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BIOLOGY OF PLANTS AND ANIMALS OCCURRING IN THE HIGHER PARTS OF MOUNT PANGRANGO-GEDEH IN WEST-JAVA

BY

W. M. DOCTERS VAN LEEUWEN

VERHANDELINGEN DER KONINKLIJKE AKADEMIE
VAN WETENSCHAPPEN TE AMSTERDAM
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CONTENTS

I. General Part.

page

CHAPTER I. Historical survey 1

CHAPTER II. Topographical Description 23

CHAPTER III. Climate 28

CHAPTER IV. Vegetation 45

CHAPTER V. Animal Life 69

CHAPTER VI. Flowering periods of the plants on the top of Mount Pangrango 84

CHAPTER VII. Pollination 92

CHAPTER VIII. Multiplication and dispersal of plants living in the higher parts of the mountains 122

II. Special Part.

CHAPTER IX. Plants from the higher parts of Mount Pangrango-Gedeh 143

CHAPTER X. Plants of other mountain tops and from the neighbourhood of Tjibodas 251

INDEX 269

PREFACE.

Since 1918 I have been engaged in a study of the pollination of the plants growing in the higher parts of Mount Pangrango-Gedeh. For this purpose I have sojourned frequently on the tops of this mountain. The data on the biology of plants and animals, collected during these successive visits, have been digested in the chapters here following, in connection with other data gathered in the course of excursions to several other mountain tops in Java. The area specially investigated, however, is the upper part of the nature-reserve "Tjibodas-Gedeh", the reserve which extends from the mountain-garden at Tjibodas to the summits of Mt. Pangrango-Gedeh. The observations on the flowering-seasons of the plants, however, have been made on the top of Mt. Pangrango only.

I hope that the present volume will serve as a basis for further investigation. Much remains to be done. I have confined myself here to the Phanerogams though it was originally my intention to embody in this report the Cryptogamous plants also. I had to waive this plan, however, because the latter are on the whole as yet insufficiently known.

In the numerous excursions, undertaken during the progress of this investigation, I have received valuable assistance from the former assistant-curator of the gardens at Tjibodas Mr. M. L. A. BRUGGEMAN, and from the present assistant-curator, Mr. C. L. L. VAN WOERDEN.

My friend, Dr. J. LOPEZ CARDOZO, has translated for me the eight chapters of the general part. To Prof. Dr. C. E. B. BREMEKAMP I am indebted for reading the manuscript of this book. To all these persons I have pleasure in tendering my most cordial thanks.

I am also indebted to the "Maatschappij ter bevordering van het Natuurkundig onderzoek der Nederlandsche Kolonien", and to the "Insulinde Fonds"; their liberality made the printing of this work possible.

Buitenzorg—Leersum.

CHAPTER I.

HISTORICAL SURVEY.

Few mountains in Java have been climbed more frequently than the twin volcanos Pangrango and Gedeh. Numerous explorers have ascended their tops and reported on what they have seen. It is not my intention to give a complete survey of all these publications; I intend to discuss in this chapter those only, which appear to me of sufficient importance. In the chapters on individual subjects I will quote however several other articles.

The summit of Mt. Gedeh was attained before that of Mt. Pangrango. It is generally believed that JUNGHUHN was the first to ascend Mt. Pangrango, and he himself supposed so too, but the earliest accounts of the ascent of this mountain derive from two other naturalists, and I will consequently start this discussion with the communications of these men.

These pioneers were KUHL and VAN HASSELT, two young biologists who had been sent to Java by the members of the so-called Natural Science Committee. By untiring labour they achieved many results, but at a very early age they both died, one shortly after the other, from diseases incurred in the course of their exhausting expeditions. In the letters, they addressed to the Committee, many data are to be found concerning the natural history of the regions visited by them. In a letter [1]) dated Buitenzorg the 8th. of August 1821, that is eighteen years before JUNGHUHN reached the top of Mt. Pangrango, KUHL and VAN HASSELT report: "We have just returned from a very difficult mountaineering expedition: for notwithstanding all previous failures we have at last succeeded in conquering Mt. Pangrango, whose summit lies 8500 feet above Buitenzorg, or 9400 feet above sea level."

In a letter [2]) dispatched on August 10th. following they write: "We are but this moment returned from the top of Mt. Pangrango (Gedé, RAFFLES, Maps of Java), which is connected by a ridge with Mt. Gedeh. The height of this mountain above Buitenzorg amounts to 8580 feet. Neither this peak nor the easterly one of Mt. Salak were ever volcanos. At these tremendous altitudes and in those cold regions we have come upon numerous lairs of rhinocerosses and the tracks trodden by these animals through the northerly vegetation of these parts have served us as a means to reach the top".

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[1]) Uittreksels uit de brieven van de Heeren KUHL en VAN HASSELT, aan de Heeren C. J. TEMMINCK, TH. VAN SWINDEREN en W. DE HAAN, Algemeene Kunst en Letterbode voor het jaar 1822, Vol. I, Haarlem, p. 103.

[2]) loc. cit., p. 152.

As we shall see further down JUNGHUHN doubts whether the said two naturalists really got to the top of Mt. Pangrango; it appeared to him more likely that they had reached the edge of the old craterwall only. But this point is lower than the 9400 feet quoted by KUHL and VAN HASSELT as the height of the top reached by them. Some doubts are indeed suggested by the fact that they made no reference at all to the *Primula imperialis,* which is so common on the top of Pangrango. This plant does not seem to have been collected by them, for otherwise it would certainly have been included in the publications of BLUME. This *Primula,* however, does not grow on the top itself, but in the crater-valley, and it is possible that KUHL and VAN HASSELT may not have visited this locality; besides they ascended the mountain in August, and as this plant does not flower very abundantly in that month, it may have been overlooked.

In their second letter, as quoted above, they mentioned the maze of tracks cleared by rhinos in the mountain forests, to which JUNGHUHN also drew attention in the account of his first ascent of Pangrango. JUNGHUHN also made use of these paths in order to reach the top. Though complete certainty cannot be arrived at, it appears very probable that KUHL and VAN HASSELT were the first to have reached the top of Mt. Pangrango.

REINWARDT, the founder of the Botanic Gardens of Buitenzorg, ascended Mt. Gedeh on the 19th. of April 1819; he mentions that the American naturalist TH. HORSFIELD had already climbed this mountain, but I have been unable to find a report of that excursion. JUNGHUHN relates that REINWARDT followed the path cleared by order of the Governor General RAFFLES along a south south-eastern slope of the mountain. This path abutted on the southern crater wall of Gedeh, the so-called Sedaratu. REINWARDT [1]) was the first to describe the vegetation of the higher part of the mountain. He did it in the following words: "At last when at still greater heights the forests of *Lauraceae* also cease, when the peaks grow narrower, and the air becomes more rarefied, when the trees can no longer protect each other, and the slopes becoming steeper and steeper can no longer hold the loose mould, then at an altitude of some 7000 feet or upwards, the aspect of the woody vegetation gradually changes; the trees become smaller and more stunted, their trunks clothed with mossy growth, and long fringes of *Usnea* hang down from their boughs; the herbs begin to display forms altogether different from what one is accustomed to behold at lower levels; the whole reminds us of the Alpine mountains of the colder north; warped boles and branches and small stiff dry leaves characterize both trees and bushes".

"It is especially the heather family, *Ericaceae,* which supplies most of the plants of these highest tops that are clad with vegetation, and with them

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[1]) C. G. C. REINWARDT, Over de hoogte en verdere natuurlijke gesteldheid van eenige bergen in de Preanger Regentschappen. Verhandel. v. h. Bataviaasch Genootschap van Kunsten en Wetenschappen, Vol. IX, 1823, p. 3.

go the fine *Rhododendron retusum*, a *Leptospermum* on Gedeh, and Salak, and elsewhere a *Myrica*. These plants, except *Vaccinium ferratum* (= *Gaultheria nummularioides*) which reminds us of our cranberries (*Oxycoccos*), are still trees, characterized by very firm heavy wood. The fig genus furnishes an exception in one of its numerous species *Ficus diversifolia*, a shrub of which the leaves are partly quite blunt and partly acute, this being in fact the only one which ascends even the highest tops.

Among these trees and shrubs there also grow other and smaller plants and herbs, all more agreeing with the northernly flora of Europe than with that of the lower areas of the Indies. On and round the top of Gedeh a yellow-flowered honeysuckle (*Lonicera*), a *Hypericum*, a stalked *Bellis* (*Myriactis nepalensis*), a shrubby white *Gnaphalium* (= *Anaphalis javanica*), a *Valeriana* described by HARDWICK, a small *Gentiana* in the lava-ash which fills the valley between the two tops of Mt. Gedeh (the aloon-aloon) etc. are very common, all plants which one would hardly expect to find in the Indies at a latitude of six degrees".

"But though in all these plants we discern the forms peculiar to the temperate or cold zones, these are nevertheless all specifically distinct from the plants familiar to us. To this rule the cryptogamous plants alone form an exception; many of these differ in nothing from the European ones".

REINWARDT also gives us some information with regard to the fauna of the highest tops. He points out that at this altitude the animal world does not present such a range of variety as the plants do. He thinks here probably of the higher orders only, for reptiles no longer occur here, and birds are also getting scarce. None but pigeons and thrushes attracted by the berries of *Vaccinium* are seen. The *Rhinoceros* alone forms an exception; these creatures then were found even on the highest tops.

On April 13th. 1824 the first Director of the Buitenzorg botanic gardens, C. L. BLUME [1]), set out for Mt. Gedeh. He reached the top of this mountain but not by the same trail which HORSFIELD and REINWARDT had followed: he travelled by the Puntjak-pass and penetrated into the mountains through the forest on the Northern slopes. The track cut by him traverses to a large extent the same parts as the path which is most frequently used nowadays. He crossed the Rawah [2]) Tji-beureum and reached the Tji-kundul falls. Thence the path ascended and he passed the hot wells and finally pitched his camp on the saddle ridge between Pangrango and Gedeh at a place known as Kandang Badak [3]).

Through the crater of Gedeh he reached the eastern part of the aloon-aloon. Of the plants observed by him he says that they belong to such species as are usually confined to the peaks of these volcanos. He

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[1]) C. L. BLUME, Over de gesteldheid van het gebergte Gedé. Verh. v. h. Batav. Genootschap van Kunsten en Wetenschappen, Vol. X, 1825, p. 57.

[2]) Rawah = morass.

[3]) Kandang Badak = Rhinoceros' coral.

enumerates various species which he found in the crater, a.o. *Rhododendron retusum, Myrica javanica, Vaccinium varingifolium, Gaultheria fragrantissima, G. leucocarpa, G. nummularioides* and *Lonicera javanica*. He also states that cryptogamous plants are found living even in close proximity to vents of the solfataras. On the precipitous inner wall of the crater were found *Myrica javanica, Vaccinium varingifolium* and *Anaphalis javanica*. On the slopes of the aloon-aloon he saw *Dianella vulcanica* [1]), now called *Dianella javanica*. In the aloon-aloon were found by him: *Thelymitra javanica* growing among stones, *Anaphalis javanica*, a few grasses, *Swertia javanica* and *Gentiana quadrifaria*. About this aloon-aloon BLUME writes: "It lies there in its pale vesture of *Gnaphalium*; its solitude unbroken but for a brooklet rising at its centre and spreading a faint murmur as it flows westward". See plate XXV.

In May 1836 L. HORNER [2]) in the company of Mr. MULLER and Mr. KORTHALS spends five days on the top of Mt. Gedeh. They follow the path cleared by BLUME twelve years before. HORNER gives 9100 feet as the height of this mountain top, stating in a note at the foot of p. 5 that this value has been taken from Messrs KUHL and VAN HASSELT, who had climbed Pangrango.

HORNER and his companions traverse the Tji-beureum swamp and pass the falls of the Tji-kundul and the hot springs, then they ascend a further 800 feet through forests consisting of trees which decrease considerably in stature and belong to entirely different species as those occurring in the forests at lower levels. The explorers then reach a small elongated tract of ground covered with a whitish earth composed of sand and mire, which is the place called Kandang Badak. Close to Kandang Badak flows, says HORNER, a tremendous lava stream, rising into a stony wall about a hundred feet high, made of piled up dark blocks and known by the name of Gunung Batu (mountain of stones). This part is wild and barren, with only here and there a few fine alpine roses (*Rhododendron retusum*). Not much else is said about the vegetation of the parts of Gedeh visited by him, this treatise being valuable principally for its geomorphological descriptions, and as such it is already referred to and recognized by JUNGHUHN.

Three years later these mountains were visited repeatedly by JUNGHUHN and he gave detailed descriptions of these excursions in his "Streifzüge durch die Wald-Gebirge G. Pangrango, Mandelawangie und Gedé, unter-

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[1]) See the note in BACKER's Handboek voor de Flora van Java, Vol. III, 1924, p. 54, note 1. JUNGHUHN mentions this plant in his "Reisen" on p. 479 and calls it *Dracaena vulcanica* BL., but according to BACKER, a valid description has never been given by BLUME. The name, however, was published by him and JUNGHUHN probably took it over from his article.

[2]) L. HORNER, Geologische Gesteldheid van den Vulkaan Gedé op Java. Verhand. Batav. Genootschap v. Kunsten en Wetenschappen, Vol. XVII, 1839, p. 3.

nommen im Jahre 1839"[1]). In this publication his observations in the spheres of botany, meteorology, topography and geology are set forth in the attractive form which is a quality of JUNGHUHN's writings.

In the botanical section are recorded the results of his numerous visits to this mountain, and it gives moreover a survey of what was then known on this subject. I think therefore that I will be allowed to dwell on it at some length.

As his first excursion did not yet take him as far as the summit of Pangrango, the description of his second expedition is of more importance to us.

On April 1st. 1839 JUNGHUHN starts which G. A. FORSTER from the hostelry (government bungalow) Bodjong Keton situated on the western slope of Pangrango. To begin with there are sketches of the forest in the lower parts of the mountains which they have to traverse on their way to the rim of the ancient crater wall. From this point they have a magnificent view of the impressive cone of Pangrango[2]). All the trees on this wall of the old crater are of a curious habit, their trunks being rugged, the branches twisted in snaky coils, crooked and gnarled. The leaves are small and leathery and usually congested at the top of the branches, so that an "alpine" character can hardly be denied to these small trees.

From the col he continues the climb to the peak of Pangrango, finding in this part a *Myrtacea, Leptospermum javanicum* covered with a thousand white blossoms as with snow. This forest is crossed in all directions by tracks trodden by rhinocerosses, as already mentioned by Messrs KUHL and VAN HASSELT. In this forest JUNGHUHN comes upon specimens of *Vaccinium varingifolium* with boles of 1 m diameter. On the top itself he perceives the *Primula imperialis* and thus describes his discovery:[3]) "Indem ich durch dieses Dickicht drang, stellte sich mir — wer schildert mein Entzücken! — eine *Primula* dar, deren Schaft sich aus der Mitte prächtiger, fusslanger Wurzelblätter mehre Fuss hoch emporhebt und seine goldfarbnen Kronen, die, doldenförmig, oder wirtelförmig zusammengestellt, durch das Laub schimmern, recht zur Schau trägt. Ich erkannte diese majestätische Pflanze — gleichsam einen Fremdling aus fernen, nordischen Zonen, hierher gezaubert und mit tropischer Pracht angethan — für neu und taufte sie auf der Stelle *Primula imperialis*. Mit diesem Schatze im Arme, ging es nun rüstig bergan, und alle Ermüdung war vergessen".

At three o'clock he reaches the western edge of the top of Pangrango; next morning he follows the edge and gains the eastern side, which affords him a splendid view of the summit and crater of Gedeh. See plate IV. He

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[1]) FR. JUNGHUHN, Topografische und Naturwissenschaftliche Reisen durch Java. Magdeburg, 1845, p. 412.

[2]) In the publications of JUNGHUHN the central cone was called: Mandelawangi. Nowadays it is known as Pangrango. In the description of JUNGHUHN we have everywhere changed the name.

[3]) p. 445.

expects to find also a big crater in the top of Pangrango, but finds instead on the skirts of the forest a grassy plain with a brook flowing across it. Two rhinos were grazing on the banks of this rivulet; on his arrival they fled into the forest. In this valley, the "Centralgrund" as JUNGHUHN calls it, he finds many plants. Besides grasses and *Anaphalis javanica* he mentions *Lichens* growing on stones and fallen boughs. Along the brook he found *Ranunculus javanicus* and a grass *Agrostis*, which at first he took for *Festuca nubigena*. The plants in this central plain were especially along the margin of the forest well developed. More towards the middle he found *Lycopodium rigidulum* (= *Lyc. miniatum*), *Gleichenia vulcanica* and *G. vestita* [1]).

Next JUNGHUHN proceeds to a description of the various trees found by him. 1. The most generally prevalent is *Thibaudia vulgaris* (= *Vaccinium varingifolium*), whose trunk can attain an enormous girth. These trunks are bent, crooked and obliquely rising, and they branch already near the ground. The crown of foliage is nearly globose, and unilateral clusters of purple flowers show among the leaves. 2. A dioecious tree, of which he does not give the name, though he gives a diagnosis. This tree is characterized by leaves that are pointed and regularly serrated at the apex. By this it is clear that no other but *Eurya acuminata* can be meant. 3. Another dioecious tree, of which he could not find any female individuals and which in habit resembles *Litsea cubeba*. This must be *Rapanea avenis*. 4. *Thibaudia rosea* (= *Vaccinium laurifolium*) with large glossy leaves and pink flowers. 5. *Gaultheria leucocarpa*. 6. *Photinia integrifolia* (= *Phot. Notoniana*). 7. *Gnaphalium javanicum* (= *Anaphalis javanica*); this small tree has a thin stem with a rugged bark and a more or less spherical crown. The plants are grey and the white flowers contrast but slightly with the foliage. 8. *Vireya retusa* (= *Rhododendron retusum*) whose tubular scarlet flowers contrast beautifully with the pale hue of *Anaphalis*. 9. *Leptospermum javanicum* (a myrtaceous shrub) whose foliage is strewn with white flowers. 10. *Hedera squarrosa* (= *Schefflera rugosa*) which pushes its straggling branches through the crowns of other trees. 11. A slender tree-fern *Cyathea oligocarpa* is also reported by him as occurring on the top. This is probably *Cyathea crenulata*, which however though common in the vicinity of Kandang Badak, is rather rare higher up.

JUNGHUHN mentions also several shrubs and herbs. *Lonicera*, *Hypericum* and *Gleichenia volubilis* are common. He enumerates further a *Carex* with brown-red panicles, probably *Carex hypsophila*, *Sanicula*, *Valeriana officinalis* (= *Valeriana Hardwickii*), *Thalictrum*, *Swertia*, *Viola pilosa*, *Plantago major* and a balsam with verticillate leaves, *Impatiens cyclocoma*.

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[1]) At present *Lycopodium miniatum* is no longer found in the open part of the central plain, but it is still present in the surrounding forest. *Gleichenia vestita* will also be looked for in vain. The plant does grow in the moist gully of the Tji-Kuripan, close to the top. In "Java" (2nd. edition, p. 602) JUNGHUHN mentions *Lycopodium rigidum* among the inhabitants of the forest; it is as a matter of fact a genuine forest plant.

A fern which is very abundant and resembles *Blechnum orientale*, viz. *Plagiogyria pycnophylla* is also mentioned. He refers further to a few fungi. One species, which was very abundant, was called by the natives djamur badak, i.e. rhinoceros fungus, because it was supposed to be a favourite food of these pachyderms. The mosses are, according to JUNGHUHN, more characteristic than the mushrooms. They cover in thick layers trunks and branches. Most of them belong to the genera *Leskea*, *Orthotrichum* and *Hydnum*. The pendulous beardmoss *Usnea* was also observed by him.

It will be in vain, JUNGHUHN says, to look for a similar forest on another mountain top in Java, for the peaks elsewhere are either covered with young volcanic products and bear no vegetation at all or a very young one, or they are covered with *Casuarina* forest, or with grass steppes consisting mainly of *Festuca nubigena*. Nevertheless the vegetation of Pangrango, which has not been disturbed for a very long time, is to be regarded as normal. The deep layer of humus points to a high age.

The 3rd. of April dawned on a misty drizzle; it was very still and everything seemed deserted by life. The sun did not come through till 8 o'clock, and then the voices of the birds began to be heard. Next morning JUNGHUHN left the mountain-top and returned to Bodjong-Keton.

Once more in the same year JUNGHUHN makes his way to the top of the mountain in company with A. KINDER, and remains there for four days, from July 28th. to 31st. For this stay he had a cabin built in the central plain. In the morning of July 29th. the plants on the plateau were covered with hoar-frost, all grasses were hung with frozen dew and the edges of the leaves, for instance of *Plantago*, were crusted with ice; the leaves of *Anaphalis* on the other hand were not covered with hoar-frost, and in the forest the dew was not frozen. There was not a stir of wind and it was dry weather and the brook, which in March had plenty of water, was by now almost dry. On July 31st. they descended by means of rhino-tracks from the cone of Pangrango in the direction of Kandang Badak and reached the col which connects Pangrango with Gedeh. They followed this level ridge for a time and ascended then towards the latter mountain. The trees so thickly covered with moss began to disappear, the specimens of *Vaccinium varingifolium* and *Gaultheria fragrantissima* grew ever smaller, the ground bore less and less vegetation and grew drier. At length the mossy humus ceased altogether, leaving the stony ground bare. Here appeared *Inga montana* (= *Albizzia montana*) which was entirely absent from Mt. Pangrango.

JUNGHUHN calculated the lapse of time between the last great eruption and the time of his visit and concluded that the forests on this part of Gedeh must be about 97 years old. The higher they climbed the more bare and stony the crater edge grew, and at last they reached the summit, which commanded a view of the aloon-aloon, and now they began to descend through spare groves of *Vaccinium varingifolium* among which stood some *Dianella javanica*, until they got to the plateau. The soil there consisted of

sand and pebbles, scantily dotted with *Anaphalis javanica* and *Festuca nubigena*, read *Calamagrostis australis*. JUNGHUHN confused this grass with *Festuca nubigena*, which, though common on the volcanos of Central and East Java is known in West Java from Mt. Papandajan only.

The other side of the aloon-aloon was thickly covered with forest consisting chiefly of *Leptospermum javanicum*, and he noticed the clear-cut boundary between this forest and the sparsely wooded part. The difference between the two parts according to JUNGHUHN is caused by the presence of sulfur and alum in the composition of the barren soil, which once formed the bottom of a crater. They climbed the Gemuruh-ridge, i.e. the outer edge of the aloon-aloon, where a few huts had been built already. Near by there was a cave in which the eggs of silkworms (silkworms were then cultivated in Java) were kept for some time, because the exposure of these eggs to low temperatures was supposed to prevent a decrease in size of the worms and cocoons.

On the 3rd. August they descended. JUNGHUHN observed that the *Vaccinium* trees covering the stony S. W. slope of Gedeh were evidently much younger than those growing on Pangrango, their trunks being less thick and knotty and the moss cushions not so strongly developed.

On November 9th. 1839 JUNGHUHN in company with Count VAN BENTHEM and Mr. VERMEULEN paid another visit to this mountain, the last one of those described in the book mentioned above. They started from Tjibunar and towards evening they reached the aloon-aloon of Gedeh, where a rhino started up just in front of them. The weather was exceptionally bad and next morning JUNGHUHN pushed on alone towards Pangrango. Halfway up the cone of this mountain he came upon a newly cleared path by which many natives were returning from the top. Huts, he found, had been built on the top of the mountain, the forest had been cleared and on the levelled ground the curator of the Botanic Gardens had planted young apple, pear, apricot and peach trees. He soon leaves the top, aggrieved by the destruction of the forest which a couple of months ago he had seen in its virgin beauty. He writes: "In wehmütiger Stimmung verliess ich diesen schönen Gipfel, wehmütig, zu sehen, wie seit der kurzen Zeit wo er zuerst durch mich auf Buitenzorg bekannt geworden war, schon so manche seiner einsamen Blüthen zertreten waren, und schon so manches seiner schönen Bäumchen unter der Axt hatte fallen müssen. Eine bedeutende Strecke seines lieblichen Waldes aus *Thiebaudien, Gaultheria, Vireya, Gnaphalium* und *Leptospermum*, in deren Schatten die *Primula imperialis* blüht, und auf deren Wurzeln die *Balanophoren* knospen, lag rettungslos dahingestreckt".

The closing months of 1840 witnessed a violent eruption of Gedeh, which was described by HASSKARL [1]). In this article there are also some

[1]) J. K. HASSKARL, Uitbarsting van den berg Gedeh, gedurende de maanden November en December 1840. Tijdschr. v. Nederl. Indië, IV, 1841, Vol. I, p. 241.

observations on the vegetation. In a note at the foot of p. 248 HASSKARL says that the track which leads by Tjibeureum and Kandang Badak to the top of Pangrango, has been greatly improved, so that the top can be reached on horseback. This is the path which was formerly followed by BLUME as far as Kandang Badak and which was pushed by the curator TEYSMANN as far as the top of Pangrango. Near Tjibeureum and at a few places higher up TEYSMANN caused gardens to be laid out for the cultivation of strawberries, peaches, white lilies, roses and *Tropaeolum*.

Above the hot springs, that is above 2200 m, a great many trees were felled by the gale which arose during the eruption, and many trees were blown down and burnt also in the vicinity of Kandang Badak. In the open spots thus formed many seedlings of *Albizzia montana* came up, and on the stumps of *Vaccinium varingifolium* the small red leaves of the young shoots were everywhere visible.

In his history of the volcanos JUNGHUHN[1]) also gives some particulars about Gedeh and Pangrango. He informs us that the ridge between the two volcanos called Pasirhalang, is the highest col between any two volcanos in Java. He also discusses the laying out of the garden by TEYSMANN on the top of Pangrango, to which he attributes the diminished capacity of the brook in the central plateau; and he relates that for several nights ice was formed in this brook. He gives also a few particulars with regard to Gedeh, a.o. that a great part of the crater wall was wrecked by the terrible eruptions of 1747 and 1748; and he concludes that the forests around Kandang Badak could not be older than 92 years. By the 1840 eruption the vegetation below the crater edge was destroyed over a distance of 100 m; down to Kandang Badak everything had been covered with a layer of ashes about two feet deep, but the plants had nevertheless sustained but little injury.

This article led to an unpleasant controversy between JUNGHUHN and TEYSMANN. TEYSMANN[2]) points out that the name of the cone-shaped mountain should not be Mandelawangi, but Pangrango, and he calls JUNGHUHN's idea that in Java clouds do not rise above 2000 m, incorrect at least with regard to the mountains of West Java. The mountains are sometimes for days and even weeks entirely wrapped in clouds; in the dry season only they may be, for some few days, entirely free. He considers JUNGHUHN's opinion of the relative dryness of the highest parts also as erroneous. The brook contains during the rainy season an abundance of water, and its water supply has not been lessened by the laying out of the

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[1]) FR. JUNGHUHN, Bijdragen tot de Geschiedenis der Vulkanen in den Nederl. Indischen Archipel. Tijdschr. v. Ned. Indië, V, 1842, Vol. 1, p. 110.

[2]) J. E. TEYSMANN, Kritische Aanteekeningen op de bijdragen van Doctor JUNGHUHN, tot de Geschiedenis der Vulkanen in den Ned. Ind. Archipel. Tijdschr v. Ned. Indië, V, 1842, Vol. 1, p. 487.

garden. TEYSMANN also contradicts the statement that hoar-frost occurs on the mountain tops, and finally he states that it was not JUNGHUHN, but Messrs KUHL and VAN HASSELT who were the first naturalists to climb Pangrango and that only the early death of those explorers prevented them from publishing a description of their expedition.

JUNGHUHN's reply [1]) was not long in forthcoming and in an article of great acerbity he attempts to refute TEYSMANN's criticisms. He maintains that the name of the cone must be Mandelawangi because most natives give it that name, and he sticks to his conception that the air above 2000 m is drier than lower down. He doubts that KUHL and VAN HASSELT had really reached the summit.

Another article from JUNGHUHN's [2]) pen on the physiognomy of the flora of the Javanese mountain tops appeared in 1845. He does not, as a matter of fact, refer especially to the flora of Gedeh-Pangrango, but this work should nevertheless be mentioned, because it contains short descriptions of various plants which are peculair to this mountain, for instance one of *Leptospermum javanicum*.

A detailed description of Gedeh was published by KORTHALS [3]) in 1848. He describes the flora which occurs on the stony upper slopes of the crater of Gedeh. The plants display a shrubby habit. Apart from the *Ericaceae* he mentions *Leptospermum, Myrica* and *Albizzia*. Among these grow *Swertia, Anaphalis javanica* and *Gnaphalium longifolium* and the blue-flowering *Dianella javanica*. The naked rock is covered with *Gaultheria nummularioides* and *Pleopeltis*, and lichens occur on projecting rocks. From this point on the upper slopes of the crater the spectator gets a view of the cone of Pangrango, which is clad in a mantle of green.

He reaches the top of this mountain and descends to the aloon-aloon, which by its barrenness suggests to the visitor a European heath. But few species of plants meet the eye; he enumerates *Anaphalis javanica, Swertia javanica*, which occurs here in very small individuals, *Gentiana quadrifaria, Thelymitra javanica* and a few grasses. Next he describes the vegetation on Mt. Gemuruh, mentioning an *Astronia* species and *Quercus pseudo-molucca*, and in their shade an undergrowth of *Ranunculus, Hypericum* and *Rubus*. In the green moss cushions thrive many epiphytic orchids: *Dendrobium Kuhlii* and *Ceratostylis latifolia*. On the mountain ridge he

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1) FR. JUNGHUHN, Kritiek over kritische Aanteekeningen. Tijdschr. voor Ned. Indië, V, 1842, Vol. 1, p. 663.

2) FR. JUNGHUHN, Physionomie van de flora van de bergtoppen van Javaansche bergen, benevens plantenbeschrijvingen. Natuur- en Geneeskundig Archief voor Ned. Indië, II, 1845, p. 20.

3) P. W. KORTHALS, Waarnemingen aangaande den berg Gedé op Java. Nederlandsch Kruidkundig Archief, Vol. 1, 1848, p. 117.

finds a.o. *Leptospermum javanicum, Rhododendron retusum* and ferns such as: *Lomaria vestita* and *Pleopeltis feei* [1]).

He also found *Scurrula fusca* as a parasite on a species of *Vaccinium*; the seeds of this plant must have been brought by birds: either by *Ixos bimaculatus* (= *Pycnonotus bimaculatus*) or by a *Turdus*.

The remaining portion of this treatise is devoted to a geological description of the mountain.

Pangrango and Gedeh are also described in the second volume of JUNGHUHN's Java [2]), the classic on this island. But the description is not so circumstantial as that given in his "Reisen" and does not contain an enumeration of the plants, so that we may leave it at this passing mention.

On July 26th. 1853 the tops were climbed by VAN DER BOR [3]). He records the existence of a log cabin on the top of Pangrango, but hardly anything is said concerning the vegetation. As to that of the Gedeh crater he merely says that owing to the continuous rain of sulphur the trees stood bare.

In 1854 MOTLEY [4]) visited the top of Pangrango. In a letter he relates how odd a sensation it was to a person arriving from Europe to come among plants like *Viola, Ranunculus, Impatiens,* etc. He also refers to *Primula imperialis,* saying that it grows only near the top. A few orchids are recorded by him, such as *Dendrobium Hasseltii* and *D. cymbidioides.* The top of Pangrango is a kind of amphitheatre, and the forest had been cleared for laying out a garden, which chiefly produced strawberries. The apples and other European fruit-trees are so thickly grown with lichens that they can hardly grow. A bush consisting of crooked stunted shrubs, chiefly *Ericaceae,* reaches up to the edge of the amphitheatre.

TEYSMANN [5]) writes that small bungalows were often put up at Kandang Badak, which were however as often wrecked by the burning-hot stones discharged from the crater of Gedeh. On the top of Pangrango a small experimental garden was laid out, which after a fair promise eventually proved a failure, owing to a lack of manure.

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1) There is probably here a confusion with *Pleopeltis triquetrum,* which in the sterile state resembles *Pleop. feei* and occurs epiphytically in the alpine forest, whilst *Pleop. feei* is only met with in bare open parts on this mountain.

