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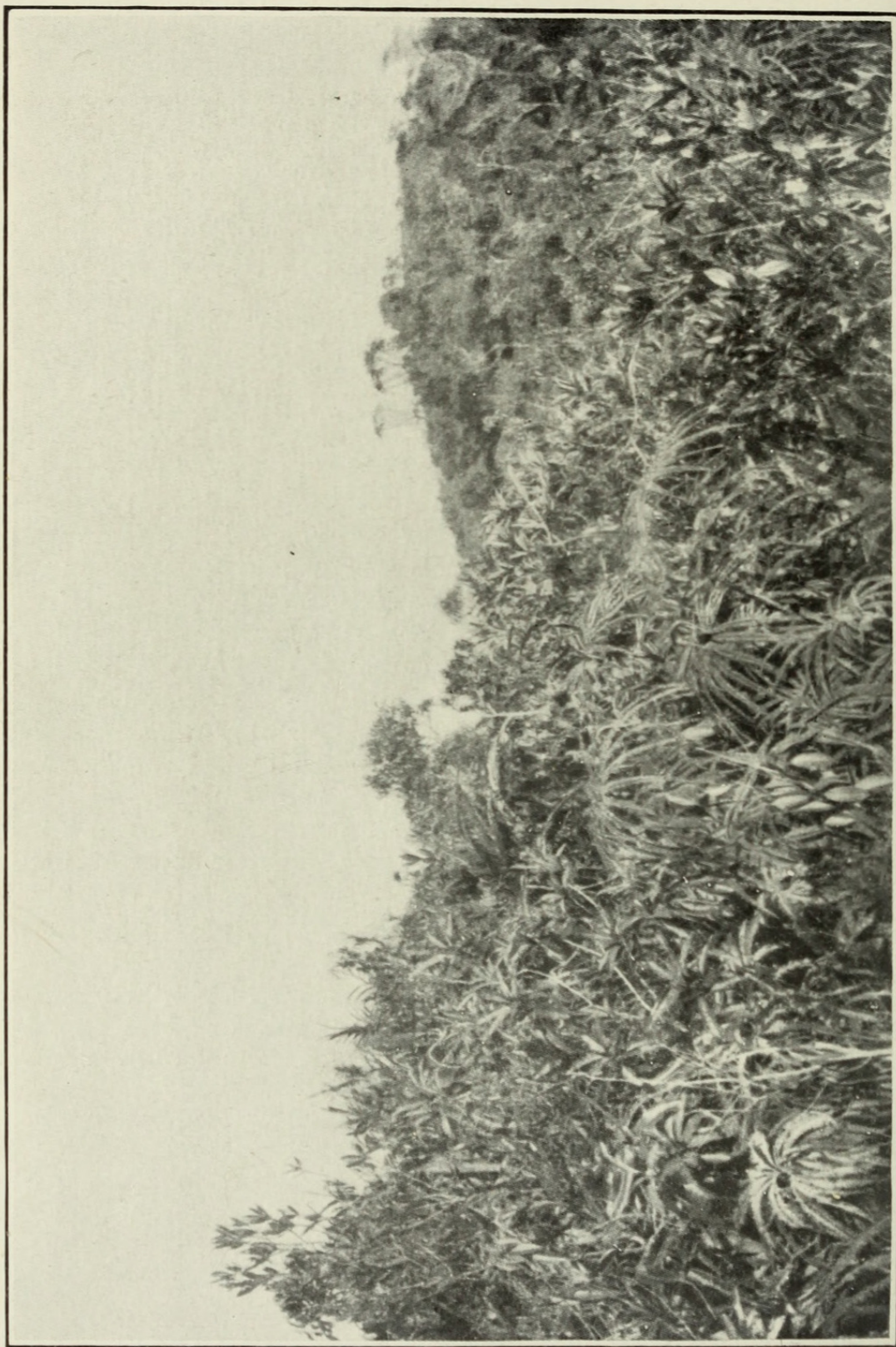
Nos. 7—8.

THE VEGETATION OF GUNONG BELUMUT IN JOHORE.

The present paper is an attempt to describe the vegetation on the upper part of Gunong Belumut, a mountain situated in the south of the Malay Peninsula, about the middle of the State of Johore. The summit is 3,321 feet above sea level, and the area here dealt with is that lying between an altitude of about 2,800 feet and the summit. The writer visited this locality in May 1923, in company with Mr. G. R. Fulton, Assistant Government Geologist, to whom he wishes to express his very cordial thanks for the opportunity of making the expedition.

The route followed was that made by Mr. J. G. Watson, Conservator of Forests, Johore, who had ascended the mountain a short time previously. Except a few plants obtained by Mr. Watson, no collections had been made on the mountain. The jungle track starts from about the 14th mile on the Kluang-Mersing road. From this point to the Sungei Berhidong at the foot of G. Belumut is about 11 or 12 miles, the track crossing the ridge of G. Chemundong at a height of 1,265 feet. From the camp by S. Berhidong, at 450 ft. above sea, to the summit of the mountain is about three miles.

