *Dimorphanthera* must be mentioned as being very common; climbing bamboos were absent. See also Gillison, 1970.

### b. Mixed forest near Lei Bivouac

The forest observed at the eastern foot of Mt Ambua is of the same mixed type as that near Ibiwara Bivouac, but far richer in species. In some places its canopy is also somewhat higher (12—25 m) and the undergrowth is then less dense. The most important (fairly common) species collected here, but not found near Ibiwara Bivouac are:

*Cun.* *Caldcluvia brassii*
*Cald.luvia fulva*
*El.* *Elaeocarpus (c), (h), (i)*
*Laur.* *Cryptocarya minutifolia*
*Sax.* *Polyosma (a)*
*Quintinia nutantiflora*
*Sphen.* *Sphenostemon papuanum*
*Sympl.* *Symplocos (c)* and *(h)*
*Theac.* *Eurya ?tigang*
*Wint.* *Bubbia (a)*

The presence of treeferns and of Conifers is similar to that described in the previous paragraph. Slightly higher upslope (*c.* 60 m), *Phyllocladus hypophyllus* occurred gregariously. Small pandan groves were found in open spots with old fire places. For the general outline of the undergrowth, we refer again to table G; some additional species do not change the aspect.

### c. Nothofagus forest

On the long slope between Habono (2000 m) and Wauwe (2650 m) species of *Nothofagus* are common in the forest. The trees occur gregariously, the groups not being sharply delimited from the mixed forest and the trees only shortly emergent from the general forest canopy.

In the plain between Wauwe and the Margarima River, however, there is a low mixed forest, described above, with scattered in it sharply delimited clumps of *Nothofagus* emerging from the general canopy. The beech trees are 10—20 m higher than the mixed forest, which is only 10—20 m high.

In the triangle roughly delimited by Mt Ambua and the Andabare and Margarima Rivers similar small groves of *Nothofagus* are present, but here amidst a forest rich in Conifers (Coniferous-Mixed forest). See also map and photo 2.

In the C.S.I.R.O. Report on the Wabag-Tari Area *Nothofagus* clumps are mentioned by Robbins & Pullen (in Perry c.s., 1965, p. 105) in the following words: 'Over much of the Western Highlands small groups of mature beech trees were dying. Such groups were visible on the air photos and could be counted in hundreds. Closer investigation revealed no obvious reason such as soil factors, lightning strikes, or biotic interference and it is suggested that they represent even-aged groves where groups of trees have reached over-maturity together and die, allowing vigorous beech regeneration.'

Being fascinated by the virtual absence of beeches outside the well-defined groves, and in order to check whether the explanation given by Robbins and Pullen would be applicable in our particular region, we made a transect through a grove of *Nothofagus rubra* and the adjoining mixed forest near Lei River, at an altitude of 2780 m. A strip of 5 m wide and 200 m long was marked and divided in 5 × 5 m squares. Three squares covered the transition from grassland to beech forest, 24 squares were situated within the *Nothofagus* grove, two squares in the transitional zone between beech forest and mixed forest (this zone is covered by the *Nothofagus* crowns, but mature beeches are absent), and 11 squares

were in the mixed forest. All individuals of *Nothofagus* were counted and measured (diameter only).

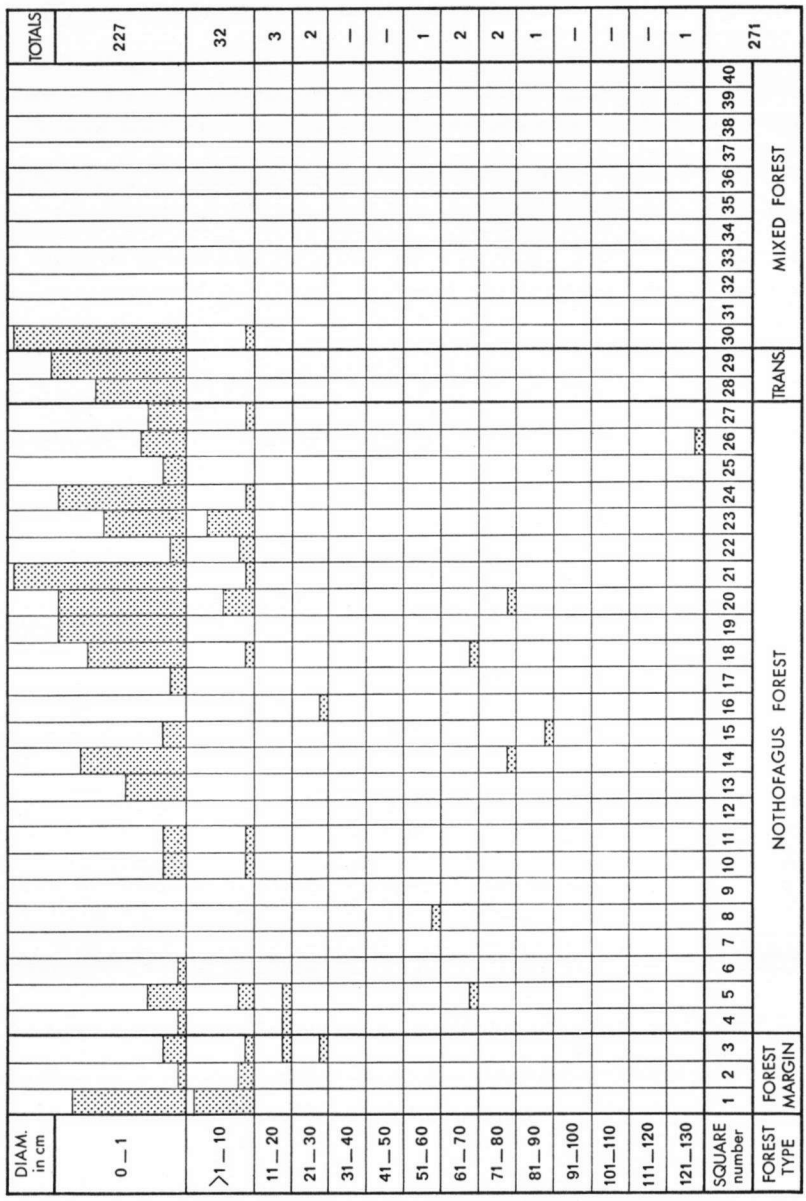


Fig. 3. Diameter-class distribution of *Nothofagus rubra* found in the forest transect near Lei River; the squares of the transect are 5 × 5 m; in the histograms 1 mm height indicates one specimen.

The results (fig. 3) show a size-class-distribution which looks very normal and highly satisfactory, and certainly does not represent an even-aged overmature stand. From this follows that this species does regenerate under its own cover. The mature trees did not show any sign of senility. The *Nothofagus* groves visited by us, consequently, do not belong to the Degraded Beech Forest that Saunders described (in Perry c.s., 1965, p. 122).

In the forest-margin, in the shade of mature trees outside the plot examined, there was a vigorous beech regeneration and behind the shrubs marking the transition grassland-forest the mature and juvenile specimens of *Nothofagus* formed a nearly vertical edge of the grove.

In the mixed forest *Nothofagus* regenaration was only found in the square next to the transitional zone. No regeneration was found more than 10 metres outside of the area covered by the crowns of the mature trees.

Table G at the end of this paper summarizes the composition of the *Nothofagus* forest (squares 4—27) and of the mixed forest (squares 30—40), the two transitional zones left out of consideration. The conclusion has to be that there is no difference between the two except for the absence or presence of *Nothofagus*. Another difference, not to be read from the produced tables, is the suppression in size of other trees by *Nothofagus*.

What we have got here, is only one type of forest, a mixed forest in which *Nothofagus* occurs only in small groves. This forest alternates with the fire-induced grassland.

The reason behind the social behaviour of *Nothofagus* in this region is not clear at all. At first we thought to have found an explanation in assuming a destruction by fire (see note 3, below) of an original, *Nothofagus*-dominated, but mixed forest. Starting from the surviving patches there could have been — in a period of diminished burning — regeneration of a forest that was essentially without beeches because of the slow dispersal-rate of *Nothofagus* (below, note 1). The draw-back of this hypothesis is that more towards the east the same beech-patches grow surrounded by a Conifer-dominated forest which can hardly be considered as of a secondary nature.

Consequently, the hypothesis that the *Nothofagus* groves are remnants of a formerly existing closed forest, comparable to that between Habono and Wauwe, is untenable. An alternative explanation we are unable to give.

A few additional notes, pertinent to the *Nothofagus*, can be made:

1. *Nothofagus* apparently spreads very slowly since regeneration was in our transect not found more than 10 metres outside the grove. Also in other places we never found regeneration of beech except in or close to *Nothofagus* clumps. For New Zealand Preest (1963, p. 418, 421) found a similar dispersal behaviour.

2. Apparently, *Nothofagus* reaches its local altitudinal limit in this plain (*c.* 2700 m). It was never seen on the mountain-slopes or -ridges, not even close to the plain, although in general *Nothofagus* prefers ridges when in mixed stands (Robbins & Pullen, in Perry c.s., 1965, p. 105, 106).

3. There are some indications of fire in the history of the groves. A *Nothofagus rubra* tree in square 4 of our plot (d.b.h. 64 cm) had a scorched scar on the side facing the forest margin. Since the scorching the tree had already grown 2½ cm in diameter, the marginal callus being 6 cm wide and 3 cm thick. In a nearby grove a stout bole of a *Nothofagus pullei* tree contained a core of 5 cm diameter showing distinctly scorched parts.

4. The aerial photographs do not give a reliable indication of the species composition of the *Nothofagus* groves. Another patch investigated by us, situated at the northern foot of Mt Ne, showed both on the photographs and in the field a dark margin around a much lighter centre (photo 2). Collecting revealed that the centre consisted of *Nothofagus pullei*,

Photo 1. Main road between Lei bivouac and Ibiwara bivouac; Mt Ne in background.


Photo 2. View from Mt Ambua S-wards over the Ibiwara plain. Mt Ne with at its base the two-coloured (1) and one other (2) *Nothofagus* grove. Mt Kerewa, in the background, with distinctly sloping layers at the left.