2) FR. JUNGHUHN, Java, zijn gedaante, zijn plantentooi en inwendige bouw. Second edition, 's-Gravenhage, Vol. II, 1854, p. 25.

3) L. VAN DER BOR, Fragment uit zijn dagboek. Een uitstapje naar de Pangrango en den Gedeh. Biang Lala. Indisch Leescabinet, Vol. III, Tome 1, Batavia, 1854, p. 110.

4) Letters from JAMES MOTLEY, Esq. to W. MITTEN, Esq. HOOKERS Journal of Botany, Vol. VII, 1855, p. 81.

5) J. E. TEYSMANN, Uittreksel uit een dagverhaal eener reis door Midden-Java. Natuurk. Tijdschr. v. Ned. Indië, Vol. VIII, 1855, p. 195.

The scientific staff of the Austrian exploring-vessel Novara also visited the top of Pangrango. They arrived in the month of May and were very unfortunate as to the weather. They describe [1]) the trip on horseback from Tjipanas, and the experimental gardens started by TEYSMANN at Tjibeureum and Kandang Badak. In thick clouds of mist they reached the top, where they found a large crowd of people and horses, and a good bungalow with every convenience and by its side a strawberry plantation with ripe fruits. As a characteristic plant of the upper zone they mention: *Gnaphalium arboreum* (= *Anaphalis javanica*). *Primula imperialis* is also found. Of birds they only mention the mountain thrush and a smaller species resembling the European wren. They append a sketch of the top, which shows in the distance the crater of Gedeh and in the foreground a bungalow and an extent of ground, except for a few old trees completely striped of its original vegetation.

A very good description is found in the work of WALLACE [2]) who in October 1861 collected in West-Java and visited the top of Pangrango. He made the excursion in the usual way via Tjibeureum and Kandang Badak, where he found a glade in the forest occupied by numerous tree-ferns and by a young plantation of cinchona. From Kandang Badak as his base he visited the crater of Gedeh and the top of Pangrango, but during his excursions he only met with mist and rain. He describes the vegetation covering these regions and gives a figure of *Primula imperialis*. The low trees gnarled and dwarfed to the dimensions of bushes attract his attention; they occur as far up as the very top but they are absent from the crater gorge. In this part were found many open spaces with thickets of a shrubby *Artemisia* and of *Gnaphalium* (*Anaphalis javanica*). Finally he reproduces MOTLEY's list of plants.

WALLACE points to the remarkable fact that here South of the equator plant species are found belonging to Northern genera and that these plants are surrounded by a complete girdle of tropical vegetation in the lower regions. Of this phenomenon he gives an explanation, which he afterwards modified and perfected in his "Island Life". He draws attention to the fact that on the Peak of Teneriffe in the Canary Islands, which rises much higher than the mountains of Java, no alpine flora is found, though the distance from this peak to Europe is much smaller. On the tops of the Alps and Pyrenees numerous plants occur which are similar or identical to plants growing in Lapland but absent in the intervening countries. Since several of these plants possess heavy seeds, which can neither be conveyed by wind nor carried by birds for long distances, their occurrence in localities so widely separated cannot be explained by assuming that they have been

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[1]) Reise der Oesterreichischen Fregatte Novara um die Erde, in den Jahren 1857, 1858, 1859, unter den Befehlen des Commodore B. VON WÜLLERSTORF-URBAIN. Beschreibender Teil, Vol. II, Wien, 1861, p. 156.

[2]) A. R. WALLACE, The Malay Archipelago. London, Second Edition, 1869, p. 114.

carried by these agents from one place to the other. He concurs with DARWIN in believing that, during the glacial periods, these plants grew in the lower regions as well, and when the ice-caps melted away and the climate grew warmer, they were pushed back by other plants to higher latitudes and to the mountain tops. The enormous length of time elapsed since the events justifies the assumption that the plants were modified in distant places into different species. The difficulty of applying this explanation to the alpine flora of the higher parts of the mountains of Java lies in the fact that Java is separated from the continent of Asia by a stretch of sea. But there was a time when this island was indeed connected with Asia, and it is supposed that the alpine plants in question would have reached the Java mountains at that time. As mentioned above WALLACE has afterwards modified this line of argument.

Owing to the bad weather he met with on the top, his success in collecting animals was not very great. A fruit pigeon, *Ptilonopus roseicollis* = *Ptilonopus porphyreus* and the mountain thrush *Turdus fumidus* were badged, but no insects were caught.

P. J. VETH [1]) also wrote about the plants of the mountains of Java. He at first was of opinion that the plants occurring there had come from Europe, but when he became acquainted with the work of WALLACE he accepted his explanation.

BECCARI [2]) also describes the flora and fauna of the Pangrango top, which he climbed several times. He found there *Gentiana quadrifaria*, *Swertia javanica*, *Ranunculus javanicus* and *R. diffusus*, *Sanicula europaea*, *Valeriana Hardwickii*, *Primula imperialis* and other plants of European families, besides *Vaccinium*, *Gaultheria* and other *Ericaceae*. The fruits of the former plants are not eaten by birds, but their seeds are small and may have arrived on this top either together with dust from other mountains carried by wind, or by adhering accidentally to the feet of marsh-birds. He considers it unlikely that these plants could be relicts of a vegetation formerly inhabiting the intervening stretches between the mountains. He thinks that the seeds of the plants occurring on the Pangrango top have been conveyed thither through the winds blowing in the N. E. monsoon and by birds arriving from more westerly regions, first from Sumatra and later also from the mountains in Asia. That there are so few species of *Compositae* on the mountains of the Malay Archipelago he thinks may be explained by the absence of suitable pollinators. But this does not hold good, he says, for the Pangrango top, for *Anaphalis javanica* is visited there by a large number of *Diptera*.

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1) P. J. VETH, Tijdschrift voor Nederlandsch Indië, Third serie, Vol. III, Part I, 1869, p. 491.

2) O. BECCARI, Malesia, 1878, Vol. 1, Fasc. III, p. 219.

In February 1892 HABERLANDT [1]) stays some time at Tjibodas and makes an excursion to Kandang Badak, but he does not get higher. He describes, however, the trees covered with thick moss cushions round Lebak Saät and gives a picture of them.

An important and interesting description of the flora of these parts has been given by MASSART [2]), who made the expedition in the autumn of 1895. He offers a detailed description of the primeval forest above Tjibodas and of the excursion to the top of Pangrango. The forest round Kandang Badak he describes as more humble than the forest at lower altitudes. On Pangrango, he says, *Leptospermum javanicum* a tree with a rounded crown dominates. He further mentions a very common tree-fern, *Aralia ferox* and *Gleichenia*. In this part of the forest he finds species of genera belonging to temperate zones, growing together with tropical forms. In front of the bungalow at Kandang Badak he notices *Poa pratensis* and *Stellaria media* and alongside the brook *Nasturtium officinale*, which does not flower here anymore than lower down. The trees growing here are seldom higher than 10 m and their trunks are often bent, especially in *Vaccinium laurifolium*, which may be either terrestrial or epiphytic in habit. Lianas are of rare occurrence apart from a few individuals of *Kadsura scandens*, from two or more species of *Rubus*, and from *Crawfurdia trinervia*. The trunks and branches are covered with mosses in which *Hymenophyllaceae* grow. In the more open parts of the forest *Lycopodium volubile* and species of *Gleichenia* are common; the parasite *Balanophora elongata* on the other hand is an inhabitant of the denser parts. In addition to *Leptospermum* the forest consists of *Vaccinium varingifolium*, *Araliaceae*, *Lauraceae*, *Rhododendron*, *Eurya*, *Rapanea*, *Ardisia*, *Symplocos*, *Alsophila* and *Cyathea*. On climbing higher the observer finds that the *Hymenophyllaceae* become rarer, and cease where the first examples of *Primula imperialis* present themselves; the flowers of this latter plant are homostylous. Besides these still other plants are recorded.

The tallest tree at this altitude is *Vaccinium varingifolium* and the only lianas are *Rubus* and *Lonicera javanica*. As epiphytes he found *Vaccinium varingifolium* and *laurifolium*, *Rhododendron*, *Nertera depressa*, a few ferns and an orchid, a species of *Dendrobium*, probably *Dendrobium Hasseltii*.

On the top of Pangrango he sees *Vaccinium varingifolium*, here between 1 and 2 m high, *Hypericum Leschenaultii*, *Anaphalis javanica* and a large number of other plants. The centre of the plateau there is occupied by a vegetation of herbs of which he mentions *Ranunculus diffusus* (*R. javanicus* is probably meant, for *R. diffusus* does not occur on the top; it grows

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[1]) G. HABERLANDT, Eine botanische Tropenreise. Leipzig, 1910, second edition, p. 230, fig. 47.

[2]) J. MASSART, Un botaniste en Malaisie. Bull. de la Société royale de botanique de Belgique, Vol. XXXIV, 1895, p. 261.

at Kandang Badak), and *Isachne pangerangensis*. The latter he quotes as an endemic peculiar to this top; this however is not true: it is common on several mountain tops.

He discusses WALLACE's theory as to the origin of those mountain plants which belong to northern genera, but points out that several of the plants growing on the mountain tops thrive also at Buitenzorg, so that several species might have come from lower regions.

The next morning he makes an expedition to Mt. Gedeh. The vegetation is very similar to that of Pangrango and he mentions a.o. a *Styrax*, which to my knowledge does not occur there. He then mentions the absence from Pangrango of *Gaultheria fragrantissima*, which is very common on Gedeh. He is struck with the absence of epiphytes in the forests on Gedeh, and supposes that the quantity of precipitation on this mountain is less than that on Pangrango. In the crater he finds many individuals of *Albizzia montana*, small plants of *Vaccinium varingifolium*, and further *Anaphalis javanica*, and a few other plants. During the whole of this excursion the weather was very bad. His plate VIII, figure 12 is a foto of the Pangrango forest at about 2800 m above sea level.

In the periodical Teysmannia some plants from Pangrango are discussed by KOORDERS [1]), a.o. *Primula imperialis*, *Rhododendron retusum*, *Rubus* species and *Gentiana quadrifaria*. Of this plant he says that it is the only cushion plant of the Javanese high mountains, a habit assumed as an adaptation to the dryness of its habitat (this *Gentiana* is not a genuine cushion plant as the shoots are far too loosely arranged, so that the leaves form by no means a dense cushion).

SCHIMPER [2]) also in his notable book on plant geography gives a description of the flora on the top of Pangrango. According to him the mountain forest which is already of lower stature than the rain forest shrinks at ± 200 m below the top into a "Krummholzwäldchen" (stunted alpine forest). (This statement is not quite correct, as the trees maintain fairly well their normal stature up to the very top of Pangrango, with only occasionally smaller examples in the crater-valley). The trunks of the small trees are stumpy and grow askew or prostrate with sparse ramification. The leathery leaves are congested at the ends of the branches. On the mountain top there rise above the lower wood here and there trees with an "umbrella"-shaped crown, *Leptospermum javanicum*, which in the month of December appear strewn with white blossoms. Among the bushes *Anaphalis javanica* and *Rhododendron retusum* are common. Dominant, however, are smooth-leaved sclerophyllous plants with a slight tendency to succulence, such as *Rapanea*, *Eurya*, *Vaccinium varingifolium* and *V.*

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1) S. H. KOORDERS, *Primula imperialis* etc. Teysmannia, Vol. X, 1899, p. 446, 453 and 456.

2) A. F. W. SCHIMPER, Pflanzengeographie auf physiologischer Grundlage, Second edition, Jena, 1908, p. 760.

laurifolium etc. In some localities the alpine thicket is replaced by alpine steppes, in which narrow bladed low grasses occur, together with *Plantago major*, *Gaultheria nummularioides* and a strongly pilose species of *Rhacomitrium*.

Mt. Gedeh was visited by GIESENHAGEN [1]) in October 1899. He too is struck with the alteration of the forest at successive altitudes, and he says that in higher altitudes the number of tree species not only diminishes, but that moreover near Kandang Badak the gigantic individuals are lacking. (This is not quite correct, for *Podocarpus imbricata* is still represented in very big examples a considerable way above Kandang Badak). The trees, says GIESENHAGEN, are of lower stature and about equal in height, the trunk frequently branching a short way up above the ground. This type of growth is chiefly a consequence of the low temperature and of the wind. A lack of moisture, he says, can certainly not be the cause, as even on sunny days the tops of Gedeh and Pangrango are often wrapped in clouds. Neither can the wind play a great part, as it does not blow any harder here than at Tjibodas where gales are frequent. Owing to the density of the forest the strength of the wind is moreover broken, and the mossflora is developed to unexampled dimensions and density. (However, in the lower areas very heavy moss-cushions are observed in the topmost branches of tall trees where the wind can exercise its greatest force). He gives also a description of the crater of Gedeh.

From August 1905 to August 1906 ERNST [2]) sojourns in Java, and in the course of those months he also stays on Pangrango-Gedeh. Several plates of his "Vegetationsbilder" are devoted to the vegetation of these tops. He describes the crater depression on the top of Pangrango and the aloon-aloon of Gedeh. ERNST points out that the vegetation of Pangrango recalls the shrub on the European high mountains. He mentions the same plants that have been found already by earlier explorers, and states that the forest round the crater-valley is bordered by a narrow fringe of ferns, *Pteris incisa*, *Gleichenia vulcanica* and *Lomaria pycnophylla*. The vegetation of the middle part of this central depression consists of low *Anaphalis* bushes, grasses, among which *Isachne pangerangensis*, and the *Cyperacea*: *Carex hypsophila*. Many mosses are also present, such as the white-haired *Rhacomitrium lanuginosum*, and *Bryum leucophyllum*, and *Ceratodon purpureum*. He mentions further an iron grey lichen: *Stereocaulon graminosum* and the wellknown *Cladonia coccifera*.

Among the trees in the out-skirts of the forest ERNST mentions *Myrica javanica*, but this does not occur on Pangrango. The remarkably slow shifting of the limit of the forest towards the centre of the crater-valley,

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[1]) K. GIESENHAGEN, Auf Java und Sumatra. Leipzig, 1902, p. 80.

[2]) A. ERNST, Die Besiedelung vulkanischer Bodens auf Java und Sumatra, Vegetationsbilder, Serie VII, Tome 1—2, 1909, plates 1 to 3.

attributed by JUNGHUHN to the slow growth of the trees, can certainly not be due to this circumstance alone, says ERNST. Neither can the barrenness of the soil be the only cause. It is probably determined in the first place by climatological factors. The temperature is very low and in the dry season the plants are often covered by hoar-frost. The alternation of two unfavourable conditions: the dryness of the air by day, which intensifies transpiration, and the nocturnal radiation and cooling, is probably the cause of the scarcity of plants in the crater-valley. In the aloon-aloon of Gedeh similar conditions prevail.

His plate I shows part of the aforesaid aloon-aloon; plate II gives a picture of the central plateau on the top of Pangrango and in the photo reproduced in plate III *Primula imperialis* and *Ranunculus javanicus* are seen. The other plant with deeply incised leaves shown there is not *Ranunculus diffusus*, but *Sanicula europaea*.

In the JUNGHUHN memorial volume [1]) KOORDERS and NIERMEIJER have reproduced a number of photographs taken by JUNGHUHN, some of them on his visit to the top of Pangrango on July 8th. 1861. Of interest to us are photo no. 2 showing the crater-valley of Pangrango (here still erroneously called Mandelawangi) with the luxuriant *Anaphalis*-vegetation; photo no. 3 showing a big *Vaccinium varingifolium* on a bare plain (an individual perfectly similar to the one pictured, perhaps the identical tree on which a big *Rapanea avenis* is now growing epiphytically, grows at the fringe of the central plateau, close to the rain-gauges); photo no. 4 is a picture of the whole crater-valley, as it still is, with a great abundance of *Anaphalis* in the foreground and in the background the *Vaccinium* forest; foto no. 5 shows the edge of the forest with big *Anaphalis*-bushes against it; photo no. 6 shows us a few big *Anaphalis*-shrubs probably in the southern part of the central plateau; photo no. 31 gives the view of the crater of Gedeh taken from the top of Pangrango.

MIEHE [2]) discusses briefly the composition of the vegetation in the Gedeh aloon-aloon. He mentions *Albizzia montana*, *Vaccinium varingifolium*, *Gaultheria fragrantissima* and *Myrica javanica* as characteristic plants. He points out that these plants are also of frequent occurrence in other craters. He considers them as pioneers, and remarks that all these pioneers are root symbionts. In such habitats ferns are less abundantly represented, though one species: *Pleopeltis feei* is common.

BACKER [3]) has also visited the Pangrango top and says: "above 2400 m atmospheric precipitation is scanty and evaporation is considerable, the soil is therefore dry and brooks are very scarce". He adds a description of the

[1]) JUNGHUHN-Gedenkboek, 1809—1909, 's Gravenhage, 1910.

[2]) H. MIEHE, Javanische Studien. Abhandl. d. Math. Phys. Klasse der Königl. Sächs. Gesellsch. d. Wissenschaften, Vol. XXXII, 1911, p. 381.

[3]) C. A. BACKER, Sawah-planten. De Tropische Natuur, Vol. III, 1913, p. 83 and 118.

crater-valley, adducing it as a splendid example of a gradual transition of a hygrophilous flora into a flora of the sclerophyllous type. (If by the former is meant the forest or the herbaceous plants in it, and by the latter the vegetation of the crater-valley, the transition is anything but gradual, indeed quite abrupt. The vegetation of the crater-valley is moreover by no means purely sclerophyllous).

In the publications hitherto reviewed hardly anything was said as to the fauna. KONINGSBERGER [1]) gives a survey of the fauna in the higher parts of Java, and in the course of this the aloon-aloon of Gedeh is mentioned. He says: "Reptiles and amphibia are no longer seen, though I am persuaded that the latter will still dwell in such an area as the aloon-aloon of Gedeh, a wide semi-circular valley formed by the outer wall of the present crater and a far wider almost equally high wall of older date. Across the centre of this valley flows a clear brook which is the source of one of the south-flowing rivers. Just, as along the watery ditches in Holland, buttercups (*Ranunculus javanicus* and *Ranunculus diffusus*), which involuntarily call to our minds the suggestion of quacking frogs, (these however do not live there), grow on its banks". He further mentions that ROEPKE found in the highest part of the Gedeh top a species of *Sciara*, of which the females possessed reduced wings. In the highest barren part of Gedeh KONINGSBERGER captured a specimen of *Vanessa cardui*.

In his book on Java and Sumatra BLAAUW [2]) devotes a chapter to his excursion to the tops of Gedeh and Pangrango. In his introduction he says that the low temperatures in these areas cause several species to die out after a reduction to dwarf form. This is, in my opinion, not correct; I am unable to give a single example of it, but rather of the contrary: at the highest limits reached by a species very big individuals are sometimes met with, e.g. of *Podocarpus imbricata* and *Disporum chinense*. Robust individuals and dwarfs of the same species moreover are occasionally found in fairly close proximity, for instance of *Swertia javanica* in the crater-valley of Pangrango. The existence of these pygmy forms is more due to bad conditions of nutrition (sensu amplio) than to a fall in temperature. His views are in fact still largely under the influence of JUNGHUHN.

Next BLAAUW proceeds to describe the neighbourhood of Kandang Badak and the excursion to the tops of Gedeh and Pangrango. On the latter the flora does not change so quickly as on the former, for the cone of Pangrango is densely wooded to the very top. According to him strawberries planted by TEYSMANN are found growing along the path to the top, but as a matter of fact this plant occurs exclusively on the top itself and

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[1]) J. C. KONINGSBERGER, Java Zoölogisch en Biologisch. Buitenzorg, 1911—1915. p. 617.

[2]) A. H. BLAAUW, De Tropische Natuur in schetsen en kleuren. Amsterdam, 1913, p. 58.

not lower. Some good photos of the vegetation illustrate this chapter and in addition two plates with reproductions from colour photos: plate 20, a picture of *Anaphalis javanica* and of *Vaccinium varingifolium*, with its bright red young leaves, and plate 21, a view of the crater-valley with cloudcapped Mt. Salak in the distance.

CROISSET VAN UCHELEN [1]) does not indeed give a description of the vegetation, but his article contains some photos, a.o. one of the old hut of Kandang Badak thatched with the straw of lalang reed-grass: On the same photo the well-known swiss botanist C. SCHRÖTER may be seen. This article is also accompanied by a good photo of the vegetation of the top of Pangrango.

In the year 1919 Tjibodas was visited by ROCK [2]) chiefly for the purpose of collecting seeds of forest trees which were to be used for the reafforestation of the deforested mountains of the Sandwich Islands. In the course of an excursion to the top of Gedeh he makes several very fine photos, of which reproductions are attached to his report. He describes the trip to Kandang Badak and further to the crater of Mt. Gedeh. On the upper slopes of this mountain the moss growth thins out and the underwood grows scantier; at first *Podocarpus imbricata*, *Schima Noronhae* and a species of *Quercus* still occur, but the dominant tree is *Vaccinium varingifolium* and *Albizzia montana* enters upon the scene. The moss grows rarer, the trees get thinner in trunk and more compact. On p. 94 is reproduced a very good photo of the moss covered forest near Kandang Badak; how this forest changes in higher regions is clearly demonstrated in the photos on pp. 96 and 97. There are also photos of the crater, of *Albizzia montana*, and of *Gahnia javanica*.

In 1920 the pollination of *Gentiana quadrifaria* was briefly discussed by myself [3]).

KARNY [4]) devoted most of his attention to animal life on the top of Pangrango. Insect life on this top is, in spite of the abundance of flowers, very meagre; it makes an almost palaearctic impression. Of *Lepidoptera* he only observed a small butterfly, *Dodona adonira windu*. The *Hypericum* flowers are visited by genuine bumblebees and on the capitula of *Anaphalis javanica* he sees many syrphus flies. Tree bugs and psyllids are also general.

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[1]) C. E. CROISSET VAN UCHELEN, Een bestijging van den Gedeh. Indië, Vol. II, 1918—1919, p. 821.

[2]) J. F. ROCK, The forest of Mt. Gedeh. West Java. The Hawaiian Planters' Record, Vol. XXII, 1920, p. 67.

[3]) W. DOCTERS VAN LEEUWEN, Naar de top van de Singgalang bij Fort de Kock. De Tropische Natuur, Vol. IX, 1920, p. 94.

[4]) H. H. KARNY, Zum Gipfel des Pangerango (West-Java). Natur, Vol. XIII, 1922, p. 297.

SEIFRITZ [1]) published a description of the altitudinal distribution of plants on Mt. Gedeh. He divides the vegetation from Tjibodas upwards into various subzones, beginning with the Rasamala subzone: 4600—5500 feet; then the *Podocarpus* subzone, 5500—7000 feet; next the herbaceous subzone: 7000—8000 feet; subsequently the *Vaccinium* subzone: 8000—9000 feet; and finally the *Anaphalis* subzone, 9400 feet. (This division is very artificial and does not give an adequate idea of the real situation, but only a more or less vague picture of the vegetation along the route followed). A few good photos of the *Vaccinium* forest and of the moss covered forest are appended; see plate 17.

According to SEIFRITZ *Vaccinium varingifolium* is the most polymorphous species of this genus, existing as he says, as a shrub, a tree and a liana, and being able to grow terrestrially and epiphytically. This is not so and there has probably been a confusion between this species and *Vaccinium laurifolium*. *Vaccinium varingifolium* is rare as an epiphyte, and grows never as a liana.

In an other article SEIFRITZ [2]) deals with the altitudinal distribution of lichens and mosses in the same mountain group. He divides the lichen vegetation into two subzones, one situated at elevations of 4600 feet and one at 9000 feet and he arrives at the conclusion that the two subzones have not a single species in common. This is not quite true, since *Stereocaulon graminosum* which is common in the barren crater valleys occurs i.a. also on the roof tiles of the buildings at Tjibodas. The subzones established by him in his previous article nos. II and III between 5500 and 8000 feet are poor in lichens. (These plants are however on the whole light-plants and in the gardens at Tjibodas they grow therefore on treetrunks and bushes, and in the forest in the treetops, where they are not at all rare. But owing to their position high up in the trees they are not within easy reach. It is true, however, that in the highest regions lichens occur which are not found at lower altitudes.)

Passing on to the mosses he says that the visitor enters a moss zone at some 5500 feet, and that these mosses are chiefly of the kinds that fringe the lower branches of trees and shrubs like garlands. In the tree-tops in this part of the forest on the other hand the mosses are of the cushion forming kinds. Near Kandang Badak almost exclusively cushion forming mosses are found. The difference in habit of various mosses at different altitudes, SEIFRITZ thinks, may be attributed to the wind.

In 1925 DAMMERMAN [3]) published a report of his researches on animals living in the soil. He produces also lists of the soil creatures near Kandang

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[1]) W. SEIFRITZ, The altitudinal distribution of plants on Mt. Gedeh. Java Bull. of the Torrey Botan. Club, Vol. L, 1923, p. 283.

[2]) W. SEIFRITZ, The altitudinal distribution of Lichens and Mosses on Mt. Gedeh. Java. Journal of Ecology, Vol. XII, 1924, p. 307.

[3]) K. W. DAMMERMAN, First contribution to a study of the tropical soil and surface fauna. Treubia, Vol. VI, 1925, p. 135.

Badak and on the Pangrango top. *Crustacea, Coleoptera, Myriapoda* and especially *Molluscs* are at Kandang Badak very abundantly represented; ants are completely absent. The soil at the top of Pangrango is much poorer in inmates. The main types present are *Coleoptera, Heteroptera* and *Arachnoidea. Molluscs* were not found by him in the soil of the top.

Between 1924 and 1927 a series of articles on the biology of plants and animals on the top of Pangrango were published by me [1]).

In his studies of the Patanas in Ceylon, STOMPS [2]) compares these grass lands with the alpine grass land on the top of Pangrango. He draws attention to the similarity of the vegetation of this Javanese mountain with that of the grassy plains in the higher parts of Ceylon; the latter he regards as permanent. We shall refer to this study again in a subsequent chapter.

SCHMUCKER [3]) offered a discussion of the flora of the higher parts of the mountains in Java, in which Pangrango is also mentioned but not discussed in detail. His views will be dealt with in an other chapter.

I published myself [4]) a small contribution to the knowledge of the distribution of certain plants of the Gedeh and Pangrango tops through the action of birds. The flora of the Pangrango top is in that paper briefly discussed, and conclusions are reached with regard to the important share which animals have in the distribution of these plants.

A study dealing with the crater plants, in which the plants of Pangrango and Gedeh were also discussed in detail, appeared from the pen of VON FABER [5]). The life of the plants is studied by him from a physiological-ecological standpoint. I shall have to refer to this article again in the course of the following chapters. Here I may confine myself therefore to the list of plants given on p. 12. These plants occur according to him on the tops of the two mountains and in the crater of Mt. Gedeh. Some of these plants have never been observed there by me. *Vaccinium lucidum* is one of the commonest epiphytes in the virgin forest above Tjibodas especially at about 1800 m, where it often grows in the thick moss cushions high up in the trees. At Kandang Badak it is however already more or less rare and neither in the crater of Gedeh nor on the Pangrango top did I ever observe

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1) W. DOCTERS VAN LEEUWEN, Uit het leven van planten en dieren op de top van de Pangrango. De Tropische Natuur, Vol. XIII, 1924, p. 97 and 152; Vol. XV, 1926, p. 57 and 141; Vol. XVI, 1927, p. 111 and 185.

2) TH. J. STOMPS, Patanas, alpine Grasfluren auf Ceylon. Veröffentl. des Geobotan. Institutes RÜBEL in Zürich, Tome 3, 1925, p. 259.

3) TH. SCHMUCKER, Beiträge zur Kenntnis der Hochgebirgsflora Javas und zur Theorie des Pflanzenausbreitung. Beih. z. Botan. Centralbl., Vol. XLIII, 1926, p. 34.

4) W. M. DOCTERS VAN LEEUWEN, Kleiner Beitrag zur Kenntnis der endozoischen Verbreitung einiger Hochgebirgspflanzen auf Java. Flora, Vol. 118 and 119, p. 81.

5) F. C. VON FABER, Die Kraterpflanzen Javas. Arbeiten aus der Treub-Laboratorium, Batavia 1927.

it. *Ficus diversifolia, Symplocos spicata, Elaeocarpus acronodia* and *Elaeocarpus angustifolia* were never found by me on the rubble heaps (Geröllhalden) in the crater of Gedeh. *Pleopeltis feei* does not occur on Pangrango; it grows however abundantly on the lava stream in the Gedeh crater. There has probably been a confusion with another fern, presumably with *Pleopeltis triquetrum,* which it resembles in the sterile condition and which is very common as an epiphyte and grows in the forest also on fallen trunks and on large boulders; or possibly with *Elaphoglossum angulatum,* which is also rather common in the forest. *Pleopeltis feei* in any case does not occur on Pangrango.

Of various tree-species VON FABER states that they may also occur epiphytically and this is doubtless true, especially of the younger stages, but as they grow older the roots growing downwards along the trunk of the host tree, reach the ground and the plants cease to be true epiphytes. As many of the species occurring here are disseminated by birds their seeds may easily land on trees. The seeds of *Albizzia montana* are probably dispersed by the wind, but this is certainly not a species of tree that can occur epiphytically in anything like large sizes. *Rapanea avenis* is listed by VON FABER as non-epiphytic, but a very big individual grows on an ancient *Vaccinium varingifolium* in the crater-valley of Pangrango, the roots of this *Rapanea* however have already reached the ground.

SCHRÖTER [1]) the well-known expert on the flora of the Alps, with whom I had the pleasure of visiting Pangrango and Gedeh, briefly described a few of the plant associations occurring on these mountains. The question whether there exists on the tops of the Javanese mountains an alpine flora, he answers in the negative.

A short survey of the fauna in the highest parts of Pangrango was furnished by DAMMERMAN [2]). He too notices that among the insects there occur a number of forms usually found in more temperate regions, or at least related to palaearctic species.

The flora of the tops of Gedeh-Pangrango was dealt with by me [3]) in an excursion-guide for the Fourth Pacific Science Congress.

A short discussion of the crater flora, accompanied by a good photo of the "Edelweiss"-vegetation in the Gedeh crater was published by RESVOLL [4]). The small trees visible in the background are however not *Vaccinium varingifolium* but *Albizzia montana.*

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[1]) C. SCHRÖTER, Exkursionen in Ost-Java. Beibl. No. 15 zur Viertel-jahrschrift der Naturf. Gesellsch. in Zürich, Vol. LXXIII, 1928, p. 591.

[2]) K. W. DAMMERMAN, Tjibodas, Zoology. Excursion-guide of the Fourth Pacific Science Congress, 1929, p. 17.

[3]) W. M. DOCTERS VAN LEEUWEN, Tjibodas, Botany. Excursion-guide of the Fourth Pacific Science Congress, 1929, p. 10.

[4]) THECLA R. RESVOLL, Kratervegetasjion på Java. Naturen, 1929, p. 321.

CHAPTER II.

TOPOGRAPHICAL DESCRIPTION.