The lower part of the ascent is through rather dry Dipterocarp forest, with Bertam (*Eugeissonia*) as the chief undergrowth. At about 2,500 ft. a transition begins to occur to a forest of crowded trees of much lower stature, gradually more and more covered with liverworts and mosses. Within about 300 ft. the change is complete from a fairly high forest to the mossy elfin forest which



Summit of Gunung Belumut, with shoulder-high scrub containing *Matonia*.

covers most of the area between 2,800 ft. and the summit. On the northern slope however the mossy forest is replaced by an open scrub in which for the most part *Matonia pectinata* is dominant, with stunted shrubs and trees growing above it at intervals (Plate I). The transition from the forest to the scrub is very sharp near the summit, but less so at lower altitudes. The name Belumut is descriptive of the mossy condition of the summit.

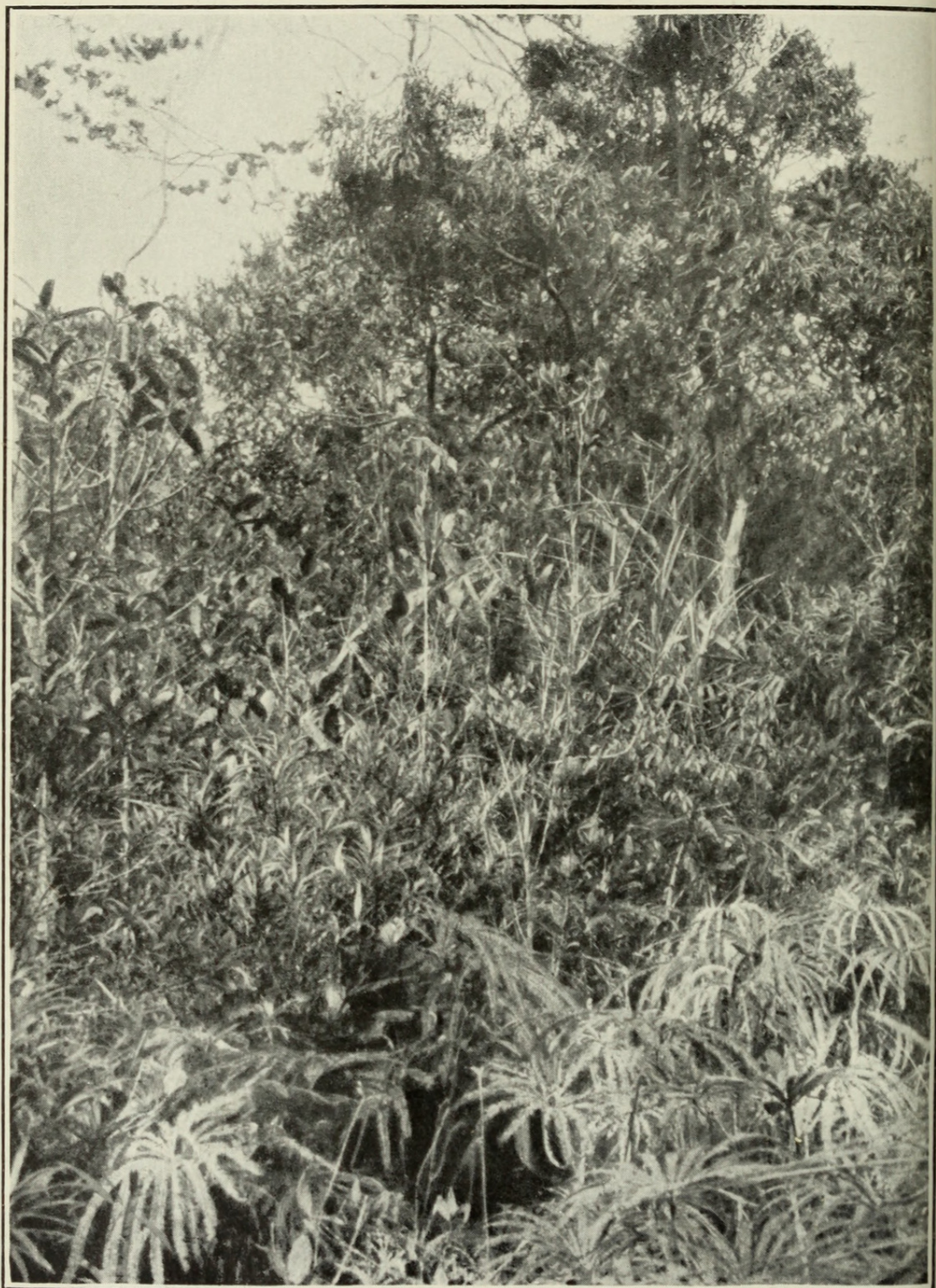
A camp was made on the summit of the mountain, and seven days spent there. As complete a collection as possible was made both of flowering plants and cryptogams, and the writer is greatly indebted to Mr. I. H. Burkill for the determination of the former, and to Mr. H. N. Dixon for the determination of mosses. The writer is responsible for naming the Pteridophytes and has attempted to identify the more important of the Liverworts which form such a conspicuous feature of the vegetation.

Climatic conditions.

During the seven days spent on the upper part of the mountain, the summit was covered with cloud every night, but either in the morning or later in the day the cloud lifted, forming again about sunset or earlier. One evening light clouds were formed on the summit about sunset (6 p.m.), but soon disappeared; and no more came till about 9 p.m. Every morning, whether there had been rain or not, the bryophytes on the trees and ground were saturated with water from the clouds. Rain occurred on four days out of the seven, but only once at all heavily. On the finest day the bryophytes were very much dried up, except in the most sheltered places, and the leaves of Hymenophyllums were distinctly shrivelled.