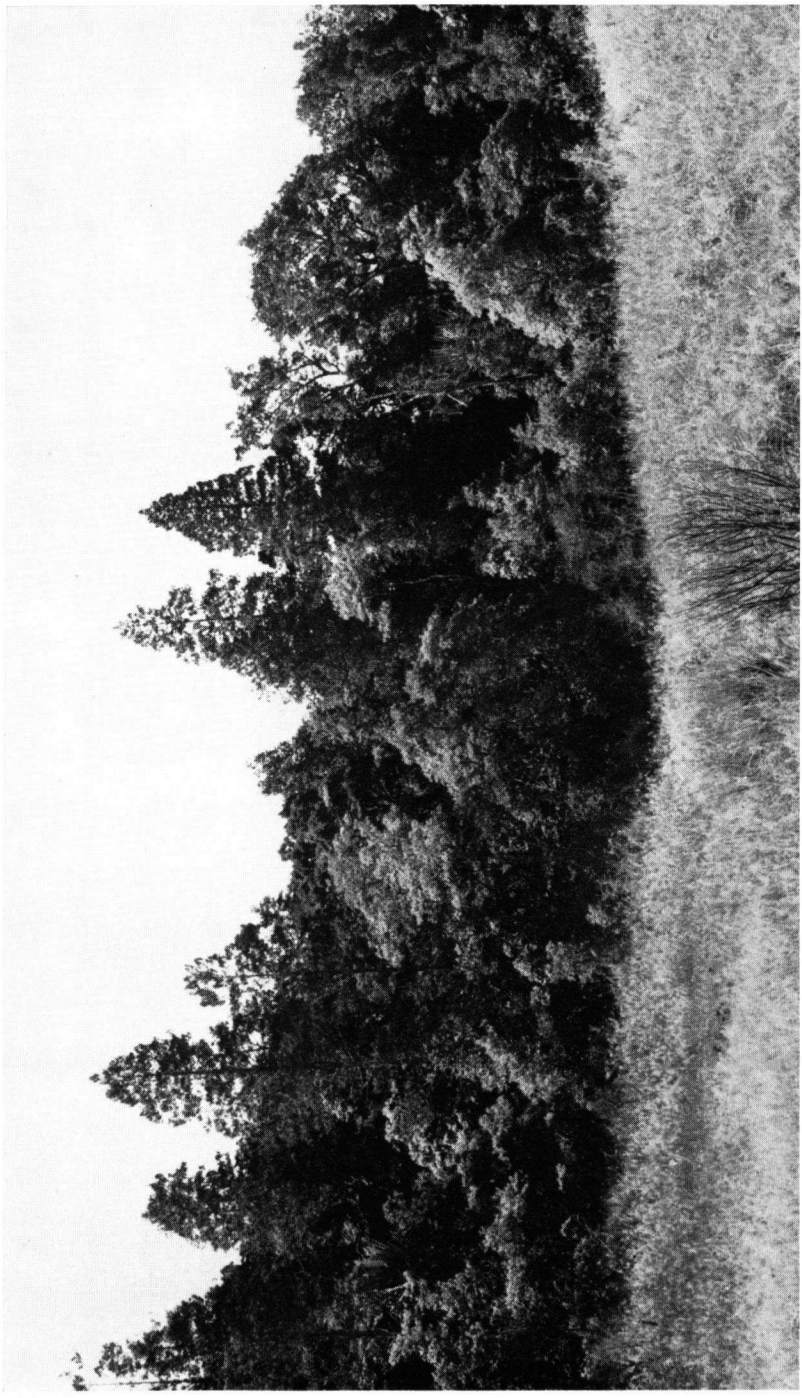

Photo 3. Coniferous—Mixed forest with *Papuacedrus papuana* emergent.

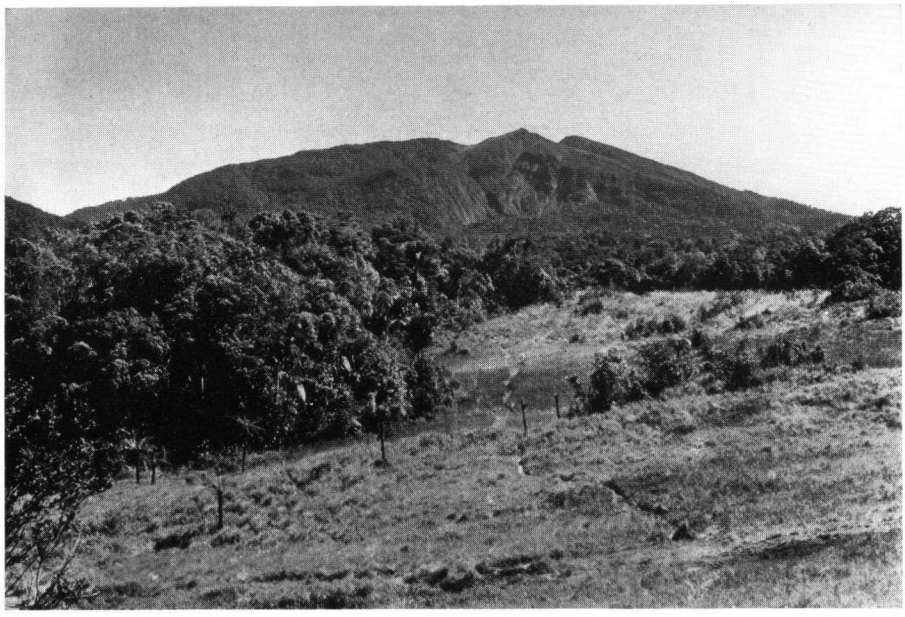

Photo 4. Mt Ambua seen from bivouac Ibiwara.

Photo 5. Margin of forest near Ibiwara, forming the first squares of the short transect laid out here.

Photo 6. *Carex phacota* is a common Cyperacea in the Ibiwara plain *(Vink 17144)*.

Photo 7. *Potentilla foersteriana* var. *ima* is regularly found in the trampled vegetation of the native tracks in the grassland of the Ibiwara plain *(Kalkman 4642)*.

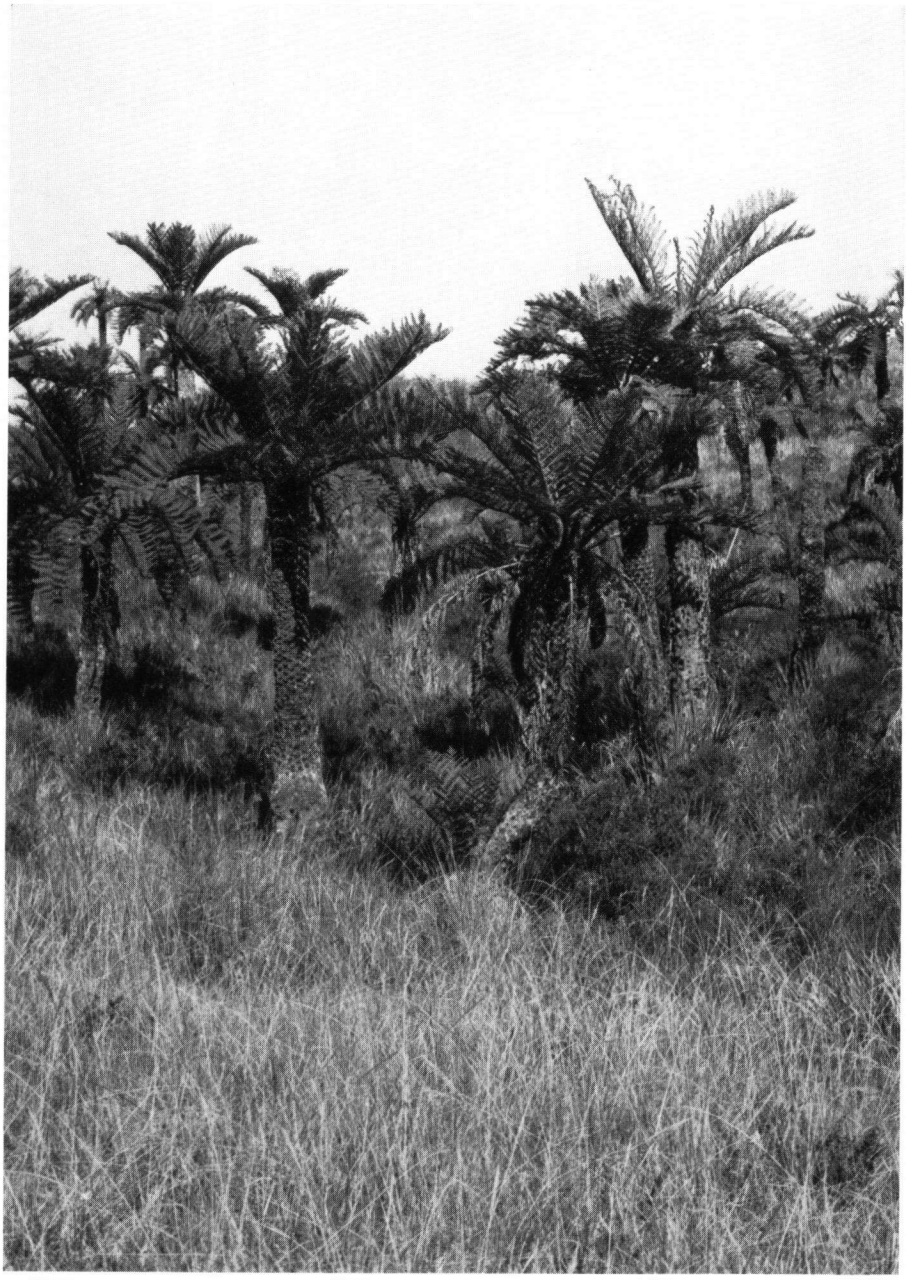

Photo 8. The most fire-resistent treefern, *Cyathea atrox* var. *inermis*, occurs often gregariously in the grassland.

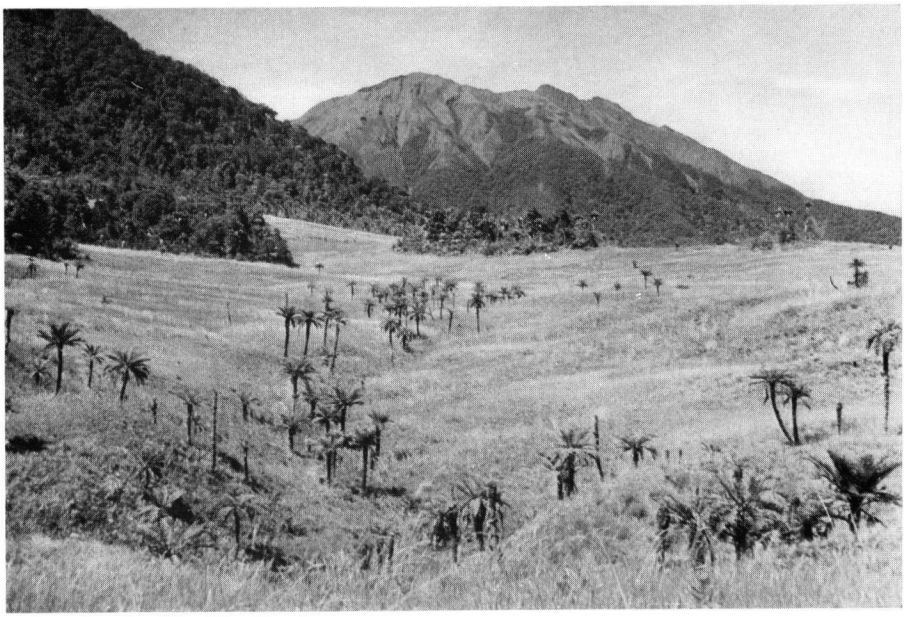

Photo 9. *Cyathea atrox* var. *inermis* prefers the moister places in the grassland. Mt Kerewa in the background.

Photo 10. Dead trees emerging from the degraded forest on the northern slope of Mt Kerewa as silent witnesses of devastating fires. Upper Benaria River in background.

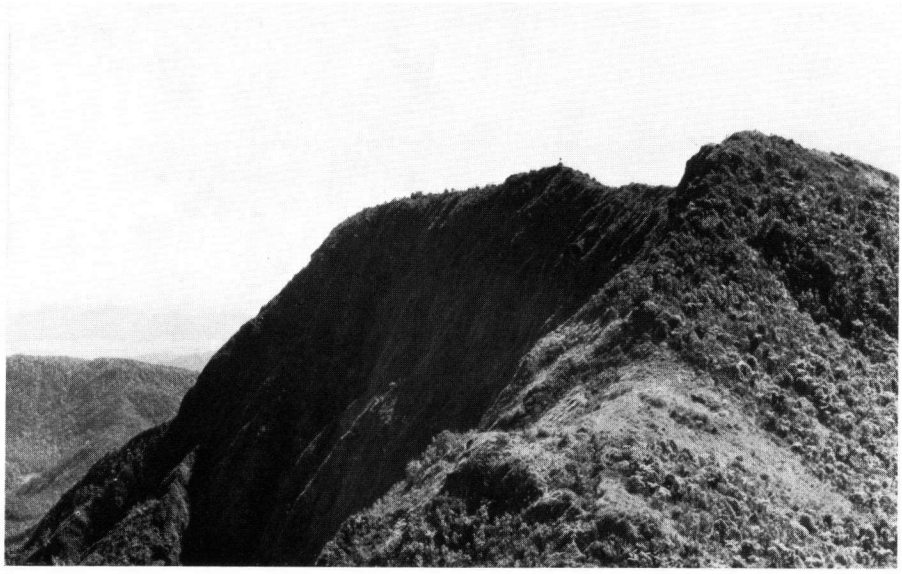

Photo 11. Mt Ambua (with a triangulation point on its highest summit, 3567 m) is a horse-shoe-shaped remnant of a pleistocene volcano. The slopes are steeply falling away towards the strongly eroded centre of the complex.