Mt. Pangrango and Mt. Gedeh together form a twin-volcano of large dimensions. Viewed from the South it displays the full magnitude of its bulk, vide plate I, and fig. 1 which is borrowed from TAVERNE's [1]) book. One recognizes at once that this mountaincomplex must be reckoned among the polyconids as it shows at the top several separate cones. The summit

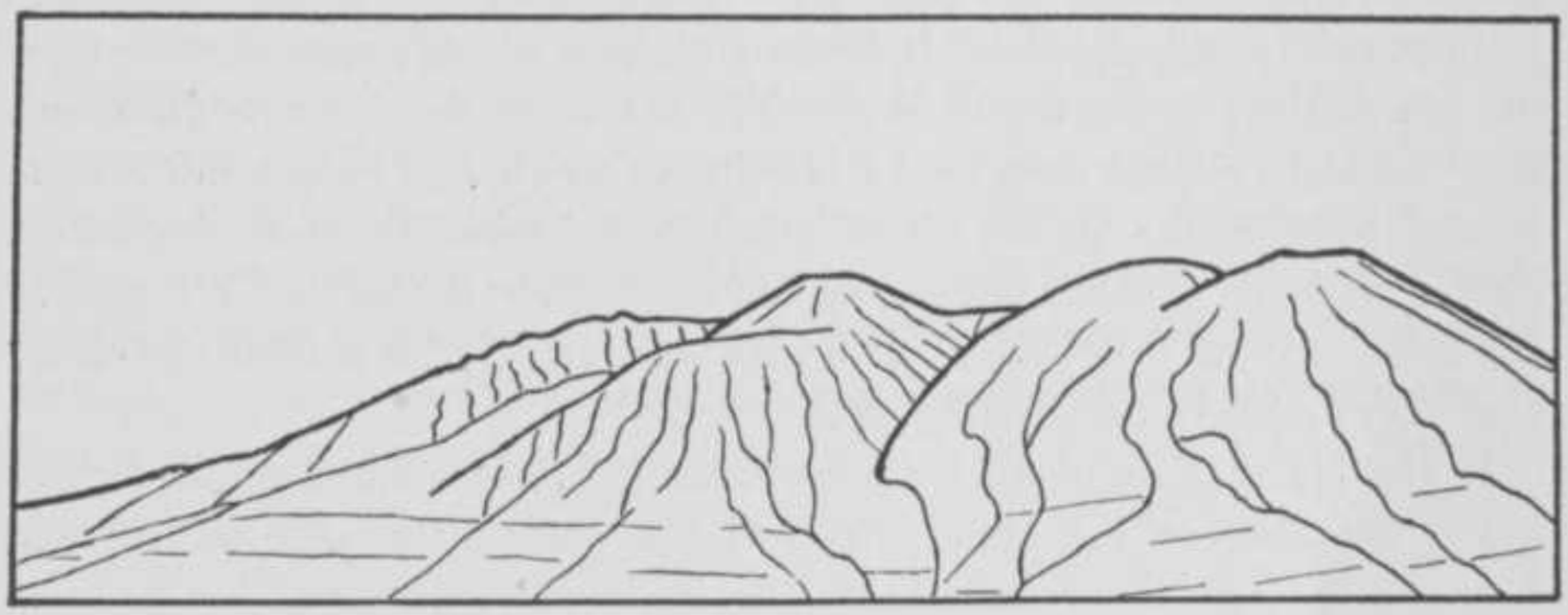

Fig. 1. The Gedeh-Pangrango, seen from the South.

of Pangrango rises to 3022 m and forms the western peak, whilst Gedeh, which rears its highest top at 2962 m above sea-level, extends its mass in an easterly direction. By a col known as Pasir Halang, on which the bungalow Kandang Badak stands, the two mountains are connected with each other, and from this point roads ascend to the top of Pangrango, the crater of Gedeh and to the peak of the same mountain. By its height and its perfect conical shape Mt. Pangrango dominates the whole mountain group, plate III, and its peak affords a wide panorama of the separate masses of the neighbouring volcanos and of the surrounding plains. On days when visibility is good the sea can be perceived to the North, West and South, together with several of the lofty mountain tops of West-Java. To the westward are seen Mt. Salak, plate V, and Mt. Karang, sometimes even the tops of mountains in South Sumatra; to the East the volcanos of the Preanger Regencies: Mts. Burangrang, Tangkuban Prahu, Tjikorai and the surrounding mountains, and in a somewhat more northerly direction Tjiremai and Slamat; the latter is situated in Central Java and rises to 3400 m. Pangrango is completely extinct, but only slightly attacked by

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1) N. J. M. TAVERNE, Vulkaanstudies op Java. Vulkanologische Mededeelingen No. 7, Den Haag, 1926, p. 86.

erosion; according to TAVERNE therefore the cone may be considered comparatively young. This cone is situated in a wide basin enclosed by a horseshoe wall, the inner side of which is very steep whilst the outer side slopes more gently towards the plain. This wall is usually called Mandalawangi. In JUNGHUHN's description this name is applied to the cone, but the latter is generally known as Pangrango, also among the natives living on the mountain.

The top of this mountain has been the scene of most of the researchwork described in the present volume. The top is not flat, but consists of a ridge in the shape of the horseshoe which surrounds a shallow depression, the break being towards the West. The highest point in this ridge reaches 3022 m, the two ends of the horseshoe are at about 3013, so that the whole wall is practically horizontal. The depression is probably the site of the extinct crater and is called in this book the "crater valley" of Pangrango; it is JUNGHUHN's „Centralgrund". It forms a plateau which slopes slightly from the North-East to the South West. The slopes of the surrounding crater wall are more abrupt only to the North. As mentioned before this wall is lacking towards the West, where it has been broken through. According to TAVERNE this part has not succumbed exclusively to erosion; a fissure in the crater bottom followed by a sudden subsidence of a part of the crater wall was probably the starting point.

In the North-East part of the crater valley rises a small brook fed by the rain falling on the inner slopes of the wall; little sources are seen bubbling up from the ground especially in the rainy season. This brook is called Tji-Kuripan (also sometimes Tjiheulang) and flows to the South West growing more and more powerful and forming here and there pools in which Rhinocerosses used to bathe; then at the edge of the plateau it dips into a narrow precipitous chasm and descends by a series of cascades towards the base of the mountain. In the west-monsoon this brook is swollen with water, but in the dry season it contains far less and sometimes it runs altogether dry, to flow again after a few days' rain. The crater valley lies at some 30 to 50 m below the enclosing wall. The vicinity of the brook possesses little vegetation, plate VIII, the surrounding slopes have more. A description of the vegetation will be given in chapter IV.

The top of Gedeh is not so simple in construction, owing to the fact that the eruption point has in course of time moved from South to North. To the South and East runs the sickle-shaped enclosing wall of the old crater, the so-called aloon-aloon. This encircling wall, called Gunung Gemuruh, of which only a part now remains, is fairly level, its highest point is 2927 m. The aloon-aloon, plate XXV, is a crescent-shaped terrace, some 4 km long and gently sloping from East to West. In the East part rises a brook, the Tji-Gunung, which flows towards the West, and contains far more water than the brook in the crater-valley of Pangrango; in the east-monsoon,

however, it mostly runs dry. This ancient crater, according to TAVERNE, had a diameter of 2 km.

On the North side of the old crater a new cone has emerged, but this one also is no longer intact, because a third crater has arisen in the North West. Great parts of these two craters have been broken up and submerged under lava. The enclosing wall of the second crater has remained intact to the South, South-West and South-East as an abrupt crescentshaped wall, plate XXII, reaching its highest point at 2962 m. The inner side of this wall is precipitous and about 300 m high, exposing layers of trachyte. On the outer side the wall slopes down gently for about 200 m into the aloon-aloon. To the North East a fragment of this crater wall, 2709 m high, is still standing; it is called Gunung Sela or Gunung Rumpang. Its top affords a fine view of the whole mountain group.

Within this crater against the southern enclosing wall, two smaller craters have been formed. The more westerly one, the Kawah Ratu has a diameter of 250 m and a depth of 200 m. To the East of this lies the smaller Kawah Lanang which is oval with diameters of 200 to 125 m, and is far shallower. This latter crater is quite extinct, and its bottom is clothed with dense vegetation; the Kawah Ratu on the other hand shows some activity: a few solfataras are smoking from the depths and near the border. At some earlier period the Kawah Lanang was powerfully active, and two lava-streams have issued from it; the more westerly one can be followed more than 2 km downwards; the hot springs on the way from Tjibodas to Kandang Badak rise from underneath. The second lava-stream, the easterly one, runs along the foot of Gunung Sela, and consists like the other one of big blocks.

On the northern brink of the second crater there exists a third eruption point, the youngest and at present the most active part of Gedeh, the so-called Kawah Wadon, plate IV. This eruption point is situated in an erosion gully, drained by the Tji-saät (= dry river). Its bed is filled with boulders and is usually dry, except during heavy rains, when the water thunders down over the stones. The walls at the top of the vent, where volcanic activity is still visible, are very steep and gorgeously coloured through weathering and by sulphurous deposits. Big clouds of steam mixed with SO_2 and H_2S gases are belched forth from the solfataras.

The third crater is difficult to find, as it is largely buried under materials discharged during the eruptions of the more recent craters. A part of it is still level and is cut across by a few steepbanked dry gullies. It is clothed with a thick vegetation of *Anaphalis javanica*, surrounded by the usual alpinoid bush and is called aloon-aloon ketjil [1]).

The above description has been derived for the greater part from the work of TAVERNE previously cited. The history of the eruption was fully described by JUNGHUHN [2]); the shape of this mountain probably underwent

[1]) ketjil = small.

[2]) FR. JUNGHUHN, Java, 2nd. edition, Vol. II, 1854, p. 31.

its greatest alterations in the course of the violent eruptions of 1747 and 1748. How the situation was before that time is unknown. The later eruptions have been less momentous, though the vegetation suffered greatly in parts. As late as TEYSMANN's visit in 1840 and later still the bungalow at Kandang Badak was repeatedly ruined by rocks ejected from the crater, and the vegetation in this part of the mountain was several times severely damaged.

A stretch extending from the higher end of the acclimatisation gardens of Tjibodas to the tops of Pangrango and Gedeh has been set apart by the Government of the Netherlands East Indies as a nature reserve. It comprises an area of some 1200 ha (some 3000 acres) under the administration of the Director of the Government Botanic Gardens. It is reserved entirely for research. Paths run across the forest in all directions. One of the main paths leads from the mountain garden along the western ridge from the Tjibodas ravine upwards and abuts on the steep northern face of Gunung Sela. This track is known as the path to "Huis ten Bosch" (the "Forest Lodge") so called from an old hunting lodge of that name, now no longer in existence. The path is on the whole very steep; one part, however, is more on less horizontal and there it branches into a number of secondary paths, along which numerous labelled and numbered trees [1]) are found. These grounds are rarely visited and are consequently among the wildest parts of the reserve. Outside the paths everything is a dense tangle, difficult to penetrate.

The other main path leads upwards through the morass of Tjibeureum. A little above this marsh at the right a side path branches off to the three waterfalls of the Tjikundul, commonly called Tjibeureum. Proceeding further along the main path one comes at about 2150 m altitude to a place called Tjipanas from the hot springs (temperature ± 50° C) issuing from under the old lava stream mentioned above and plunging down the precipice. Big clouds of steam rise up from the hot water, and fill the gorge, especially on rainy days. From there the path ascends steeply along the cascades, towards the mountain-bungalow at Kandang Badak. The bungalow is intended for tourists who visit this mountain in large numbers.

For naturalists a second bungalow has been built, situated in the forest a little more to the East, with a view of Gunung Sela and Kawah Wadon. This lodge is named Lebak-Saät, plate XXVI. A. Both lodges are situated at about 2400 m altitude. The Lebak-Saät lodge contains a sitting room, two cubicles for two persons each, a small laboratory and a dark room.

From Kandang Badak a path formerly laid out by TEYSMANN leads to the top of Mt. Pangrango. From the crater valley on the top the mountaineer can descend by a path in a westerly direction to the Pasir Datar

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[1]) S. H. KOORDERS, Flora von Tjibodas, Batavia, 1918, p. 20.
M. L. A. BRUGGEMAN, The numbered trees, shrubs and lianas in the forest of Mt. Gedé near Tjibodas, West-Java. Bull. d. jard. bot. de Buitenzorg, Série III, Vol. IX, 1927, p. 196.

estate and by a northerly one to the Gunung Mas estate. A second path goes from Kandang Badak to the top of Mt. Gedeh, with a side track leading to the crater fields of that mountain. By way of the summit of Gedeh we can descend to the aloon-aloon and from there we can walk on past Gunung Gemuruh and through the Perbuwati estate to Sukabumi. The path from Gunung Gemuruh crosses a footpath which ends again in the aloon-aloon. From this end of the crater terrace a footpath goes in the direction of Tjiandjur. Further paths in this neighbourhood will be mentioned in chapter IV.

CHAPTER III.

CLIMATE.

Our knowledge of the climate of these higher regions rested until recently on observations of scientists who had usually visited the mountain tops for a short time only, and was consequently rather fragmentary. In the last few decennia however a systematic study of the weather conditions on volcano tops has been made by the staff of the Meteorological Observatory at Batavia. On the tops of several mountains, in Java as well as in Sumatra, instruments that are examined at regular intervals as well as self-registering apparatus have been put up. In this way the daily course of temperature, humidity, rainfall and sunshine is recorded. These data have been elaborated by C. BRAAK [1]) in his book on the climate of the Dutch East Indies, which devotes in the second volume a special chapter to the climate of Pangrango.

However important these observations may be as a source of information with regard to the climate, they are insufficient for the purpose of the ecologist. VON FABER [2]) has therefore carried out additional observations, which give us a better insight into the circumstances under which the plants live. VON FABER has found among other things that the humidity close to the soil and among bushes is quite different from that of the free air, so that in the shade of these bushes plants may grow which will otherwise thrive only in a comparatively moist environment and which accordingly do not occur in the open patches or are far less well developed there. For the subject treated in this book the study of the climate on an ecological basis has only a subsidiary importance; as the ecology of the crater plants has been fully dealt with in VON FABER's study, the reader may be referred to that work.

A general knowledge of the climate is however of great importance for the study of the relations between plant life and animal life, since the behaviour and especially the flight of the insects, which play a part in pollination, is strongly influenced by the condition of the atmosphere. Therefore it is necessary to gain an insight into the climate at the top of Mt. Pangrango.

The first data relative to the climate of Pangrango were supplied by JUNGHUHN [3]) in his "Reisen" which embodies a meteorological journal. The

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[1]) C. BRAAK, Het klimaat van Nederlandsch Indië. Vol. II, Weltevreden, 1929, p. 207.

[2]) F. C. VON FABER, Die Kraterpflanzen Javas. Arbeiten aus dem Treub-Laboratorium, No. I, 1927, p. 14.

[3]) FR. JUNGHUHN, Topographische und Naturwissenschaftliche Reisen auf Java. Magdeburg, 1845, p. 435.

data collected on the top of Pangrango have moreover been elaborated in the general climatological sketch in his book „Java", where it is found as an appendix to his discussion of the fourth plant zone. JUNGHUHN in his "Reisen" relates that when staying on the top of Pangrango on July 28th. 1839 (it was the middle of the dry season) he met there with warm and still weather. In the morning of July 29th. hoar frost was noted. Not till the afternoon did mists begin to brush over the top; these subsided towards the evening and the clouds were massed like towers in the depth below. Next morning, the 30th., the thermometer stood at 3° Fahrenheit below freezing point and all the plants in the crater valley were covered with hoar frost. Down below lay a billowy sea of clouds. Towards eleven o'clock, without any noticeable stir of wind, mist veils were whirling rapidly through the crater-valley. The next night too a good deal of hoar frost appeared, but in the early morning of July 31st. the thermometer marked 38° Fahrenheit.

On November 10th. and 11th., that is in the rainy season of the same year, a strong and steady easterly wind was blowing. The weather was variable and mist veils swept continually over the top.

The climate of the fourth zone was described in detail by JUNGHUHN in his work "Java". Above the wreath of clouds the atmosphere becomes rapidly drier both relatively and absolutely. The maximum diurnal temperature on the tops of the mountains is reached later than in the plains because the tops are, according to JUNGHUHN, seldom covered by clouds, so that the increase in temperature is not impeded. The maximum temperature is usually reached towards 3 o'clock, after which a rapid decrease sets in. Higher on the mountains it rains but seldom; in the dry months no rain ever falls in this zone and at othertimes only while westerly winds prevail, and even then it are only misty-drizzles. The nights, moreover, are always dry. At this altitude the South East trade-wind blows constantly, but during the night the wind abates or dies down. On the highest tops, such as those of Slamat, Ardjuno and Semeru, JUNGHUHN never observed westerly winds, and on the top of Pangrango a few times only in the month of January. But as a rule this West-wind only blows for a day or half a day, and it may be weeks and even months before it rises once more. For weeks at a stretch he camped on the top of Pangrango in the months of January, April and November, and every time gentle easterly winds prevailed. Only once in April 1839 the East and North winds rose for half a day to the force of a gale; they were accompanied by mist and drizzles. In the course of an hour the wind veered through all the points of the compass. A rapid alternation of extreme drought and humidity is characteristic for this zone. The above holds good for the months of the dry monsoon; in the so-called rainy season it sometimes happens that the tops are wrapped in clouds, sometimes for as much as two days at a stretch.

In his "Contributions to the History of the Volcanos in the Dutch East Indies" JUNGHUHN again discusses the climate of the mountain tops. His

statements were subjected to sharp criticism by TEYSMANN, see page 9. According to the latter JUNGHUHN's notion that the clouds do not rise higher than 3000 to 4000′ up against the mountains, is incorrect, for as seen from Buitenzorg the summits are mostly wrapped in clouds. For days and sometimes even weeks at a stretch the mountains will be wreathed in clouds, hanging about the tops. TEYSMANN also states that the mountain tops are not at all drier than the lower regions in Java.

JUNGHUHN replies circumstantially and pointedly to TEYSMANN's criticism and maintains that the atmosphere above 6000′ is decidedly drier than below that level.

JUNGHUHN's statement that it seldom rains on the tops of the loftiest volcanos and even then only in the form of misty drizzles has been generally accepted, and his belief that the atmosphere there may be called dry, has become firmly rooted in botanical literature. SCHIMPER [1]) uses this idea in his discussion of the alpine vegetation of tropical countries; he is of opinion that the plants in these regions have a xerophytic structure and that this structure may be accounted for as an adaptation to the dry climate of the tops. (HOLTERMANN [2]) already doubted whether the plants of the craters really show a xerophytic structure, and VON FABER [3]) points out that the *Ericaceae*, which constitute the main components of the crater vegetation, are by no means extremely xerophytic in type. Of the other plants growing in these localities some are mesophytic, others hygrophytic; their evaporation is very considerable).

SCHMUCKER [4]) also discusses the climate and comes to the same conclusions as SCHIMPER. He says that the topzone of the volcanos is situated above the moist mountainzone and above the cloud belt which ceases at about 2500 m. According to SCHMUCKER the rainfall on the top of Pangrango is 2000 mm a year. (In reality the amount of rain falling on this mountain is far greater, in some years twice as much, the average rainfall for 19 years being 3258 mm). One tenth of the total quantity of rain, about 150 mm falls between early February and October, in 9 months therefore, so that the tops in West Java too show a pronounced dry season. In East Java this drought is still more pronounced and the climate must be termed arid. According to SCHMUCKER an even and cool climate prevails equably throughout the year, a few months only showing a moist climate; otherwise the climate is dry and in East Java even very dry.

The meteorological observations carried on for the last 20 years and my own observations during my frequent sojourns on the top of Mt. Pangrango

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[1]) A. F. W. SCHIMPER, Pflanzengeographie auf physiologischer Grundlage. Second edition, Jena, 1908, p. 16.

[2]) C. HOLTERMANN, Der Einfluss des Klimas auf den Bau der Pflanzengewebe. Leipzig, 1907, p. 75.

[3]) F. C. VON FABER, loc. cit., p. 92.

[4]) TH. SCHMUCKER, Beiträge zur Kenntnis der Hochgebirgsflora Javas. Beih. z. botan. Centralblatt, Vol. XLIII, 1926.

and on other volcanos show that belief in the dryness of the fourth zone is untenable, and that explanations of the peculiar organisation of the plants on the high tops based on this belief should be put aside. The precipitation on the Pangrango top is very considerable though varying much from year to year. In the extremely dry year 1913 only 1979 mm of rain fell, in 1916 and 1917 on the other hand more than 4000 mm. The average annual rainfall for 19 years is 3258 mm. Even in the so-called dry months a good deal of rain often falls. In the dry year 1914 the rainfall in the months of July, August and September was respectively 1 mm, 10 mm and 2 mm; in 1923 the figures were 364 mm, 2 mm and 94 mm, and in 1921 even 147, 118 and 191 mm! The average rainfall for July is 75 mm, with an average of 14 rainy days. The month with the maximum rainfall is not November as stated by SCHMUCKER, but February, which shows an average rainfall of 474 mm, followed by January and December with 450 and 440 mm respectively, whilst November has an average rainfall of 365 mm.

SCHRÖTER [1]) also briefly discusses the climate of the highest mountain tops in Java.

A brief sketch of the climate on the top of Pangrango has already been published elsewhere by me [2]); I repeat it here somewhat elaborated and supplemented with the data of BRAAK and VON FABER.

Climatic conditions in the tropical plains of Java, apart from the differences between the dry and the rainy monsoons, are more or less equable and therefore monotonous. "In the Indies one lacks", writes BRAAK [3]) "the surprises, not always agreeable may be, offered by the changeable climate of the temperate regions". The temperature fluctuates comparatively little about the average, the rains return with regularity and the movements of the atmosphere may on the whole be called very quiet. How different it is on the top of Mt. Pangrango and in fact also on the summits of the other lofty Javanese volcanos! This conclusion can be drawn already from the results recorded by meteorological instruments, but the varying atmospheric conditions are also felt strongly and directly by our self. Owing to the transparence of the atmosphere and also to the reflection from the huge masses of white clouds, radiation on these tops is far more intense than in the plain, and consequently the difference between sunny periods and periods, when the sunlight is intercepted by clouds, is very marked. There is also a wide difference between the condition of the atmosphere in the forest and in the open tracts; the blazing glare that beats on the bare tops of Mt. Slamat and Mt. Semeru in the dry season can become almost

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[1]) C. SCHRÖTER, Exkursionen in Ost-Java. Beiblatt No. 15 zum Vierteljahrschrift des Naturforsch. Gesellsch. in Zürich, Bd. LXXIII, 1928, p. 586.

[2]) W. DOCTERS VAN LEEUWEN, Uit het leven van planten en dieren op den top van de Pangrango. II. Het klimaat. De Tropische Natuur, Vol. XIII, 1924, p. 152.

[3]) C. BRAAK, Het Klimaat van Nederlandsch Indië, Vol. I, Batavia, 1927, p. 53.

unbearable, especially when the humidity of the air is very low. On such days it is even possible that the wall of the bungalow exposed to the sun becomes quite hot whilst the opposite wall is quite cold: contrasts which are also quickly felt by our self.

Especially in the West monsoon when the atmosphere is still and the sun is shining it can be ineffably delightful on the mountain heights. The hues of the flowers and of the young verdure, the freshness of the air, the busy life of insects and of birds, the bracing temperature, the wide panorama from the Pangrango top, which extends beyond the coasts of the western part of Java, all these give impressions vainly to be sought for elsewhere in the tropics.

When the sun sets the temperature falls rapidly; the cooling is keenly felt and the beholder of the gorgeous display of colours thrown by the setting sun on the low-lying clouds shivers in spell-bound rapture.

Turning over the leaves of my diary I find however that the records of such splendid days are few and far between. There have indeed been many mornings with more or less of sunshine, but often the clouds came rolling up soon and palled everything in grey mist, and I remember many days when the mists were already at daybreak hanging round the tops and stayed for days together. Such days are somber and chill; no sounds are heard; insects hardly fly and the birds are silent; only the ever busy bumble-bee remains on the wing and visits noiselessly flower after flower.

The movement of the air is on the mountain tops on the whole less than in lower-lying regions; the winds rising along the flanks of the volcanos are by their own speed carried along past the tops. Consequently the force of the winds on the highest part of the Pangrango top is less than in the crater-valley a little lower down. Through the gap in the crater wall the winds enter the valley, blow through the length of it and pass out on the other side. JUNGHUHN's opinion that at night the winds on the tops usually subside is incorrect. On the contrary the wind will often increase a good deal after sunset, to abate or cease again in the morning. Many a night I have spent in the crater-valley with a high wind blustering round the hut. As to the velocity of the wind not many data are available, but according to BRAAK a strength 5 in Beaufort's scale may be considered exceptional. Air movements exercise a marked influence on plants, because they promote evaporation. There is little evidence, however, of a direct influence of these comparatively light winds on the growth and development of plants.

On very sparsely wooded ridges of other mountains where strong winds regularly blow this may sometimes be different. SCHRÖTER [1]) for instance describes characteristic wind-forms of *Vaccinium varingifolium* from Mt. Ardjuno-Weliran in East-Java and gives an illustration of a wind-stunted bush. This individual has a trunk which is remarkably thick in proportion

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1) C. SCHRÖTER, loc. cit., p. 584, fig. 7.

to the height of the plant and is pressed against the ground; the branches are horizontal. In the trunk of one of the specimens examined 25 annual rings were counted [1]). Such examples do not occur on Pangrango, not even in the crater-valley. The *Anaphalis* bushes which grow there in large numbers are all erect and branched in every direction; nor do the other plants show the influence of the wind.

Among the sublimest phenomena one can witness from the mountain tops is the cloud-sea covering the plain at early dawn. During the night the clouds have subsided into a white mass with a level upper surface; the atmosphere, especially if it has been raining, is then of a remarkable transparency, and allows the wonderstruck spectator to perceive in the far distance mountain tops rising above the white cloud lake. But hardly has the sun risen above the horizon when the clouds get hazier; and they begin to roll up along the flanks of the mountains, eventually vanishing and dissolving wholly or in part, see plate IV.

In the driest months of the year the tops are above the cloud belt; in the wet season, however, they are not. In the West monsoon the whole

Average monthly number of periods of 100 % humidity of various length and average number of days per month.
1912—1918.

Length of periods in days	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1/2—1	2.9	2.4	2.4	2.6	1.4	1.4	1.0	0.9	1.6	3.1	2.6	3.1
1—2	1.4	0.9	1.6	0.1	0.4	0.1	0.4	—	0.3	1.3	0.7	1.1
2—3	1.4	0.4	0.3	0.3	—	—	—	0.3	—	—	—	1.1
3—4	0.3	—	0.3	—	—	—	—	0.1	—	—	0.1	0.4
4—5	0.4	—	0.4	—	—	—	—	—	—	—	0.1	0.1
5—6	—	—	—	0.3	—	—	—	—	—	—	0.1	0.1
6—7	0.1	0.3	0.3	—	—	—	—	—	—	—	—	0.1
7—8	0.1	0.1	—	—	—	—	—	—	—	—	—	—
8—9	0.1	—	0.1	—	—	—	—	—	—	—	—	—
9—10	0.1	—	—	—	—	—	—	—	—	—	—	—
17—18	0.1	—	—	—	—	—	—	—	—	—	—	—
Number of days	17.6	7.1	10.9	4.4	1.7	1.3	1.4	1.9	1.6	4.3	4.9	10.8

[1]) Prof. BREMEKAMP told me that these plants on Mt. Weliran grow only in the neighbourhood of the sofataras and that their growth is influenced considerably by the acid sulphurous vapours.

mountain is often not long after sunrise whelmed in clouds; usually, however, the latter are formed at a lower altitude. The tops are in that season often swathed in clouds for days together, see plate II. The relative humidity may also keep for days at a stretch at 100 %, i.e. at complete saturation, so that the hygrograph traces a perfectly horizontal line; see a.o. diagram 4 on p. 28 in VON FABER's book. The table on page 33 shows the frequency of this condition on the top of Pangrango in the years 1912—1918. The figures give the length of the periods of 100 % humidity in days. Such periods may occur even in the height of the East monsoon.

Such day-long foggy periods only occur when the wind drives the clouds up towards the mountain tops; on calm days the mists dissolve during the night and the early hours of the morning are bright.

The solarimeter on Mt. Pangrango records at what moments the top was wrapped in clouds. Below is given a table showing how often on the average per month the sun did not shine for some days at a stretch. The next table shows on the other hand the number of days when the sun shone uninterruptedly from morning till night. A comparison of the first one of these two tables with the previous one will bring out the fact that the number of sunless days is less than that of days of 100 % humidity, which means that the sun may for a short time break through without causing a decrease in humidity.

If, as we have seen, the mountain tops are in the rainy season often wrapped in mist for days at a stretch, this is seldom so in the dry season; the fluctuations in humidity in that season are usually very great. When the clouds remain below the tops, the latter may be very dry, so for instance in the night of Sept. 20th. to 21st. and from 22nd. to 23rd. in 1913.

Number of sunless periods of various length per month.

1918—1925.

Length of periods in days	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.5	1.5	1.3	1.0	1.2	1.2	0.4	0.1	0.1	1.0	1.8	1.3
2	0.5	0.9	0.4	0.4	—	0.1	0.4	0.1	—	0.4	—	0.3
3	0.3	0.1	0.3	—	—	—	—	—	—	0.3	—	—
4	0.4	0.3	—	—	—	—	—	—	—	—	0.1	0.1
5	0.1	0.1	0.1	—	—	—	—	—	—	—	—	—
6	0.1	0.1	—	—	—	—	—	—	—	—	—	—
11	—	0.1	—	—	—	—	—	—	—	—	—	—
Number of days	6.1	7.4	3.4	1.8	1.3	1.5	1.1	0.4	0.1	2.5	2.3	2.3

Number of periods of various length with 100 % sunshine per month.
1918—1925.

Length of periods in days	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	—	—	—	0.1	1.0	0.5	1.6	1.0	0.9	0.9	0.4	0.1
2	—	—	—	—	0.1	0.1	0.6	0.5	0.3	—	0.1	0.3
3	—	—	—	—	0.1	0.4	0.4	0.1	0.1	—	—	—
4	—	—	—	—	—	—	—	0.1	—	—	—	—
5	—	—	—	—	—	—	0.1	—	—	—	—	—
Number of days	—	—	—	0.1	1.6	1.9	4.6	2.9	1.8	0.9	0.6	0.6

When, however, the clouds rise a few hundred meters higher so as to envelop the top in fogs, the humidity rises again to 100 %, as it happened in the night from Sept. 21st. to 22nd. This rapid fluctuation in humidity is visible in the diagram reproduced in figure 2, which was registered between Sept. 20th. and 23rd. of the year 1913, that is to say in the dry season.

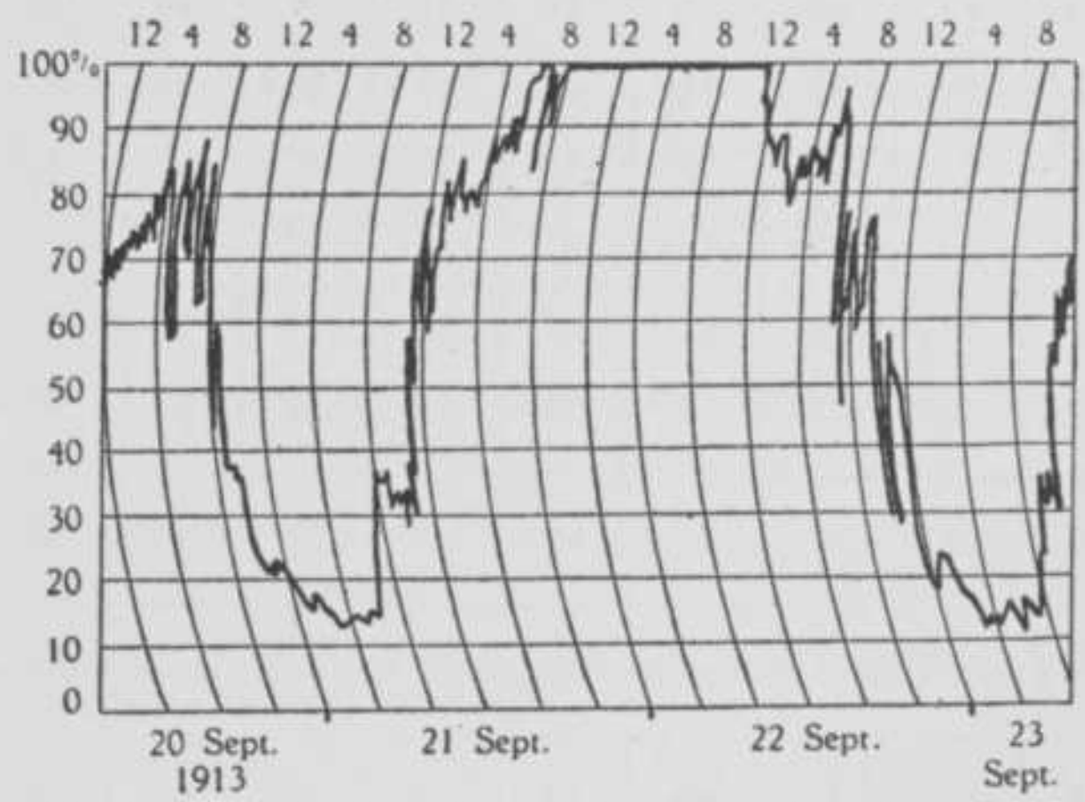

Fig. 2. Relative humidity of the top of Mt. Pangrango.