Unfortunately no daily record was kept of the direction of winds, but on those days on which the facts were noted the evening winds forming the clouds came from the south-west. This is probably a seasonal matter, dependent on the monsoons. Lying to the south and south-west of G. Belumut are two or three other lower ridges stretching east and west. Lines of cloud formed first on these ridges, but did not pass on as such to Belumut. The wind blew up the southern slopes of the mountain, forming cloud as it ascended, and the summit was soon covered with thick mist. Judging by the appearance of cloud formation as observed on the other ridges, the cloud was continually added to from the south and dissipated by the continuing wind towards the north. In these circumstances the southern slope would receive most of the moisture, and no doubt this condition prevails throughout the south-west monsoon. During the north-east monsoon there may be heavier rain and more continuous clouding, affecting the south slope considerably as well as the north.

Observations of temperature were not made. When sunny it was quite hot on the summit, probably not much cooler than the low



At the junction of the Matonia-scrub with the mossy forest,
on the western ridge Gunong Belumut.

country, but in the cloud and at night it was much cooler, probably down to about 15° C.

Geology; Soil conditions.

The writer is indebted to Mr. G. R. Fulton for particulars of the geological nature of the country round G. Belumut. This mountain and the ridges south of it (of which the nearest, G. Berchuak, was ascended) are formed of hornblende granite, while the ridge to the north, of which G. Berhidong forms the highest part, is of rhyolite.

On the eastern ridge of G. Belumut, just below the summit, in the forest, there were nearly 30 cm. of dark soil above the weathered granite which formed a yellowish clay with much grit. The upper layers of the soil contained many small roots but very little of undecomposed plant material. The lower layers contained less organic matter and were more gritty. Granite of this character may weather to a stiff clay, but it is possible that in such exposed positions as these ridges the silicates may be first weathered and partly washed away before the grains of silica are decomposed, the result being a more or less sandy soil. On the north face, in more open places in the Matonia scrub, the soil is very sandy and has a much thinner layer containing humus. On the south face, where the slope is steep with many large boulders, the soil is largely present in hollows and crevices between the rocks, which are themselves covered with a more or less thick mat of vegetation, at least of bryophytes and ferns.

The rhyolite of G. Berhidong gives a fine clay soil with hardly any sand, and it would be interesting to know whether the vegetation on its summit shows any difference from that on G. Belumut. Unfortunately an attempt to make the ascent failed, and time was not available to make a second.

The Mossy Forest.

1. General.

The best development of the mossy forest is on the south slope. This is far steeper than that to the north, with very large boulders of granite. The trees here are fully 30 ft. in height. Their trunks up to almost shoulder height are thickly covered with masses of liverworts and, less abundantly, mosses. Higher up, the covering of bryophytes is thinner, and different species are found. The uppermost part of the tree often bears lichens, which sometimes encroach on the mosses, and phanerogamic epiphytes. On the ground (here very uneven) is a carpet of mosses; herbaceous vegetation is not well developed, but several species occur, as well as pandans, a few palms, and ferns. Locally a bamboo (*Dendrocalamus flagellifer*?) is quite abundant. As one climbs up on to the ridge there is a sudden dwarfing and much closer growth of the trees, most of which are here not more than 25 feet, the bases still covered with enormous spongy masses of liverworts. Continuing over the ridge on to the north slope, one comes out into the open scrub (See Plate II).

2. The Trees.

Walking in the forest down the ridge westwards from the summit, the following were noted as the largest trees seen. Only those of 30 cm. or more in girth were measured.

| Number measured. | Species. | Maximum girth. |
|---------------------|-------------------------------|-------------------|
| 8 | <i>Calophyllum canum</i> | 46 cm. |
| 6 | <i>Tetractonia</i> n. sp. | 68.5 |
| 5 | <i>Podocarpus neriifolius</i> | 91 |
| 4 | <i>Gordonia imbricata</i> | 56 |
| 3 | <i>Tristania merguensis</i> | 46 |
| 3 | <i>Eugenia caudata</i> (?) | 76 |
| 2 | <i>Parinarium parviflorum</i> | 45 |
| 2 | <i>Eugenia oblata</i> (?) | 43 |
| 1 | <i>Garcinia</i> sp. | 38 |
| 1 | <i>Quercus rassa</i> | 38 |

The *Tristania* was not seen flowering, so that its identification is not certain, but it is most probably the species named, which is abundant on Mt. Ophir.

An area of about 20 feet (6.1 m.) square was selected, situated on the top of the south slope, one edge being almost along the summit of the western ridge, near the summit of the mountain. In this all woody plants (rattans excepted) above 2 m. in height were measured as regards diameter at breast height, and their total height estimated.