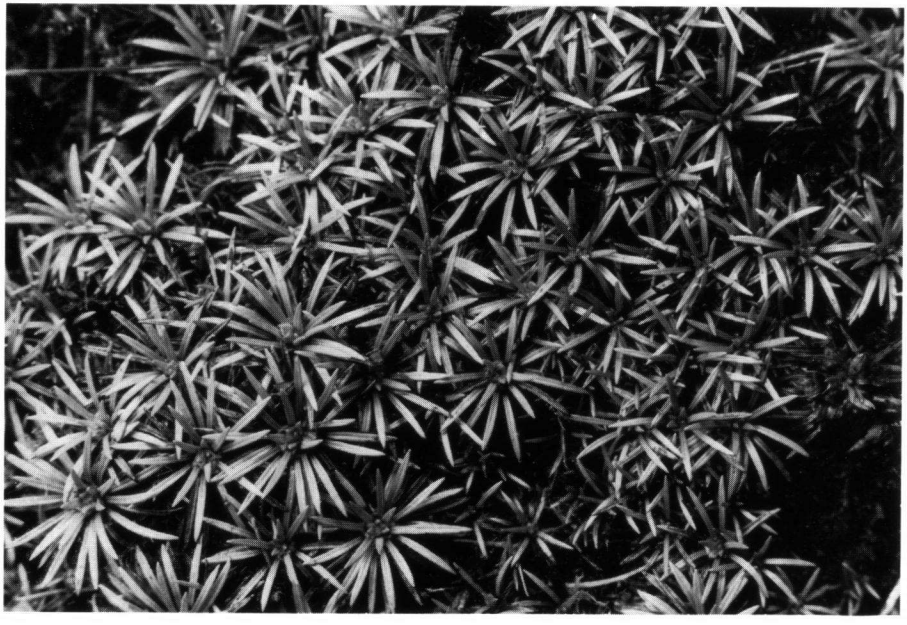

Photo 12. *Plantago depauperata* was found on Mt Ambua only, where it occurred in subalpine bog *(Kalkman 4971)*.

Photo 13. The deeply eroded centre of Mt Ambua is drained by the Arua River flowing through a deep incision in the western wall towards the Tari Basin.

Photo 14. *Plantago depauperata* with open capsules.

Photo 15. Like Mt Ambua, Mt Kerewa (3555 m) is a ruin of a pleistocene volcano. The picture shows the deeply eroded centre.

Photo 16. *Gleichenia hooglandii* is a species of grasslands and forest margins *(Kalkman 4660)*.

Photo 17. Grassland on one of the summits (3540 m) of Mt Kerewa the day after a grass-fire. Kalkman with some Tigibi workers.

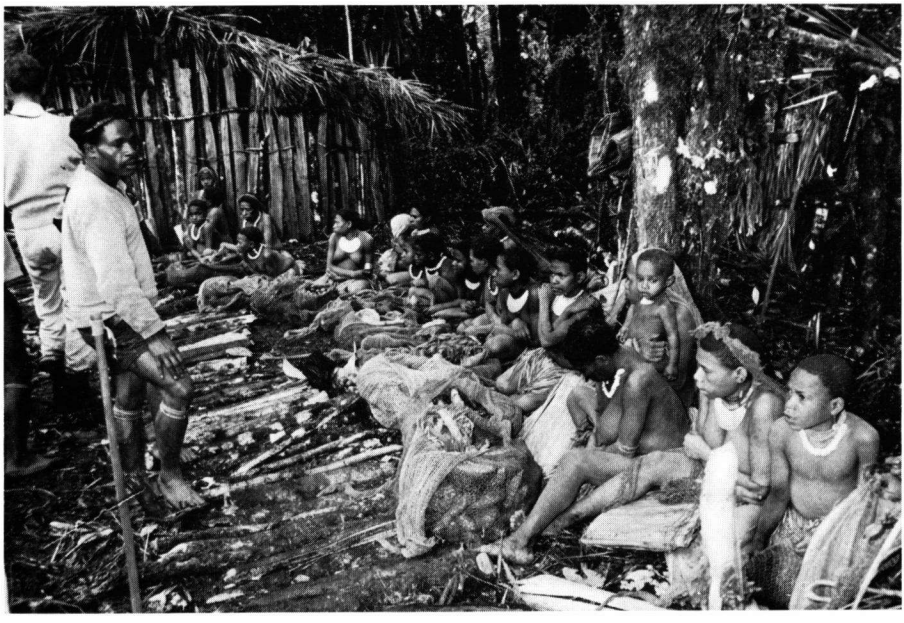

Photo 18. People from Tigibi selling sweet potatoes and vegetables in our base-camp Ibiwara (photo A. N. Gillison).

Photo 19. *Blumea lacera* var. *lacera* is a characteristic component of the grasslands in the plain *(Kalkman 4659)*.

Photo 20. The interior of the mossy forest on Mt Ne at *c.* 3170 m altitude.

Photo 22. *Podocarpus brassii* is one of the few shrubs surviving repeated burning of the grassland in the plain *(Kalkman 4639)*.

Photo 21. *Rubus lorentzianus*, common in shaded places in grasslands and in open spots in the forest *(Kalkman 4948)*.


Photo 23. Aerial view of the central part of the Ibiwara plain. Ibiwara bivouac indicated by a triangle; Mt Ne at bottom of photo; 1 and 2: *Nothofagus*-groves as in photo 2. *Crown Copyright.*

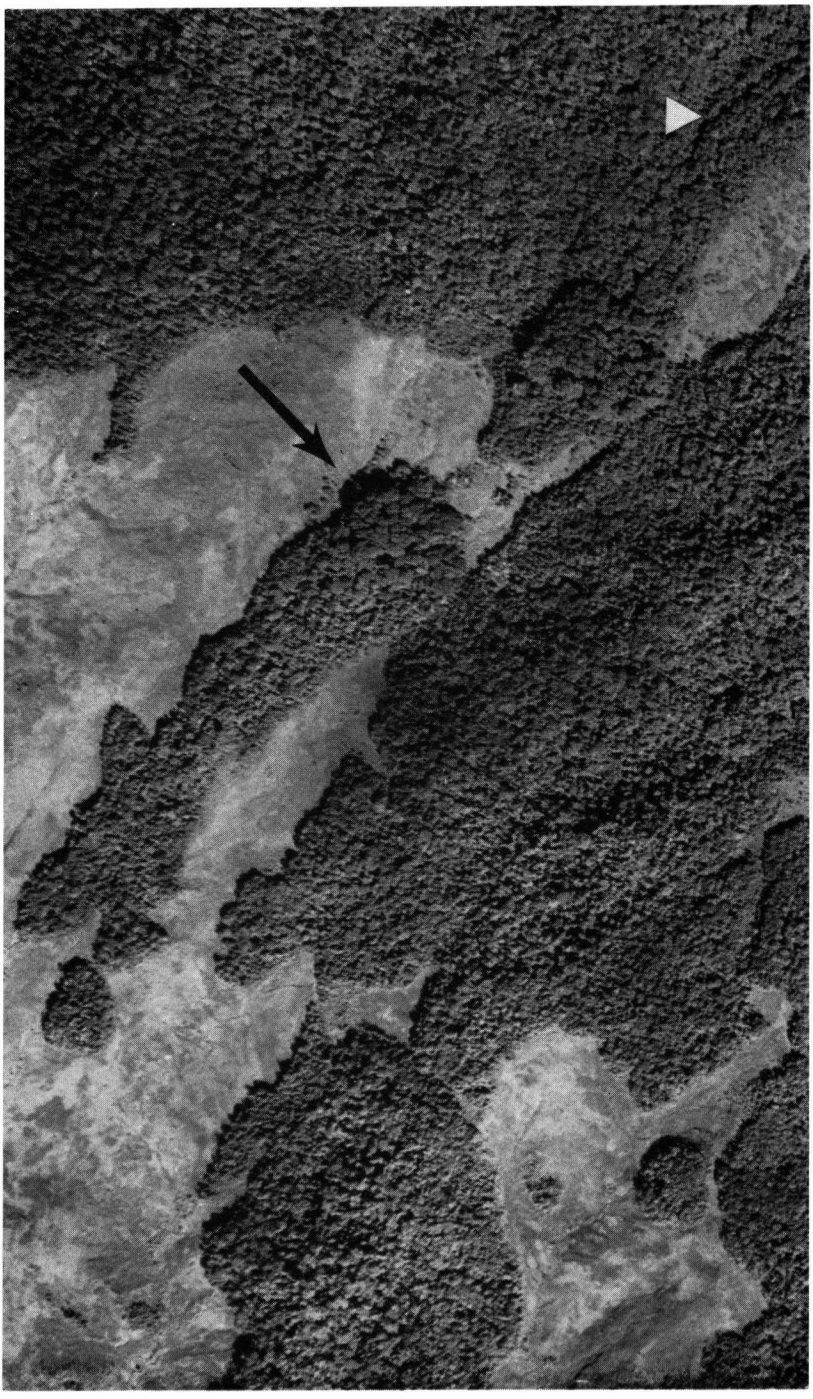

Photo 24. Aerial view of area near Lei bivouac (triangle). Arrow indicates *Nothofagus rubra*-grove discussed in chapter 7 c. *Crown Copyright.*

Photo 25. Ibiwara River running through valley grassland and lined by treeferns. *Crown Copyright. Photo's 23—25 by courtesy of the Director of National Mapping, Dept of National Development, Canberra.*

the margin was formed by *Nothofagus rubra*. Groves in the neighbourhood, consisting of *Nothofagus pullei*, had a photo-aspect similar to the centre of the two-coloured grove. The above-mentioned grove near Lei River, however, which in the field looked quite similar, consisted entirely of *Nothofagus rubra;* the photo-aspect is intermediary between those in the two-coloured grove. Although different species undeniably show different photo-aspects, absence or presence of young flush may be the reason for the irregularities mentioned. Looking through the aerial photos we also observed the tendency to a denser canopy in the centre of large groves.

### d. The Coniferous—Mixed forest

As the primary aim of our exploration was the inventarisation of the mountains Ambua, Kerewa, and Ne, we touched only lightly the area of Coniferous forest which begins just outside our working area and stretches far to the north and east. As already mentioned, scattered in this area of Coniferous forest many groves of *Nothofagus* occur. The forest outside the groves is not homogeneous but shows large differences in density of Conifers. In aerial photographs this is especially obvious for the emergent *Libocedrus papuana*.

We made a short reconnaissance trip to one of the patches that is dominated by *Libocedrus* (photo 3). The following list, admittedly very incomplete, gives an impression of its species contents.