The results of the hygrograph communicated above afford an insight into the degree of cloudiness and the degree of atmospheric humidity prevailing on the Pangrango-top. The records of the solarimeter teach us how much sunshine falls upon this top and how this is spread over the years and months. The sunshine is expressed in percentages of complete sunshine; as a standard for the latter the amount of sunshine descending per half hour from a cloudless sky during the period from 8 a.m. to 4 p.m. has been taken: this value is represented by 100, and the amounts of sun-

shine actually received are expressed in percentages of this norm. Below follows a table of the results of sunshine observations for the years 1917—1925. This shows clearly the annual course: the average percentage is in July more than four times as high as in February.

Half-hourly amounts of sunshine expressed in percentages of complete sunshine.

1917—1925	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
8.00— 8.30	31	22	41	46	53	50	68	69	66	55	42	28	48
8.30— 9.00	35	20	43	49	61	62	76	71	70	55	46	29	51
9.00— 9.30	34	20	41	51	62	66	78	72	69	54	49	31	52
9.30—10.00	32	21	37	48	64	68	81	71	71	55	48	32	52
10.00—10.30	32	18	36	43	67	69	81	70	70	53	45	35	52
10.30—11.00	32	18	34	40	68	68	80	69	68	51	43	33	50
11.00—11.30	35	19	32	39	66	68	79	67	66	50	45	32	50
11.30—12.00	32	17	33	36	64	68	74	61	64	48	42	28	47
12.00— 0.30	31	21	30	30	53	60	70	59	54	42	38	28	43
0.30— 1.00	31	17	27	26	48	54	70	57	51	38	35	26	40
1.00— 1.30	28	16	23	24	45	49	65	53	44	36	34	23	37
1.30— 2.00	24	12	19	21	41	46	63	48	41	32	29	18	33
2.00— 2.30	17	11	17	20	39	42	57	46	37	30	25	15	30
2.30— 3.00	12	8	15	19	38	40	55	43	35	27	21	13	27
3.00— 3.30	9	5	14	15	37	38	56	44	36	24	14	10	25
3.30— 4.00	7	4	11	12	32	34	51	42	35	21	10	7	22
Average	26	16	28	32	52	55	69	59	55	42	35	24	41

Monthly and annual averages of sunshine, expressed in percentages.

1918	7	8	35	39	49	73	72	54	64	49	38	32	43
1919	31	28	44	40	23	53	86	49	59	52	15	27	42
1920	18	—	—	24	73	59	84	33	33	24	39	31	(42)
1921	34	10	19	17	70	53	52	62	56	42	41	—	(42)
1922	25	12	13	35	41	41	66	52	52	43	34	11	35
1923	31	27	37	46	52	35	36	83	59	56	52	14	44
1924	45	19	23	25	39	55	76	68	58	18	21	28	40
1925	20	6	28	34	72	71	81	69	56	49	42	37	47

This course is still clearer when the monthly averages are represented in a diagram as in figure 3.

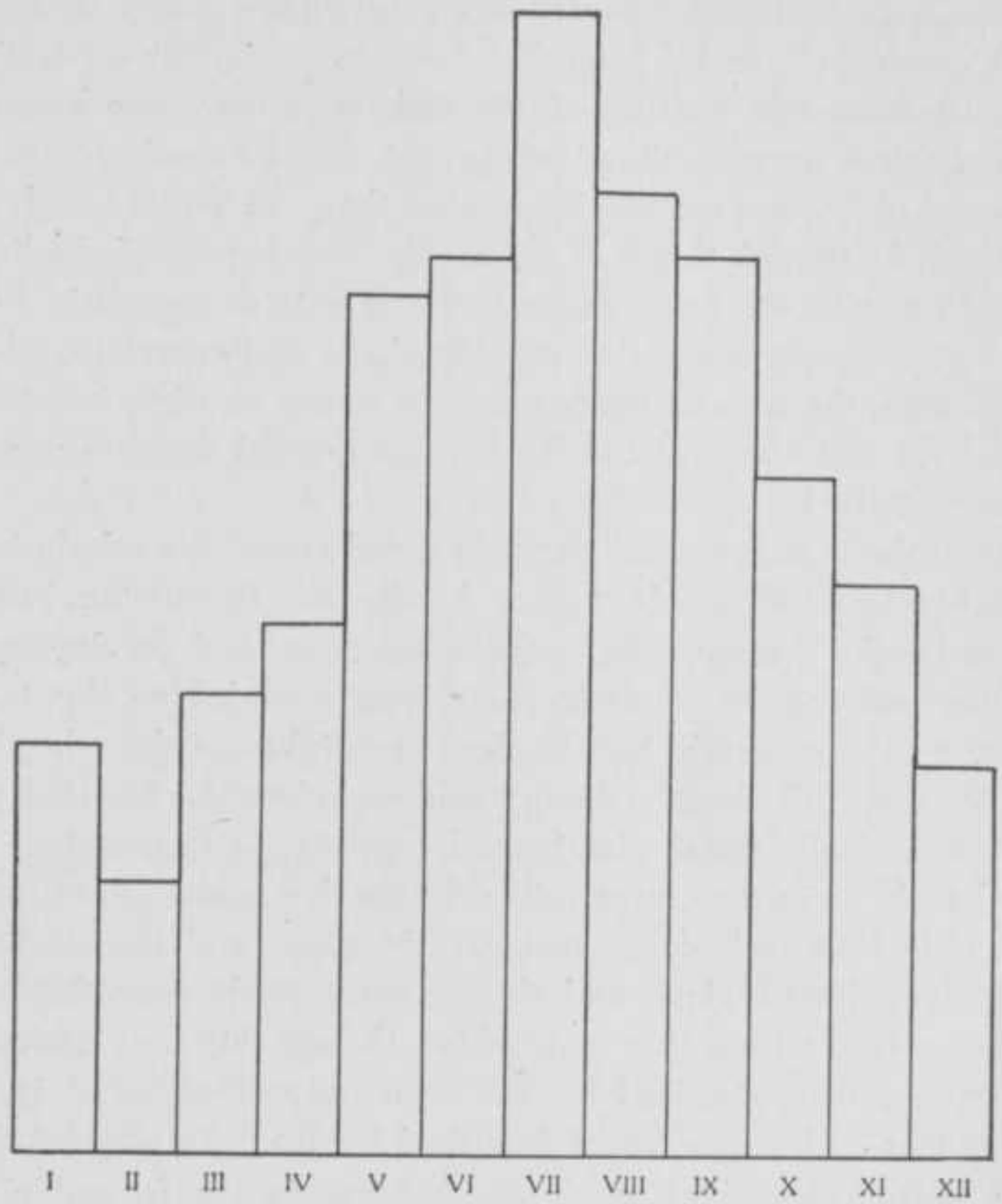

Fig. 3. Monthly averages of sunshine on the top of Mt. Pangrango.

These contrasts between overcast and sunshiny skies affect our body strongly, animals, especially insects are also very sensitive to these fluctuations. On days when there is a frequent alternation of bright and cloudy periods the insects are markedly inactive.

The average temperature on the top of Mt. Pangrango is 9° C., but there are wide fluctuations in the daily course. The soil-temperature at 30 and 60 cm depth corresponds with the average air temperature, at least in the forest. In an open patch of grass, however, the average temperature was 12° C., or 3° higher.

VON FABER [1]) points out that the crater-plants are but superficially rooting and that to them the temperature at smaller depths is of more importance. In several places, however, the roots penetrate to rather considerable depths, and the difference between the temperatures at 10—15 cm and at

[1]) F. C. VON FABER, loc. cit., p. 24.

30 cm is very slight. VON FABER measured temperatures 2 cm below the surface, and he found that on an exposed sun-beaten soil the difference between the soil and the atmospheric temperatures may be as high as 13° C. But in such localities hardly any plants grow; only such plants as *Gentiana quadrifaria* and *Thelymitra javanica* which give practically no shade profit from this heating of the soil. It is moreover by no means certain that this is an unqualified advantage, for the specimens growing in such exposed places are usually far smaller than the plants which are even slightly shaded; though this is of course like the absence of shading plants also bound up with the scant amount of nutrients contained in such soils. As soon as the plants themselves provide shade and especially where they grow in clumps, the ground temperature in sunny weather is considerably lower, and for the forest plants the surplus ground temperature is of no significance at all [1]).

The atmospheric temperature depends greatly upon the nebulosity; when the top is blanketed in clouds there is hardly any fluctuation, but as soon as the sun breaks through, the temperature rises, and on days when the sun has been shining the whole morning from a stark blue sky, it may get very warm on the mountain top. In clear dry nights on the other hand the temperature may fall sharply though seldom below the freezing point. In the forest and even in the shade of smaller groves the temperature does not drop as sharply as in the crater valley. In the dry season night-frosts very often occur in this part of Pangrango; the grass and the smaller plants are then covered with rime, and the stagnant pools near the brook are sometimes covered with a thin crust of ice, though this is of extremely rare occurrence and was observed by me once only. Hoar-frost is however rather frequent and was already described by JUNGHUHN [2]) for this same valley. A thermometer laid beside my hut among the frosted plants one morning registered 2° of frost at sunrise. The table below incorporates the mean air-temperatures, but these figures are those registered by instruments put up in a closed meteorological cabin.

When the sun is blazing and is being reflected from remparts of white clouds massed around the mountain, it may be very hot, even disagreeably so, but with the slightest curtaining a chill is felt. It is especially this fall in temperature which causes animals, especially insects (with the exception of the bumble-bee) to respond so markedly to clouding. Some plants also are keenly sensitive to variations in temperature; the flowers of *Gentiana quadrifaria* for instance open far earlier on sunshiny days than in hazier weather, and on rainy days they will hardly open at all. The orchid *Thelymitra javanica* opens its flowers on very warm days only when the sun gives plenty of heat from early morning; and plants growing in open

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1) C. G. G. J. VAN STEENIS, Schets van de Flora van den G. Tjibodas bij Tjampea. De Tropische Natuur, Vol. XX, 1931, p. 81.

2) FR. JUNGHUHN, Reisen, p. 472.

Mean air-temperature, in degrees Centigrade on the top of Mt. Pangrango.

1912—1925	2*am*	4	6	8	10	12	2*pm*	4	6	8	10	12	Daily average
Jan.	7.5	7.4	7.5	8.5	9.8	10.6	10.4	9.3	8.3	7.9	7.7	7.6	8.5
Febr. . . .	7.8	7.7	7.7	8.7	10.2	10.8	10.5	9.6	8.6	8.2	8.0	7.9	8.8
March . .	7.5	7.4	7.4	8.7	10.3	10.9	10.4	9.5	8.4	8.0	7.8	7.7	8.7
April . . .	8.2	8.0	8.0	9.8	11.7	12.3	11.8	10.8	9.4	8.8	8.7	8.4	9.7
May . . .	8.2	8.0	8.0	9.9	12.3	12.7	12.1	11.0	9.3	8.6	8.5	8.3	9.7
June . . .	7.6	7.5	7.5	9.8	12.3	12.8	12.1	10.7	8.9	8.2	8.0	7.9	9.5
July . . .	7.0	6.9	7.0	9.3	12.0	12 6	12.0	10.5	8.5	7.6	7.4	7.2	9.0
Aug. . . .	6.9	6.8	6.8	9.4	12.0	12.7	11.8	10.2	8.2	7.5	7.3	7.2	8.9
Sept. . . .	6.7	6.5	6.6	9.2	12.0	12.6	11.6	10.1	8.3	7.5	7.2	7.0	8.8
Oct. . . .	6.8	6.6	6.8	9.2	11.6	12.1	11.3	9.9	8.4	7.6	7.3	7.1	8.7
Nov. . . .	7.2	7.0	7.0	9.1	11.2	11.7	11.1	9.8	8.4	7.9	7.7	7.4	8 8
Dec. . . .	7.1	7.0	7.1	8.7	10.2	10.8	10.2	9.2	8.1	7.7	7.5	7.3	8.4
Annual . .	7.4	7.2	7.3	9.2	11.3	11.9	11.3	10.0	8.6	8.0	7.8	7.6	9.0

localities show flowers more widely open than those growing under bushes or in groves.

The great fluctuations in temperature are clearly shown in the following record, figure 4, taken from July 15th. to 17th., i.e. in the dry season:

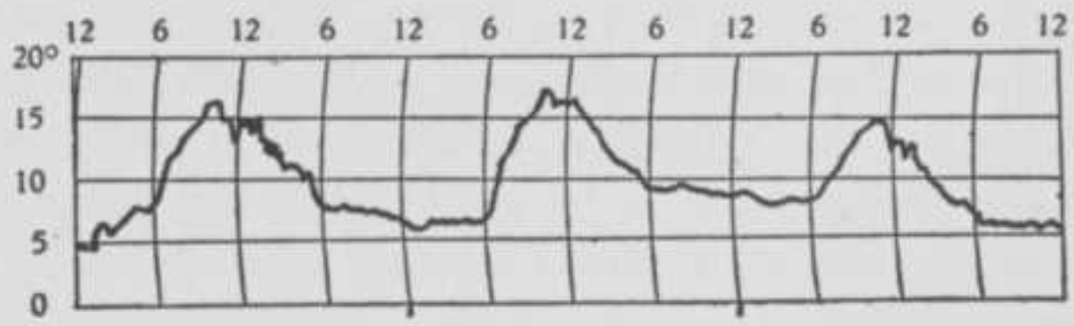

Fig. 4. Temperature on the top of Mt. Pangrango.

The observations on relative humidity have also yielded interesting data. On the top of Mt. Pangrango relative humidity decreases in the morning and increases in the course of the afternoon ; but in the night it may greatly diminish again, which does not happen in the plains. This nocturnal fall in humidity occurs especially in the dry season. From the diagram reproduced in figure 5 this daily course is very apparent: during the period represented, from August 15th. to 20th. 1915, the relative humidity at 12 o'clock noon was between 90 and 100 %, but about 12 o'clock midnight it fell to less than 30°.

But owing to the frequent interchange of fog, rain and sunshine the curve is not by any means always so regular. For days at a stretch the relative

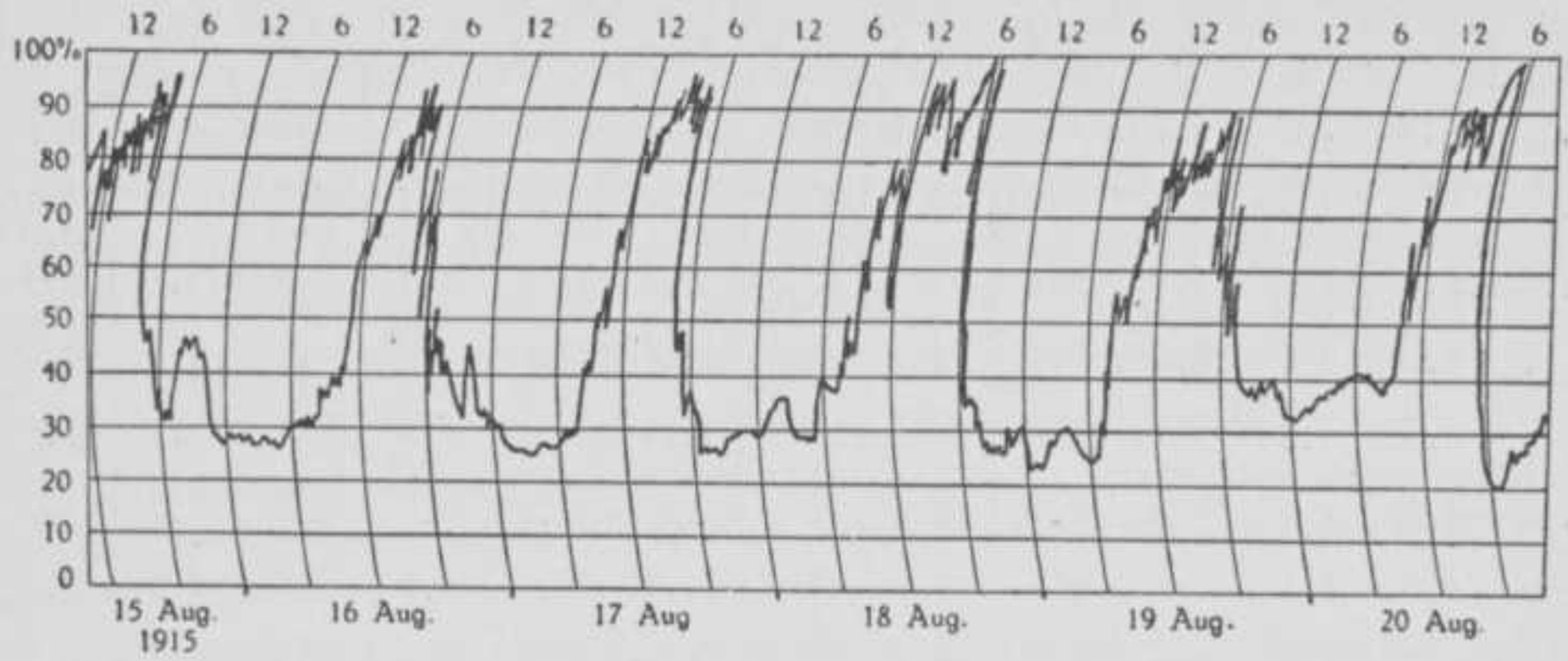

Fig. 5. Relative humidity on the top of Mt. Pangrango.

humidity may remain approximately constant at a very high level, so that the hygrograph traces a straight hirizontal line; a protracted spell of low relative humidity however never occurs. Wide fluctuations are particularly apt to occur in the dry season. In the daytime the air of the lower region, heated by the sun, may rise so high that the fogs reach the top, but in the night an almost desertlike atmosphere may surround the top. Such dry moments are rare, however, and nights of great dryness are often succeeded by nights when the relative humidity reaches 100 %; see the record on p. 35 registered between September 20th. and 23rd. 1913. The very rapidity of these changes makes that the dryness does not exercise much influence on the vegetation. I visited the top of Pangrango at the end of August 1924 in company with Dr. BRAAK. When we got to the top everything was very dry, though the trees and herbs looked fresh, but the moss-cushions on the trunks and branches were yellowish-brown and were dry to the touch. On August 27th. the relative humidity amounted to about 20 %, but during the following days it went up again to nearly 100 %. The moss-cushions were soaked full of water and had once more turned green. How extreme the daily fluctuations sometimes are can be seen in the record taken between June 17th. and 22nd. 1925, when both moments with very low and with very high indexes occurred.

According to Dr. BRAAK [1]) the lowest minimum observed was 6 %; it was observed on July 13th. 1924. The annual average is 83 % and therefore very high; the monthly averages fluctuate between a maximum of 93 % in February and a minimum of 70 % in July.

According to JUNGHUHN [2]) but little rain falls on the tops of the loftiest

[1]) C. BRAAK, Het klimaat van Nederl. Indië, Vol. II, p. 223.
[2]) FR. JUNGHUHN, Java, Vol. I, p. 560.

volcanos, and then only in the form of mist-rains. But during my stay on the Pangrango top and on many other tops in Java I have met with very

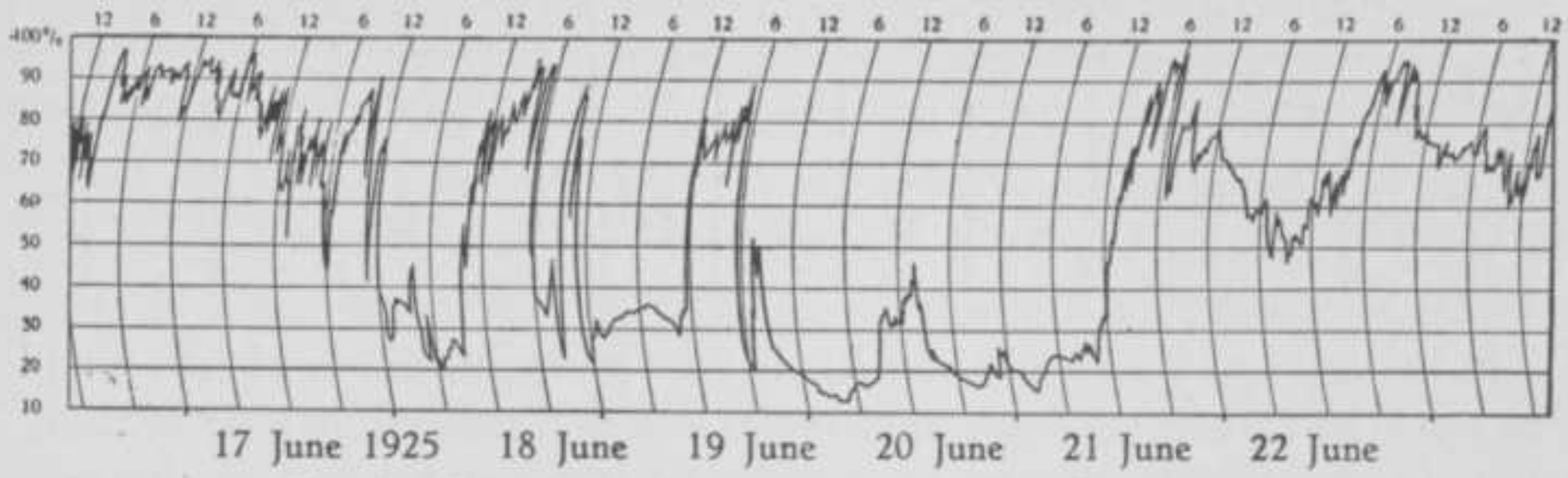

Fig. 6. Relative humidity on the top of Mt. Pangrango.

heavy showers. As a matter of fact the amount of precipitation on the top of Mt. Pangrango is indeed, as shown by the following chart of the monthly and annual aggregates, very high :

Monthly and annual aggregates of rainfall in millimeters.

	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1912					165	140	196	61	155	261	408	256	
1913	272	174	63	163	154	48	2	125	75	137	384	382	1979
1914	424	351	235	265	220	118	1	10	2	41	454	572	2693
1915	386	515	566	247	258	167	10	60	251	211	402	388	3461
1916	694	292	532	407	145	98	64	175	242	440	342	575	4006
1917	469	528	270	361	245	96	70	142	166	420	490	748	4005
1918	732	789	412	269	182	48	19	215	27	107	332	584	3716
1919	454	646	432	433	452	129	19	42	61	134	660	336	3798
1920	422	336	487	432	86	54	35	277	289	484	319	323	3544
1921	333	869	445	200	86	101	147	118	191	201	251	446	3388
1922	397	499	412	355	191	107	78	73	84	243	328	275	3042
1923	376	450	273	175	106	214	364	2	94	157	371	442	3024
1924	273	326	505	397	202	145	30	85	89	494	485	346	3377
1925	702	684	388	233	69	13	33	36	103	110	137	368	2876
1926	425	311	418	274	251	61	17	12	130	239	220	439	2797
1927	519	179	480	264	263	59	79	121	64	162	367	628	3185
1928	396	563	539	422	126	109	36	210	47	269	356	550	3650
1929	554	437	411	204	97	97	58	59	52	213	275	400	2856
1930	268	590	430	411	276	32	174	64	61	286	345	296	3233

Average rainfall and number of rainy days, 1912—1930.

	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Rainfall . . .	450	474	405	306	188	97	75	99	115	244	365	440	3258
Number of days	28	25	29	26	23	20	14	17	19	25	27	28	281

In the dry months of July and August the average amount of rain is still as much as 75 and 99 mm respectively, and the average number of rainy days 14 and 17. But in some years these months may be very dry indeed; in July 1913, 1914 and 1915, in August 1914, 1923 and 1926 and in September 1914 the rainfall was practically nil; but these are rare exceptions. On the more eastern mountain tops of Java there falls also a great deal of rain, though less than on the top of Pangrango, where, as we have seen, the average amount of rainfall for a period of 18 years is 3258 mm.

Fig. 7. Monthly averages of rainfall on the top of Mt. Pangrango.

On the top of Mt. Merbabu in Central Java the average annual rainfall is 2669 mm, with monthly averages for June, July, August and September of 110—55—52 and 109 mm respectively; on the top of Mt. Weliran in East-Java (both tops are over 3000 m in height) the annual rainfall

averages 2405 mm, the average rain indexes for the driest months being 73—21—25 and 30 mm.

The climate of the tops in East-Java can therefore certainly not be called arid as SCHMUCKER [1]) does. Occasionally the rainfall in a month can be very high: on the Sindoro top in Central Java for instance in January 1929 no less than 1174 mm of rain was registered; the total amount of rain fallen there in that year was 3509 mm, whilst in the months of July and August there fell 0 mm of rain, which shows the enormous range of variation.

I had personally the doubtful privilege of spending a few days on the Pangrango top in February 1921, the rainiest month recorded there so far. Fog, heavy showers and squalls swept continually past my chalet, no less than 869 mm falling in that single month. Cut inflorescences of *Primula imperialis* which I had left outside my hut were a full month later still quite fresh, the tops had curved upwards, a new whorl of flowers had opened, and an older verticil had set fruit.

A comparison of the rainfall on the Pangrango top with that on the top of Singgalang in Central Sumatra shows that the rainfall on the latter is more evenly distributed. The average rainfall is not much larger but in the wet season several monthly averages are lower. In July, the driest month, the mean humidity of Pangrango top is 70 %; of Singgalang in August on the other hand 89 %. During the driest parts of the day the atmosphere on Pangrango is generally nearly twice as far removed from saturation as on Singgalang, the highest saturation deficit being on Pangrango (in July) 54 %, and on Singgalang (in May) 32 % only. The climate of the latter mountain is therefore very moist and yet the same plant-types grow there as on Pangrango. Open patches of grass however are not found on Mt. Singgalang, but their presence on Pangrango is not due to a lower humidity; they owe their origin to other causes. In East-Java the atmosphere of the tops is undoubtedly drier though it is not so dry that a description of the climate as arid would be justified, but it explains perhaps the predominance of forests of *Casuarina Junghuhniana*. The presence of grass steppes dominated by *Festuca nubigena* however must be due to other causes.

The rain falls chiefly in the afternoon, but there may be heavy rainfalls in the night also, as I myself experienced repeatedly on Pangrango as well as on Tjikorai, Sumbing, Sindoro and Lawu. Brief heavy downpours, so frequent in the lower regions of the tropics, are however rare on the mountain tops. Instead of heavy showers the tops receive gentle rains and misty drizzles usually of long duration, and as the quantity of moisture falling on the tops is not much less than what falls lower down, its influence on the degree of humidity must be far greater.

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[1]) TH. SCHMUCKER, loc. cit., p. 40.

VON FABER [1]) devoted a detailed discussion to the so-called light-climate, comparing the light-climate of the mountain-tops with that of the tropical plains. From the investigations carried out by him on the quality of the light in the moist parts of the tropics (Buitenzorg) it appears, he says, that this light is poor in chemical rays and rich in red and infra-red ones. This conclusion, however, should not be accepted without further substantiation, and is probably not correct. VON FABER founds his conclusion on photochemical measurements and on the experience of photographers, who newly arrived from Europe overrate the intensity of the light and under-expose their plates or films. He supposes that these failures may be attributed to the low intensity of the chemical rays.

The investigations of BOEREMA and VRIJ [2]) have shown however that tropical sunlight is rich in ultra-violet rays, even in the plain. Taking the relation existing between the total intensity of the sun's radiation and the intensity of the ultra-violet radiation as more or less constant, we must conclude, that the greater total radiation on the mountain-tops will comprise also a greater U. V. radiation than in the plains. According to VRIJ [3]) the opinion that the light in the moist parts of the tropics must be poor in ultra violet rays, does not rest on any exact measurements. The sensitiveness of the photographic plate is greatest in the neighbourhood of 4500—4800 A.U. and decreases again in the direction of the ultra violet rays; this is almost exactly the reverse of what is often maintained by laymen. That the exposures in the tropics should be taken so much longer than in the temperate regions finds its reason in a quite different circumstance, says VRIJ. In the tropics the sun stands much higher in the sky than in higher latitudes, and objects in vertical positions therefore receive less light per cm^2, and this renders a longer exposure necessary. On the tops of the mountains a shorter exposure is sufficient, because these tops are in all directions open to the light, and because in addition the amount of light reflected by the glaring white clouds is often very large.

The investigation of the ultra-violet radiation of tropical light is still in its first stage, and so long as the subject has not been thoroughly thrashed out by physicists we must be careful in drawing inferences.

The tables and diagrams have been borrowed from BRAAK's book. The tables of the monthly and annual aggregates of rainfall have, however, been extended to the year 1930.

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1) F. C. VON FABER, loc. cit., p. 32.

2) J. BOEREMA and M. P. VRIJ, Ultra-violet in tropical sunlight. Proceedings of the Fourth Pacific Science Congress, Java, 1929, Vol. IIB, Batavia-Bandoeng, p. 857.

3) M. P. VRIJ, Problemen bij het Fotografeeren in de Tropen. Natuurkundig Tijdschrift v. Nederl. Indië, Vol. XC, p. 234.

CHAPTER IV.

THE VEGETATION.

The forest covering the north-western slopes of Mts. Pangrango and Gedeh, extends from the Mountain Garden "Tjibodas", situated at about 1500 m above sea-level, to the summits of the two mountains. This forest constitutes the Nature Reserve "Tjibodas-Gedeh" [1]), which was handed over by the Government of the Netherlands East Indies to the Botanic Gardens to serve for purposes of research. It covers an area of over 3000 acres. Its vegetation has been left undisturbed for so long that it may be regarded as untouched. In a few places only i.e. near the waterfalls of Tjibeureum, near Kandang Badak, and on the top of Pangrango, small plots were cleared upwards of 90 years ago by the then curator Mr. TEYSMANN, and used for acclimatisation experiments with European plants. These plots have all been abandoned and are largely grown over again, though some of the introduced plants have held their own. In the forest, near the waterfalls of Tjibeureum, for instance, individuals of *Marica coerulea* are still found. Near Kandang Badak a few specimens of *Cupressus sempervirens* rise above the surrounding vegetation, whilst *Rosa canina* grows by the roadside and climbs high up into the trees. *Rumex alpinus* close by the hut of Kandang Badak, is perhaps also a remnant of TEYSMANN's cultures. *Digitalis purpurea* was planted there latterly, but, though it holds its ground, it does not spread. On the Pangrango-top a few plants brought thither in former days are still present. Everywhere in open patches and under light brush wood *Fragaria vesca* is scattered about, but it is not spreading any further; two forms are still clearly distinguishable, the one robuster and with larger flowers, the other one smaller. *Pirus malus* which used to occur in a few rather stunted individuals, has of late years been exterminated almost entirely; *Rubus fruticosus* is also found in a few large groups, but though it flowers richly throughout the year, it never bears fruit. In one patch *Rosa rubiginosa* and a species of *Cotoneaster* are maintaining their position, but they never bear flowers. The most remarkable plant is a beech nearly a century old, which is about five feet high and has developed into a thickly ramified shrub. COSTER [2]) devoted a special study to this plant. Starting from Tjibodas some plants have spread through the forest and hold their own in a few places, such as a Japanese bamboo,

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[1]) K. W. DAMMERMAN, Preservation of Wild Life and Nature Reserves in the Netherlands Indies. Fourth Pacific Science Congress, Java 1929, p. 39.

[2]) CH. COSTER, Die Buche auf dem Gipfel des Pangerango. Ann. d. Jard. bot. de Buitenzorg, Vol. XXXV, 1926, p. 105.

Cestrum aurantiacum, Eupatorium janthinum and a *Galathea*-species. Besides these several weeds, mostly of American origin, have run wild along the roads and in open patches, so for instance *Eupatorium pallescens* and *E. riparium, Bidens pilosa, Erigeron linifolius, Galinsoga parviflora* and grasses such as *Poa annua* and *P. trivialis. Cerastium caespitosum, Drymaria hirsuta* and *Stellaria media, Brassica oleracea, Cardamine hirsuta, Oxalis corniculata, Solanum tuberosum, Sonchus asper* and *Artemisia vulgaris* belong also in this group. Some seeds which I had brought from the islands of Hawai were strewn out on the top of Pangrango, but an *Oenothera* only has stood its ground. *Taraxacum officinale* was sown out near Lebak Saät and on the top of Pangrango, and this keeps up its position there. On the same top I planted a few specimens of *Anemone Sumatrana* brought from Mt. Singgalang in Central Sumatra and some plants of *Dendrobium Jacobsonii* from Mt. Lawu were put on the *Cupressus* trees near Kandang Badak, and an *Impatiens* from Sumatra with yellow flowers was planted above Huis ten Bosch. The rest of the plants belong to the indigenous flora.