The following is a summary of the measurements made in the selected area. Many of the trees were not flowering or fruiting, and their identification is consequently somewhat doubtful, especially in the case of *Eugenia*.

| No. of individuals. | Species. | Diameter. Max. | | | Max. height. |
|------------------------|--------------------------------|----------------|---------|--|--------------|
| | | Max. | Mean. | | |
| 14 | <i>Eugenia caudata</i> | 10.2 cm. | 4.3 cm. | | 7 m. |
| 14 | <i>Eugenia oblata</i> | 11.4 | 3.8 | | 9 |
| 10 | <i>Eugenia microcalyx</i> | 6.4 | 3.6 | | 9 |
| 5 | <i>Calophyllum canum</i> | 10.2 | 6.9 | | 10.5 |
| 5 | <i>Adinandra</i> sp. | 4.3 | 2.8 | | 7.5 |
| 4 | <i>Garcinia diversifolia</i> | 12.7 | 5.1 | | 9 |
| 3 | <i>Eugenia subdecussata</i> | 7.6 | 4.3 | | 7.5 |
| 3 | <i>Wikstroemia Candolleana</i> | 3.8 | 2.8 | | 3.5 |
| 3 | <i>Symplocos adenophylla</i> | 8.1 | 4.3 | | 9 |
| 3 | <i>Pandanus</i> sp. | | | | 5 |
| 3 | <i>Elaeocarpus petiolatus</i> | 1.3 | 1.3 | | 2.5 |
| 3 | <i>Ilex Griffithii</i> | 4.8 | 3.6 | | 7.5 |
| 3 | <i>Pinanga disticha</i> | | | | 2.5 |
| 3 | <i>Xanthophyllum Wrayi</i> | 11.4 | 4.8 | | 7.5 |
| 3 | <i>Daphniphyllum laurinum</i> | 11.4 | 8.1 | | 9 |
| 2 | <i>Eugenia venulosa</i> | 10.2 | 7.6 | | 7.5 |
| 2 | <i>Quercus Rassa</i> | 7.6 | 5.6 | | 9 |

| No. of individuals. | Species. | Diameter. | | Max. height. |
|------------------------|--------------------------------|-----------|-------|-----------------|
| | | Max. | Mean. | |
| 2 | <i>Myrsine Porteriana</i> | 8.7 | 5.6 | 7.5 |
| 2 | <i>Lasianthus</i> sp. | 3.3 | 2.2 | 5.5 |
| 1 | <i>Eugenia bracteolata</i> | 4.6 | | 6 |
| 1 | <i>Microtropis ophirensis</i> | 2 | | 2.5 |
| 1 | <i>Eugenia claviflora</i> | 4.6 | | 3.5 |
| 1 | <i>Quercus Wenzigiana</i> | 2.2 | | 3.5 |
| 1 | <i>Elaeocarpus parvifolius</i> | 2 | | 3 |
| 1 | <i>Gaertnera Königii</i> | 2 | | 2.5 |
| 1 | <i>Timonius penangensis</i> | 4.6 | | 6 |
| 1 | <i>Vaccinium Teysmanni</i> | 1.3 | | 2.5 |
| 1 | <i>Tristania merguensis</i> | 1 | | 2 |
| 1 | <i>Ardisia</i> sp. | 2 | | 4.5 |
| 1 | <i>Tetractonia</i> sp. | 7.6 | | 10.5 |
| 1 | <i>Podocarpus neriifolius</i> | 28 | | 9 |
| 1 | <i>Palaquium obovatum</i> | 15.2 | | 10.5 |
| 1 | <i>Parinarium parviflorum</i> | 8.7 | | 9 |
| 1 | <i>Lindera bibracteata</i> | 2 | | 2.5 |

Mean diameter of all trees measured 4.5 cm.

Only one specimen of *Podocarpus neriifolius* was present in this plot, being a very old tree lying over obliquely, its topmost shoots reaching about 9 m. vertically above the ground. This species was quite abundant in the mossy forest, though probably less so than in the Matonia scrub and when one looked at the slopes of the mountain from the summit or from the neighbouring peak of G. Berchuak, its pale yellow-green foliage showed up strikingly. The disappearance of the Podocarp on the lower slopes was practically coincident with the lower limit of the mossy forest.

Gordonia imbricata and *Tetractonia* sp. have very much the same habit and form of leaf, and it was not found possible to distinguish the two with certainty from a distance. Both are taller than the majority of the other trees and have a very open mode of branching, with few large rounded leaves. On looking along the ridge from the summit of the mountain one was at once struck with the way in which these two trees both projected above the general level of the forest. They were also both prominent among the isolated trees in the Matonia scrub, and grew taller there also than any others. It was not possible to decide which was the more numerous, but it is thought that the *Tetractonia* is probably so, at least in the scrub.

Calophyllum canum was one of the most striking trees as one walked through the forest, on account of its very straight growing trunks. The smaller leaved *C. venustum* was less abundant.

Tristania merguensis was found particularly in the scrub, but also in the forest, especially on the ridge. There were often very old trees in the transition zone between forest and scrub, with very thick bushy branches, some apparently dead.

The above were the most noticeable of the larger trees; of smaller trees the list shows that *Eugenia*s make up a large proportion.

It is very noticeable that all the trees are of xerophytic character, with small simple usually entire coriaceous leaves.

The mean diameter of 4.5 cm. indicates that the forest is of close growing slender trees. On approximately 400 square feet (37 sq. metres) 103 woody plants of more than 2 m. in height were recorded, giving an average distance apart of about 2 ft. (60 cm.) The thick growth of liverworts round the bases of all plants increased the apparent closeness of the trees. The oldest trees were sometimes fallen over obliquely, one being noticed almost fallen to the ground with several upright branches growing from it. For the most part the small trees grow fairly straight. There is little or nothing of the formation of aerial supporting roots, described as characteristic of the mossy forest on Mt. Maquiling, Luzon. On the south slope where the mossy forest is best developed the steepness and the presence of large granite boulders prevent the trees from growing so closely, but here, being more protected, they are on the whole taller and have larger crowns; the bamboo is also more abundant. A slender *Pandanus* is fairly frequent in the forest, and is often quite tall, while small plants of a broad leaved species, possibly *P. atrocarpus*, were found quite near the summit of the mountain.