Species seen in a Conifer-dominated mixed forest, east of Mt Ambua, alt. 2670 m

| | |
|---|---|
| *Act.* | *Saurauia (a)* and *(c)* |
| *Aq.* | *Ilex (a)* |
| *Cupr.* | *Libocedrus papuana* |
| *Daphn.* | *Daphniphyllum gracile* |
| *El.* | *Elaeocarpus (c)* |
| | *Sericolea spec.* |
| *Eric.* | *Dimorphanthera collinsii* var. *collinsii* |
| *Euph.* | *Claoxylon (b)* |
| | *Macaranga (a)* |
| *Gesn.* | *Cyrtandra (a)* and *(b)* |
| *Laur.* | *Litsea exsudens* |
| *Log.* | *Fagraea salticola* |
| *Mon.* | *Levieria parvifolia* |
| *Mor.* | *Streblus urophyllus* var. *urophyllus* |
| *Myrs.* | *Rapanea (j)* |
| *Myrt.* | *Syzygium ?adelphicum* |
| *Pand.* | *Freycinetia spec.* |
| | *Pandanus spec.* |
| *Pip.* | *Piper (a)* and *(b)* |
| | *Piper (d)* * |
| *Pod.* | *Dacrycarpus expansus* * |
| | *Phyllocladus hypophyllus* |
| | *Podocarpus bracteatus* |
| *Pter.* | *Cyathea aeneifolia* |
| | *Dicksonia hieronymi* |
| | *Pteris (b)* * |
| *Rhamn.* | *Rhamnus spec.* * |
| *Ros.* | *Rubus laeteviridis* |
| | *R. ledermannii* var. *ledermannii* |
| | *R. tsiri* |
| *Rub.* | *Psychotria spec.* * |
| | *Timonius belensis* |
| *Rut.* | *Evodia (b)* |
| *Sax.* | *Polyosma (b)* |
| *Theac.* | *Eurya (b)* * |
| *Urt.* | *Cypholophus spec.* |
| | *Procris spec.* |
| *Wint.* | *Bubbia (a)* |
| | *Drimys piperita ('coriacea')* |
| *Zing.* | *Alpinia (b)* |

* Species which were not observed outside this forest.

Saunders described (in Perry c.s., 1965) his Coniferous—Mixed forest as follows: 'This type is found on sites similar to those of the Coniferous forest, but where the growth of broad-leaf trees has not been inhibited..... The forest consists of two elements, a broad-leaf element similar to the mixed forest type at the same altitude, and a coniferous element similar to the coniferous forest type. Species from each element combine to form a forest with a moderately open canopy 80—100 ft high. Some conifers, mainly *Papuacedrus*, are emergent.'

This agrees nicely with our own observations and with our species list. Just as we found the *Nothofagus* groves to be mixed forest with *Nothofagus* species superimposed, we gained the idea that the Coniferous forest we visited was a mixed forest with a dominating Coniferous element. The latter is not entirely absent from the mixed forest in other places, but there it plays an unimportant role. The differences between the mixed forest and the present conifer-dominated forest is only due to differences in the frequencies of elements from more or less the same bulk of species.

The presence of *Nothofagus* groves both in the mixed forest and in the Coniferous—Mixed forest stresses the similarity between the two major types.

There is a possibility that the extent of the Coniferous—Mixed forest has been larger in the direction of Mt Ne, and that selective cutting (see next paragraph) along the much-frequented roads between the Tari Basin and the Margarima Basin has changed the aspect of the forest.

**e. Other forest types**

On a corner of the border between Coniferous—Mixed forest and grassland we found a patch of *Quintinia*-dominated forest, also clearly recognizable on the aerial photographs.

The origin of such a forest became clear when few days later we returned to Ibiwara Bivouac. The forest patch near which the Bivouac was built and in which our local workers had built shelters for themselves and for the carriers, had in the course of the months seriously been depleted. By cutting trees for building material and firewood the originally mixed forest had been changed into a monodominant stand of *Quintinia* with still a rather complete canopy. The reason why *Quintinia* remained untouched is completely obscure.

In the pass between Mt Ne and Mt Kerewa we found a patch of *Phyllocladus-Quintinia*-dominated forest, rather open, with climbing bamboo present and with many fire-places. Apparently a similar selective cutting had taken place during the harvest of *Pandanus* nuts. Hundreds of very young *Phyllocladus* seedlings were present. Although no mature trees were seen, seedlings of *Dacrycarpus cinctus* were not rare.

The bark of *Phyllocladus hypophyllus* is useless, but that of *Libocedrus papuana* is highly valued for roofing of temporary shelters. Hunting parties and *Pandanus*-gatherers may have thinned out this species considerably over the years in the areas frequented by them. We have seen our workers use the bark of *Dacrycarpus cinctus* as well, which may explain the absence of mature trees of this species in the *Phyllocladus-Quintinia*-forest.

## 8. SHRUBBERIES BELOW THE MOUNTAIN SUMMITS (3100—3565 m alt.)

On Mt Kerewa as well as on Mt Ambua, between the forest and the low vegetation of the summit regions, a shrubby vegetation is found. A similar scrub is also present on Mt Ne, but there the low vegetation on top of it is not developed.

The shrubby vegetation is not sharply demarcated, neither from the forest below it, nor from the 'grassland' above. On Mt Kerewa especially the transition is very gradual; here the degraded forest itself is very open already, and with higher altitude the trees become gradually lower, more stunted and shrub-like. On Mt Ambua the boundary between the mossy forest and the scrub is more distinct, although of course not sharp.

It is clear that those shrubberies have originated and are maintained by human influence: fire. Charred remnants of trees were seen several times. The altitude of both

Kerewa and Ambua is such that without human interference the forest would extend right to the summits, probably in a lower, more open form, and possibly interspersed with more heath-like vegetations on the most exposed parts and a low herbaceous covering on the wet spots.

On the northeastern slope of Mt Ambua this does, in fact, happen. To our regret it was impossible to make a closer investigation of that less-disturbed side of the mountain since that would have involved two more camps.

Naturally there are large similarities between the shrubberies of the three mountains, most of the species being encountered on at least two of them. If we take them all together and leave out of consideration those species which were only once seen during our expedition, there are more than 50 species of Vascular Plants in these shrubberies. They can be divided into four categories, as follows:

1. Species which are found both in proper forest and in the scrub and which — to our experience — do not display a definite preference for either of the two habitats.

*Act.* *Saurauia (a)*
*Aq.* *Ilex (a)* *
*Daphn.* *Daphniphyllum gracile* *
*El.* *Sericolea (a)*
*Eric.* *Diplycosia rupicola* *
*Myrs.* *Rapanea (a)* *
*Myrt.* *Syzygium vaccinioides*
*Xanthomyrtus (a)* *
*Pter.* *Cyathea aeneifolia*
*Pteris (a)*
*Ros.* *Prunus pullei* *
*Sax.* *Quintinia (a)*
*Theac.* *Eurya ?tigang*
*Wint.* *Drimys piperita ('heteromera')* *

2. Species which clearly belong to the forest flora, and which only occasionally are found in the scrub.

*Apoc.* *Alyxia spec.*
*Aral.* *Schefflera (d)*
*Cun.* *Weinmannia (a)*
*Cupr.* *Libocedrus papuana* *
*El.* *Elaeocarpus (h)*
*Euph.* *Omalanthus (a)* *
*Rut.* *Evodia (d)*
*Symp.* *Symplocos (c)*
*Wint.* *Drimys piperita ('giluwe')*
*D. piperita ('coriacea')* *

3. Species which grow as lianas or epiphytes in the forest, and which also occur — but then often terrestrial — in the scrub.

*Eric.* *Dimorphanthera collinsii* var. *collinsii* *
*D. cornuta* var. *cornuta* *
*D. dekockii* var. *pubiflora*
*Rhododendron nov. spec. (a)* *

4. Species which are not or only occasionally found in the interior of the forest.

*Act.* *Saurauia (d)*
*Car.* *Cerastium spec.*
*Sagina spec.*
*Comp.* *Olearia durifolia*
*O. lanata*
*Cun.* *Caldcluvia brassii* *
*Epac.* *Styphelia suaveolens*
*Trochocarpa nubicola*
*T. papuana*
*Eric.* *Rhododendron beyerinckianum* *
*Rh. nummatum*
*Rh. womersleyi*
*Rh. yelliotii*
*Vaccinium cruentum* *
*V. keysseri* var. *keysseri*
*V. schoddei* *
*Myrs.* *Rapanea (c)*
*Myrt.* *Xanthomyrtus ?calothrichoides*

| | | | |
|---|---|---|---|
| *Pitt.* | *Pittosporum pullifolium* * | *Sap.* | *Dodonaea viscosa* * |
| *Pter.* | *Cyathea atrox* * | *Scr.* | *Hebe albiflora* * |
| *Ros.* | *Rubus lorentzianus* * | *Theac.* | *Eurya (a)* |
| | *R. papuanus* | *Wint.* | *Drimys piperita ('montis-wilhelmi')* |
| *Rub.* | *Coprosma (a)* * | | |

From this list it can be seen that the flora of the shrubberies is not a 'diluted' forest flora, but that most of its species are restricted to the open vegetations and are, in fact, light-demanding plants that cannot survive in the closed forest. They are of course not only found in the closed girdle bordering the upper margin of the forest, but also scattered in the low summit vegetation.

The lower margin of the forest, where the latter borders the grassland in the plain, is a habitat comparable to the scrub some 500—650 m higher. Two fifths of the species from the above list have indeed been found in forest margins in the plain (those marked with *).

On the other hand, about a dozen species are regularly found in the forest margins in the plain, without being present in the scrub. This group includes a.o. *Vaccinium auriculifolium*, *Scaevola oppositifolia*, *Jasminum* and *Astilbe rivularis*, species which — at least locally — do not extend their altitudinal range beyond *c.* 3300 m.

### 9. THE GRASSLANDS IN THE PLAIN (2650—2800 m alt.)

The grasslands in the plain are of pyrogenous origin. During the expedition several patches were burned off by people passing through and in many places charred remnants were found at the bases of grasses and sedges and on the soil between them. From these observations it was clear that generally the grassland is burned in patches only, the nightly rain and natural barriers like forests and wet places with low vegetation barring the extension of the fire over the whole plain.

Together with the differences caused by the micro-relief and the moisture of the soil this patchy burning causes a mosaic pattern in the grassland vegetation. Some of the locally dominant species are: *Imperata cylindrica*, *Danthonia archboldii*, *Machaerina rubiginosa*, *Gahnia javanica*, and *Pteridium aquilinum*.

Only a few shrubs are able to survive the repeated burning, e.g. *Styphelia suaveolens*, *Rhododendron commonae*, *Xanthomyrtus (e)*, *Podocarpus brassii* (rare), and *Eurya brassii*. Along the brooklets the fire-resistant treefern *Cyathea atrox* var. *inermis* is very common and forms a characteristic element in the landscape (photo 8 and 9).

In wet places with an open grass- or Cyperaceous cover small herbs like *Lactuca*, *Tetramolopium procumbens*, *Eriocaulon* spp., *Haloragis micrantha*, *Hypericum ?habbemense*, *Utricularia* spp., *Lycopodium* spp., *Epilobium ?prostratum*, *Plantago aundensis*, *Viola arcuata*, and *Xyris capensis* var. *schoenoides* are common.

The narrow tracks harbour a complex of species that can stand trampling and compact soil. Here we find *Abrotanella*, *Eriocaulon* spp., *Plantago aundensis*, *Polygonum nepalensis*, *Ranunculus* spp., *Potentilla foersteriana* var. *ima*, and *Hydrocotyle ?mexicana*.