The vegetation extends without interruption from 1500 m to above 3000 m, and belongs therefore to the two highest of the four belts into which JUNGHUHN in his standard-work "Java" has divided the vegetation of the island. The composition of the virgin forest in the third belt which extends from Tjibodas upwards to some 2400 m above sea-level, has been described so often (see for instance HABERLANDT [1]) and MASSART [2]) that I need not dwell on it again, the more so because my researches have mainly been confined to the highest region. I will therefore restrict my remarks to JUNGHUHN's fourth zone.

Many plants which belong to the vegetation of this highest belt also occur lower down. *Vaccinium laurifolium* which presents itself on the Pangrango-top as an irregularly ramified shrub and is to be found in the vicinity of Kandang Badak either as a big liana, or as an epiphyte, is to be found in the forest near Tjibodas at 1400 m above the sea as an epiphyte only; thus far, however, I have not found it there in flower. *Myrica javanica, Eurya acuminata, Albizzia montana,* to mention only a few examples, exist far down in the third zone. Under the falls of Tjibeureum at about 1700 m altitude, several plant species are found which reach their full development in the fourth zone only. A striking thing is the occurrence here of *Pleopeltis feei* and *Ranunculus diffusus,* plants which occur nowhere in the surrounding forest. They grow here on rocks which are continually exposed to the spray. The fern grows abundantly in the open crater of Gedeh and on sparsely grown lava streams elsewhere.

The higher one ascends in the third zone the more numerous the

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[1]) G. HABERLANDT, Eine botanische Tropenreise. Leipzig, 1910, Zweite Auflage, p. 211.

[2]) J. MASSART, Un botaniste en Malaisie. Bull. d. l. Soc. royale de bot. de Belgique, Vol. XXXIV, 1895, p. 250.

representatives from the fourth zone are becoming, and above the hot springs, that is, above 2200 m one enters a part where representatives of the two zones mingle in about equal strength. Inversely, various plants which find their fullest development in the lower belts ascend far up into the fourth zone. Stout specimens of *Podocarpus imbricata* occur on the Pangrango-cone up to 2700 m; there are likewise a few species of *Quercus* in the lower parts of this cold zone.

The mountain laboratory Lebak Saät and the mountain bungalow Kandang Badak are situated at 2400 m above sea-level in the midst of a dense forest. This forest is usually described as alpine. SCHMUCKER [1]) and SCHRÖTER [2]) however, are of opinion that the name alpine is out of place here, because by an alpine vegetation is meant a plant association existing above the tree line. The alpine vegetation of the Alps consists largely of so-called "espalier" bushes, that is to say low shrubs with twigs adpressed to the soil, and of cushion-plants. Genuine espalier-bushes do not occur on the Javanese mountain-tops; the nearest approach is shown by *Gaultheria nummularioides*, but this is in reality, as it roots from the branches, a creeping plant. Cushion-plants too, are entirely missing; the only plant at all comparable to them would be *Gentiana quadrifaria*.

As the idea of an "alpine vegetation" is bound up with the idea of the "tree limit", we ought to have certainty about the latter, before we could speak of an alpine flora in the tropics, but there is as yet no agreement on this point.

SCHMUCKER points out that in West Java even on mountains 3100 m high the tree limit is not quite reached; as regards Central Java the same author states that there are mountains up to 3300 m high and more, but their tops are denuded of all vegetation. This is true of Mt. Slamat, which is 3432 m high; the highest 300 m of this mountain consists of young lava, as yet but little weathered and disintegrated, on which nothing is found but lichens and a few foliaceous mosses. Mt. Sumbing on the other hand, which rises to 3371 m, bears on its very summit trees between 3 and 4 m high of *Vaccinium varingifolium* and *Albizzia montana*.

The tree limit is therefore not yet reached at these altitudes. In East Java we find Mt. Semeru (Mahameru), 3680 m high, but the upper 500 m consist of unweathered ashes, on which plant life is not yet possible [3]). On the border-line between this ash-cone and the wooded slopes, at an altitude of about 3200 m, *Casuarina*-trees more than 8 m high are found. This upper fringe of the forest suffers a good deal from the continual avalanches of ashes, by which frequently large parts of the forest are destroyed. There is however no reason for supposing that these *Casuarina*'s could not grow

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[1]) TH. SCHMUCKER, Beitr. z. Kenntnis der Hochgebirgsflora Javas und zur Theorie der Pflanzenverbreitung. Beihefte z. bot. Centralblatt, Vol. XLIII, 1926, p. 34.

[2]) C. SCHRÖTER, Exkursionen in Ost-Java. Beiblatt N. 15 zur Vierteljahrsschrift der Naturf. Gesellsch. in Zürich, Vol. LXXIII, 1928, p. 554.

[3]) I found in 1925 near the very top only one plant of *Anaphalis*.

up to the summit of Mt. Semeru, and it is therefore to be assumed that the upper tree limit is not reached on any mountain in Java, and that consequently a flora of a really alpine character cannot occur there.

Nevertheless we need a word to denote that the vegetation of the fourth JUNGHUHN zone differs substantially in many respects from that of the lower plant-zones. In what follows I will therefore call this flora "alpinoid", because the plants of the highest mountain tops in Java share many characteristics with the genuine alpine flora. To find a true alpine flora within the tropics one has to climb still higher, the true limit lying probably between 4000 and 5000 m.

Besides forests these mountain tops frequently present larger or smaller stretches in which trees are absent or rare, and which bear a vegetation consisting of smaller plants, especially grasses and sedges but sometimes also low bushes. These open patches are often sharply separated from the surrounding forest. In other countries such stretches, covered with a low vegetation which lie like islands in the forest are also met with, the "patanas" of Ceylon being a wellknown example. In connection with an investigation of these areas, STOMPS [1]) discusses the climate and especially the tree line in the tropics. STOMPS, starting from the treatise of H. BROCKMANN-JEROSCH, "Baumgrenze und Klimacharakter", argues, that in Ceylon as it is an island with but little general elevation, lying moreover in the middle of the ocean, an exceptionally low tree line is to be expected. With regard to the highest tops in Java he arrives at the same conclusion. In that island also, he says, the upper tree line is at a considerably lower altitude than in other tropical regions. In my view this thesis is not corroborated by the facts, for where on the mountain-tops in Java the soil is suitable for tree growth, the tree limit is never reached. Whether this limit would have been reached a few hundred metres higher up, is a question we can not answer, because the top of Java's highest mountain, Semeru, cannot bear now any higher plants. The open patches scattered about in these alpinoid forests owe their origin to other causes, climate and altitude being of slight importance. The absence of trees there is largely due to the composition and physical structure of the soil, according to VON FABER [2]) one factor being the formation of forest-peat. The Pangrango-top also affords an example of such vegetation in a hollow below the wooded top. JUNGHUHN, who visited this top in 1839 supposed that the trees had been destroyed in the last eruption of the crater, and believed that in the course of time they would once more penetrate from the forest into the open patch. This, however, has not yet happened thus far, and it is therefore evident that the soil is not suited to the growth of trees. Another fact, which should not be forgotten, is that the bushes of *Anaphalis*

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[1]) TH. J. STOMPS, Baumgrenze und Klimacharackter in den Tropen. Verhandl. der Klimatolog. Tagung in Davos, 1925, p. 1 of the off-print.

[2]) F. C. VON FABER, Die Kraterpflanzen Javas. Weltevreden, 1927, p. 64.

javanica are killed time and again by night-frosts which in the depression are often severe.

Although the forests in these regions still contain many species of plants which occur also in lower parts, yet their habit is clearly distinguishable from that of the forests in those other parts. It are accordingly the trees that have undergone most markedly the transforming influence of the higher altitude, whereas the shrubs and herbs are usually little different in habit from those in other forests. Though other kinds of herbs and bushes occur, they do not show any special features. Neither do the young individuals of the trees show a peculiar habit; they do not acquire the particular form of the adult trees until they grow older. Their stature remains much lower; in the lower part of the fourth zone they still frequently attain more than 15 m in height, but the higher we get the smaller they become and in the highest and most exposed situations, trees above 5 to 6 m high are rare. Moreover they ramify as a rule low near the ground, the branches spreading laterally, so that the trees become more shrublike. Some species, *Leptospermum* for instance, are "umbrella"-shaped, plate VII, others are more rounded; their wood is mostly very hard and the trunk often twisted or warped and knotty, with a rough bark scaling off in flakes or in fibres; the leaves are mostly small, narrow and leathery and they are congested at the ends of the branches.

Especially on mountains with plenty of rainfall, such as Pangrango, these forests are characterized by an uncommonly rich development of moss cushions. Not only, and not even mainly, on the ground, but principally against the trunks and on branches, all sorts of mosses, both *Musci frondosi* and *Hepaticeae*, form thick cushions which impart to the whole forest a bizarre aspect, that of the so called moss covered forest, luxuriantly developed from Kandang Badak up to the top of Pangrango. In the more unfertile parts of these mountains, such as the slopes of Mt. Gedeh on which the forests are also much younger than on Pangrango, these moss cushions are not so richly developed, and in parts hardly developed at all, plate XXI, they will also be looked for in vain in the crater of Gedeh. On these barren and very exposed grounds, which are often comparatively young unweathered lava-streams, the trees remain a good deal lower, whilst the patches that are not entirely devoid of vegetation are overgrown with a dense and hardly penetrable tangle.

The trees of these forests belong to various families, a particular family being frequently represented by a single species only. They are the following: *Podocarpus imbricata*, a forest giant, which occurs as high up as 2700 m. *Albizzia montana* which, however, does not occur very generally in these forests, as it prefers more open grounds, crater-fields, waysides, and the banks of brooks. Their seeds must nevertheless be present in the soil in large quantities, or they must be very easily dispersed, for seedlings of this tree are found in large numbers in stretches cleared either by arched squalls, by man, or by landslides. When later on the forest trees proper

restore a thick vegetation, the *Albizzia*'s, which had been the first to come up, are found to die out again as they are not replaced by new individuals.

Quercus pallida and *Q. spicata* are in these mountains mainly confined to the lower parts of the fourth zone; the same holds good of *Litsea javanica* whilst *L. cubeba* behaves in the same way as *Albizzia*. *Polyosma ilicifolia* is a small tree, of rather frequent occurrence in the undergrowth of the forest, and not to be found above 2700 m. *Myrica javanica* is more common in open spaces, especially on bare crater-slopes, than in the forest itself. On Mt. Pangrango it will be looked for in vain. *Daphniphyllum glaucessens* is confined to the lowest parts and belongs to the undergrowth; *Acer niveum* is also nearly absent from the higher parts and where it occurs here it seldom grows to a good size, whilst in the third zone it may rise to the stature of a forest giant. The species of *Elaeocarpus* occur everywhere, and have developed especially in the lower parts into fair-sized trees. *Eurya acuminata* is very general, up to the top of Pangrango and forms one of the most noticeable elements of the forest-flora; it does not occur by any means so frequently in open patches and is usually accompanied by other trees, but on the top of Pangrango there is a spot where this tree occurs gregariously in large numbers. *Schima Noronhae*, a forest giant, is also developed especially in the lower part of the forest, where it is conspicuous by its intensely red young foliage and large white flowers. *Eugenia jamboloides* is also a denizen of the lower parts, whilst *Leptospermum javanicum*, which belongs to the same family, is present everywhere up to the tops of the mountains. On the slopes of Mt. Sela it is predominant in the forest-flora, and in the flowering-season the "umbrella"-shaped crowns, towering over the tops of the other trees, are laden with a snowy mantle of flowers, a sight already described by JUNGHUHN. *Astronia spectabilis* is again a denizen of the lower parts. *Schefflera rugosa* occurs throughout the forest, but seldom gregariously; it is found on the top of Pangrango also where it is the only tree with large digitate leaves. Of the *Ericaceae Rhododendron retusum* and *Vaccinium varingifolium* are arboreous, *Vaccinium laurifolium* being more like a shrub or a liana. *Rhododendron retusum* occurs everywhere, both as a tree in the forest and as a small bush on the lava streams of Mt. Gedeh. The commonest tree in these woods is *Vaccinium varingifolium*. It occurs everywhere, and here and there it forms nearly the whole of the forest vegetation with hardly any competitors, plate XXI; as a small shrub it is found in the same localities as *Rhododendron retusum*, but it is far commoner; it strikes the eye by its bright-red young leaves. *Rapanea avenis* is also generally prevalent, but is not so numerous in scantly-grown spaces as the previous species. The species of *Symplocos* are also common; *S. sessilifolia* occurs as a bush up to the highest tops. *Viburnum coriaceum* is common in the forest, but on the top of Pangrango, it occurs in few individuals only; in the bare part of the mountain I only know of one specimen forming a tall thick bush. *Anaphalis javanica* may grow into a small tree; it does not live in the forest itself,

but keeps to its margins and to light open spaces. Of the tree-ferns *Cyathea crenulata* ascends high up in the mountains, but is more general in the lower parts, where it may locally determine the character of the forest.

Besides young specimens of the above-mentioned trees this forest also contains various shrubs. *Cyclolophus* occurs only in open patches in the lowest part; *Dichroa* and *Hydrangea* are also found in the lowest parts; the former is met with on the sides of Mt. Sela up to a height of 2800 m. *Neillia*, a small more or less climbing bush in the lower part of the forest, is rare. Various species of *Rubus* occur in the forest round Kandang Badak, but *R. lineatus* is the only one which reaches the top of the mountain; it shows a preference for the edge of the forest, where it often forms a dense jungle; *Perrottettia* is also general, but only in the lowest part of this region.

Hypericum, a bush or a straggling shrub, is found in the higher parts of the forest, especially on the margins, but it is on the whole more a denizen of open spaces. *Melastoma setigerum* and *Aralia ferox* on the other hand occur in the lower area. *Schefflera lucescens*, a straggling shrub with long branches, almost liana-shaped, occurs on both mountains up to high altitudes, but on the tops it is entirely absent. The three *Gaultheria*'s are shrubs, *G. fragrantissima* and *G. leucocarpa* occur in light alpinoid forest, but the creeping *G. nummularioides* must be regarded as rare there; all three prefer more open localities. *Rhododendron javanicum* is to be found in the lower part of the forest zone as a shrub, but in the third zone it is mostly met with as an epiphyte. *Vaccinium laurifolium*, a large straggling shrub, sometimes almost liana-shaped, occurs everywhere and climbs high up into the trees.

Very common, locally even forming closed associations, is *Ardisia javanica*, which may be met with as high up as 2700 m. *Geniostoma* again is limited to the lower parts; *Cyrtandra arborescens* forms local colonies and may present itself up to 2900 m altitude, though it is nowhere general. *Allaeophania* is to be considered general especially on the slopes of Gedeh and in a few localities near Kandang Badak and somewhat higher; *Lasianthus lucidus* and *Gnaphalium longifolium* occur only in the very lowest part; the latter however is absent in the forest itself.

The number of lianas and trailing and creeping herbs is not particularly large in these forests. *Piper arcuatum* is confined to the lower part; *Clematis Leschenaultiana* too, although in other mountains it may occur as high up as 3000 m; on Gedeh-Pangrango it is common in certain parts only. *Kadsura* too, is a plant which belongs to a lower zone; some specimens however reach Kandang Badak. *Nepenthes* is in this area not found in the forest, but one specimen is growing in the crater of Gedeh. *Embelia* is also confined to the lower part. *Crawfurdia* occurs everywhere scattered through the forest and is also present on the tops of these mountains. *Lonicera* grows everywhere as a liana, save in open patches, where

it occurs as a tall shrub. *Melothria* like *Pratia montana* on the other hand occur only in the very lowest region.

The number of herbs in this kind of forest is not very large; they belong to the ferns and the phanerogams. Of the grasses *Isachne albens* occurs especially along forest tracks, the other grasses however are more confined to open grounds. The *Carices* also are more common there than in the forest, though all the species may be found in it. *Gahnia* grows here and there in the forest itself and along the dry river-bed of the Tji-Saät, but it is more at home in the open parts of the crater. *Dianella javanica* does not grow on the Pangrango slopes, but it is present in the forests on the Gedeh-top and along the Tji-Saät. *Disporum* is found here and there; it reaches its upper limit near Kandang Badak. The forests shelter however various terrestrial orchids: *Calanthe abreviata* and *Goodyera bifida* (rare) in the lower parts; *Phajus flavus*, however, may be found near the top of Gedeh. The two species of *Myrmechis* on the other hand are to be found everywhere; *M. glabra* is present even up to the highest parts of Pangrango. *Platanthera Blumei* is a genuine forest plant and everywhere present.

Colonies of *Elatostema* are found occasionally in the forest up to an altitude of 2900 m, *Pilea* on the other hand is confined to very moist patches in the lower parts. *Polygonum chinense* occurs everywhere, sometimes as a climbing plant, sometimes as a shrub, *P. paniculatum* is more common in open spaces. The two species of *Ranunculus* occur here and there in the forest, but they are more common along tracks and in open spaces. *Cardamine africana* is found sporadically up to the tops of the mountain. The two species of *Impatiens* are also common in some parts, especially alongside forest-tracks; *I. javensis* is confined to the lower parts, whereas *I. cyclocoma* occurs also at higher altitudes, up to 2700 m. *Viola pilosa* and *Sanicula europaea* are true forest plants; they are found everywhere. *Primula imperialis* occurs on Mt. Pangrango only, along the path through the forest and in the forest on the top, in the latter especially in the outskirts. *Swertia javanica* is also a common sight up to the highest parts. *Solanum nigrum* and *Plantago major* are rare in the forest, but more frequent in open spaces; of the latter luxuriant specimens are found along the path from Kandang Badak to the top of Pangrango and on the top itself. *Argostemma* and *Ophiorrhiza* are found occasionally in the lowest parts, while *Nertera* is everywhere very common. *Valeriana*, which is rare in the densest parts of the forest, is generally present in the more open parts, but is also found outside the forest. Among Composites, *Dichrocephala* and *Myriactis* are traceable in the forest and in open places, up to the highest parts; the other plants of this family, however, occur lower down.

Parasites are poorly represented: *Scurrula lepidota* is very common in the vicinity of Kandang Badak only, and the root-parasite *Balanophora* occurs in the forest up to the top of the mountains.

Epiphytes are found especially among the mosses and ferns and among Orchids. *Peperomia* and a single *Ericacea*: *Diplycosia* are found in the

lower belt of the forest. Many other plants, however, grow occasionally as epiphytes.

From the above survey it appears that the lower belt of the forest is richest in species, and this holds good for all classes of plants. The lower belt is a mixed or transitional region, in which many species still occur which are properly denizens of lower parts and find their upward limit at elevations between 2400 to 2600 m.

The old forest on the slopes of Pangrango, as we shall see subsequently, is richer in species than the younger forest on the slopes of Gedeh, where during the last eruptions the vegetation was badly ruined.

I will give now descriptions of the vegetation in different parts of the mountain.

1. *From Kandang Badak to the top of Pangrango.*

From Kandang Badak a path climbs in hairpin zigzags up the S.E. slope of Pangrango. Right up to the top of this mountain the track runs through dense alpinoid forest. Here and there where the road follows the edges of the ridge, it affords a view over the lower ridges and over the plain, but everywhere else the road is cut through the forest. The latter consists of the elements specified in the foregoing sections; the underwood is very dense and all stems and boughs are thickly clad with moss. Along the path many herbs thrive which occur occasionally only inside the forest, *Plantago major*, various species of *Carex*, *Sanicula* and *Ranunculus diffusus*, the latter especially in the lower part, are particularly noticeable. It is not until an altitude of 2600 m is reached that *Primula imperialis* begins to assert itself; the higher on the mountain the more robust the specimens become and the more plentiful their flowers and fruits. At first one still meets many herbs such as *Begonia* and *Impatiens* and several terrestrial orchids, but higher on the number of species diminishes. This is true also of the shrubs and trees. *Podocarpus imbricata* and *Ardisia javanica* for instance are not found at a higher altitude than about 2700 m; and above 2500 m one will look in vain for *Albizzia montana*. The forest presents one of the most luxuriant examples of alpinoid vegetation in West-Java; and up to the summit the vegetation remains equally dense, though the number of species decreases. Especially in the lower region the number of epiphytic species is very large: mosses, liverworts, ferns and orchids are all represented; *Peperomia* is also found here. Higher up both the number of species and the number of individuals decrease, the mosses however form an exception. On leaving the path the observer finds that terrestrial herbs are also growing scarcer and that everything is smothered in moss cushions in which a few species of epiphytic ferns and orchids only find a place. True terrestrial herbs are: *Platanthera Blumei*, *Nertera*, *Lycopodium miniatum* and the two species of *Myrmechis*; and all these plants grow also in the moss cushions clothing the tree trunks and the fallen logs; the latter especially are often thickly covered with them.

Herbs, however, which otherwise thrive best in the more open parts of the forest will often assert themselves when space has been cleared by a gale. When the forest recovers they disappear again. In the deeply trodden tracks and cuttings of the highest parts various plants are found which are not so much at home in the forest itself: *Gaultheria nummularioides, Hypericum, Anaphalis* a.o., and the steep banks are covered with the liverwort *Palavicinia*. After climbing some 600 m higher, the visitor reaches the ridge which encloses like a big horse-shoe the so-called crater-valley, and which rises to some 3020 m. From this part a forest path ascends very gently to the highest point, where the stone pillar of the triangulation-survey has been put up. For the purposes of this survey the forest has been thinned in this part of the top, but everywhere else the mountain crest is covered with dense moss-clad forest. Old individuals of *Vaccinium varingifolium*, with a trunk diameter of more than 1½ m and a height of more than 5 m are growing there.

Along the forest-path the vegetation consists partly of a fairly pure growth of *Eurya acuminata*. Besides the two trees referred to, there are also well-grown specimens of *Leptospermum*, which often tower over the surrounding trees, plate VII. *Photinia Notoniana* in not so many individuals, plenty of *Rhododendron retusum, Rapanea avenis, Symplocos sessilifolia, Schefflera rugosa* and an occasional *Viburnum coreaceum*; *Vaccinium* however is everywhere predominant. As lianas are found *Lonicera* and *Vaccinium laurifolium* and the herbaceous trailer *Crawfurdia* is very common.

Save *Rubus lineatus* and very large specimens of *Vaccinium laurifolium* no genuine shrubs occur here; what is found in the shape of shrubs are young individuals of the forest trees and occasionally an individual of *Gaultheria leucocarpa*. Herbs, apart from ferns such as *Plagiogyria pycnophylla*, are: *Platanthera Blumei, Carex hypsophylla, Myrmechis glabra, Polygonum chinense* (rare in the forest), an occasional *Cardamine africana* and more generally present: *Viola pilosa, Swertia javanica, Balanophora elongata, Nertera, Sanicula, Dichrocephala* and *Myriactis*. These herbs grow sometimes also epiphytically, whilst the following are exclusively epiphytic: *Dendrobium Hasseltii* and a few ferns: *Asplenium praemorsum, Polypodium fasciatum, P. nutans* and *Hymenophyllum paniculiflorum. Dryopteris adnata, Dryopteris filix mas* and *Polystictum aculeatum*, which occur also as epiphytes are more common as terrestrial plants.

At the end of the forest path we come to the top, where much of the timber has been cleared, so that the vegetation here can certainly not be described as undisturbed. This piece of ground is covered with plant species which we will meet again in the crater-valley, where the vegetation is still in the original state. On this open patch I sowed in 1922 *Taraxacum officinale* and species of *Oenothera*, a native of the slopes of Mt. Haleakala in the island of Hawaii. The plants have held their own; the dandelion grows as a very small plant with comparatively large flower-heads.

From the ordnance-survey pillar a narrow path leads along the inner slope of the rim into the crater-valley. On this stretch the vegetation was cut down by TEYSMANN; as was reported also by JUNGHUHN on his last visit, it consisted undoubtedly of forest. At present the whole of this gently sloping inner wall is grown over with shrubby forms probably of the same trees that used to form the forest. Some plants, such as *Hypericum* and *Anaphalis*, which do not generally occur in the real alpinoid forest, have here developed in the fuller light, but they will doubtless disappear, when the ground is once more covered with forest: a process which is gradually advancing. At all events the vegetation of this inner slope cannot be regarded as normal, as will become clear when we compare it with the vegetation covering the opposite slope, where the alpinoid forest is found fully developed.

At the end of the footpath one gets to small level patches thickly overgrown with tussocks of *Calamagrostis*; here grows in the form of a low bush the beech planted by TEYSMANN, and a few small apple trees and European blackberries. Here and there some parts are dotted with forest, but finally we reach the crater-valey with its striking vegetation. This valley is the lowest part of the depression; it stretches in a narrow strip from N.E. to S.W., and gradually slopes down in that direction. Seen from above, this narrow band makes a strange pale effect owing to the presence of *Anaphalis*. On the West, North, and South sides the valley is enclosed by old alpinoid forest; there is no gradual transition, but the forest ends suddenly; the trees on the outer edge are neither smaller nor less thickly moss clad than those occurring deeper inside the forest. The sides of this valley slope gently towards the centre, and a brooklet, the source of the Tji-Kuripan, flows in the lowest part. This rill is fed by the rain-water falling on the inner side of the valley; its capacity is therefore dependent on the rain-fall. In the rainy season it always contains water, in the dry season only if there have been showers for a few days. At the N.E. end of the crater-valley the water wells up from the ground, which is swampy here in the rainy season, but there are also small sources at other points, plate X; a number of side-rillets, usually dry and only containing water in rainy weather, flow down to the main brook. Here and there the brook forms shallow pools, but especially towards the S.W. end the bed is dug out about ½ m in the ground, and forms in various places small ponds. The bottom of this crater-valley consists of rubble and contains but little digested humus. The vegetation is remarkably poor, especially alongside the brook, but grows richer as the margin of the forest is reached. Plate VIII shows a very barren part, with penurious individuals of the grass *Isachne pangerangensis*, and among the grass, cushions of mosses, chiefly of *Rhacomitrium lanuginosum* are found, but little else. The moss is distinguished by the dead, white filaments at the ends of the leaves, which give the plants a white aspect. In the *Isachne* association other plants germinate, such as *Agrostis*, *Anaphalis* and *Swertia*, but they mostly die

after a short time; *Swertia* produces here very small starved individuals, which however in spite of all bear flowers, though sometimes only one, figure 55.

In moist spots and even in the brook grows *Laurembergia*, conspicuous by its red stems. This plant forms dense mats because the twigs put forth rootlets and firmly grip the soil. In many places, especially in shallow rain-gullies, a peculiar association is formed of this plant with the almost black-coloured moss: *Enthostodon Buseanus*, plate IX. SCHRÖTER [1]) calls this association "schneetälchenähnlich" ("like that in little snow valleys") as it recalls the association of *Arenaria biflora* with *Polytrichum* in the Alps. The circumstances are however so entirely different, that the similarity between the two associations can only be superficial.

In the brook itself are found, beside some filamentous algae, such as *Spirogyra*, principally cushions of *Scirpus fluitans*. They grow on the edge and partly also in the water, and further in swampy patches among the grass. At a few yards' distance from the brook the soil gets drier, and here begins the *Anaphalis*, consisting of scattered bushes. The ground is chiefly covered with a brown or nearly black coral-like lichen, *Stereocaulon graminosum*; *Rhacomitrium* also forms cushions here. Between them grow in various places *Gentiana* and *Thelymitra* and also specimens of *Agrostis*, and though other plants occur here occasionally, they mostly lead but a languishing existence. *Anaphalis* forms small bushes about 60 to 100 cm high which are smallest in the middle of the crater-valley and grow larger towards the edges; many of them are killed by the severe night-frosts which frequently occur in this valley. On the ground, but especially against the thin trunks of the *Anaphalis*, grows a very big lichen, *Cetraria sanguinea*, with scutelliform apothecia, which may reach 2½ cm diameter: the *Anaphalis* bushes are often pulled down by the weight of these lichens. There also occur in these localities various *Cladonia's*, and also *Lycopodium Wightianum*, which with its strongly ramified closely massed branches and short upright ears covers quite considerable patches; see plate XVII.

Towards the edges the vegetation grows ever richer; *Agrostis*, like *Calamagrostis* covers small patches here and there, together with large tussocks of *Carex hypsophylla*, plate XII. At the N.E. end there are a few clumps of *Gahnia javanica*, which, however, do not look very flourishing. *Ranunculus javanicus*, *Cerastium caespitosum* and *Gaultheria nummularioides* are also present. The skirt of the forest is bordered with a belt of big *Anaphalis* bushes, which may attain 2 m in height; see plate VII. It is in this skirt that all sorts of plants already referred to sprout quite luxuriantly, and here is the locality of *Primula imperialis*, which however is also abundant in more open parts of the forest on the crater-ridge. Here are also to be met with colonies of the brown, shortly petiolate *Gleichenia*

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[1]) C. SCHRÖTER, Exkursionen im Ost-Java. Vierteljahrschr. der Naturf. Gesellsch. in Zürich, Vol. LXXIII, 1928, p. 591.

vulcanica. In a few places the moss *Rhacomytrium lanuginosum* which otherwise favours open spaces, forms on the trunks and limbs of trees cushions more than a yard thick, in which all sorts of plants may grow; see plate XI.

Near the S.W.end of the crater-valley a side-rill of the brook forms a shallow groove with about the same vegetation as the one already described. The centre is entirely filled with a thick carpet of *Isachne pangerangensis*, through which the water trickles. It is especially in this part, on the edge of the forest that *Swertia javanica* occurs in masses. *Fragaria vesca*, which fails in the crater-valley occurs here, though it is more common in that part of the crater-depression, which at one time was cleared, but which is now overgrown with brushwood.

It is also noteworthy that communities of *Funaria hygrometrica f. javensis* develop especially on and among the charcoal left by campfires; *Cerastium* and *Sonchus* may be found there too.

The trunks of *Anaphalis* in the belt edging the forest are thickly covered with all sorts of lichens.

At the S.W. end of the crater-valley the enclosing crater-wall is broken through, and through the gap the brook plunges into a steep gully, leaping further down in small falls and cascades. For about 100 yards it is possible to follow the brook in its downwards course; then the gully becomes impracticable. In that deeply-carved and chilly ravine of the Tji-Kuripan *Thalictrum javanicum* occurs locally in large masses and *Pimpinella Leeuwenii*, which was discovered on Pangrango, and has not been found elsewhere, grows on the slopes. In this cleft the grasses of the crater-valley are also found and between them *Primula imperialis* and small specimens of *Gleichenia vestita*. *Viola pilosa* and the root-parasite *Balanophora elongata* are also common here.

Along the margin of the forest in the crater-valley itself are found *Lonicera javanica*, which is liana-shaped, but occurs also in more open patches as a bush and likewise *Hypericum*, which straggles high up into the trees. This latter plant however attains its best development on the N.E. side on the inner slope of the crater-valley. A large stretch is covered here with an impenetrable growth of *Hypericum* scrub. These parts also bear large bushes of *Rubus lineatus*, which is also common along the forest-skirts.

Leaving the crater-valley by the south-side and keeping the forest on the right, one gets about half-way up the slope in an *Anaphalis* association of a luxuriance unequalled anywhere in these mountains; nowhere except in one part on Mt. Sumbing [1]) did I see anything like it. *Anaphalis* here forms a little wood, consisting of trees some 4 m high; the ground is thickly clad with moss, in which numerous herbs grow: *Swertia*, *Gaultheria nummula-*

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1) W. M. DOCTERS VAN LEEUWEN, Beitrag zur Kenntniss der Gipfelvegetation der in Mitten-Java gelegenen Vulkane Soembing und Sindoro. Bull. d. Jard. bot. d. Buitenzorg, Série III, Vol. XI, 1930, p. 38.

rioides, Myriactis, Nertera, Viola, Lycopodium miniatum and *Carex hypsophylla*. The *Anaphalis* trunks are richly coated with mosses and lichens. Such a miniature forest has also been described by JUNGHUHN [1]).

At the end of this thicket we again enter the *Vaccinium* forest and in a short time we reach the top of the zigzag path leading to Kandang Badak.