Plate III shows a typical part of the forest close to the area in which the trees were measured.

Undershrubs were few. The following were collected: *Allo-morphia exigua*, *Memecylon Hullettii*, *Gelonium glomerulatum*, *Daphniphyllum* sp., *Ardisia* sp., *Goniothalamus macrophyllus*, *Elaeocarpus petiolatus*. These are all quite large leaved in comparison with the trees of the forest, and the leaves less coriaceous.

Pinanga disticha was fairly frequent, and also a rattan, *Calamus brevispadix* Ridl. A second *Calamus* and a *Daemonorhops* were not so common. *Freycinetia valida* was present.

3. Ground vegetation.

(a) **Herbaceous flowering plants.** These were never very abundant. The following were the most abundant species, and, with seedlings of woody plants, formed the chief ground vegetation: *Sonerila bicolor*, *Paraboea pyrolaefolia*, *Didymocarpus platypus*, *Pentaphragma* sp., *Argostemma spinulosum*, *Cephaelis cuneata*, *Zingiber puberula*, *Alpinia rafflesiana* (occasional). *Loxocarpus* sp. and *Sonerila erecta* were found chiefly on granite boulders where only a thin covering of mosses was present. *Balanophora multibracteata* was locally quite common. In the more open parts, especially in the broader transition zone between forest and scrub at somewhat lower altitudes (about 3000 ft.) *Cypripedium barbatum* was very abundant, being the most frequent herbaceous plant.



Typical mossy forest, near the summit of Gunong Belumut,
upon the south face.

(b) **Pteridophytes.** These were not so abundant as might have been expected. Of small species, *Selaginella plumea* Spr. and *S. acutangula* Spr. (?) were frequent, *S. Wattii* Bak. being found chiefly on rocks and among liverworts on tree trunks. The following ferns were frequently seen: *Taenitis blechnoides* (nearly always with simple leaves), *Schizoloma divergens* (less abundantly than at lower altitudes), *Lindsaya repens* (mostly small sterile plants), small plants of *Trichomanes rigidum*, and an *Alsophila* (a species found also on Mt. Ophir, possibly undescribed) the stems of which reached several feet in height. Young plants of the last named were also common. In one place several plants of *Cheircopleuria bicuspis* (Bl.) were found, in the shelter of a large rock. *Tapeinidium biserratum* v. A. v. R. (*Davallia biserrata* and *D. gracilis* Bl.), both less and more divided forms, were found in more open places on the south slope. *Gleichenia linearis*, *G. laevigata* (Willd.) *G. glauca* (Thb.), and *G. hirta* Bl. were occasional throughout the forest, usually with long petioles which carried the leaves up among the branches of the trees. *Lycopodium casuarinoides* Spr. had the same habit, often with stems several yards long, especially on the ridges; its thickly tufted leafy branches, bearing very numerous strobili, were very abundant amongst the bushes close to the summit. *L. cernuum* was also present, but not in such quantity.

(c) **Bryophytes.** A large part of the ground surface had some growth of mosses or liverworts, in addition to those present on the trees. It was difficult to estimate the relative abundance of these, as the writer was not familiar with the different kinds. Conspicuous were *Leucobryum javense* (Brid.) Mitt. and *L. Bowringii* Mitt., and thick tufts of *Rhizogonium latifolium* Bry. Jav.; *Sematophyllum secundum* (Hornsch. and Reinw.) was also frequent. No doubt other smaller mosses were equally abundant. *Trichosteleum Boschii* (Doz. and Molk.) Jaeg., *Trismegistia rigida* (H. and Rw.) and *Isopterygium albescens* (Schwaegr.) Jaeg. were also found on the ground. Liverworts were not so numerous as on the trees, but species of *Metzgeria* and *Aneura* were common both on the ground and on the bases of the trees.

4. Epiphytes.

(a) **Bryophytes.** The liverworts present in greatest quantity were *Mastigophora diclados* (Brid.) Nees, which was present everywhere and appeared to withstand considerable dessication, and a large species of *Bazzania*. The *Mastigophora* formed almost pure cushions, sometimes several inches in thickness, round the bases of many of the trees. Mixed with it were small quantities of more delicate species of *Frullania*, and various other plants which appear referable to the genera *Bazzania*, *Chiloscyphus* and *Plagiochila*. *Lepidozia subintegra* Lindenb. (?), a very fine hair-like species with minute leaves, was often present in masses, sometimes mixed with *Mastigophora diclados*. *Trichocolea tomentella* (Huds.) Nees, was also fairly abundant.

Of the less abundant species a handsome large-leaved *Schistochila* was very noticeable. A *Pleurozia* was found chiefly on the upper part of tree trunks, where no other species would grow. Its habit of growing very closely appressed to the surface of the bark is no doubt an advantage in such situations. Where it was most exposed it was often deep red in colour. It was often fertile.