Two cushion plants were found in the plain, only on old, wide, muddy tracks: *Centrolepis philippinensis* and *Oreobolus ambiguus*. Apparently these species, found on the mountain summits as well, can survive at the lower altitudes only under special conditions.

This description gives only a very superficial impression. Mr Gillison made some plots in the grassland near Ibiwara Bivouac in order to get a more detailed picture. He reported on this subject elsewhere (1969).

For a more complete survey, see table H at the end of this paper.

## 10. THE GRASSLAND AROUND THE MOUNTAIN SUMMITS (3200—3565 m alt.)

The summit regions of Mt Kerewa and Mt Ambua are covered with a pyrogenous 'grassland' (photo 17). The latter term should not be taken too literally, because in many places plants other than grasses dominate the aspect of the vegetation.

There are many different communities in this vegetation and only the most superficial remarks can be made here.

The larger part of the slopes, plateaus, and ridges is covered with a dry, mainly herbaceous layer of at most ½ m high. Some parts however, both flat and sloping, are much wetter and here the plant cover looks more 'alpine'. In the moist spots fire of course will have had less influence than in the drier parts.

The dry parts are often locally dominated by one (grass-, sedge-, or fern-)species. In other places, however, there is a mixture of two or more species dominating the aspect. Just as in the pyrogenous grasslands in the plains a complicated interplay of several factors, pedological and biotic (time of burning) is responsible for the mosaic-like distribution of the seral associations.

The following species often dominate the vegetation: *Gahnia javanica, Danthonia archboldii, Deyeuxia brassii, Gleichenia bolanica,* and *G. vulcanica.*

A great many other species may be found, more or less common, in this low vegetation. The most common ones are:

| | |
|---|---|
| *Bor.* | *Trigonotis papuana* |
| *Comp.* | *Anaphalis (b)* |
| *Cyp.* | *Carex celebica* |
| *Epac.* | *Styphelia suaveolens* |
| *Eric.* | *Gaultheria mundula* var. *mundula* |
| | *Vaccinium amblyandrum* var. *amblyandrum* |
| *Gent.* | *Gentiana ettingshausenii* |
| | *G. piundensis* |
| *Hyp.* | *Hypericum ?habbemense* |
| *Lyc.* | *Lycopodium (j)* |
| | *Lycopodium (m)* |
| *Pter.* | *Blechnum (a)* |
| | *Plagiogyria tuberculata* var. *decrescens* |
| *Ros.* | *Potentilla hooglandii* |
| | *P. parvula* |
| *Scr.* | *Hebe albiflora* |
| *Theac.* | *Eurya brassii* |

Scattered in this low vegetation small trees, shrubs, and stragglers occur, up to 2½ m high, either solitary or in small thickets. These thickets are in their composition similar to the more closed shrubberies between forest and grass (chapter 8).

The wet places have a quite different flora, and a much more interesting one. Here we find cushion plants *(Oreobolus* spp. and *Centrolepidaceae)* and 'belly plants' like *Haloragis, Eriocaulon,* and *Plantago* spp.

Among the most commonly found species of the wet places are:

| | |
|---|---|
| *Camp.* | *Lobelia angulata* |
| | *L. archboldiana* |
| *Centr.* | *Centrolepis philippinensis* |
| | *Gaimardia setacea* |
| *Comp.* | *Abrotanella spec.* |
| | *Keysseria radicans* var. *radicans* |
| | *Tetramolopium procumbens* |
| *Cyp.* | *Oreobolus ambiguus* |
| | *O. pumilio* |
| *Erioc.* | *Eriocaulon nov. spec. (a)* |
| *Gram.* | *Monostachya oreoboloides* |
| | *Poa ?wisselii* |
| *Hal.* | *Haloragis micrantha* |
| *Lil.* | *Astelia papuana* |
| *Lyc.* | *Lycopodium (a)* |
| *Plant.* | *Plantago aundensis* |
| | *P. depauperata* |
| *Pter.* | *Schizaea malaccana* |
| *Ran.* | *Ranunculus pseudolowii* |
| *Umb.* | *Trachymene tripartita* |

From the comprehensive list (table H, at the end of this paper) some other conclusions can be drawn.

1. The topregion of Mt Ambua is distinctly richer than that of Mt Kerewa. Very few species were only seen on Mt Kerewa, whereas numerous species were only seen on Mt Ambua. This cannot be explained by the more intensive investigation of the latter mountain (7 collecting days in the summit region of Mt Kerewa, 15 days in that region on Mt Ambua). The main reason is a larger variation in habitats on Mt Ambua: dry places, slightly damper places, distinctly wet slopes, a small brooklet, more amply wooded slopes. In contrast, Mt Kerewa is quite dry in the parts we visited.

2. Although, especially on Mt Ambua, several high-mountain genera are represented in the summit flora (*Centrolepis, Gaimardia, Keysseria, Oreobolus, Monostachya, Plantago*, etc.), several others are conspicuously absent (*Myosotis, Geranium, Libertia, Detzneria, Euphrasia, Oreomyrrhis*). In how far this may be due to what Van Steenis (1961) called the 'elevation effect' is difficult to say so long as the distribution of species over the New Guinean mountains is so erratically known.

3. There is a distinct likeness between the flora of the summit region and that of the grassfields in the plains some 500 metres lower. Quite a number of species have an ecological amplitude allowing them to cover the whole range between *c.* 2500 (or less) and *c.* 3600 m altitude, and they consequently were met with in the whole of the expedition area wherever the circumstances (open or little-shaded places) permitted.

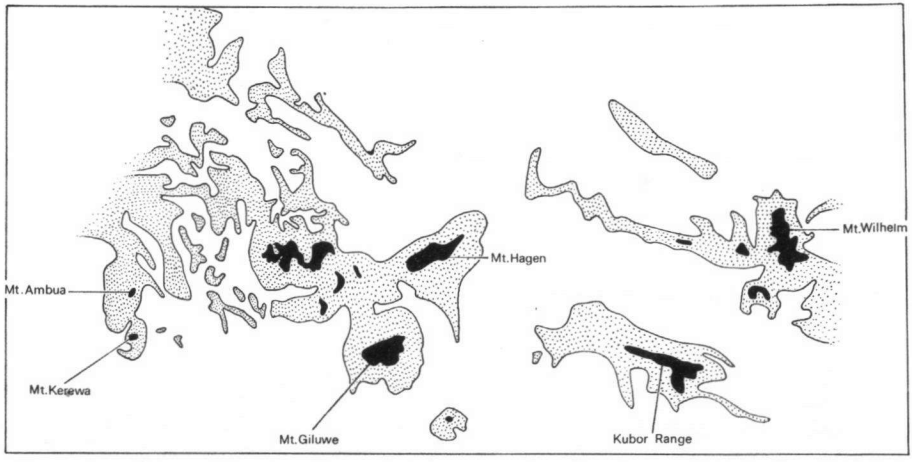


Fig. 4. Approximate delineation of areas above 8000 feet (dotted) and 11000 feet (black) in part of the highlands of eastern New Guinea.

## 11. FLORISTIC COMPARISON WITH OTHER REGIONS

With the data collected during this expedition it is possible to make a first step towards comparative floristics within the Central Highlands of Papua/New Guinea.

In such a comparison only those localities can be used that meet the following requirements: thoroughly explored, all data available, mutually comparable in size and altitude.

Only the following localities are suitable then (fig. 4): Mt Wilhelm (collections made by New Guinea Forestry, Van Balgooy, 1965, and many others), Kubor Range (collections made by Pullen in 1957 and by Pullen & Vink in 1963), Mt Giluwe (collection Schodde, 1961), and the Doma Peaks (present expedition).

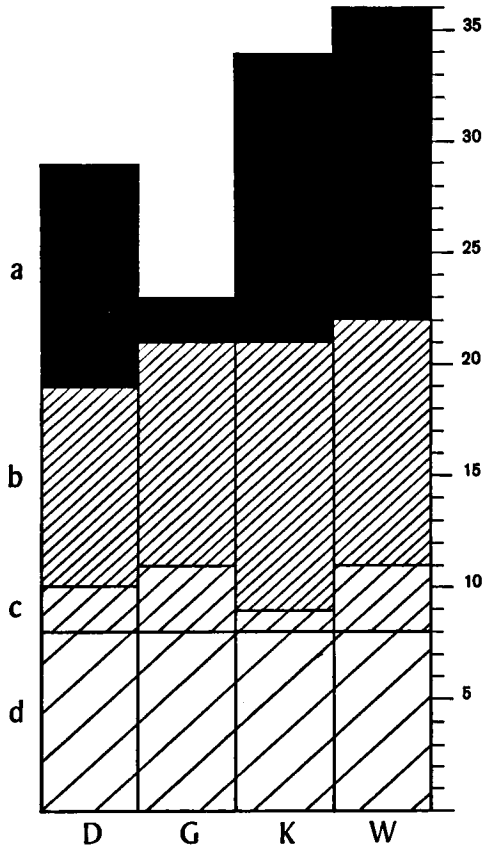


Fig. 5. Number of Ericaceous taxa collected in the Doma Peaks region (D), on Mt Giluwe (G), the Kubor Range (K), and Mt Wilhelm (W). *a:* taxa not in common with any of the other three mountains *b:* taxa in common with one other mountain; *c:* taxa in common with two other mountains; *d:* taxa occurring on all four mountains.

Mt Albert Edward shows a collection density too low to be useful. The Mt Wilhelmina collections originate from a far larger area with a larger range of altitudes. Both mountains are, moreover, situated far away from the group of four mentioned above.

It is of course impossible to compare complete lists of species: in too many families and genera identification to the species is yet impossible. Therefore our comparison is based on the members of the family *Ericaceae* only, a family which is well suited for this purpose because of the large number of taxa, the wide altitudinal range, the conspicuous flowers (which, consequently, are not easily overlooked by collectors), the recent monographic work by Sleumer, the complete publication of all collections.

In table J are enumerated all Ericaceous taxa (71 species and infraspecific entities respectively) which have been collected in one or more of the four localities mentioned. The number of taxa from each locality appears to be of comparable size, and ranges from 23 (Mt Giluwe) to 36 (Mt Wilhelm).

The material considered was collected from the following altitudinal ranges:

| | |
|---|---|
| Doma Peaks | 2000—3560 m |
| Mt Giluwe | 1920—3800 m |
| Kubor Range | 1800—4040 m |
| Mt Wilhelm | 1980—4000 m |

Fig. 5 summarizes the unexpected results of the comparison. With the exception of Mt Giluwe, on each of the mountains a remarkably high proportion of the taxa is not shared with one of the other mountains under consideration. This is not due to endemism; taxa only known from the one mountain and from nowhere else in New Guinea, number only a few.

It would be logical to assume that two mountains share a larger number of species, when the distance between them is shorter. In a broad sense this is true:

| | | |
|---|---|---|
| Doma — Wilhelm | 207 km | 11 species in common |
| Doma — Kubor | 163 km | 10 species in common |
| Giluwe — Wilhelm | 123 km | 13 species in common |
| Doma — Giluwe | 87 km | 16 species in common |
| Giluwe — Kubor | 78 km | 11 species in common |
| Kubor — Wilhelm | 55 km | 17 species in common |

It appears, however, that the likeness of Mt Giluwe and the Kubor Range is much less than could be expected from their mutual distance. This 'gap' could be due to a defective communication between these mountains through the Nebliyer — Kaugel valley system. The connection between Mt Giluwe and Mt Wilhelm is more continuous through Mt Sugarloaf, Mt Hagen, and the Wahgi — Sepik Divide.