2. *From Kandang Badak to the crater of Gedeh.*

The track to the crater leaves the path to Mt. Pangrango on the left and follows, gently climbing, for a time the saddle-neck between the two mountains. Here we find the same kind of alpinoid forest as in the neighbourhood of Kandang Badak; its rather impressive half-reclining tree trunks are thickly moss-clad, see plates XIX and XX. The undergrowth is very close and we find all sorts of herbs, as *Swertia, Sanicula, Ranunculus diffusus* and various grasses and *Carices*; *Allaeophanea* is also common and in addition we find young specimens of *Albizzia*, which we did not see on the excursion to Pangrango. The wood contains also *Aralia ferox*. About three quarters of an hour's march brings us to the crater's edge at circa 2550 m altitude, and from there we descend steeply by a short path, through a thick wilderness of *Polygonum chinense*, (with the galls of *Farysia emodensis*), and of *Rubus lineatus*.

All of a sudden the vegetation changes completely. The edge consists of a dense scrub of *Vaccinium varingifolium, Anaphalis javanica* and *Albizzia montana*, with a few specimens of *Rhododendron retusum*; but a few yards away from the edge we enter the floor of the crater with its very scanty vegetation. Scattered about we see some of the plants before mentioned, which, *Albizzia montana* excepted, assume the form of small bushes. *Albizzia* presents itself in the shape of a small many-branched tree, laden with the large fungus-galls caused by *Uromycladium Tepperianum*.

The soil gets barer and barer; it consists of blocks of a hard lava, of which small and larger pieces strew the floor of the crater. On the ground live small red liverworts: *Marsupiella vulcanica* and *Haplozia javanica* and especially the lichen *Stereocaulon graminosum*, which is shown in the foreground of plate XXIV; this plate pictures one of the most barren parts of the lava-stream. In the crevices and between the rubble the rhizomes of the crater-fern *Pleopeltis feei* have fixed themselves; the leaves of the latter are vertically. In these places are also found small specimens of the plants mentioned above and of *Gaultheria fragrantissima* and *G. leucocarpa*. It is the most barren part of the mountain; besides the plants just mentioned it bears nothing but a few individuals of *Lycopodium clavatum* and *Gaultheria nummularioides*.

The ground rises slowly towards the edge of the crater in which volcanic activity is still going on: the Kawah Ratu. To the South of it rises the precipitous trachyte wall of the second crater. This wall is almost vertical,

1) FR. JUNGHUHN, Java sec. edit. 's-Gravenhage, 1853, Vol. I, p. 582.

and bears little vegetation; see plate XXII; nevertheless a number of plants have gained a hold on its ledges and in its crevices. From the right-hand side, i.e. the western side, an extension of the forest in the form of small bushes advances up to this wall; its constituents are: *Albizzia, Vaccinium varingifolium, Pleopeltis feei, Gahnia, Anaphalis, Gaultheria fragrantissima* and *G. leucocarpa, Myrica* and *Polygonum chinense.*

At the foot of this perpendicular wall the rubble lies piled up, and in the gullies washed out by rains small specimens of *Myrica* grow in files; see plate XXIII. We may conclude therefore that the seeds of this plant are not only dispersed by birds, but also by rain-water, for it is inconceivable that the birds would have dropped their excrements in these gullies only! A few individuals of this tree are found here and there between the gullies.

Over the northern wall of the Kawah Ratu we reach by a steep descent the small eastern crater, the Kawah Lanang. This crater has the form of a shallow basin with a level bottom and steep rims. The northeasterly part of the bottom is in the rainy season boggy, and numerous tussocks of *Carex hypsophila,* mingled with a few plants of *Agrostis* grow there. The opposite drier part of the crater-floor bears a quite different vegetation, to wit, *Anaphalis javanica.* With many tussocks of *Agrostis, Thelymitra,* three kinds of *Gaultheria,* groups of *Swertia,* and *Lycopodium clavatum* and *L. Wightianum*; in addition plenty of young individuals of *Symplocos* and *Leptospermum,* together with the plant-species already met with at the beginning of this excursion. At the foot of the crag there is also some *Rubus lineatus* and on the rock itself *Pleopeltis feei,* and *Hymenolepis spicata,* besides plenty of *Stereocaulon graminosum.*

The Kawah Ratu is still slightly active, the Kawah Lanang is now dormant; both these craters however have been very active in earlier days and have belched forth huge lava-streams, one of which can still be traced down to the hot springs on the road of Tjibodas to Kandang Badah at about 2200 m altitude. The lava-streams are as yet little weathered and but thinly covered with vegetation. At this lava-stream, as in other spots in the crater there grow specimens of *Gahnia javanica* I have found here also a male individual of *Nepenthes gymnamphora*; in spite of repeated efforts I have not been able to find a second specimen of this plant.

We return to Kandang Badak by the same way.

3. *From Lebak Saät to the Kawah Wadon and back across the crater field of Mt. Gedeh.*

The laboratory of Lebak Saät (plate XXVI A) stands at the margin of the rich alpinoid forest which we have described already of the neighbourhood of Kandang Badak. In front of the laboratory the forest has been cleared for a few dozen yards, and from there eastwards there is a level part with a sandy soil, in which a few deep channels of brooks, mostly dry, have been washed out. We here find a vegetation consisting of the usual crater-plants, but in a very special form: the trees are thin-stemmed, rising

up to 6 m high, and are fairly wide apart. As a result the ground is lightly shaded and yet it is not closely covered with herbs. In and along the channels of the brooks the ground is overgrown with the bright-green liverwort: *Haplozia vulcanica* and the undergrowth is again made up of young specimens of the trees composing the forest: *Vaccinium varingifolium, Rhododendron retusum, Symplocos sessilifolia, Rapanea avenis* and *Leptospermum javanicum* in great abundance; in addition also the shrubs *Gaultheria leucocarpa* and *G. fragrantissima* and *Rubus lineatus. Schefflera lucescens* occurs here also. The hemiparasitic *Scurrula lepidota* is very common. The stems of trees are heavily loaded with mosses and liverworts; of the latter it is especially the orange-brown *Mastigophora diclados* which forms thick cushions. Epiphytic ferns too are very common, for instance several species of *Hymenophyllaceae,* especially the smaller forms, Epiphytic orchids are also frequent. As herbs there are present *Crawfurdia trinervis, Myriactis, Gahnia* and two *Lycopodia,* to wit *Lycopodium clavatum* and *L. volubile*; the latter climbs high up in the small trees. This level stretch is not very extensive and only some 200 m broad; to the south it is bounded by the usual alpinoid forest, to the north by a younger forest with an uncommonly thick undergrowth of ferns, On making one's way up in one of the dry gullies, one gets into the bed of the Tji-Saät, a gulch strewn with boulders, but carrying water only after heavy showers. This river rises at the bottom of the crack which forms the Kawah Wadon. All sorts of crater-plants are found along its banks; *Albizzia montana* grows there also and large tussocks of *Gahnia* and of *Dianella javanica* with its pale-blue flowers, which only occurs in a few places on this mountain. The bottom of the channel consists of white sand; the boulders are covered with lichens; here and there are found large specimens of the otherwise epiphytic orchid: *Dendrobium Hasseltii,* not with pendulous but with rigidly upright twigs. Slowly we ascend over the big boulders and reach the end of the chasm after half an hour's walk, having noticed the still strong activity of the solfataras. We leave the gully and ascend on the east side of the crater a lava-stream with but little plant-life on it, and force our way through small shrubs of *Vaccinium varingifolium* and *Rhododendron retusum* up to the ridge. The latter is covered with dense brushwood, where we find also plenty of *Myrica javanica* and *Albizzia montana.* This lava-stream is cut through by the crater chasm, so that we can bend our way south above this chasm, thus reaching the craters of Gedeh referred to in the previous excursion, and thence return home. The whole of the lava-field bears the same plants that have been enumerated in the description of that excursion, all of shrub-like habit. Occasionally they form a thick brushwood, but many places are but thinly covered with vegetation.

4. *From Kandang Badak to the summit of Gedeh and back through the crater.*

At the start we follow the path that leads to the crater, see excursion 2,

but soon we have to take to the right. The path runs in a southerly direction, rising at first slowly and then more quickly, so that we climb the western slope of Gedeh in a slanting line. At first the forest remains in the main similar to that in the neighbourhood of Kandang Badak, but when we have climbed about 100 m we see that the aspect of the forest gradually changes, chiefly because the mosses, both on the ground and on the trees, become less abundant. In spite of this change the composition of the forest remains nearly the same; neither does the undergrowth, which is very dense, show a different aspect from that in the forest already described. At 2600 m altitude the scarcity of mosses grows ever more noticeable, the trees become thin-stemmed, and less copiously ramified, so that the forest makes a more European impression. The undergrowth consists largely of *Ardisia javanica*, and of young individuals of the forest trees; that *Gaultheria leucocarpa* begins to show itself is a sign that the vault of foliage becomes less dense and that more light reaches the ground. The stems of the trees are covered with large crusty lichens, and this too is a sign that the forest becomes less dense. Meanwhile the path is getting continually steeper and bends to the S.E. The trees are getting still sparser, and they ramify nearer the ground, whilst some species of trees namely *Vaccinium varingifolium*, *Rhododendron retusum* and to a slightly less degree *Symplocos sessilifolia* become more frequent. The herbaceous vegetation gets thinner too and consists mainly of certain species of *Carex*, *Swertia*, *Sanicula*, *Myriactis*, *Nertera* and a few ferns. Epiphytes occur sparingly in this forest. Here and there one already perceives a few specimens of *Anaphalis*.

Gradually this forest merges into the vegetation at the base of the crater-ridge. We have now reached an altitude of about 2800 m. The forest consists in the main of *Vaccinium* and *Rhododendron*; other tree-species occur sporadically. The trunks are slender and usually free from mosses, though crusty *Hepaticeae* and *Musci frondosi* still occur; lichens on the other hand are very abundant; see plate XXI. The ground is scantily covered, bearing small dense-leaved individuals of *Sanicula* and further here and there various other herbs particular to the mountain forest. *Valeriana*, *Anaphalis*, *Cardamine africana* and *Swertia* are among the most common plants. *Nertera* is also plentiful here and there, but the herbaceous undergrowth gives nevertheless an impression of poverty. This forest accompanies us up to the crater-edge, where we are about 2850 m above sea-level.

Comparing the vegetation at the same altitude of Pangrango and of Gedeh, we find on the former mountain a dense luxuriant moss-clad forest, and on Gedeh a thin-stemmed, sparse forest, without any moss-growth worth mentioning. Climatic differences cannot be the cause of this disparity, and we shall have to find its explanation principally in the difference in age of the forest, and in the nature of the soil. The Pangrango forest is very old and the soil is covered with a thick layer of humus, whilst on Gedeh the soil consists of but slightly weathered lava

covered with such a very thin layer of humus that the lava pierces everywhere through it. This part of the mountain has moreover suffered severely from eruptions, which not so long ago were still very violent.

Emerging from the forest we suddenly come upon the edge of the deep crater-pit and by way of this ridge we can reach the summit. The flora now becomes very poor, small shrubs of *Vaccinium varingifolium*, *Rhododendron* and *Anaphalis* and bushes of *Myrica* occur everywhere in the bare rocky soil. The branches of the plants are hung all over with thick fringes of beard-moss, *Usnea*, in various species. Especially in the highest parts of the top, which command a splendid panorama of the entire surrounding country, the vegetation becomes very poor, and the plants look starved. *Gaultheria nummularioides* grows between the shrubs and other *Gaultheria* species represented by very small specimens are also found; further some isolated very thin tussocks of *Carex hypsophylla*, *Agrostis* and *Calamagrostis* and *Gahnia* and plants of *Polygonum chinense*. But all shrubs and bushes here bear flowers, for instance *Anaphalis* 30 cm high, *Vaccinium* and *Rhododendron* plants 40 cm high are already flowering plentifully. The soil is covered thickly with *Stereocaulon graminosum*. From the ordnance-survey pillar the path runs N.E. and eventually N., closely following the rim of the crater basin. Little by little the vegetation becomes somewhat richer and the forest covering this ridge is in many respects like that described of the opposite slope, except that we find here a fairly large number of individuals of *Dianella javanica*. At the end of this path we find, attached to a small tree, a chain by means of which one can clamber down the 5 m more or less, of precipitous rockwall.

Thus one gets to the most easterly part of the crater-basin, a rocky waste with a dense vegetation of *Vaccinium* and other crater-plants. Proceeding further West one soon arrives at the barer part of the crater-basin and reaches at last the Kawah Ratu, whence one goes home, along the way already described.

5. *From Kandang Badak to the crater-basin of Mt. Gedeh, and back by way of the eastern edge of that crater.*

We follow the route of excursion 2 as far as the E.-end of the Kawah Lanang and then follow the lava-stream upwards in a n.-easterly direction. At first we proceed through sparse *Vaccinium* bushes, which soon get closer together and are mixed with *Myrica* and plenty of *Albizzia*, all thickly veiled with *Usnea*. This forest, though made up of small thin-stemmed trees about 3 m high, soon becomes so dense that one has to cut one's path with a chopper. A strikingly large proportion of *Gaultheria fragrantissima*, here developed into small trees with slender stems about 8 cm in diameter at the base, is characteristic for this forest. In open spaces *Stereocaulon* grows on the bare soil, together with *Anaphalis*-shrubs. Finally one gets in a small ravine stretching in a curve, first in a northerly and then in a north-westerly

direction, wherein a narrow brook flows which tumbles down in cascades. The edges of the ravine are covered with young alpinoid forest, but the central part is pale with *Anaphalis*. *Carex*, *Agrostis* and *Calamagrostis* occur here also and form dense associations; in more open parts grows the white moss *Rhacomitrium lanuginosum*, while *Gentiana* and *Thelymitra* also occur abundantly. *Plagiogyria* too, is common here, together with various sorts of herbs, such as *Valeriana*, *Myriactis*, *Viola* and *Ranunculus javanicus*. I looked however in vain for *Primula*. The gully is very moist, and *Anaphalis* is thickly covered with mosses and lichens.

This part of Gedeh is practically never visited. The ravine ends South-West of Gunung Sela, and from this point we turn into the *Vaccinium*-forest, which stretches in a westerly direction on the slope of the lava-stream, and thus we reach the steep lava-field North of the Kawah Wadon, by which we descend to the dry bed of the Tji-Saät.

6. *From Kandang Badak to the summit of Gedeh and to Gunung Gemuruh.*

We ascend Mt. Gedeh until we have reached the ordnance-survey pillar (see excursion 4). From here we get a splendid view of the cone of Pangrango to the West, and of the aloon-aloon of Mt. Gedeh to the South. From the triangulation pillar a footpath descends steeply to the lowest point of the aloon-aloon which lies some 200 m below the summit of Gedeh. There is a brook here flowing from East to West; at the Western end this brook, called the Tji-Gunung, has worn out a deep channel and finally leaps down into a inaccessible precipitous ravine. In the rainy season this brook holds far more water than the Tji-Kuripan in the crater-gorge of Mt. Pangrango, but in the dry season it is mostly dry. The slopes on either side, both of Gedeh and of Gemuruh, are entirely covered with a dense alpinoid forest; that on the top-ridge of Gedeh is young, thin-stemmed and not a real moss-clad forest. The central part of the aloon-aloon is entirely grown over with *Anaphalis*, and viewed from above it makes a strange, pale effect. In 1914 a part of the alpinoid forest at the western end of Gun. Gemuruh was destroyed by a forest-fire, and since then a thick scrub wilderness of *Anaphalis* has sprung up (see plate IV) which in course of time will make place once more for forest.

The ground in the middle consists of rubble, and is just as barren as that near the brook on the top of Pangrango. The *Anaphalis* plants here are small, not above 50 to 60 cm in height, and the soil is covered throughout with *Stereocaulon graminosum* and especially with *Rhacomitrium lanuginosum*. This moss forms smaller or larger sods among the *Anaphalis*, see plate XXX B; and where *Anaphalis* is failing, large stretches are covered exclusively with this moss. Seen from above such parts give the impression of a ground covered with salt crusts.

In the central part of the aloon-aloon the same plants are found which occur in the crater-valley of Pangrango, with the exception of *Primula*; in

marshy patches as well as in drier parts here and there *Laurembergia* is found with peculiar mite-galls, see figure 39.

At the Western extremity, where the brook flows through a deep gully, a fairly rich flora has developed along its banks. *Ranunculus javanicus, Scirpus fluitans* and numerous other herbs with which we are already familiar, are quite common here.

We follow the footpath which bends away to the South and having clambered up a steep slope we reach the ridge of Mt. Gemuruh. On the southside of this path a cottage of the mountainsports club has been built. To the West goes a footpath in the direction of the small town of Sukabumi. We follow the path along the top-ridge of Mt. Gemuruh, from where we have a view of the aloon-aloon; see plate XXV. This path rises and descends as it follows the mountain ridge which encloses the aloon-aloon in a wide circle. The forest on this ridge is very dense and old, a genuine moss-clad forest; but it is not so luxuriant as that on Mt. Pangrango.

A few hundred yards from the point where we struck the ridge, there is a cave of masonry in the mountain-wall, some 5 m deep, described already by JUNGHUHN [1]). This cellar was built at the suggestion of Mr. DIARD for keeping the eggs of silk-worms at a low temperature. The Government of the Neth. Indies had introduced the silk-culture, but as the cocoons were getting smaller and smaller, some remedy had to be found. Mr. DIARD suggested that this deterioration could be prevented by storing the eggs for a few months at a constant low temperature (in the cellar the temperature was about 10° C.). As this method, however, did not lead to any results the vault was soon abandoned. At present the natives, who no longer know for what purpose it was originally used, sacrifice there.

To the end of the ridge we remain in the forest. Here however where it dips into the eastern part of the aloon-aloon, it becomes thinner-stemmed and less mossy. In this part *Elaeocarpus acronodia* is very common, but otherwise we find here the same plants as in the moss-clad forest of Mt. Pangrango.

The end of the aloon-aloon is closely covered with low brushwood, the soil underneath being clothed with *Lycopodium clavatum*. From this point we follow the central part of the aloon-aloon and finally we reach the footpath leading up the slope of Mt. Gedeh, by which we return home.

7. *To the old crater of Mt. Gedeh.*

Near the Lebak Saät laboratory a more or less horizontal open space forms the remnant of an old crater, which is now almost entirely covered by lava-streams ejected by younger eruption points. This place is reached by passing through the *Vaccinium*-forest in front of the cottage, and then descending by one of the dry gullies, not towards the East, but towards the

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1) FR. JUNGHUHN, Topograph. u. Naturwiss. Reisen durch Java. Magdeburg, 1845. p. 481.

North-West. After pushing our way for a few hundred yards through a dense alpinoid forest, we come upon a rather bare part, mostly level, but with some deep water courses with steep banks. This level stretch bears a few *Albizzias*, most of them dead, and a close vegetation of *Anaphalis*. It is surrounded by the usual alpinoid forest and seen from the higher points it shows like a pale-grey field in the midst of the dark-green forest. Along the latters fringe *Leptospermum* flourishes in special abundance.

On the ground the same flora is found as in the crater-valley of Pangrango and on the aloon-aloon of Gedeh. The soil here is also broken and stony, and bears plenty of *Stereocaulon* and *Rhacomitrium* and many herbs such as *Gentiana, Myriactis, Thelymitra, Swertia, Agrostis* and *Calamagrostis, Gahnia, Carex hypsophila, Lycopodium clavatum* and *L. Wightianum*.

8. *From Lebak Saät via Gunung Sela to Tjibodas.*

We follow the dry boulder-filled gully of the Tji-Saät and turn to the left of the Kawah Wadon to begin our ascension, (see excursion 3), but this time we do not take the right-hand path, but penetrate in the *Vaccinium* forest by a footpath to the left. This forest consists of the usual elements, and is very dark; the trees are thin-stemmed and not very thickly covered with mosses. We follow the crest to the *Anaphalis* ravine which we visited on excursion 5; we cross it and enter once more a *Vaccinium* forest; the path first mounts and then descends steeply over large blocks of lava thickly overgrown with mosses and ferns, and ultimately we come into a ravine under the perpendicular bare southern wall of Gunung Sela. This wall we follow in a westerly direction until it gets less steep and becomes covered with forest, and there we can ascend steeply to the ridge of Gunung Sela, which runs from West to East and is covered with dense alpinoid forest. Turning to the right we reach the extremity of the ridge where we get a wide view, especially over the crater basin of Gedeh itself. On turning to the left, and following the steep rim, we reach a point from where a ridge leads to Tjibodas; here some thin logs have been laid down along the wall to allow the passage from the rim of Sela to the top of the ridge. From there one may descend very steeply over big lava-blocks and through a dense alpinoid forest. The ridge is entirely covered with *Leptospermum* trees. Seen from above in the flowering season the forest looks as if snow clad. This forest is very dense, and the luxurious undergrowth consists among others of *Plagiogyria pycnophylla* and *P. glauca*.

This is a practically unvisited part of the mountain; wild hogs and deer are very common, and the lairs of the former made of heaped up leaves can be frequently observed; panthers occur here also. After descending a few hundred yards we reach a comparatively level part in which many tracks have been laid out. We find here in the alpinoid forest a large number of trees belonging to those to which by S. H. KOORDERS in 1890 number plates were attached. From here a steep path leads along the place

formerly occupied by the shooting-box "Huis ten Bosch" to Tjibodas, taking us out of the fourth zone of JUNGHUHN into the third. We get now the same series of changes as we found in setting forth from Tjibodas to Kandang Badak, but now in inverse order.

PHANEROGAMS, OCCURRING ON THE HIGHER PARTS OF MOUNT PANGRANGO-GEDEH.

GYMNOSPERMAE.

1. Podocarpus imbricata BL.
2. Cupressus sempervirens L.

MONOCOTYLEDONAE.

GRAMINEAE.

3. *Agrostis infirma* BUESE [1]).
4. *Calamagrostis australis* BUESE.
5. Isachne albens Trin.
6. *Isachne pangerangensis* Z. et M.
7. *Poa annua* L.
8. Poa trivialis L.

CYPERACEAE.

9. Carex baccans NEES.
10. *Carex hypsophila* MIQ.
11. Carex longebracteata STEUD.
12. *Gahnia javanica* Z. et M.
13. *Scirpus fluitans* L.

LILIACEAE.

14. Dianella javanica KUNTH.
15. Disporum chinense DON.

ORCHIDACEAE.

16. Calanthe abreviata LINDL.
17. Ceratostylis latifolia BL.
18. Ceratostylis simplex BL.
19. Coelogyne miniata LINDL.
20. Dendrobium cymbidioides LINDL.
21. Dendrobium gracile LINDL.
22. *Dendrobium Hasseltii* LINDL.
23. Dendrobium Jacobsonii J. J. S.
24. Dendrobium Kuhlii LINDL.
25. Dendrochilium cornutum J. J. S.
26. Eria appendiculata LINDL.
27. Eria floribunda LINDL.
28. Eria multiflora LINDL.
29. Goodyera bifida BL.
30. *Myrmechis glabra* BL.
31. Myrmechis gracilis BL.
32. Oberonia Costeriana J. J. S.
33. Phajus flavus LINDL.
34. Pholidota globosa LINDL.
35. *Platanthera Blumei* LINDL.
36. Taeniophyllum glandulosum BL.
37. Taeniophyllum tjibodasanum J. J. S.
38. *Thelymitra javanica* BL.

DICOTYLEDONAE.

PIPERACEAE.

39. Peperomia reflexa DIETR.
40. Piper arcuatum BL.

MYRICACEAE.

41. Myrica javanica BL.

URTICACEAE.

42. Cypholophus lutescens WEDD.
43. Elatostema pedunculosum MIQ.
44. Pilea trinervia WIGHT.

FAGACEAE.

45. *Fagus silvatica* L.
46. Quercus pallida BL.
47. Quercus spicata SM.

LORANTHACEAE.

48. Scurrula lepidota G. DON.

BALANOPHORACEAE.

49. *Balanophora elongata* BL.

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[1]) The names of the plants growing also on the summit of Mt. Pangrango are printed in italics.

POLYGONACEAE.
50. *Polygonum chinense* L.
51. Polygonum longisetum DE BR.
52. Polygonum paniculatum BL.
53. Rumex alpinus L.

CARYOPHYLLACEAE.
54. *Cerastium caespitosum* GILIB.
55. *Drymaria hirsuta* BARTL.
56. Stellaria media L.

RANUNCULACEAE.
57. *Anemone sumatrana* DE VRIESE.
58. Clematis Leschenaultiana DC.
59. Ranunculus diffusus DC.
60. *Ranunculus javanicus* REINW.
61. *Thalictrum javanicum* BL.

MAGNOLIACEAE.
62. Kadsura scandens BL.

LAURACEAE.
63. Litsea cubeba PERS.
64. Litsea javanica BL.

CRUCIFERAE.
65. *Brassica oleracea* L.
66. *Cardamine africana* L. subsp. *borbonica* O. E. SCH.
67. Cardamine hirsuta L.

NEPENTHACEAE.
68. Nepenthes gymnamphora NEES.

SAXIFRAGACEAE.
69. Astilbe indica BL.
70. Dichroa febrifuga LOUR.
71. Hydrangea oblongifolia BL.
72. Polyosma ilicifolia BL.

ROSACEAE.
73. *Cotoneaster species.*
74. *Fragaria vesca* L.
75. Neillia thyrsiflora DON.
76. *Photinia Notoniana* W. et A.
77. *Pirus malus* L.
78. Rosa canina L.
79. *Rosa rubiginosa* L.
80. Rubus alpestris BL.
81. *Rubus fruticosus* L.
82. Rubus Hasskarlii MIQ.
83. *Rubus lineatus* REINW.

LEGUMINOSAE.
84. Albizzia montana BTH.

OXALIDACEAE.
85. *Oxalis corniculata L.*

EUPHORBIACEAE.
86. Daphniphyllum glaucescens BL. var. Blumeanum J. J. S.

CELASTRACEAE.
87. Perrottetia alpestris LOES.

ACERACEAE.
88. Acer niveum BL.

BALSAMINACEAE.
89. Impatiens cyclocoma MIQ.
90. Impatiens javensis STEUD.

ELAEOCARPACEAE.
91. Elaeocarpus acronodia MAST.
92. Elaeocarpus punctata HASSK.

THEACEAE.
93. *Eurya acuminata* DC.
94. Schima Noronhae REINW.

GUTTIFERAE.
95. *Hypericum Leschenaultii* GAUD.

VIOLACEAE.
96. *Viola odorata* L.
97. *Viola pilosa* WALL.

BEGONIACEAE.
98. Begonia isoptera BRYAND.
99. Begonia robusta BL.

MYRTACEAE.
100. Eugenia jamboloides K. et V.
101. *Leptospermum javanicum* BL.

MELASTOMATACEAE.
102. Astronia spectabilis BL.
103. Melastoma setigerum BL.

ONAGRACEAE.
104. *Oenothera species.*

HALORRHAGIDACEAE.
105. *Laurembergia coccinea* KANITZ.

ARALIACEAE.
106. Aralia ferox MIQ.
107. Schefflera lucescens KOORD.
108. *Schefflera rugosa* HARMS.

UMBELLIFERAE.
109. *Pimpinella Leeuweni* WOLFF.
110. *Sanicula europaea* L.

ERICACEAE.
111. Diplycosia heterophylla BL.
112. Gaultheria fragrantissima WALL. var. punctata J. J. S.
113. *Gaultheria leucocarpa* BL.
114. *Gaultheria nummularioides* DON.
115. Rhododendron javanicum BENN.
116. *Rhododendron retusum* BENN.
117. *Vaccinium laurifolium* MIQ.
118. Vaccinium lucidum MIQ.
119. *Vaccinium varingifolium* MIQ.

MYRSINACEAE.
120. Ardisia javanica DC.
121. Embelia pergamacea DC.
122. *Rapanea avenis* BL.

PRIMULACEAE.
123. *Primula imperialis* JUNGH.

SYMPLOCACEAE.
124. *Symplocos sessilifolia* GUERCKE.
125. Symplocos spicata ROXB.

LOGANIACEAE.
126. Geniostoma haematospermum STEUD.

GENTIANACEAE.
127. *Crawfurdia trinervis* HASSK.
128. *Gentiana quadrifaria* BL.
129. *Swertia javanica* BL.

SOLANACEAE.
130. Solanum nigrum L.
131. Solanum tuberosum L.

SCROPHULARIACEAE.
132. *Veronica javanica* BL.
133. Digitalis purpurea L.

GESNERIACEAE.
134. Cyrtandra arborescens BL.

PLANTAGINACEAE.
135. *Plantago major* L.

RUBIACEAE.
136. Argostemma montanum BL.
137. Allaeophania rugosa HOOK.
138. Lasianthus lucidus BL.
139. Ophiorrhiza longiflora BL.
140. *Nertera depressa* BANKS. et SOL.

CAPRIFOLIACEAE.
141. *Lonicera javanica* DC.
142. *Viburnum coriaceum* BL.

CUCURBITACEAE.
143. Melothria punctata COGN.

VALERIANACEAE.
144. *Valeriana Hardwickii* WALL.

CAMPANULACEAE.
145. Pratia montana HASSK.

COMPOSITAE.
146. Ageratum conyzoides L.
147. *Anaphalis javanica* SCH. BIP.
148. *Artemisia vulgaris* L.
149. Bidens pilosa L.
150. Blumea silvatica DC.
151. *Dichrocephala chrysanthemifolia* DC.
152. *Erigeron linifolius* WILLD.
153. Eupatorium pallescens DC.
154. Eupatorium riparium ENGL.
155. Galinsoga parviflora CAV.
156. Gnaphalium indicum L.
157. Gnaphalium longifolium BL.
158. Gnaphalium luteo-album L.
159. *Gnaphalium species.*
160. Gynura aurantiaca DC.
161. Lactuca rostrata BOERL.
162. *Myriactis nepalensis* LESS.
163. *Sonchus asper* L.
164. *Taraxacum officinale* L.

CHAPTER V.

ANIMAL LIFE.

"It must be admitted", writes KONINGSBERGER [1]), "that this region has thus far been very imperfectly studied. The biological exploration of these areas is however attended with so many and such varied difficulties and is moreover so expensive, that our knowledge can increase but very slowly".

JUNGHUHN [2]) refers in his sketch of the fourth plant-zone to a few species of animals and their modes of life. He writes : "No living creature is met in the forest. Nowhere the chirping of an insect is heard and nowhere the singing of a bird is audible, — neither is it necessary to look out for snakes. A dead silence reigns everyhere. The animal kingdom, which in the lower zones shows such a rich variety of forms, the insect-choir, the host of birds, it looks as if they are extinct on these beautiful cool flower-decked mountain tops. The fauna is proportionate to the flora, the variety of plants growing on these narrow mountain tops being also limited. The number of birds and mammals living here, however, is certainly far smaller than the variety of plants. When pushing one's way through the brushwood one sometimes starts a pigeon from its nest : *Columba oxyura (= Sphenurus oxyurus)* and *Columba porphyrea (= Ptilinopus porphyreus)*. More often one sees in the brushwood a black bird resembling a thrush, *Turdus javanicus*, which is so little shy that one may get quite near to it."

"Several of the small trees and shrubs of which the forest is made up and *Agapetes vulgaris (= Vaccinium varingifolium)* and *Gautiera repens (= Gaultheria nummularioides)* also bear sweet black berries, which in addition to the fruits of *Myrica javanica* and of *Eurya tristyla (= Eurya acuminata)* form the main food of these birds. The fine threads of the beard-moss hanging from the twigs form with a little weaving an excellent building material for their nests".

He then passes on to a detailed description of the tracks trodden in these wilds by Rhinocerosses. He describes [3]) the flight of a falcon : *Falco severus*, hovering over a crater, where he also sees numerous swifts on the wing. Towards nightfall flights of yellow birds [4]) of the size of canaries skirt the ground, chirping as they return to their nests. These

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1) J. C. KONINGSBERGER, Java, Zoölogisch en Biologisch. Buitenzorg, 1911—1915, p. 617.

2) FR. JUNGHUHN, Java, Second edition, Vol. I, 1853, p. 608.

3) FR. JUNGHUHN, Java, loc. cit. p. 613.

4) FR. JUNGHUHN, Java, loc. cit. p. 614.

birds are very likely white-eyes, *Zosterops fallax*, now *Oreosterops javanica frontalis*. A small carnivorous animal : *Mustela henrici* is, according to JUNGHUHN, also commonly found.