Of Mosses *Sematophyllum secundum* and *S. rigens* Broth. (previously collected only on Mt. Ophir) were recorded as present on the lower parts of tree trunks. On the upper branches of the trees, in very exposed situations, were found large compact cushions of *Syrrhopodon borneensis* (Hpe.) Jaeg.

The upper branches of the trees had also lichens on them, but these were not collected. One of the lichens was often seen growing over and apparently smothering bryophytes growing in rather exposed positions.

(b) **Pteridophytes.** The most abundant epiphytic fern was *Hymenophyllum serrulatum* (Pr.), an unusually slender form. *H. denticulatum* Sw. was also common. A very small species, apparently closely allied to *H. borneense* Hk., was found twice only. These all grew among the liverworts on the tree trunks. Usually somewhat higher up, also among bryophytes, the following were quite common: *Polypodium decorum* Brack., *P. malaicum* v. A. v. R., and a small species near to *P. cornigerum* Bak.; *Scleroglossum sulcatum* (Mett.) v. A. v. R. was not so frequently noticed, and *Polypodium cucullatum* Nees and Bl. was seen once only. On still higher branches *Humata repens* (L. fil.) was occasionally present: and *H. heterophylla* (Sw.) and *Oleandra neriiformis* Cav. (both sterile) were each seen once. One plant of *Lycopodium phlegmaria* was found in a very exposed position on the upper branch of a tree in the scrub; it was very stunted.

(c) **Phanerogams.** Epiphytic flowering plants were not very numerous. They were found on trees both in the forest and in the scrub. The most striking were *Pachycentria tuberculata*, *Medinilla Clarkei* (also on rocks on summit) and another *Medinilla*. *Dendrobium uniflorum* and *Ceratostylis gracilis* were the only orchids at all abundant in exposed positions; in the forest, on lower branches, *Podochilus sciuroides* was frequent. *Eria poculata* was occasional, also *Bulbophyllum* and *Coelogyne* sp., not in flower. *Rhododendron jasminiflorum*, *R. longiflorum*, *Elytranthe retusa* and *Hydnophytum formicarum* were occasional, also a small *Dischidia*. *Corysanthes mucronata* was found in several places growing in the masses of liverworts on the tree trunks, apparently just come into flower. Its tubers and roots were embedded in the spongy substratum, the small solitary leaves and flowers showing just above the surface. Some of the plants were exceedingly minute.

Of climbers, *Nepenthes ampullaria*, *N. Rafflesiana* (?) and *Smilax laevis* were frequent, but more usually present in the more open scrub.

The *Matonia* scrub.

Near the summit of the mountain, this vegetation consists typically of a close shoulder-high growth of *Matonia pectinata*, associated with various plants of similar stature, and isolated trees and shrubs of varying size. The most important of the former are *Pandanus ornatus*, *Gahnia javanica*, *Lepidospermum chinense* and *Dipteris conjugata*. *Dipteris* is not found in the most exposed places, being obviously less xerophilous than *Matonia*, and though almost always present was never seen dominant. The orchids *Spathoglottis aurea* and *Bromheadia palustris* were quite abundant; and *Euthemis leucocarpa* was occasionally seen. Underneath the *Matonia*, and especially round the bases of trees and shrubs, mosses and liverworts covered the ground as in the forest.

In the most open places, on very sandy soil, *Gleichenia circinata* and *Actinoschoenus filiformis* were the dominant plants, and here also on the ground were noticed the more xerophytic liverworts and *Leucobryum* spp.

The following trailing and climbing plants were frequent: *Nepenthes ampullaria*, *N. ? Rafflesiana*, *Dissochaeta annulata*, *Vitis gracilis*, *Smilax laevis*, and *Lycopodium casuarinoides*. *Gleichenia linearis* was present, but never abundant.

The most conspicuous trees also present in the mossy forest were; *Tetractonia*, *Gordonia*, *Podocarpus*, *Calophyllum* spp., *Tristania*. *Podocarpus* was very abundant, including many small plants, and its yellowish foliage made it conspicuous. All the trees were somewhat dwarfed as compared with their growth in the forest, *Calophyllum* most markedly, *Tetractonia* and *Gordonia* least so. The larger trees had a very weather-beaten appearance. Epiphytes were few, and stunted owing to exposure.

Other woody plants noted as frequent were *Quercus Rassa* (producing fruit at a height of only 3 feet) *Timonius pinangensis*, *Symplocos adenophylla*, *Melastoma* sp., *Elaeocarpus reticosus*, *Adinandra dumosa*, *Hedyotis congesta*, *Ardisia Barnesii*. On the very summit, surrounding the few huge granite boulders, was a very dense growth of shrubs, with some *Matonia*. *Freycinetia valida* was climbing on these, and *Scleria* sp. was collected. Under the shade of the rocks grew a *Lophatherum*. On the boulders were a few epiphytes, including *Medinilla Clarkei*, *Sonerila erecta*, *Bulbophyllum* sp., and *Humata repens*.

Some 300-400 feet below the summit, on the western ridge, the trees in the scrub were much larger and closer, and the *Matonia* much less, and a broad transition zone between scrub and forest developed, in which *Cypripedium barbatum* was very abundant. The transition from scrub to mid-mountain forest was not seen.

The same scrub was found on the northern face of Gunong Berchuak to the S. E. of Belumut. This hill has twin summits close together, both about 3,000 ft. above sea, and it was interesting to find that on the northern side of the southern summit there was still open *Matonia* scrub.