Mt Giluwe seems to have a less 'personal' flora than the other three mountains. It cannot be predicted, of course, in how far this will remain unchanged when more mountains (e.g. Mt Hagen) will be included in such a comparison.

## 12. ACKNOWLEDGEMENTS

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The people of Tigibi and Benaria have become friends when we were working together in the field.

We are also grateful to Mr G. van der Wegen for the description of our rock samples and to several of our colleagues for making identifications of our collections.

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## 14. INSAIT LONG DISPELA RIPOT
(Summary in Neo-Melanesian)

Dispela ripot i toktok long wok bilong Dr C. Kalkman na Mr W. Vink, bilong Rijksherbarium long Leiden, Holland, wantaim Mr A. N. Gillison na Mr D. G. Frodin bilong Division bilong wok long Botany, long Lae. Oli bin mekim dispela wok long yar 1966 long ol dispela ples klostu long Tari: mauden Ambua, mauden Ne, mauden Kerewa na wanpela ples istap namel oli kolim Ibiwara. Oli bungim ol plaua, ol lip bilong diwai na ol diwai; olgeta samting em oli bungim wantaim inap long 1,975. Bihain, bai oli salim ol dispela samting igo long ol masta long university or bigpela skul we oli wokim wanpela buk oli kolim Flora.

Dispela ripot bai toksave long ol kain diwai i stap long bus na ol kain plaua antap long mauden. Ripot ia i pinisim lukluk long plaua, long lain oli kolim *Ericaceae* i stap long ol dispela ples na antap long mauden Giluwe, mauden Kubor na mauden Wilhelm.

Mipela i laik tok tenkyu long ol pipal bilong Tigibi na Benaria em oli bin wok wantaim mipela.

Table E. The forest at different altitudes on Mt Ambua

| | | not mossy | | mossy | |
|---|---|---|---|---|---|
| | | 3150 m | 3250—3300 m | 3300—3365 m | |
| *Aquif.* | *Ilex (a)* | + | + | + | |
| *Daphn.* | *Daphniphyllum gracile* | + | + | + | |
| *El.* | *Elaeocarpus (h)* | + | + | + | |
| | *Sericolea (a)* | + | | + | |
| *Eric.* | *Dimorphanthera collinsii* var. *collinsii* | + | + | + | |
| *Euph.* | *Omalanthus (a)* | + | | | Also in scrub, 3390 m |
| *Myrs.* | *Rapanea (b)* | + | + | + | |
| | *Rapanea (d)* | + | + | + | |
| *Myrt.* | *Syzygium vaccinioides* | + | + | + | |
| *Pip.* | *Piper (a)* | + | + | + | |
| *Ros.* | *Prunus pullei* | + | | | Also in scrub, 3550 m |
| | *Rubus lorentzianus* | | + | + | Also in forest, below 2800 m |
| | *R. laeteviridis* | + | + | + | |
| | *R. tsiri* | + | + | + | |
| *Rub.* | *Amaracarpus (a)* | + | + | + | |
| | *Timonius belensis* | + | + | + | |
| *Rut.* | *Evodia (b)* | + | + | | Also in scrub, above 3300 m |
| *Sax.* | *Quintinia (a)* | + | + | + | |
| *Sympl.* | *Symplocos (b)* | + | + | + | |
| | *Symplocos (c)* | + | | + | |
| *Theac.* | *Eurya ?tigang* | + | + | + | |
| *Wint.* | *Bubbia (a)* | + | + | + | |
| | *Drimys piperita ('giluwe')* | + | + | + | |
| | *D. piperita ('heteromera')* | + | + | + | |
| *Zing.* | *Alpinia (b)* | + | | | Also in scrub, 3390 m |
| *Act.* | *Saurauia (a)* | + | | | |
| *Apoc.* | *Alyxia spec.* | + | | | |
| *Aral.* | *Harmsiopanax aculeata* | + | | | |
| *Chlor.* | *Ascarina philippinensis* | + | | | |
| *Cupr.* | *Libocedrus papuana* | + | | | |
| *Eric.* | *Dimorphanthera cornuta* var. *cornuta* | + | | | |
| *Mon.* | *Levieria parvifolia* | + | | | |
| *Mor.* | *Streblus urophyllus* var. *urophyllus* | + | | | |
| *Myrs.* | *Rapanea (f)* | + | | | |
| *Podoc.* | *Dacrycarpus cinctus* | + | | | |
| *Ros.* | *Rubus ledermannii* var. *ledermannii* | + | | | |
| *Rut.* | *Evodiella (a)* | + | | | |
| *Sax.* | *Polyosma (a)* | + | | | |
| | *Polyosma (d)* | + | | | |
| *Sphen.* | *Sphenostemon papuanum* | + | | | |
| *Wint.* | *Drimys piperita ('coriacea')* | + | | | |
| *Pter.* | *Cyathea aeneifolia* | + | + | | Also in scrub, above 3300 m |
| | *Dicksonia hieronymi* | + | + | | |
| *Ros.* | *Rubus archboldianus* | + | + | | |
| *Rub.* | *Amaracarpus (b)* | + | + | | |
| *Sax.* | *Polyosma (b)* | + | + | | |
| *Ros.* | *Rubus montis-wilhelmi* | | + | | |
| *Sympl.* | *Symplocos (j)* | | + | | On Kerewa also at 2940 m |

| | | not mossy | | mossy | |
|---|---|---|---|---|---|
| | | 3150 m | 3250—3300 m | 3300—3365 m | |
| *Thym.* | *Wikstroemia androsaemifolia* | | + | | Also much lower, at 1600 m |
| *Eric.* | *Dimorphanthera dekockii* var. *pubiflora* | | + | + | |
| *Ep.* | *Styphelia suaveolens* | | | + | Also lower, 2700 m, in open vegetation |
| *Eric.* | *Rhododendron anagalliflorum* | | | + | |
| | *Rh. beyerinckianum* | | | + | idem |
| | *Vaccinium apiculatum* | | | + | |
| | *V. keysseri* var. *keysseri* | | | + | |
| *Pter.* | *Histiopteris* | | | + | Also lower, 2800 m |
| *Wint.* | *Drimys piperita* ('*montis-wilhelmi*') | | | + | |

[1]) Species which were observed only once during the expedition have been left out of this table.

Table F. Comparison of the Ne mossy forest with the mossy and not-mossy forest types on Mt Ambua

| | mountain | Mt Ne | Mt Ambua | |
|---|---|---|---|---|
| | aspect | mossy | not mossy | mossy |
| | altitude | 3150 m | 3150 m | 3300 m |
| *Act.* | *Saurauia (a)* | — | + | — |
| *Apoc.* | *Alyxia spec.* | — | + | — |
| *Aq.* | *Ilex (a)* | + | + | + |
| *Aral.* | *Harmsiopanax aculeata* | — | + | — |
| *Chlor.* | *Ascarina philippinensis* | — | + | — |
| *Cun.* | *Weinmannia (a)* | + | — | — |
| *Cupr.* | *Libocedrus papuana* | — | + | — |
| *Daphn.* | *Daphniphyllum gracile* | — | + | + |
| *El.* | *Elaeocarpus (h)* | + | + | + |
| | *Sericolea (a)* | + | + | + |
| *Ep.* | *Styphelia suaveolens* | — | — | + |
| *Eric.* | *Dimorphanthera collinsii* var. *collinsii* | + | + | + |
| | *D. cornuta* var. *cornuta* | — | + | — |
| | *D. dekockii* var. *pubiflora* | — | — | + |
| | *Diplycosia rupicola* | + | — | — |
| | *Rhododendron anagalliflorum* | + | — | + |
| | *Rh. beyerinckianum* | + | — | + |
| | *Vaccinium apiculatum* | — | — | + |
| | *V. keysseri* var. *keysseri* | + | — | + |
| *Euph.* | *Omalanthus (a)* | + | + | — |
| *Gram.* | *Nastus spec.* | + | — | — |
| *Mon.* | *Levieria parvifolia* | + | + | — |

| | | mountain | Mt Ne | Mt Ambua | |
|---|---|---|---|---|---|
| | | aspect | mossy | not mossy | mossy |
| | | altitude | 3150 m | 3150 m | 3300 m |
| *Mor.* | *Streblus urophyllus* var. *urophyllus* | | + | + | — |
| | *S. urophyllus* var. *salicifolius* | | + | — | — |
| *Myrs.* | *Rapanea (a)* | | + | — | — |
| | *Rapanea (b)* | | — | + | + |
| | *Rapanea (d)* | | + | + | + |
| | *Rapanea (f)* | | — | + | — |
| *Myrt.* | *Syzygium vaccinioides* | | + | + | + |
| | *Xanthomyrtus papuana* | | + | — | — |
| *Ochn.* | *Schuurmansia henningsii* | | + | — | — |
| *Pip.* | *Piper (a)* | | — | + | + |
| *Podoc.* | *Dacrycarpus cinctus* | | — | + | — |
| *Pter.* | *Cyathea aeneifolia* | | + | + | — |
| | *Dicksonia hieronymi* | | + | + | — |
| | *Histiopteris spec.* | | — | — | + |
| *Ros.* | *Prunus pullei* | | + | + | — |
| | *Rubus archboldianus* | | + | + | — |
| | *R. lorentzianus* | | — | — | + |
| | *R. laeteviridis* | | — | + | + |
| | *R. tsiri* | | — | + | + |
| | *R. ledermannii* var. *ledermannii* | | — | + | — |
| *Rub.* | *Amaracarpus (a)* | | — | + | + |
| | *Amaracarpus (b)* | | — | + | — |
| | *Timonius belensis* | | + | + | + |
| *Rut.* | *Evodia (b)* | | — | + | — |
| | *Evodia (e)* | | + | — | — |
| | *Evodiella (a)* | | — | + | — |
| *Sax.* | *Polyosma (a)* | | — | + | — |
| | *Polyosma (b)* | | — | + | — |
| | *Polyosma (d)* | | — | + | — |
| | *Quintinia (a)* | | + | + | + |
| *Sph.* | *Sphenostemon papuanum* | | — | + | — |
| *Sympl.* | *Symplocos (b)* | | — | + | + |
| | *Symplocos (c)* | | + | + | + |
| *Theac.* | *Eurya ?tigang* | | — | + | + |
| *Wint.* | *Bubbia (a)* | | + | + | + |
| | *Drimys piperita ('montis-wilhelmi')* | | + | — | + |
| | *D. piperita ('giluwe')* | | + | + | + |
| | *D. piperita ('coriacea')* | | + | + | — |
| | *D. piperita ('heteromera')* | | — | + | + |
| *Zing.* | *Alpinia (a)* | | + | — | — |
| | *Alpinia (b)* | | + | + | — |
| Number of species recorded [1] | | | 33 | 45 | 29 |
| Number of combinations | 11 species | | + | + | + |
| | 20 species | | + | + | (+ or —) |
| | 15 species | | + | (+ or —) | + |
| | 19 species | | (+ or —) | + | + |

[1] Species which were observed only once during the expedition, have been left out of this table.