In later days also naturalists did not report much about animal life and they have left our knowledge as yet very incomplete. But I too am not in a position to furnish a complete survey. The object of my study was an investigation of the pollination and I have consequently occupied myself chiefly with the animals playing a part in it. But on the frequent occasions when I stayed in these parts and on my excursions through the mountain forests I have made observations on other animals also, which ; though far from complete, may be incorporated here. Particulars relating to the pollination of flowers and to the dispersal of seeds by animals are to be found in chapters VII and VIII.

The number of animal species found at these altitudes is comparatively small. Several of them are not confined to these parts but occur also in lower regions ; they visit the mountain tops when there is food to be found for them. As we have seen many plants occur as high up as Kandang Badak, but are absent above that altitude, and the same applies to animals ; in the vicinity of Kandang Badak animal species occur which are not found at higher altitudes or which are at least rare.

THE MAMMALS.

Three kinds of monkeys live in the forests above Tjibodas. The Java Gibbon, *Hylobates leuciscus* is not uncommon, but it usually keeps to the denser inaccessible parts of the primeval forest. On their rambles groups of these small apes get in the neighbourhood of Kandang Badak ; I have thus far not seen them higher up, but, when one stays on the top, one hears their cries rising up from below. Of course it can not be inferred with certainty that these animals do not visit the higher parts, for they are capable of travelling over long distances. In the more open forests in the neighbourhood of the top they do not however find the same conditions of life, food and security, as are afforded to them by the denser forests of lower altitudes. The cause of their absence from the forests round the top is probably to be looked for in reduced security and not in scarcity of food, for a large number of the trees existing there bear edible fruits.

The two species of monkeys : *Pithecus pyrrhus sondaicus* (= *Pithecus maurus*) and *Pithecus aygula* (= *Pithecus mitratus*) seldom occur above 1800 m. I never saw these monkeys at Kandang Badak ; they too seem to feel more at home in the dense forests in the lower zones.

The large Javanese deer *Cervus hippelaphus* and the Muntjak (*Muntiacus muntjak*) often visit the highest tops. Their droppings can be found there, but the animals are rarely seen. Only once I saw two large deer crossing the crater valley of Pangrango and disappearing into the forest,

and once I observed in that part a muntjak. On the grass-covered tops in East-Java for instance on Mt. Hijang, as JUNGHUHN [1]) reports, deer used to be common, but they have been almost entirely exterminated and are now seldom seen; on the Hijang plateau however they are at present increasing again.

Wild boars are still very common in unfrequented parts. In the thick wildernesses of the northern slopes of Gedeh and especially on the slopes of Gunung Sela, a tract hardly ever visited by man, numerous lairs can be found. These nests are built up of leaves, of ferns especially of the very common *Lomaria vestita* and of species of *Carex*. In a large circle round the nest the leaves of the ferns are bitten off close to the rhizome, and the *Carex* stalks near the ground, and this material is heaped in a low pile. The female gets underneath and makes a sort of couch in which the young are born. Which of the two species mentioned by DAMMERMAN [2]) as living in the forests above Tjibodas: *Sus verrucosus* and *Sus vittatus* occurs in the highest part of these mountains, I cannot say. On other mountains also hogs and their lairs can be found on the highest tops. I saw numbers of them on the tops of Gunung Kawi, Sumbing and Gunung Ipis (near Mt. Papandajan). The highest nest was found by my son [3]) in the crater of Mt. Sumbing at 3200 m altitude; it was made of the leaves of *Imperata cylindrica*. The food of these wild swine consists of parts of plants, and also of animals, especially insects and their larvae and earthworms. Carcasses are also speedily disposed of by them, as I [4]) once had an opportunity of observing on Mt. Muriah. A large part of this food they get by digging in the soil, and the ground is sometimes over a large area thoroughly disturbed by them. Tussocks of all kinds of grasses, on the mountain tops of East-Java chiefly those of *Festuca nubigena*, are torn up to get at the grubs living underneath.

According to KONINGSBERGER [5]) these wild hogs visit the higher zones when there is food for them, such as for instance the *Balanophora's* in the higher parts of the mountains in West-Java. It must be remarked, however, that it is not merely a question of visiting, for in various parts of the upper region of Gedeh and also on the tops of other lofty volcanos the animals are permanently present and have their lairs there. That the *Balanophora*'s are used as food by pigs I do not believe, for on my frequent wanderings through these regions I have never seen that they had been gnawed at. The pigs of course plough up large patches of ground in hunting for their

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1) FR. JUNGHUHN, Java, Vol. I, Second edition, 1853, p. 634.

2) K. W. DAMMERMAN, Tjibodas, Zoology. Excursion-guide of the Fourth Pacific Science Congress. Java, 1929, Excursion C. 3, p. 21.

3) HANS DOCTERS VAN LEEUWEN, Beitrag zur Kenntniss der Avifauna der Mittel-Javanischen Vulkane, Soembing und Sindoro. Treubia. Vol. X, 1929, p. 439.

4) W. DOCTERS VAN LEEUWEN, Waar blijven de lijken van de grote zoogdieren, die van ouderdom sterven? De Tropische Natuur, Vol. V, 1916, p. 123.

5) J. C. KONINGSBERGER, Java, Zoölogisch en Biologisch, p. 425 and 614.

food, and in doing so they may lay bare large lumps of *Balanophora*, but otherwise they leave them alone.

Wild pigs are largely pursued and hunted by man, and in these high and often impenetrable regions they are therefore more secure. Their only natural enemies here are probably panthers and wild dogs and in East-Java possibly also tigers.

The panther, *Felis pardus*, is not uncommon in these parts. A few times I came upon its droppings and foot prints on the banks of the brook on the Pangrango top. Sometimes one hears its raucous cry from the forest, and the well near Kandang Badak is one of its watering places. Food in the form of deer but especially of pigs is plentiful, monkeys also appear to be devoured; nor are smaller animals such as dogs despised. In the Muriah mountain, where I stayed in a hut near the forest, a panther feasted on one occasion on chickens' bones thrown away by me.

Another, smaller beast of prey, a species of marten, *Mustela flavigula f. henrici* is said to live here too. JUNGHUHN [1]) calls it common in the forests of mountain tops and came upon it in the Rhinoceros paths. MUELLER [2]) observed it on the crater-wall of Gedeh. I have never seen this animal; it probably preys on birds. According to JUNGHUHN it hunts the mountain-thrush *Turdus javanicus fumidus*.

The Javanese skunk, *Mydaus javanensis* (=*Mydaus meliceps*) is very common. It occurs from Tjibodas to the top of Pangrango, but the animal is not so often seen, because it does not make its appearance till late in the afternoon and carries on a nocturnal existence. On the Pangrango top it sometimes comes forth as early as three in the afternoon. It digs under the grass tussocks and dislodges them and the moss covering of the soil with its naked flesh-coloured snout and strong fore-paws; it is not easily disturbed in its search for food. The latter consists mainly of insects and their grubs and of earth-worms. Large patches of ground are dug up, so that it often looks as if pigs had been at work. The skunk moves slowly with a wobbling gait, and digs up its food, and when it has got hold of something it raises its head and crunches the captured insects. The four short paws are furnished with strong fossorial claws, the snout is pink; it is bare because it is continuously used in digging. The rest of the body is covered with a dark brown fur, marked on the head and throat with a white patch, and on its back with a dark stripe running down to the tail.

The skunk or "stinking badger" is notorious for its habit of ejecting, when disturbed, a highly malodorous secretion. This fluid also lodges in the hairs of its fur so that it carries the offensive smell along with it. The fluid is secreted from two muscular-walled perineal glands discharging into the rectum, and it is squirted from the anus in a spray of small drops which adhere for a long time to the objects touched before they are finally

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[1]) FR. JUNGHUHN, Java I, Second edition, 1853, p. 615.

[2]) S. MUELLER, Over de zoogdieren van den Indischen Archipel.

evaporated. The stench not only affects most unpleasantly our smelling organ, but it attacks the respiratory organs and produces a choking sensation and nausea. Dogs that have attacked the creature and been bespattered try to get rid of the stink, which clearly sickens them by rolling about.

The habits of this unsocial animal are otherwise not yet well known ; in the morning it seems to withdraw in its den ; the young are born there too.

On sunshiny days the odour of the skunk is often clearly perceptible and the wanderer thinks he is crossing its track, but this is not always true : there is a common fern : *Didymochlaena lunulata* which spreads the same sickening smell from the upper side of the leaves, especially when they are heated by the sun. Whether it is the same substance is unknown, but the effect on our olfactory organs is much the same, though not so powerful. In West-Java the natives call the skunk : "sigung" and the fern is called by them "paku (= fern) sigung". As this plant often grows in clusters the stench may be intense. It is certainly a remarkable peculiarity that an animal and a plant occurring in the same area should emit the same odour. To the animal the odour certainly is a powerful means of defence ; what significance it has to the plant would be difficult to find out.

According to the natives there also lives in these parts a wild dog, *Cuon javanicus*, which hunts in packs. This animal is timorous and I have myself never seen it, though I did once hear a kind of barking which probably came from this animal.

Bats occur as far as the highest parts and at Kandang Badak they can often be seen flitting about in the twilight. I do not know however to what species they belong ; they are not included in DAMMERMAN's [1]) list.

The forest above Tjibodas is inhabited by various kinds of rats ; they also occur higher up near Kandang Badak ; on the top of Pangrango I identified one species only, viz. *Rattus lepturus* which occurs also lower down. It is a robust animal, whose thick fur betrays that it belongs to colder regions. The animal lurks in the daytime in the thick moss cushions covering the soil and the tree-trunks, and its habits are nocturnal. Still it may be observed in the early morning hours and shortly before sunset outside its cover. The colour of the coat is a dark brown, the under parts are white and this colour is continued on the nether side of the long tail. An adult animal is about 12 cm long, its tail some 20 cm ; the latter droops or curves upwards, when the animals are running. On the ground they often move with little hops, but they may also be observed in trees. They are very good climbers who can scramble up the thinnest branches of *Vaccinium varingifolium* to secure its berries. Their food consists largely of these edible fruits and the undigested seeds are found in their droppings. Other fruits and seeds too have been found in their intestines. When kept in captivity the animals eagerly accept various juicy fruits, and they un-

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1) K. W. DAMMERMAN, Tjibodas, Zoology. Excursion-guide of the Fourth Pacific Science Congress, 1929.

doubtedly play an important part in the dispersal of the seeds of all sorts of plants in these regions. Near Kandang Badak I once on an afternoon observed such a creature eating the small fruits of *Cerastium caespitosum*; but in that case the seeds themselves were probably used as food. Still it is possible that a few seeds may have clung to the animal's coat and may thus have been carried away and spread.

The Flying Lemur, *Galeopterus variegatus* also lives in the forest and once I observed one on the top of Pangrango.

Another small mammal: a shrew: *Crocidura orientalis* is common both in the forest and in the grassy tracts on the top. This plump black velvety little creature is often moving about in the day-time busily occupied in catching flies. In captivity one of these animals devoured 25 big blow flies in one afternoon; they are very voracious.

When in 1839 JUNGHUHN ascended the top of Mt. Pangrango Rhinocerosses were still living there. At the present day not one is left, but their memory is preserved in the name Kandang Badak (= Rhinoceros corral).

THE BIRDS.

Bird life is scanty on the tops of our volcanos. Several species of birds living in the neighbourhood of Kandang Badak i.e. in the lowest part of the fourth plant-zone, are rare or absent higher up. Small flocks of shrikes, *Crocias guttatus* (= *Laniellus leucogrammicus*), the fan-tail, *Rhipidura phoenicura*, the mountain- bulbul ("kutilan"), *Pycnonotus bimaculatus barat*, the mountain scimitar-babbler, *Pomatorrhinus montanus*, and the small wood-warbler, *Brachypteryx leucophris* occur very regularly round Kandang Badak. The sweet song of *Brachypteryx*, which according to an American visitor resembles that of the American mocking-bird, is heard all day long in that neighbourhood; higher up this little creature grows rarer. *Dicaeum trochileum* (= *Dicaeum flammeum*) is also very general in the forests round Kandang Badak. Like the species of *Scurrula* which are spread by them, the birds grow rarer in the forests higher up, and on the top of Pangrango both are entirely absent.

On the top of Pangrango I observed the following species. The wood-hen *Gallus gallus bankiva* (=*Gallus ferrugineus*) is infrequent there, but its peculiar crowing is often heard from the forests below the top, especially in the early morning hours. The wood partridge, *Arborophila* (=*Arboricola*) *javanica* often scratches up large patches of forest soil in search of its food which consists partly of worms and insects living in the ground and under dead leaves; another part of its food are the fruits of grasses and *Carices* occurring in the forests up to the top; its call is often heard, but it comes from below. This ground partridge is especially in the vicinity of Kandang Badak very common.

A pigeon species, *Macropygia unchall* (= *Macropygia leptogrammica*) is found in the forests of the top, but more common is the fruit pigeon

Sphenurus sphenurus korthalsi. This robust bird also nests in the vicinity of the top. It feeds on the fleshy fruits of various trees, and will therefore come up for further discussion in the chapter dealing with the dispersal of seeds.

A small elegant swift, *Collocalia brevirostris vulcanorum,* nests in crevices in the steep crater wall of Gedeh and often pays "flying visits" to the top of Pangrango. In rapid flight it skims along the open spaces in pursuit of insects. A real swallow, a migratory bird, *Hirundo rustica gutturalis* occasionally visits the top. According to BARTELS [1]), a few flycatchers like *Dendrobiastes hyperythra vulcani* (= *Muscicapula hyperythra*) and *Cryptolopha trivirgata* are living on the top of Pangrango, but I have not yet observed them.

A warbler *Cettia montana,* a small grey bird feeding on insects, steals through the grass tussocks and among the low bushes. Of the thrushes, BARTELS mentions *Oreocincla dauma horsfieldi* and *Enicurus leschenaulti*; the former was observed by me a few times, but the latter I have not yet seen.

Very common, however, is the mountain thrush *Turdus javanicus fumidus,* reported already by JUNGHUHN and by other naturalists. It is a big brown-black bird with a yellow bill, a lively but very tame creature, which whistles its shrill cry chiefly towards evening when they are playing together and dart from bush to bush or bathe in the brook. During the daytime they are seen in the trees on whose fruits they principally live, though all sorts of insects, slugs and worms are not disdained. In May and June I often found their moss-built nests fixed in forks of *Anaphalis* bushes. Once I found a nest with young birds on the steep bank of the brook, where it was concealed among moss and ferns. As it feeds on the pulpy fruits of numerous mountain plants this bird is of great importance for the dispersal of their seeds. Three varieties of this thrush-species exist in the high mountain zone of Java.

On mountains such as on Mts. Sumbing and Sindoro [2]) where plants like *Vaccinium varingifolium* and *Myrica javanica* occur at low altitudes, this bird is also met with lower down, so that their existence seems to depend on the presence of these trees and not the reverse, as VON FABER writes [3]).

The elegant little sun-bird, *Aethopyga eximia* clad in brilliant hues of red and green is also common. It is an assiduous flower visitor, frequenting especially *Rhododendron retusum, Lonicera javanica* and *Rubus lineatus,* but it feeds not only on honey but also on insects.

A white-eye occurs also regularly on the top, usually flying about in small flocks; it differs from the species of the genus *Zosterops* by the

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[1]) W. DOCTERS VAN LEEUWEN, Uit het leven van planten en dieren op de top van de Pangrango. IIIa. de Dieren. De Tropische Natuur, Vol. XV, 1926, p. 63.

[2]) HANS DOCTERS VAN LEEUWEN, Beitrag zur Kenntniss der Avifauna der mittel-javanischen Vulkane Soembing und Sindoro. Treubia, Vol. X, 1929, p. 439.

[3]) F. C. VON FABER, Die Kraterpflanzen Javas. Batavia, 1927, p. 117.

absence of a white ring round the eye and by its size: it is *Oreosterops javanica frontalis* (=*Zosterops fallax*). It is especially busy in the early morning hours, when it utters its high long drawn-out cheeping. Its diet consists of insects and honey, especially from *Vaccinium* flowers, and moreover of fruits. It builds its nest of skilful woven mosses in the branches of *Anaphalis javanica*.

Reptiles and fishes do not occur on the tops. In the lake Rano Kombolo on Mt. Semeru, at ± 2500 m above sea-level, I observed many specimens of a small species of toad and *Ixalus pallidipes* has been described [1]) from a locality near the top of Mt. Pangrango, but I have never seen it.

THE INSECTS.

Insect life on the top of Pangrango is as on the top of other high mountains in Java comparatively poor. DE MEYERE [2]) relates in his description of *Sciara heteroptera* on Mt. Gedeh, that according to ROEPKE, who had made many expeditions to the higher parts of the mountains of Java, all tops are poor in insect life. It depends, however, very much on the weather conditions whether insects do or do not fly; in sunny weather they are seen everywhere, but in rainy or even misty periods they disappear all except the bumble-bees. On bright days, however, the number of insects may be very large. This wealth, however, is not produced by a large number of species but by the large number of individuals of a few species, chiefly of *Diptera*.

Apart from these *Diptera* most groups are represented by a small number of species only; some, indeed, do not occur at all. *Coleoptera* are on the Pangrango top rare; *Libellulidae* (or dragon-flies) also. These predacious insects appear on the top in sunny weather and they prey over the grassy patches and along the brook. It is possible that one or more species are living here and complete their metamorphosis in the brook. Mr. LIEFTINCK told me that *Procordulia sumbawana* might do this, but I have not as yet found any dragon-fly larvae in the brook. *Hymenoptera* and *Lepidoptera* occur on the top in small numbers; *Diptera* however are represented by a fairly large number of species. Various species of *Psyllidae* can also be collected.

I have mainly confined myself to those insects which visit the flowers. A list of them with the plants frequented by each of them, will be found at the end of Chapter VII, which deals with pollination.

Hemiptera-Heteroptera. A small bug c. 2½ mm long, grey-brown in colour, is frequently found on the inflorescences of *Anaphalis javanica*; it is a species of *Nysius*, related to *Nysius sundanus*. It is hardly ever absent

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1) TH. BARBOUR, Some new Amphibia Salienta. Proc. Biol. Soc. Washington, Vol. XXI, 1908, p. 190.

2) J. C. H. DE MEIJERE, Studien über Südostasiatischen Dipteren, VI. Tijdschr. v. Entomologie, Vol. LVI, 1913, p. 320.

from flowering individuals of this plant. Larger kinds, belonging to the genera *Sastragala* and *Adinatia*, are also found in the bushes; they were recorded and depicted by KARNY [1]).

Hemiptera-Homoptera. *Psyllidae* are very common in the bushes. These insects are at home in temperate regions; in the tropical plains they are, with the exception of the gall-producing species not common. On the mountain tops on the other hand they occur regularly. Two kinds cause galls, one on *Photinia Notoniana*, the other on *Symplocos sessilifolia*, see figure 53. The former lives both on the leaves and on the flowers; the leaf-galls are very simple: the two halves of the leaf remain adpressed enclosing a narrow gall-chamber, in which the *Psyllidae* with their larvae live; the exterior of the gall is dotted with irregular knobs, and the whole leaf remains smaller than normal. The infected flowers develop badly, open but partly and they do not form any fruits. In some years the infection is so general that hardly any opened flowers are seen and very few fruits are formed. The other gall, that on *Symplocos*, also arises on the leaves, of which a whole cluster at the top of a young twig usually is infected. In this kind also the leaf remains folded, the two halves become gibbous, and form a spacious gall chamber in which a large number of psyllid-larvae live. The midrib is usually bent in the shape of a bow, so that the gall-tops are turned towards the twig; the infected leaves are not green but white, often with a pale violet gloss. This gall is sometimes so abundant that all young shoots of a tree bear them; the development of psyllids is checked by the larva of a syrphus-fly, living in the gall and feeding on the psyllid larvae.

Thysanoptera. Thripses also occur in a few species on the top. They live in all kinds of flowers; I found them in those of *Anaphalis javanica*, *Dichrocephala chrysanthemifolia*, *Hypericum Leschenaultii*, *Myriactis nepalensis*, *Polygonum chinense* and *Swertia javanica*. One species produces galls at the end of sterile branches of *Anaphalis*. The young leaves remain closely pressed together, forming an irregular clew in which the animals live in all stages of development. In some years these galls are very common, in other years rather rare.

Lepidoptera. On the top of Pangrango the *Lepidoptera* are chiefly represented by butterflies. Various species of *Lycaenidae* occur there, and especially remarkable is the general presence of a species of *Dodona*; the representatives of this genus are on the whole rather rare and represented in collections by very few specimens.

Dodona adonira windu flies regularly in nearly all seasons of the year, but is most numerous from November to July. It occurs also at lower altitudes, as far down as Tjibodas. This butterfly was described by ROEPKE [2])

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[1]) H. H. KARNY, Zum Gipfel des Pangrango (West-Java) Natur. Leipzig. Vol. XIII, 1922, p. 301, fig. 8.

[2]) W. ROEPKE, Eine neue *Dodona* aus dem West-Javanischen Hochgebirge. Treubia, Vol. II, 1921-1922, p. 84.

under the name of *Dodona aponata vanleeuwenii*, but TOXOPEUS [1]) who was in a position to compare material collected by himself in the top of Pangrango with material in European musea, arrived at the conclusion that it is a melanistic form: *vanleeuwenii* of a highly variable species, viz. *Dodona adonira windu* [2]). The ground colour of the male is brown; the wings are marked with black bands. The slightly larger females are pale-blue, giving this impression especially when on the wing; they also bear black bands on the wings. In sunny weather the males may often be seen on the inflorescences of *Anaphalis*, where they sit for a long time with wings adpressed or expanded, sucking now and then in the flowers; after a short flight, they usually settle down again: in this way they remain for hours on the same spot. The females I never saw at rest; they flutter about bushes and trees, and when they are perceived by the males, a headlong whirling flight follows; in which they rise high over the trees, where they are soon lost to sight; afterwards the male usually returns to its resting place. TOXOPEUS suggests that the caterpillars may feed on the leaves of *Primula imperialis*. I have never been able to find them on the leaves of this plant and the latter never show traces of being gnawn by caterpillars. The caterpillar of a related species *Zemeros flegyas javanus*, lives on *Maesa indica*, a *Myrsinacea*; consequently it might be possible that the *Dodona* caterpillar should live on the *Myrsinacea* of Pangrango, viz. *Rapanea avenis*. The leaves of that tree are often badly gnawn, but I have never found *Dodona* caterpillars on them. Moreover *Rapanea* is very common on the mountains of Java, whilst this species of *Dodona* appears to be confined to the Pangrango-Gedeh region, which renders it less probably that the caterpillars of this butterfly should live on *Rapanea*.

According to TOXOPEUS [3]) several other *Lycaenidae* occur on the top, namely, all the species existing at Tjibodas, even *Cosmolyce baetica*. He mentions: *Celastrina ceyx ceyx*; *Celastrina lavendularis floresina*; *Celastrina singalensis astarga* and *Celastrina dilecta paradilecta*. I myself collected among the flower visitors: *Celastrina askasa*.

Vanessa canace javanica, with the splendid blue on its wings, can be found, though rarely, in moist spots, where it sits with wings expanded basking in the sunshine. The ubiquitous *Pyrameis* (= *Vanessa*) *cardui* also occasionally visits the top. The caterpillars of this butterfly feed, according to LEEFMANS [4]) in the lower parts of the mountain, for instance at Tjibodas, on the leaves of *Artemisia vulgaris*. This plant also grows on the top of Pangrango, but I have never found the caterpillars there. These butterflies

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1) L. J. TOXOPEUS, Verslag van de 58ste wintervergadering. Tijdschr. v. Entomologie, Vol. LXVIII, 1926, p. XV; and Vol. LXXII, 1929, p. 216.

2) W. ROEPKE, De vlinders van Java. Batavia, 1932, p. 99, fig. 173.

3) L. C. TOXOPEUS, Eine Revision der javanischen, zu *Lycaenopsis* und verwanten Genera gehörenden Arten. Tijdschr. v. Entomologie, Vol. LXX, p. 234.

4) S. LEEFMANS, Van een cosmopolitische vlinder. De Tropische Natuur, Vol. XIII, 1904, p. 39.

visit the top probably on hot days ; KONINGSBERGER [1]) observed them on the almost bare crater-rim of Gedeh.

Other species of butterflies, *Danais albata* for instance, which is fairly general at Kandang Badak, come to the top also. They may be seen flying up the steep narrow ravine of the Tji-Kuripan, winging their further flight through the open crater-valley, to descend on the other side of the mountain. Especially on hot calm days many butterflies may be observed along that route.

Heterocera were but seldom caught by me, as they do not often come to the light. I once found a large number of *Noctuidae* inside my hut; probably the caterpillars had crept into the bamboo walls to pupate there, and the moths after their emergence had been unable to find the way out. They proved to be *Arcta coerulea*. This moth was found a few times more in the hut, but never again in such large numbers. Another moth occurring on the top is *Agrotis c-nigrum*, it occasionally comes to the light; it is probably the pollinator of the delightfully fragrant terrestrial orchid *Platanthera Blumei*. In several flowers of this plant I had found the anthers empty and pollinia adhering to the stigma and to various other parts, and on the moist stigmata I detected in addition large quantities of moth scales. I have never observed the insects on them in the open, but at one time *Agrotis c-nigrum* visited at night some cut inflorescences of this orchid which had been placed in front of my hut. Other *Noctuidae* I have not observed, though it is probable that a few more species will be living there. Several times I saw caterpillars, but I had no means of hatching them.

Some *Microlepidoptera* are also living on the top, especially *Pyralidae* and *Tortricidae*, which fly up from the grass and bushes when one approaches. Some species fly by day also, such as the common *Scoparia murificalis*, which visits the inflorescences of *Anaphalis*.

Hymenoptera. The number of representatives of this family is on the mountain tops not very large; a few only occur regularly and in a large number of individuals, and must be reckoned among the conspicuous inhabitants of these parts. Some species are among the most active pollinators and are therefore of great importance to plant life.

Fig 8. *Chamaesyrphus nigripes*. DE MEIJ. × 3.

Various species of dark-coloured ichneumons occur and some of them, a.o. one belonging to the genus *Pterocormus* are flower-visitors.

Ants are not only absent from the open part of the top but they are not represented either in the soil fauna of the alpinoid forest. *Vespidae* do occur, however. *Polistes diabolicus*, which I observed here once only as a visitor on the

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1) J. C. KONINGSBERGER, Java, Zoölogisch en Biologisch. Buitenzorg, 1911—1918, p. 618.

flower-heads of *Anaphalis*, but which I also observed on Mt. Papandajan on the same plant, occurs sporadically and is often absent for long periods. ROEPKE [1]) reports this wasp from Mt. Merapi, where he observed large numbers of it as visitors of the flowers of *Vaccinium*. *Vespa velutina* occurs regularly on the top of Pangrango, but never in large numbers. It is probably a visitor only, for I have never as yet found any nests there. They do come on the flowers but not to get vegetable food there, but to hunt the flies that swarm on them. On the top of Gedeh and principally in the bare part of the crater this wasp is very common, nesting there, not in bushes or trees, but against big rocks. For their nests they usually choose the vertical or somewhat beetling surfaces of those rocks and build irregular hemispherical yellowish or gray nests against them. Sometimes they build in the ground. The animals are easily disturbed and very agressive. If one draws near their nest, especially on sunny days, the big wasps come out of their entrance-hole, to crawl about nervously on the surface and then on the slighest provocation to attack suddenly in large numbers. They are consequently held in great fear.

Fig. 9. *Pegomyia bistriata* STEIN. × 3.

Commoner than this wasp is the honey-bee: *Apis indica*, but it does not live regularly at the top. It sometimes visits it for several days at a stretch, then disappears again for a long time; nests of this bee I have not as yet found here. One often sees it sucking in moist spots, but it also visits a number of flowers to collect honey and pollen. On the top of Pangrango I observed it on *Eurya acuminata*, *Symplocos sessilifolia*, *Fragaria vesca*, *Lonicera javanica*, on the former two plants in large numbers, on the latter two a few times only. It is however to be found most numerously on the capitula of *Anaphalis*, on which it remains busy a long while, to fly away laden with the orange pollen grains. In lower parts I watched this bee also on various plants.

The most important insect for pollination is the thick-haired black bumble-bee: *Bombus rufipes* var. *obscuripes*. It is always to be found on the top, both in sunny and in overcast cloudy and rainy weather; it disappears during heavy showers only. I observed them on windy misty days, visiting the flowers of *Lonicera* on their swishing twigs. They start their labour already before the first sun rays are seen in the crater-valley and do not cease till after sunset. On the top one usually sees the small workers, the much heavier females I saw

Fig. 10. *Megaspis zonalis* F. × 2.

[1]) W. ROEPKE, Ueber den Höhenflug des Männchen von *Polistes diabolicus* SAUSS. Tijdschr. v. Entomologie, Vol. LIX, 1916, p. 175.

occasionally near the top, so that I presume they will also nest there, but I have not found as yet any nests. In the lower regions those nests are not rare; they are made in a cavity in the ground, under the roots of trees or under stones. The two nests I examined consisted of an irregular lump of rounded cells resting on a layer of grass-stalks. The creatures are not very agressive, unless their nest is disturbed, but then they will sting viciously. KONINGSBERGER [1]) says of them "their nature is very mild, and even when troublesomely disturbed they confine themselves to a buzzing demonstration".

This bumble-bee is present throughout the year, in the dry season however the number of individuals visiting the top diminishes. By their unceasing activity they are among the most effective pollinators; in the chapter on pollination this value will be discussed at some length. They are found on all high mountains; wherever there are plants, they too are present. They also occur at lower altitudes, but not below 1200—1400 m. At this elevation they occur together with the carpenter bees *Xylocopa*, which in lower areas fill the part of the bumble-bee as flower visitors. On Mt. Kawi I observed another kind of bumble-bee, with much smaller males; they are also dusky, but they are chiefly characterized by the brown-haired end of the abdomen; it is *Bombus rufipes*, var. *flavipes*.

Fig. 11. *Eristalis bicornutus* DE MEIJ. × 2.

Diptera. On sunny days, especially in the months of May to July, these insects swarm on the top both in a large number of species and of individuals. KONINGSBERGER and TOXOPEUS [2]) also point to the abundance of flies; the latter writes: "Um die *Anaphalis* Blüten summt es von Tausenden Fliegen". These creatures are, however, very sensitive to weather conditions; in sunshiny weather they appear in crowds and fly from flower to flower. Sometimes the hover-flies are so numerous that their humming noise is distinctly audible. In rainy and foggy weather, however, they hide. On days when bright intervals and clouds alternate they are seen everywhere during the sunny spells, but as soon as clouds screen off the sunshine they vanish.

BECCARI [3]) was also struck with the large numbers of flower-visiting *Diptera*. The species collected by me were investigated and described by DE MEYERE [4]); the older material collected on the top of Pangrango by

[1]) J. C. KONINGSBERGER, loc. cit., p. 617.

[2]) L. C. TOXOPEUS, Eine Revision der Javanischen zu *Lycaenopsis* und verwandten Genera gehörenden Arten. Tijdschr. v. Entomologie, Vol. LXX, p. 234.

[3]) O. BECCARI, Malesia, Vol. I, Fasc. III, p. 219.

[4]) J. C. H. DE MEYERE, Studien über Südostasiatischen *Dipteren*. No. XVI. Tijdschr. v. Entomologie, Vol. LXVII, 1924, p. 214.

KONINGSBERGER had already been described a few years before by that eminent expert on *Diptera* [1]).

The dark-blue tinted *Calliphorines* are especially prevalent, flying about everywhere and penetrating even into the hut where they often become a nuisance by their tiresome buzzing.

The *Syrphidae* or Syrphus-flies are the most generally representatives of this insect group. They are regular guests of a great variety of flowers, but mostly of the flower-heads of *Anaphalis javanica*. Very common is the small species *Chamaesyrphus nigripes*, see figure 8, which I caught on 17 different species of flowers. General also are *Syrphus confrater*, *S. koningsbergeri*, *S. serarius*, *S. serarioides* and *S. latistrigatus*, and *Eristalis bicornutus*, figure 11. The large *Megaspis chrysopygus* and *M. zonalis*, figure 10, I found on Pangrango only on very dry hot days in the month of July.

Fig. 12. *Syrphus latistrigatus* DE MEIJ. × 2.