Comparison with other descriptions of mossy forest.

There are various references in Mr. Ridley's papers to mossy forest on the mountains of the Malay Peninsula, but no detailed account anywhere. It seems probable that everywhere in the cloud belt dwarfed mossy forest prevails, while the tops of the highest peaks in the main range are covered with a xerophilous scrub in which *Matonia* is usually present. On isolated hills such as Kedah Peak* the mossy forest is found at much lower altitudes than on the mass of the main range, and the same is true of Belumut. The peculiarity of Belumut in having mossy forest on the south slope only must be due to local conditions of weather and topography. The scrub and forest on Belumut appear to correspond with the open rock vegetation and the valley woods of the Padang of Gunong Tahan as described by Ridley.¹ There is no detailed description of the vegetation of the top of Mt. Ophir, (distant 66 miles from Belumut) but most of the species collected on Belumut have been found also on Mt. Ophir.² The writer cannot however attempt a floristic comparison in the present paper.

The Belumut mossy forest appears to be very similar in general organisation and appearance to that described by Miss L. S. Gibbs on Mt. Kinabalu in British North Borneo,³ though most of the species are different. Miss Gibbs' Pl. 6 fig. 3 shows a tree of *Leptospermum flavescens* which has a very similar habit to the *Tristania* on Belumut. In another paper Miss Gibbs has short notes on similar forest on the ridges of the Arfak Mountains in New Guinea.⁴

The mossy forest on Mt. Maquiling in Luzon described by Brown⁵ differs in various respects, but it is said that all such vegetation on the Philippines is not quite of the same type (p. 102). The differences from Belumut are principally in the prevalence of plants with aerial roots, and in the greater abundance of tree ferns and herbaceous ground vegetation. On Mt. Maquiling the growth of woody plants was about as dense as on Belumut, 157 individuals representing 17 species being recorded on 50 sq. metres; on Belumut 106 individuals representing about 30 species were found on 37 sq. metres. On Mt. Maquiling there was a bigger proportion of plants with non-entire leaves on the summit than at lower altitudes, whereas on Belumut the only tree with noticeably toothed leaves was *Parinarium parvifolium*. On both mountains trees of the mossy forest all have simple and rather small leaves.

The brothers Sarasin give brief descriptions of mossy forest on the mountains of Celebes,⁶ and some photographs.

*See Ridley, *Journ. S.B.R. Asiatic Society* No. 34 pp. 23-30 (1900).

1. *F.M.S. Museums Journ.* Vol. 6. p. 132. (1915).

2. See Ridley's paper in *Journ. S.B.R. Asiatic Society* No. 35 pp. 1-28 (1901).

3. *Journ. Linn. Soc., Bot.* Vol. 42 pp. 1-240 (1914).

4. *A contribution to the phytogeography and flora of the Arfak Mountains etc.* (Read before the British Assn. 1916) Taylor and Francis, London.

5. Brown, W. H.; *Vegetation of Philippine Mountains*. Manila, Bureau of Science publication No. 13 (1919).

6. Sarasin, P. & F. *Reisen in Celebes*. Wiesbaden, 1905.

Giesenhagen (*Ann. Jard. Bot. Buitenzorg*, 3rd. Suppl. pp. 711-789, 1910) gives a description of the conditions under which a great development of moss growth occurs in various localities in Java and Sumatra, with a discussion of the growth-forms which mosses assume. He does not deal with the conditions under which the different growth-forms appear. There is a reference to this, however, in a short paper recently published by W. Seifrizz (*Journ. of Ecology*, Vol. 12, pp. 307-313, 1924) in which the altitudinal distribution of mosses and lichens on G. Gedeh in Java is discussed. From about 5500 to 7000 feet there is a moss zone, in which the pendent type is very abundant; this is the zone of *Podocarpus imbricatus*. The next zone, from 7000 to 8000 feet is "very open in character, with a prolific growth of herbs on the forest floor. Mosses and lichens are very poorly represented." The highest zone, 8000 to 9200 feet, is "a foggy, windswept region typified by small gnarled trees, mostly of the genus *Vaccinium*." In the lower part of this zone there is much moss growth, but entirely of compact tufted forms, clinging close to the tree trunks; the cause of the difference between this and the lower moss zone is ascribed to the great force of the winds in the higher zone, accentuated by the lower stature of the trees. In the upper part of this zone the vegetation is more open, and the consequent greater light and reduced humidity account for the replacement of mosses by lichens. The conditions on G. Belumut are quite different, probably owing to the limited range in altitude of the cloud zone. There is nothing comparable to the great development of the pendent type of moss found in the fairly high *Podocarpus* forest on G. Gedeh. It needs more protection from wind than is found in the dwarf forest on Belumut. Closer growing mosses are found, but again not exclusively, as in the upper zone on G. Gedeh. The great preponderance of liverworts is not described at all from G. Gedeh; there must be on G. Belumut conditions favourable for the growth of liverworts, particularly of *Mastigophora diclados*, which are absent from the upper zone on G. Gedeh.