Table G. Transect near Lei River.[1]) Comparison of Nothofagus forest (squares 4—27) with mixed forest (squares 30—40)

| | | Noth. | mix. | | | Noth. | mix. |
|---|---|---|---|---|---|---|---|
| *Act.* | *Saurauia (c)* | + | + | *Myrt.* | *Syzygium ?adelphicum* | + | + |
| *Apoc.* | *Alyxia spec.* | + | + | | *S. vaccinioides* | + | A, B |
| | *Parsonsia spec.* | + | — | | *Syzygium (a)* | + | + |
| *Aq.* | *Ilex (a)* | + | A, B | | *Syzygium (b)* | + | + |
| *Arac.* | *Alocasia spec.* | + | + | | *Xanthomyrtus (a)* | + | B |
| *Aral.* | *Schefflera (a)* | + | A | | *Xanthomyrtus (f)* | + | + |
| | *Schefflera (b)* | + | + | *Pand.* | *Freycinetia spec.* | + | + |
| *Cun.* | *Schizomeria gorumensis* | — | + | | *Pandanus spec.* | + | + |
| | *Schizomeria (a)* | + | A | *Pip.* | *Piper (a)* | + | + |
| | *Weinmannia (a)* | + | A, B | *Podoc.* | *Phyllocladus hypophyllus* | + | A |
| *Daphn.* | *Daphniphyllum gracile* | + | A, B | | *Podocarpus bracteatus* | + | + |
| *El.* | *Elaeocarpus (c)* | + | + | *Pter.* | *Cyathea aeneifolia* | + | + |
| | *Elaeocarpus (h)* | + | + | | *Dicksonia hieronymi* | + | + |
| | *Elaeocarpus (i)* | + | + | | *Histiopteris spec.* | — | + |
| *Eric.* | *Dimorphanthera collinsii* var. *collinsii* | + | + | | *Marattia spec.* | — | + |
| | *D. cornuta* var. *cornuta* | + | + | *Ros.* | *Prunus grisea* var. *grisea* | + | + |
| | *Rhododendron beyerinckianum* | — | +[2]) | | *P. pullei* | + | A, B |
| | *Rh. ?pleianthum* | + | + | | *Rubus laeteviridis* | + | + |
| *Euph.* | *Breynia cernua* | — | + | | *R. tsiri* | + | + |
| | *Glochidion (b)* | + | A | | *R. ledermannii* var. *ledermannii* | + | + |
| | *Macaranga (a)* | — | + | *Rub.* | *Timonius belensis* | + | + |
| | *Macaranga (b)* | + | + | *Rut.* | *Acronychia (a)* | + | + |
| *Fag.* | *Nothofagus rubra* | + | — | | *Melicope sarcococca* | + | + |
| *Gesn.* | *Aeschynanthus (a)* | — | + | *Sax.* | *Polyosma (a)* | + | + |
| | *Cyrtandra (a)* | + | + | | *Polyosma (b)* | + | A, B |
| | *Cyrtandra (b)* | — | + | | *Quintinia epiphytica* | + | + |
| *Halor.* | *Gunnera macrophylla* | + | A | | *Quintinia (a)* | + | + |
| *Laur.* | *Cryptocarya minutifolia* | + | + | *Sph.* | *Sphenostemon papuanum* | + | + |
| | *Litsea exsudens* | — | + | *Sympl.* | *Symplocos (b)* | — | + |
| *Log.* | *Fagraea salticola* | + | A | | *Symplocos (c)* | + | A, B |
| *Melas.* | *Beccarianthus (a)* | — | + | | *Symplocos (h)* | + | + |
| | *Medinilla (a)* | + | A | *Theac.* | *Eurya ?tigang* | + | A, B |
| *Mon.* | *Levieria parvifolia* | + | + | *Thym.* | *Wikstroemia androsaemifolia* | + | + |
| | *Palmeria (a)* | + | + | *Urt.* | *Procris spec.* | + | + |
| | *Steganthera (a)* | + | + | *Vit.* | *Tetrastigma (a)* | + | + |
| *Mor.* | *Ficus (a)* | + | + | *Wint.* | *Bubbia (a)* | +[3]) | + |
| | *Streblus urophyllus* var. *urophyllus* | + | + | | *Drimys piperita* ('*coriacea*') | + | + |
| *Myrs.* | *Rapanea (b)* | + | A, B | *Zing.* | *Alpinia (a)* | + | + |
| | *Rapanea (d)* | + | B | | *Alpinia (b)* | + | + |
| | *Rapanea (j)* | + | + | | *Zingiber spec.* | + | + |

[1]) Plants only seen once during the expedition were left out of this table.
[2]) Plant of forest margin, here in little gap.
[3]) Observed just outside the plot.

A and B: species in the transect restricted to the *Nothofagus* squares, but in other localities present in mixed forest without *Nothofagus*:
A: in other mixed forest at same altitude, 2700—2800 m.
B: in mixed forest or scrub on the mountain slopes, 2850 m or higher.

Table H. Flora of the grasslands in the Ibiwara Plain, on Mt Kerewa, and on Mt Ambua

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Bor.* | *Trigonotis papuana* | A | K | | | *G. pullei* var. *pullei* | A | K | |
| *Burm.* | *Burmannia disticha* | | | P | | *Rhododendron commonae* | A | K | P |
| *Camp.* | *Lobelia angulata* | A | K | | | *Vaccinium amblyandrum* | | | |
| | *L. archboldiana* | A | | | | var. *amblyandrum* | A | K | |
| | *Wahlenbergia marginata* | | | P | *Erioc.* | *Eriocaulon hookerianum* | | | P |
| *Car.* | *Cerastium spec.* | | | P | | *E. novoguineense* | | | P |
| | *Sagina spec.* | | K | | | *E. nov. spec. (a)* | | K | |
| *Centr.* | *Centrolepis philippinensis* | A | | P | | *E. nov. spec. (b)* | | | P |
| | *Gaimardia setacea* | A | | | *Euph.* | *Glochidion (b)* | | | P |
| *Comp.* | *Abrotanella spec.* | A | | P | *Gent.* | *Gentiana ettingshausenii* | A | | P |
| | *Anaphalis (a)* | | | P | | *G. piundensis* | | K | P |
| | *Anaphalis (b)* | A | K | P | | *G. spec.* | A | | |
| | *Blumea lacera* var. *lacera* | | | P | | *Swertia papuana* | | | P |
| | *Crassocephalum crepidioides* | | | P | *Gram.* | *Anthoxanthum angustum* | A | | |
| | *Emilia spec.* | | | P | | *Arundinella furva* | | | P |
| | *Erechtites spec.* | A | K | P | | *Danthonia archboldii* | A | K | P |
| | *Gnaphalium spec.* | A | | P | | *Deschampsia klossii* | | | P |
| | *Helichrysum bracteatum* | | | P | | *Deyeuxia brassii* | A | | |
| | *Keysseria radicans* var. *radicans* | A | | | | *D. ?macgregorii* | A | K | |
| | *Lactuca spec.* | A | K | P | | *Dichelachne novoguineensis* | | | P |
| | *Myriactis cabrerae* | | | P | | *Echinopogon ovatus* | | | P |
| | *Sonchus asper* | | | P | | *Eulalia leptostachys* | | | P |
| | *Tetramolopium procumbens* | A | | P | | *Festuca nubigena* | A | | |
| *Cyp.* | *Bulbostylis densa* | | | P | | *Hierochloë redolens* | A | | |
| | *Carex alpina* | A | | | | *Imperata cylindrica* | | K | P |
| | *C. capillacea* | | | P | | *Isachne arfakensis* | | | P |
| | *C. celebica* | A | | | | *I. spec.* | | | P |
| | *C. maculata* | | | P | | *Monostachya oreoboloides* | A | | |
| | *C. michauxiana* var. *asiatica* | A | | P | | *Miscanthus floridulus* | | | P |
| | *C. neoguineensis* | | | P | | *Poa languidor* | A | | |
| | *C. perileia* | | | P | | *P. ?wisselii* | A | | |
| | *C. phacota* | | | P | *Halor.* | *Haloragis halconensis* | | | P |
| | *Cyperus brevifolius* | | | P | | *H. micrantha* | A | K | P |
| | *C. sanguinolentus* | | | | *Hyp.* | *Hypericum ?habbemense* | A | K | P |
| | ssp. *melanocephalus* | | | P | | *H. japonicum* | | | P |
| | *C. unioloides* | | | P | *Junc.* | *Juncus prismatocarpus* | | | P |
| | *Eleocharis brevicollis* | | | P | *Lent.* | *Utricularia (a)* | | | P |
| | *E. tetraquetra* | | | P | | *Utricularia (b)* | | | P |
| | *Gahnia javanica* | A | K | P | *Lil.* | *Astelia papuana* | A | K | |
| | *Lipocarpha chinensis* | | | P | *Lyc.* | *Lycopodium (a)* | A | K | P |
| | *Machaerina gunnii* | | | P | | *Lycopodium (b)* | | K | P |
| | *M. rubiginosa* | | | P | | *Lycopodium (c)* | | K | P |
| | *Oreobolus ambiguus* | A | K | | | *Lycopodium (j)* | A | K | P |
| | *O. pumilio* | A | | P | | *Lycopodium (k)* | | | P |
| | *Rhynchospora rugosa* | | | P | | *Lycopodium (l)* | A | | |
| | *Schoenus curvulus* | A | K | | | *Lycopodium (m)* | | K | |
| | *Scirpus inundatus* | | | P | *Myrt.* | *Xanthomyrtus (e)* | | | P |
| | *S. merrillii* | A | | P | *Onag.* | *Epilobium keysseri* | A | K | P |
| | *S. subcapitatus* | A | | | | *E. ?prostratum* | A | K | P |
| *Dips.* | *Triplostegia glandulifera* | | | P | *Orch.* | *Bulbophyllum spec.* | | K | |
| *Dros.* | *Drosera peltata* | | | P | | *Spathoglossum spec.* | | | P |
| *Ep.* | *Styphelia suaveolens* | A | K | P | | *Spiranthes spec.* | | | P |
| | *Trochocarpa dekockii* | A | | | *Oxal.* | *Oxalis corniculata* | | | P |
| | *T. dispersa* | A | | | *Plant.* | *Plantago aundensis* | A | | P |
| | *T. nubicola* | | K | | | *P. depauperata* | A | | |
| *Eq.* | *Equisetum debile* | | | P | *Podoc.* | *Podocarpus brassii* | | | P |
| *Eric.* | *Diplycosia rupicola* | A | K | | *Pol.* | *Polygonum nepalense* | | | P |
| | *Gaultheria mundula* var. *mundula* | A | K | | *Pter.* | *Blechnum fluviatile* | | K | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Blechnum (a)* | A | K | P | | *P. papuana* | A | |
| | *Blechnum (c)* | A | | | | *P. parvula* | A | K |
| | *Cyathea atrox* var. *inermis* | A | | P | | *Rubus lorentzianus* | A | K P |
| | *Gleichenia bolanica* | A | K | P | | *R. papuanus* | A | K |
| | *G. erecta* | A | | P | *Rub.* | *Anotis spec.* | | P |
| | *G. hooglandii* | | K | | | *Coprosma (a)* | A | K P |
| | *G. vulcanica* | A | K | P | | *Galium (a)* | | P |
| | *Lindsaea odorata* | | | P | | *Galium (b)* | | P |
| | *Plagiogyria tuberculata* var. *decrescens* | A | K | P | | *Nertera (a)* | A | |
| | *Pteridium aquilinum* | | | P | | *Nertera (b)* | A | K P |
| | *Schizaea malaccana* | A | | | *Sax.* | *Astilbe rivularis* | | P |
| | *Thelypteris beddomei* | | K | P | *Scr.* | *Hebe albiflora* | A | K |
| *Ran.* | *Ranunculus basilobatus* x *wahgiensis* | | | P | | *Veronica archboldii* | | P |
| | *R. pseudolowii* | A | K | P | *Theac.* | *Eurya brassii* | A | K P |
| | *R. ?wahgiensis* | | | P | *Umb.* | *Hydrocotyle ?mexicana* | | P |
| *Ros.* | *Potentilla foersteriana* var. *foersteriana* | A | | | | *Trachymene saniculaefolia* | | P |
| | *P. foersteriana* var. *ima* | | | P | | *T. tripartita* | A | |
| | *P. hooglandii* | A | | P | *Viol.* | *Viola arcuata* | | P |
| | | | | | *Xyr.* | *Xyris capensis* var. *schoenoides* | | P |

A: Summit region of Mt Ambua, *c.* 3360 m and higher.
K: Summit region of Mt Kerewa, *c.* 3200 m and higher.
P: The grassy plains near Ibiwara, between Mt Ne and Mt Kerewa, and towards Margarima, alt. *c.* 2650—2800 m.