Regarding the biology of liverworts, a paper of Goebel's is of importance (*Ann. Jard. Bot. Buitenzorg*, 7, pp. 21-69, 1888). He describes the various water-holding lobes present on the leaves of many species, distinguishing three types; species possessing these are all epiphytic. The only notable species on Belumut that comes under any of his categories is the *Pleurozia* (*Physotium*), which is among the most specialised of all. It occurs in exposed places on the upper parts of tree trunks, where its large water sacs are of great service. *Frullanias* were not found abundantly on Belumut; two species grew amongst the *Mastigophora*, no doubt partly protected by it. *Mastigophora* itself possesses no water sacs; its finely divided small leaves are able to hold a certain amount of water, but it will dry up fairly easily. Probably its habit of growing in large spongy masses prevents complete dessication of the whole plant.

Karsten (*Ann. Jard. Bot. Buitenzorg*, 12, pp. 119-122, 1892) gives a list of liverworts found in Amboyna, on mountains 1250 and 1050 m. (4100 and 3450 feet). At about 700 m. *Agathis* was found, and above the *Agathis* a dwarf forest of *Leptospermum*, *Vaccinium*, *Podocarpus* etc., the trees being overed with bryophytes. He mentions particularly very fine species of *Schistochila* (*S. sciurea*) and *Pleurozia* species of which were also among the most conspicuous liverworts on Belumut. He gives a list of species, including *Mastigophora diclados*, but this is not mentioned as specially abundant.

Causes of the development of mossy forest.

Brown states that mossy forest is confined to the cloud belt (l. c., p. 103), and this appears to be well borne out by all other records. The great abundance of mosses, liverworts and Hymenophyllaceae, in varying proportions, is a feature which probably could only occur in such situations. It does not seem to have been pointed out, however, by previous writers, that these plants may have frequently to stand a considerable degree of dessication, as was undoubtedly the case on Belumut. The second feature which all these forests have in common is the dwarfing of tree growth. The heavy growth of epiphytes has been suggested as one cause, but this alone cannot be responsible, since trees in the open scrub on Belumut were more dwarfed than the same species in the forest. Brown, by careful correlation of many measurements of environment conditions at different altitudes on Mt. Maquiling, concludes that the dwarfing is due to a combination of lowered temperature and decrease in light intensity as compared with conditions on the lower slopes of the mountain.

Miss Gibbs' suggestion (Kinabalu, p. 47) that mossy forest may be due to edaphic factors, leading to the conclusion that it is a secondary formation, does not seem to be well founded, though doubtless edaphic factors are responsible for variations in its composition and physiognomy. Brown remarks that mossy forest probably does not constitute a single homogeneous type, but that our present knowledge does not suffice to classify the various forms it may adopt, and this seems a very reasonable conclusion.

The pioneer vegetation on the summit of Gunong Belumut must have been of a xerophilous nature, owing to the fact that clouding is not continuous and that there are intervals of considerable insolation. Matonia scrub therefore probably represents an early stage in the development history of the summit vegetation, becoming transformed gradually into mossy forest in those parts where clouding was most frequent. The condition of the north slope thus represents as arrested early phase in the development, which is doubtless in equilibrium, having reached as advanced a stage as conditions will permit. Edaphic factors may be partly responsible for this arrest in development, but observations made up to the present are too limited for any definite opinion to be given.

Considering the mossy forest as the climax plant association of the cloud zone, it is interesting to compare it with climax associations of temperate regions. The most striking fact which is at once evident is that we have here no single dominant species. We appear rather to have present a number of species of about equal stature no one of which has sufficient advantage over the others to approach dominance. All have rather small simple leaves decidedly coriaceous in texture. The most numerous appear to be various species of *Eugenia*. In their variety these trees agree rather with the second storey of the Dipterocarp forest than with the upper storey, in which there appears to be definite dominance of one or a few species. *Gordonia* and *Tetractonia* and possibly others certainly project above the bulk of their neighbours, but it is doubtful whether they protect the other trees in any way.

R. E. HOLTUM.

TWO HYBRID TREES OF HEVEA BRASILIENSIS \times H. CONFUSA.

In the Gardens Bulletin, II (1919) p. 113, an account was given of a *Hevea* tree found in the Economic Garden, and determined to be *Hevea confusa*. That species is known to be a very inferior producer of rubber, and a danger to rubber-cultivation where its presence can lead to hybridisation. For that reason the tree was destroyed at once. It had newly fruited and seedlings had been raised of which two were kept for observation in a remote part of the Botanic Garden.

Those two have just flowered at the age of five years, and been destroyed in their turn, so that nothing of the objectionable type persists. They had been under observation through their growth, and their flowers have been very carefully examined: the result has been a complete demonstration that both trees were hybrids with *H. brasiliensis* as the male parent.

This demonstration of cross-pollination between the two species is not as interesting as another given by Mr. H. C. Pearson in the *India Rubber World* for October 1st, 1919, p. 46, for in that, seed of a fine *H. brasiliensis* in Trinidad produced plants which showed *H. confusa* in their constitution originating from a tree one-hundred yards away, the distance between the two parents having been very much less in the Singapore. But it is interesting as a demonstration of the great degree to which cross-fertilisation is carried in the Rubber tree. It is a cross in the opposite direction to Mr. Pearson's namely of male *H. brasiliensis* on female *H. confusa*. It is also a lesson that from a plantation of even pure *H. brasiliensis*, if first class seed is wanted, the inferior yielders should be removed, as cross-pollination occurs to such a great extent.



Holttum, R. E. 1924. "The Vegetation of Gunong Belumut in Johore." *The Gardens' bulletin; Straits Settlements* 3, 245–257.

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