Table J. The Ericaceae of four mountains in Papua/New Guinea

| | Doma Peaks | Mt Giluwe | Kubor Range | Mt Wilhelm |
|---|---|---|---|---|
| *Agapetes* | | | | |
| *rubrocalyx* var. *pilicalyx* | — | — | + | — |
| *vitis-idaea* | — | — | + | + |
| *Dimorphanthera* | | | | |
| *alpina* var. *alpina* | + | + | — | — |
| *amoena* | — | — | + | + |
| *clemensiae* | + | — | — | — |
| *collinsii* var. *collinsii* | + | — | — | — |
| *collinsii* var. *montis-wilhelmi* | — | — | + | + |
| *cornuta* var. *cornuta* | + | — | — | — |
| *cornuta* var. *tenuiflora* | + | + | — | — |
| *dekockii* var. *dekockii* | — | — | + | — |
| *dekockii* var. *chlorocarpa* | — | + | — | — |
| *dekockii* var. *pubiflora* | + | — | — | — |
| *denticulifera* var. *denticulifera* | — | + | — | + |
| *denticulifera* var. *pubens* | — | — | — | + |
| *kempteriana* | + | — | — | — |
| *leucostoma* | — | — | — | + |
| *microphylla* | — | — | + | + |
| *robbinsii* | — | — | — | + |
| *womersleyi* | — | — | + | — |
| *Diplycosia* | | | | |
| *rupicola* | + | + | — | — |
| *varians* | — | — | + | — |
| *Gaultheria* | | | | |
| *mundula* var. *mundula* | + | + | + | + |

| | Doma Peaks | Mt Giluwe | Kubor Range | Mt Wilhelm |
|---|---|---|---|---|
| *pullei* var. *pullei* | + | + | + | + |
| *Rhododendron* | | | | |
| *anagalliflorum* | + | — | + | — |
| *atropurpureum* | — | — | + | + |
| *beyerinckianum* | + | + | + | + |
| *christi* | + | + | — | — |
| *commonae* | + | + | + | + |
| *culminicolum* var. *culminicolum* | — | + | + | + |
| *gaultheriifolium* var. *gaultheriifolium* | — | — | + | + |
| *gaultheriifolium* var. *expositum* | — | — | — | + |
| *herzogii* | — | — | — | + |
| *hooglandii* | — | — | + | — |
| *inconspicuum* | — | — | — | + |
| *macgregoriae* var. *macgregoriae* | + | + | + | + |
| *macgregoriae* var. *glabrifilum* | + | — | — | — |
| *maius* | — | — | — | + |
| *nummularifolium* | + | — | + | — |
| *pleianthum* | + | + | — | + |
| *rarum* | + | — | — | + |
| *saruwagedicum* var. *saruwagedicum* | — | — | + | — |
| *saruwagedicum* var. *alpinum* | — | — | + | — |
| *saxifragoides* | — | + | — | — |
| *superbum* | — | + | + | — |
| *vandeursenii* | — | — | — | + |
| *villosum* | — | — | — | + |
| *womersleyi* | + | + | + | + |
| *yelliotii* | + | — | — | — |
| *nov. spec. (a)* | + | — | — | — |
| *Vaccinium* | | | | |
| *albicans* var. *albicans* | — | — | + | + |
| *amblyandrum* var. *amblyandrum* | + | + | + | + |
| *amblyandrum* var. *maiusculum* | — | — | + | — |
| *amblyandrum* var. *pungens* | — | + | — | + |
| *amplifolium* var. *oblongum* | — | — | + | + |
| *amplifolium* var. *stabilipes* | — | — | + | — |
| *ampullaceum* | — | — | — | + |
| *apiculatum* | + | + | — | — |
| *auriculifolium* | + | — | — | — |
| *crassistylum* | — | — | + | — |
| *cruentum* | + | + | — | + |
| *evandinervium* | — | — | + | — |
| *fissiflorum* | — | — | — | + |
| *keysseri* var. *keysseri* | + | + | + | + |
| *keysseri* var. *acutatum* | — | — | — | + |
| *molle* var. *mollissimum* | — | — | — | + |
| *myrsinoides* | — | — | + | — |
| *reticulato-venosum* | + | — | — | — |
| *schoddei* | + | + | — | — |
| *sparsum* | — | — | — | + |
| *striicaule* var. *striicaule* | — | — | + | — |
| *striicaule* var. *denodes* | — | + | + | — |
| Total number of taxa | 29 | 23 | 34 | 36 |
| Taxa not shared | 10 | 2 | 13 | 14 |

## APPENDIX

### COLLECTION NUMBERS OF NON-IDENTIFIED SPECIES

For shortness' sake the names of collectors have been omitted. Numbers 4601—5228 and 5332 were collected by Kalkman, 16801—17540 by Vink, 25101—25227 by Gillison, 26959—27000, 28101—28500, and 32001—32116 by Frodin. The collections of Gillison and Frodin are in the N.G.F. series.

**Act.** *Saurauia (a):* 5132, 25194; *Saurauia (c):* 4785, 17254, 25191; *Saurauia (d):* 4764, 5069, 17282. **Aquif.** *Ilex (a):* 4819, 4863, 5136, 5157, 16960, 17070, 28216, 28323. **Aral.** *Schefflera (a):* 4838, 5172, 26980, 28237; *Schefflera (b):* 4841, 16993, 17529, 28359; *Schefflera (d):* 4817, 25158; *Schefflera (e):* 16975. **Comp.** *Anaphalis (a):* 4611, 25175; *Anaphalis (b):* 4977, 17053, 25167. **Cunon.** *Schizomeria (a):* 25157, 28126, 28198. *Weinmannia (a):* 4859, 4860, 17098, 25132, 26964, 28131. **Elaeoc.** *Elaeocarpus (b):* 4717, 28123; *Elaeocarpus (c):* 17239, 28199, 28256; *Elaeocarpus (h):* 4794, 4861, 5133, 17313, 17457, 26975; *Elaeocarpus (i):* 25196, 28107, 28167. *Sericolea (a):* 4814, 4993, 5134, 17065, 17269; *Sericolea (b):* 4741, 17025, 17231, 25118, 26969, 28124; *Sericolea (c):* 17038, 28342. **Eric.** *Rhododendron nov. spec. (a):* 16991, 17041, 17078, 17280, 25152, 28220. **Erioc.** *Eriocaulon nov. spec. (a):* 4833; *Eriocaulon nov. spec. (b):* 4890, 16967. **Euph.** *Claoxylon (a):* 17091, 17167, 25190, 28157; *Claoxylon (b):* 17509. *Glochidion (a):* 17096; *Glochidion (b):* 28306, 28321. *Macaranga (a):* 4791, 25144, 26981; *Macaranga (b):* 5180, 28317. *Omalanthus (a):* 4701, 4911, 4990, 17460, 25120, 26995, 28274. **Gesn.** *Aeschynanthus (a):* 17199, 25184, 28127, 28319. *Cyrtandra (a):* 16912, 16914, 28111; *Cyrtandra (b):* 17493, 28158. **Laur.** *Cryptocarya (a):* 28327. **Lentib.** *Utricularia (a):* 4949; *Utricularia (b):* 4607. **Lyc.** *Lycopodium (a):* 4622, 4780, 17135, 17146, 17285; *Lycopodium (b):* 4634, 4751; *Lycopodium (c):* 4633, 4752, 28375; *Lycopodium (d):* 4883; *Lycopodium (g):* 4700, 28272; *Lycopodium (j):* 4624, 4773, 4980, 28373; *Lycopodium (k):* 4623, 28374; *Lycopodium (l):* 5052; *Lycopodium (m):* 4772. **Melast.** *Beccarianthus (a):* 5191, 28155. *Medinilla (a):* 4673, 26992. **Monim.** *Kibara (a):* 17031, 17093, 17232, 26989, 28211. *Palmeria (a):* 5179, 17209, 28259. *Steganthera (a):* 17029, 17208. **Morac.** *Ficus (a):* 5332. **Myrs.** *Rapanea (a):* 4800, 4816, 16990, 17125, 28346; *Rapanea (b):* 16972, 17340, 17483; *Rapanea (c):* 17293, 17374; *Rapanea (d):* 4862, 5005, 17453; *Rapanea (e):* 4788; *Rapanea (f):* 4913, 25198, 28214, 28282, 28289; *Rapanea (j):* 5187, 26987. **Myrt.** *Syzygium (a):* 4854, 4896, 16940, 26991; *Syzygium (b):* 28129, 28212. *Xanthomyrtus (a):* 17079, 17120, 26976; *Xanthomyrtus (e):* 17156, 25150, 28261; *Xanthomyrtus (f):* 17476, 28170, 28354. **Pip.** *Piper (a):* 4709, 17365, 17514, 25137, 26966; *Piper (b):* 4739, 17506, 26993, 28260; *Piper (d):* 5200. **Pter.** *Blechnum (a):* 4641, 4877, 17075, 17260, 17396; *Blechnum (c):* 17428. *Pteris (a):* 4697, 4969, 17024, 17434; *Pteris (b):* 5203. **Rub.** *Amaracarpus (a):* 4740, 5004, 5010, 17363, 28246; *Amaracarpus (b):* 5106, 5161. *Coprosma (a):* 4614, 4757, 4765, 4981, 4984. *Galium (a):* 16943; *Galium (b):* 16946, 25151. *Nertera (a):* 17297; *Nertera (b):* 4688, 17406. **Rut.** *Acronychia (a):* 17198, 17512, 25121, 25145, 26970, 26990, 28318; *Acronychia (b):* 4910. *Evodia (a):* 17039, 17088, 17237, 25192, 26961; *Evodia (b):* 5105, 17456, 28330; *Evodia (d):* 16941, 17106, 28219, 28308; *Evodia (e):* 4868; *Evodia (f):* 5156. *Evodiella (a):* 17203, 17227, 28284, 28326. **Sax.** *Polyosma (a):* 17459, 17485, 28245, 28355; *Polyosma (b):* 4918, 5041, 5174, 17229, 17463, 28128; *Polyosma (d):* 4886, 5159, 25135, 25138, 28356. *Quintinia (a):* 4732, 4789, 4965, 5158, 17123, 17526, 25122. **Sympl.** *Symplocos (b):* 5042, 17308, 17455; *Symplocos (c):* 4743, 4746, 4870, 4951, 5127, 5128, 17173, 17314, 25226, 26983, 28215; *Symplocos (h):* 5183, 28257; *Symplocos (j):* 5043, 17037. **Theac.** *Eurya (a):* 4795, 4815, 4983, 17095; *Eurya (b):* 17507. **Vit.** *Tetrastigma (a):* 5196, 28213. **Wint.** *Bubbia (a):* 5163, 17067, 17126, 17166, 17238, 17368, 17494, 26965. **Zing.** *Alpinia (a):* 4712, 4792, 28203, 28315; *Alpinia (b):* 4987, 28314; *Alpinia (c)* :4696.