The names of the species collected by me are to be found in the list of pollinators. A few species have not yet been identified. It is very likely that most species come to the top as visitors only, as this small top affords but few suitable breeding-places. They breed and develop mostly in the lower zones. In the rainy season I found the larvae of two species of hoverflies in the moss-grown marshy spot near the source of the brook, but I did not succeed in rearing the imagines. Larvae of another species I found in the galls caused by *Psyllidae* on the leaves of *Symplocos sessilifolia*. The larva is comparatively small and it develops into the common species of *Chamaesyrphus*, mentioned above. I often noticed the adult fly sitting on the galls.

A big rough haired *Tachinid*: *Goniophama braueri* is very common, but I never as yet saw it visiting any flowers. This insect is reported by KONINGSBERGER [2]) also as an inhabitant of these regions; he was unable to discover its host, and I have not succeeded either. Besides this species are found a number of smaller ones, most of which visit flowers. They are: *Servilliopsis buccata*, figure 13, *Servillia flavopilosa*, *Echinomyia angulata*, and *Bucentes nigripalpes*.

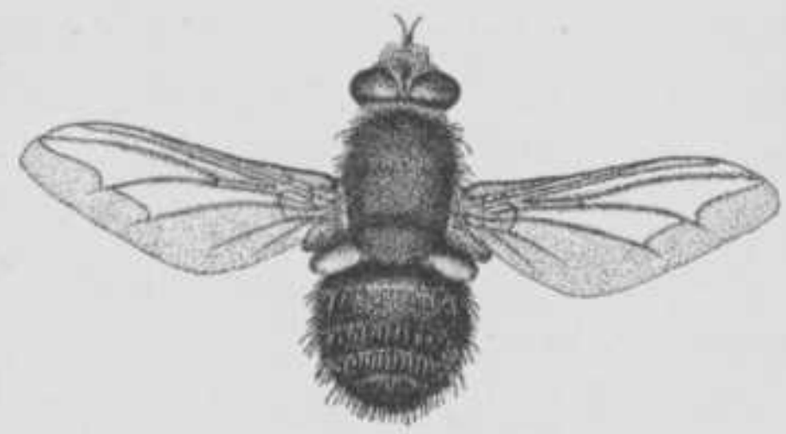

Fig. 13. *Servilliopsis buccata* TOWNS. × 3.

Among the *Anthomyiidae* occur also several flower-visitors. I collected: *Limnophora prominens*, *Lispocephala boöps*, *Pegomyia bistriata*, figure 9,

1) J. C. H. DE MEYERE, Studien etc. No. IX. Tijdschr. v. Entomologie, Vol. LVII, 1919.

2) J. C. KONINGSBERGER, loc. cit., p. 618.

and *Coenosia anipila*. They belong to the smaller species. These flies occur regularly on a large variety of plants.

Very common, but only on the capitula of *Anaphalis* is a beautifully marked tiny *Trypetine: Tephritis montana*. There occurs another as yet unidentified representative of this family. An elegant slender little fly: *Rhadinomyia orientalis*, which belongs to the *Ortalinae* is very common, and is especially to be found on *Anaphalis*. It very often comes to the lamp-light in the evening. The *Bibionid*: *Dilophus nigriventris* is also one of the flower-visitors.

Of the *Muscidae* may be mentioned: *Calliphora fulviceps, Idiella quadrimaculata*, and *Idiella unicolor*, all flower-visitors. Other representatives of this family which, as they do not visit flowers, have not been collected by me, are also present. Various blow-flies are very common and they are often troublesome. On nearly all high tops these blue-bottles can be seen in huge numbers and the question arises: on what do the larvae of these flies live? Among natives the idea is current that larger animals such as swine, deer, and panthers repair to the mountain tops when they are ill, so that the latter must be strewn with the carcasses of these animals. Personally I have never come upon the corpses of those animals, but the large numbers of blow-flies occurring here would lend plausibility to this supposition. These flies swoop down on all kinds of meat and also on woollen blankets and thick clothes, on which they often deposit their larvae.

DAMMERMAN [1]) investigated the fauna of the soil, and the animals living on the surface among dead leaves and in the moss cushions. On the top of Pangrango he did not find a single ant, but there were a few species of beetles belonging to the families of the *Carabidae* and *Staphylinidae*. In addition there frequently occur larvae of *Diptera*, and *Hemiptera*. In the moss cushions he found a thrips of the genus *Rhaebothrips*. Apart from insects the soil fauna also comprised: *Aptera, Oniscoidea, Myriapoda, Arachnoidea*, among which there were spiders and mites, and finally also *Molluscs* and worms.

In this moist habitat with its thick moss cushions a rich fauna of *Molluscs* might reasonably be expected, but the latter is in fact limited to a number of very inconspicuous forms. Miss W. VAN BENTHEM JUTTING informed me that at 2400, 2800 and 2900 m on Mt. Gedeh and on Mt. Pangrango she had collected the following species: 2 kinds of *Diplomuratina, Clausilia* spec., *Parmarion* spec., *Lamprocystis* spec., and *Carychium javanum*.

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[1]) K. W. DAMMERMAN, First contribution to a study of the tropical soil and surface fauna. Treubia, Vol. VI, 1925. p. 107.

CHAPTER VI.

FLOWERING PERIODS OF PLANTS ON THE TOP OF MOUNT PANGRANGO.

A knowledge of the flowering times is of the utmost importance in an ecological study of the plant communities, and it is quite necessary for the study of the visiting and pollinating by insects.

In works of a floristic nature the data on this subject are scant and moreover seldom sufficiently reliable. In the "Exkursionsflora" of S. H. KOORDERS nothing is said about flowering times; in the fragments of a manual of the Flora of Java by C. A. BACKER, on the other hand, of most plants the time of anthesis is given.

Such dates are of course valuable only if collected with an expert knowledge of the facts and with the necessary insight. The flowering seasons are however as a rule gathered from the notes on the collecting labels of Herbarium specimens. Plant collectors of course gather material as far as possible from plants in flower, but the labels very rarely contain information with regard to the number of individuals found in that condition. As a consequence the dates in such works show only in what months flowering material was collected, a kind of information which is scientifically worthless because too vague. Moreover such dates are often completed by interpolation, i.e. when blossoming material has been collected in different months but not in some months between, those intervening months are often included in the flowering period, which may mean a misrepresentation. If the difficulties are already great in a smaller flat country like Holland with a comparatively uniform climate, those difficulties become almost insurmountable in a tropical country like Java with its vast range of variety in altitude and climate and the attendant differences in ecological conditions; it is obvious that considerable variations in the flowering seasons of the plants must correspond to these differences.

A continuous observation of the plants in a well defined area is necessary to find out in what seasons of the year they have their main flowering-periods there, and when they bear few or no flowers.

A few plants may be discussed to illustrate this; and for this purpose plants have been selected from a single mountain, Pangrango, and only such as occur at its top.

Of *Anaphalis javanica* flowering material may be collected in almost every month. On studying the florescense it was found however that so very few individuals of this plant flower from September to February,

that they may be neglected. In March and April more plants begin to bear flowers and in May a fairly large number are already in bloom. The main flowering however falls in June and July ; in August the number of flowering individuals begins to shrink considerably, fruits instead of flowers are then developing on the plants.

Swertia javanica flowers on the top of Pangrango in the months of May, June and July. In the other months an occasional flowering plant and sometimes a small colony of flowering plants may be found here or there, but of this plant also the florescence may at this season be put at nihil. On Mt. Lawu I collected *Swertia oxyphylla* [1]) in November 1925. A large number of individuals had passed out of flower and had withered down to the root-stock, after a long search however a few blossoming ones could be discovered. Of this plant also the principal flowering season falls much earlier in the year.

A comparatively small difference in altitude causes in some plants a variation in the flowering period. *Primula imperialis* grows on Pangrango from about 2400 m upwards to the top, where it occurs most abundantly : the individuals in lower areas regularly flower a good deal earlier than those on the top, the difference sometimes amounting to more than a month. The same thing is to be observed in the flowering-period of *Carex hypsophila,* which likewise occurs both at the top and in lower parts of Pangrango. On Mt. Lawu I noticed [2]) that the individuals of *Thalictrum javanicum* occurring upwards of 3100 m high did not flower, whilst those at altitudes between 2000 and 2800 m were in full bloom. In June 1920 *Strobilanthes cernuus,* on Mt. Gedeh, was entirely past flowering below 1800 m, but was still in full flower at higher altitudes. These examples might be easily and copiously added to.

ZOLLINGER [3]) makes a similar observation in his description of an excursion to the summit of Mt. Salak near Buitenzorg and writes : "In ascending the mountain one observes certain plants which flower later as the altitude increases, so that at the mountain's foot one finds ripe fruits, a little higher unripe ones, a little higher still, the open flower and finally nothing but buds".

It is well known to climbers of the high volcanos of Java that the tops are richest in colour in the months of May and June. This applies also to Pangrango-Gedeh ; this wealth of colouring is caused by the flowering of numerous plant species and furthermore because at that time of the year most of them expand their new leaves. The young foliage of the mountain plants namely is largely coloured in bright reds and browns. Seen from Pangrango the top of Gedeh appears suffused with a red glow ; this

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[1]) W. M. DOCTERS VAN LEEUWEN, De alpiene vegetatie van de Lawoe-vulkaan in Midden-Java. Natuurk. Tijdschr. v. Ned. Indië, Vol. LXXXV, 1925, p. 37 and p. 45, no. 44.

[2]) W. M. DOCTERS VAN LEEUWEN, loc. cit., p. 37.

[3]) H. ZOLLINGER, Togt naar de Salak. Natuur en Geneeskund. Archief voor Nederl. Indië, Vol. I. 1844. p. 243.

colour is produced chiefly by the bright red of the young leaves of *Vaccinium varingifolium,* which forms the greater part of the vegetation.

Of most plants flowering material may be gathered in the forementioned months, while towards the end of the year the number of florescent plant species and individuals grows considerably less. This phenomenon drew my attention, and suggested to me the existence of a periodicity in the florescence of the plants on the mountain-tops, in relation with the periodicity of the climate. As will have appeared from the discussion of the climate, even the top of Pangrango with its abundance of rain shows a difference in humidity, rainfall and sunshine between the months of the Westmonsoon and those of the Eastmonsoon. From the curves reproduced on p. 37 and 42 it will be seen that the average rainfall is greatest in the months of January and February and least in July ; inversely the average percentage of sunshine is least in the former months and highest in July. Though in many years the Eastmonsoon on this top is delayed and high humidity may still prevail for weeks in July and August, the periodicity referred to above always remains perceptible. My surmise, however, that the florescences should be connected with this climatic periodicity, soon proved incorrect. There are plants which flower regularly throughout the year and others whose anthesis is restricted between narrow limits. It therefore proved necessary to collect data as far as possible of all plants on the top with regard to their flowering-time. The investigation would have been most exact if it had been possible to note regularly the numbers of individuals of each species, side by side with the numbers of plants in flower. This was of course impracticable as such counts would have occupied a far too large part of the few days available, apart from the fact that in a dense vegetation it is not always possible to determine with certainty the number of individuals of a plant species without pulling up and thus destroying the plants. In the forest this is even entirely out of the question.

It has not been possible to collect sufficient material of all plant species, as some of them occurred in too few individuals, and these are consequently left out in the following discussion.

On each visit I noted in a list my impression of the florescence of the various plants, that is, whether many, a fair number, few or no individuals of a species bore flowers. When an occasional plant was in flower here or there the flowering was regarded as nihil. Of course this method is not an exact one, but by regularly visiting all parts of the top I was able to gather sufficient data. Some practice and the habit of surveying the flowering a few times on each visit, afforded me the necessary routine in collecting amply sufficient data for a survey.

Data acquired in this manner of 32 plant-species are brought together in a table I; the Roman figures at the tops of the 12 main columns denote the 12 months of the year, the figures over the narrower colums stand for the years when the observations were made. The initials of the above

terms of frequency (m., f.m., f. or n.) then denote the greater or lesser wealth of flowering plants of each species. If for a given year no sufficient impression could be obtained concerning one or more plant species this was indicated by a dash (—). In the first few years it was not always possible for me to form my opinion with sufficient certainty, but this grew easier as time went on.

Finally figures were substituted for the words: 3 (many), 2 (a fair number), 1 (few), 0 (none) and with these figures curves were drawn showing at a glance when the chief florescence occurs. These curves are reproduced in the chapter dealing with the biology of the respective plants.

The table shows that each plant has its own flowering time, that is a time when the largest number of individuals bear flowers; I will call this the main florescence. When grouping the flowers according to the incidence of their main florescence it will be found that no general rule emerges. The groups which can be distinguished have been given below, but even among the plants thus grouped together there are marked differences in the matter of the main florescence.

First group. This comprises the plants which flower with about equal frequency throughout the year. Sometimes, especially in years when the dry season (Eastmonsoon) is clearly marked by a long spell of dry weather, the florescence shows a decline in the months of August to October, and especially in September. Plant species which occur both in shady localities and, though less generally, in more open patches, are chiefly subject to this climatic influence, for instance *Polygonum chinense, Ranunculus javanicus* and *Rubus lineatus*. Plants such as *Sanicula europaea, Viola pilosa* and *Thalictrum javanicum* (I refer exclusively to plants on the Pangrango top) which grow mostly in shaded positions, do not show this decline to the same degree. In December 1924 and 1925 *Thalictrum* was not so richly in flower as usually in that month.

The plants of this group therefore care little or nothing about alterations in the weather conditions; they are largely herbs which live mostly in the shade and are consequently not so much affected by the dry monsoon as are trees and shrubs, which are more exposed. *Cerastium caespitosum* grows preferably in open patches or among grass tussocks above which it rises, in sunny spots therefore. Accordingly this plant shows a noticeable decline in florescence in the months from July to October or November.

Second group. This comprises plants that have their main anthesis in the drier months. It is composed of a large number of plants and they differ among themselves in the duration of the florescence and in the months in which it falls. *Anaphalis javanica* flowers especially in June and July; *Hypericum Leschenaultii* from May to August; *Leptospermum* in May and June; *Vaccinium varingifolium* and *laurifolium* flower chiefly in May; *Swertia javanica* also has a brief main florescence, in June. On *Vaccinium*

varingifolium flowers may be found in various months, but in April the proportion of plants in flower increases greatly, whilst in May everything is in full flower. *Leptospermum* and *Swertia* on the other hand bear few or no flowers during the greater part of the year, so that these may be neglected ; suddenly they begin to flower, and cease as suddenly.

None of these plants have their main florescence confined to the driest month of the year, viz. July, and neither to August or to September, when the rainfall begins to increase again ; they flower especially in May and June, that is partly in the transitional period from the wet to the dry season.

Curious is the behaviour of *Thelymitra javanica,* which forms as it were a transition between the plants of the second and of the third group. The anthesis proper starts in the rainy month of February, it develops its full florescence from March to June, but plants in flower are still to be found in July and in August, that is some individuals are delayed and have fallen behind the main body ; when of the majority the aerial parts have already withered a few individuals are still flowering. On the top of Gedeh on stony ground among alpine scrub I found a plant in flower as late as October 27 (1929). Of this plant the main florescence therefore extends from the latter part of the rainy season until well into the dry season.

Third group : Plants whose main florescence falls in the rainy season. These plants also show differences among themselves as regards the months in which they chiefly flower and the duration of the florescence. *Plantago major* already starts flowering in August, but the main florescence does not begin till October and extends till January, after which the flowering sinks into insignificance. Of *Gentiana quadrifaria* flowering specimens may indeed be found throughout the year, but from March to June the number of plants in flower is comparatively low ; the richest flowering of this plant belongs to a period from August to February, that is from the end of the dry season to the month with the heaviest rainfall. *Laurembergia coccinea* flowers little in the months from September to December ; I do not possess any notes as to its flowering in January ; the main florescence falls from February (perhaps January?) to April, which is intelligible, as this plant grows either in the brooks or alongside in marshy patches which go dry in the Eastmonsoon. *Primula imperialis* has its main florescence in the rainy months December to February though it is possible to gather flowering material of this plant almost throughout the year. *Eurya acuminata* has its main florescence in the same months as *Primula,* but also in the dry months specimens in full bloom may be found. *Symplocos sessilifolia* on the other hand practically does not flower from February till September ; the flowering starts suddenly in October, but is at its height from November to February ; *Gaultheria nummularifolia* has its main flowering season from December to March.

Fourth group. This is constituted by those plants whose florescence

TABLE I.

	I	II			III			IV		V			VI			VII		VIII		IX		X		XI		XII	
	'20	'21	'22	'27	'20	'21	'23	'25	'27	'20	'21	'24	'19	'24	'28	'20	'25	'21	'24	'21	'27	'21	'24	'21	'25	'23	'24
Anaphalis javanica . . .	n	n	n	n	f	f	f	f	f	f	f	fm	m	m	m	m	m	f	f	f	f	n	n	n	n	n	n
Cerastium caespitosum . .	fm	m	m	—	m	m	m	m	m	m	m	m	m	m	fm	m	f	m	m	fm	f	fm	m	m	f	m	m
Eurya acuminata	m	m	m	m	f	f	f	f	f	f	f	f	—	fm	f	fm	fm	m	fm	f	fm	fm	m	m	fm	m	m
Gaultheria leucocarpa . .	m	f	fm	m	—	m	fm	fm	fm	—	m	m	fm	fm	m	fm	f	f	m	f	m	m	m	m	f	m	m
Gaultheria nummularioides	m	m	m	—	—	m	—	fm	fm	—	f	m	—	n	n	n	n	n	fm	f	fm	fm	fm	m	f	f	m
Gentiana quadrifaria. . .	m	m	m	m	f	f	f	f	f	f	f	fm	f	n	f	f	n	m	—	m	m	m	m	m	m	m	m
Hypericum Leschenaultii .	f	f	f	—	f	f	f	f	f	fm	m	m	m	m	m	m	m	m	fm	fm	n	f	n	f	n	n	f
Laurembergia coccinea . .	—	—	m	—	—	m	—	m	m	+	f	m	—	m	n	—	n	n	n	n	fm	fm	n	—	n	n	fm
Leptospermum javanicum.	n	f	f	n	n	f	n	n	n	f	f	m	m	m	m	f	f	n	n	n	n	n	n	n	n	n	n
Lonicera javanica	m	f	fm	fm	m	f	m	m	m	fm	m	m	fm	m	m	m	m	m	m	m	fm	m	fm	m	f	fm	m
Photinia Notoniana . .	f	f	f	f	fm	f	fm	f	fm	m	f	fm	fm	fm	f	f	f	n	n	n	n	n	n	m	f	n	fm
Pirus malus	n	fm	fm	n	f	n	f	n	f	fm	n	n	n	n	n	n	n	n	n	n	n	n	n	—	n	n	n
Plantago major	m	f	fm	n	f	f	f	n	n	n	f	n	n	n	n	n	n	f	f	f	f	m	m	m	m	m	m
Platanthera Blumei . . .	m	m	m	—	fm	m	f	—	—	fm	fm	f	—	n	f	—	f	n	f	n	—	f	—	m	—	n	—
Polygonum chinense . . .	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	fm	fm	fm	fm	m	m	m	m
Primula imperialis	m	m	m	m	m	m	fm	f	f	f	m	f	f	f	f	n	f	f	f	f	f	f	f	m	fm	m	m
Ranunculus javanicus . .	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	fm	fm	fm	fm	fm	fm	fm	m	m	m
Rapanea avenis	f	n	f	f	f	f	f	f	fm	m	fm	f	—	n	—	n	m	n	n	n	n	n	n	f	f	n	f
Rhododendron retusum. .	f	f	f	fm	f	f	f	f	m	f	m	f	f	f	f	fm	f	n	n	n	n	n	n	f	n	f	f
Rubus lineatus	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	fm	m	fm	m	m	m	m	m
Sanicula europaea. . . .	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
Schefflera rugosa	f	n	f	f	f	f	n	n	n	f	f	f	—	—	f	—	f	fm	f	fm	f	fm	f	f	f	n	f
Sonchus asper	fm	n	f	m	f	f	f	m	m	f	m	–	m	n	f	—	f	n	n	n	f	n	n	—	n	m	m
Swertia javanica	n	f	n	n	f	f	n	n	n	f	f	m	m	m	m	fm	fm	n	n	n	n	n	n	n	n	n	n
Symplocos sessilifolia . .	m	n	n	n	n	n	n	n	n	n	n	n	f	n	n	n	n	n	n	n	n	—	fm	m	m	m	m
Thalictrum javanicum . .	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	f	m	f
Thelymitra javanica . . .	n	fm	m	fm	m	m	m	m	m	m	m	m	m	m	fm	f	f	f	n	f	n	n	n	n	n	n	n
Vaccinium laurifolium . .	n	n	f	n	f	f	f	f	f	m	m	m	f	f	n	n	f	n	n	n	n	n	n	n	f	n	n
Vaccinium varingifolium .	f	f	f	fm	f	f	f	f	m	m	m	m	f	f	f	f	f	f	f	f	f	f	f	fm	f	f	f
Valeriana Hardwickii . .	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
Veronica javanica. . . .	m	—	—	—	—	—	f	m	m	—	—	f	—	f	—	—	—	—	f	—	n	—	f	—	—	f	—
Viola pilosa	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m

is spread irregularly over the year. This impression of mine may have arisen partly from the meagre number of specimens of these plant-species occurring on the top of Mt. Pangrango, partly from factors which are unknown to me.

Of *Rhododendron retusum* and *Schefflera rugosa* but few individuals are found on the top itself. *Gaultheria leucocarpa* is however fairly common on the top of Pangrango, and it flowers almost uninterruptedly all the year round, and always plentifully or fairly so. The main florescences fall from October to January and then again in May. *Lonicera javanica* shows the same behaviour, but the two main florescences come from April to August and then again in January. *Photinia Notoniana* occurs in large numbers, but the florescence is not specially abundant in any month. In November 1921 I saw many flowering individuals; in the same month of 1925 (a particularly dry year) there were on the contrary very few plants in bloom. The irregularity in the case of this plant may possibly be accounted for by infection by *Psyllidae*, by which the leaves and flowers are frequently badly attacked.

Table 2 on pag. 90 contains the data derived from observations on 19 plants of general occurrence, nearly all of them with a well marked main florescence; the flowering of these plants has been expressed in monthly figures. By adding up the figures of the columns a series of 12 monthly totals is obtained, which can be set out in a curve, figure 14

Fig. 14. Monthly averages of flowering on the top of the Mt. Pangrango.

The manner of arriving at this curve is a rough and ready one, and it does not pretend to be exact, but it does nevertheless show at a glance that the greatest general florescence falls in May, and that it gradually declines to September; after that month there is a renewed increase until a second

maximum is reached in January. Subsequently the flowering sags again, keeping at about the same level in March and April, and increasing suddenly in May.

This tallies with the general experience that the Pangrango top shows

TABLE II.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Anaphalis javanica	—	—	1	1	2	3	3	1	—	—	—	—
Eurya acuminata	3	3	1	1	1	1	2	2	2	2	2	3
Gaultheria leucocarpa	3	2	2	2	3	2	2	2	2	3	3	3
Gaultheria nummularioides	3	3	3	2	2	—	—	1	1	2	2	3
Gentiana quadrifaria	3	3	1	1	1	1	1	3	3	3	3	3
Hypericum Leschenaultii	1	1	1	1	3	3	3	2	1	1	1	1
Leptospermum javanicum	—	—	—	1	3	3	1	—	—	—	—	—
Lonicera javanica	3	2	2	3	3	3	3	3	2	2	2	2
Photinia Notoniana	1	1	2	2	2	2	1	—	—	—	1	1
Plantago major	3	1	1	—	—	—	—	1	1	3	3	3
Polygonum chinense	3	3	3	3	3	3	3	3	2	2	3	3
Primula imperialis	3	3	2	1	1	1	1	1	1	1	2	3
Ranunculus javanicus	3	3	3	3	3	3	3	2	2	2	2	3
Rhododendron javanicum	1	1	1	1	2	1	1	—	—	—	1	1
Swertia javanica	—	—	—	—	2	3	2	—	—	—	—	—
Symplocos sessilifolia	3	—	—	—	—	—	—	—	—	2	3	3
Thelymitra javanica	—	2	3	3	3	3	1	1	—	—	—	—
Vaccinium laurifolium	—	—	1	1	3	1	—	—	—	—	—	—
Vaccinium varingifolium	1	1	1	2	3	1	1	1	1	1	1	1
	34	29	28	28	40	34	28	23	18	24	29	33

the greatest wealth of colouring in May; after that month the number of flowering individuals diminishes, whilst a rapid increase of the blossoming accompanies the setting in of the rainy season. The decrease of the flowering in the rainy season after January is not so marked as in the dry months. For botanical excursions in the mountains the months of May and June are generally the most favourable, because then the largest number of plant species are in flower, and the weather too is pleasanter

than in December and January. But in the latter period as well, there are a great many plants in bloom and to a large extent other species than in May and June.

This investigation has shown that there is no general periodicity in florescence corresponding to the climatic periodicity, but that each plant behaves in its own way.

Plants flowering in the rainy season are less favourably circumstanced as regards pollination than those flowering in the dry season, because in the rainy season there are with the exception of *Bombus rufipes* hardly any pollinating insects about. Those plants are consequently less visited than those flowering in the dry season, and they have therefore fewer chances of cross-pollination. We shall see in the following chapter how this difficulty has been solved.

CHAPTER VII.

POLLINATION.

If our knowledge of pollination in the tropics in general is scant, that of pollination of the higher parts of the mountains in the tropics is practically non-existent. In the publications of older authors notes are occasionally met with as to insects visiting flowers on the higher mountain-tops. A summary of these data has been given in the chapter on the fauna. They, however, are sadly fragmentary, and do not afford us a clear insight. We read that insects such as wasps and bees visit certain flowers, but what part they take in pollination is seldom stated. BECCARI [1]) for instance, mentions that the capitula of *Anaphalis javanica* are often visited by *Diptera ;* and KNUTH made some observations during his visit to Mt. Pangrango, which have been incorporated in his standard-work on floral biology. All these and other data drawn from the literature have been embodied in the descriptions of the various plants in Ch. IX.

What follows here rests entirely upon my own observations made in the course of years on Pangrango-Gedeh and on many other volcanic peaks of Java. I have compared these observations with those concerning the pollination of mountain plants published in SCHRÖTER's [2]) manual by the well-known flower-biologist GÜNTHART.

On passing from the plains into the alpine regions in Europe, the observer is impressed with the wealth of flowers, the density of the floral carpet and its rich colouring. This impression is even stronger on ascending the high mountains in the tropics. Especially where the lowlands are still covered with primeval forest, flowers impart but little colouring to the scene. Those of the trees are mostly confined to the topmost branches and the undergrowth is composed partly of saplings, which do not flower as yet, and partly of shrubs and herbs whose flowers are inconspicuous. These plants moreover are strongly intermixed so that closed communities consisting of a single species are rarely met with. A long search must often be made in the forest for a plant in the flowering stage. This alters however as one ascends higher in the mountains. Already in JUNGHUHNs third zone that is between 1500 and 2500 m altitude, there is a decreasing number of species and the trees become less tall, especially in the higher parts. More light penetrates through the canopy and there is more likelihood of finding several individuals of the same species near to each other.

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[1]) O. BECCARI, Malesia, 1878, Vol. I, Fasc. III, p. 221.

[2]) C. SCHRÖTER, Das Pflanzenleben der Alpen, Second edition, A. GÜNTHART, Die Blütenbiologie der Alpenpflanzen, 1923, p. 1028.

Between 1600—1800 m the undergrowth in the forest on the slopes of Mt. Gedeh and also of some other Javanese volcanos consists largely of the frutescent *Strobilanthes cernuus*. For several years no flowers are produced till at length all the plants burst almost at the same time into flower. The undergrowth is then shrouded in white by the thousands of its inflorescences.

Not till one reaches the higher regions with their sub-alpine, or perhaps better tropically alpine or alpinoid flora, does one find a greater abundance of bright flowers; now the landscape shows such wealth of colour as will vainly be looked for elsewhere in the tropics. The student is inclined to parallel these regions with the alpine zone in Europe, but beside points of similarity, such as the height, and the low barometric pressure, there are also points of difference. Similar differences exist also between the tropical alpine belts and the polar region in the north. In the Alps and in the polar region the activity of the plants is restricted to a few months; during the other months they are covered with snow, and dormant. In the tropics snow is absent except on tops upwards of 5000 m high, but these regions are snow-covered throughout the year, and only very steep rocks, on which the snow will not remain, afford the vegetation a small chance. Hail falls very sporadically on the tops of Javanese volcanos, and the nights are often cold enough for a slight frost (on Mt. Semeru I once experienced 5° C. of frost) but this cold does not cause a prolonged arrest in the development of the plants, because in the day-time the temperature rises far above the freezing point. Especially in the season when frosts occur, that is in the East-monsoon, the sky is usually clear and the sun will heat the mountain-tops powerfully day after day. The difference in seasons is not caused here, as it is in Europe, by the alternation of cold and heat, but by the alternation of humidity and drought. In the eastern part of Java this factor is more pronounced, in West-Java it is less noticeable, but it is never of so great importance as the severe cold and the snow covering which exert their influence for months in the Alps and in the circumpolar regions. On the Javanese volcano-tops flowers are met with throughout the year, albeit that the flowering is not equally rich in all months. (On this point compare chapter VI on the flowering-times). As mentioned before, the similarity consists in the great height involving low barometric pressure, which however does not exert a very marked influence on the plants; in the evaporation, which is at least temporarily very considerable in both regions, and finally in the intensive irradiation.

As there are in the higher mountainous regions of Java no submerged plants flowering under water, pollination by means of water currents plays no part.

All the greater is the importance of the wind. In the area on Pangrango-Gedeh studied by me, there occur 164 Phanerogamous plants; 12 of them have been left out of account in the following survey, either because they are introduced plants, which do not produce flowers or fruits, or because

they occur so sporadically that they are of no significance. These are *Cupressus sempervirens, Dendrobium Jacobsonii, Digitalis purpurea, Fagus silvatica, Rumex alpinus, Anemone sumatrana, Cotoneaster species, Pirus malus, Rosa canina* and *R. rubiginosa, Solanum tuberosum* and *Viola odorata*. Of the 152 remaining plants, growing at heights over 2400 m, 22 are pollinated by winds, that is 14.5 %. On the top of Pangrango itself there are 57 plant-species, 11 of which are pollinated by the wind, i.e. 19.3 %. The number of plant-species on the top is, however, so small, that one more or less in one of the groups, alters the percentage considerably; still, these figures teach us that the percentage of wind-fertilized flowers shows a marked increase towards the top. I will compare these figures now with those given by LOEW in his "Blütenbiologische Floristik"; I borrow these figures from SCHRÖTER's work quoted above.

According to LOEW, out of 689 alpine plants 108, i.e. 16 % are wind-pollinated. He also informs us that 22 % of the plants occurring in the European plains are anemophilous. From these figures follows that in the Alps the proportion of wind pollinated flowers is smaller than in the plains. This applies also to other European mountains, In the Arctic region it is just the reverse. The percentage of anemophilous plants found in Iceland is 38 %, in Greenland 38.8 %, in Nova Zembla 32.4 % and on Spitsbergen 37 %. The percentage of wind-pollinated plants in those regions is therefore more than double that in the Alps. It is especially the large number of *Gramineae* and *Cyperaceae* occurring here which increases the proportion of anemophilous plants in the circumpolar regions. In these regions the vegetation period is short and the number of wind-pollinated plants is proportionally large. In the Alps, likewise characterized by a short vegetation period, the number of wind-pollinated flowers on the other hand is smaller than in the plains. If, however, the proportion is calculated for different altitudes, the percentage of wind-pollinated flowers is found to increase as one ascends higher up the mountain. In the very highest part, where 241 plants occur, 18.1 % have wind-pollinated flowers. There is therefore an increase in that type of plants, and this is also due to the relative preponderance of the *Gramineae*, but in comparison with the proportion in the circumpolar regions, the proportion of wind-pollinated flowers in the Alps is small.

Let us now return to the higher parts of the Javanese mountains, where on Pangrango-Gedeh of the plants growing above 2400 m 14.5 % are wind-pollinated, while of the plants growing on the top of Pangrango (3000 m) this figure is 19.3 %. With regard to a few other volcano-tops I possess the following data: at altitudes over 2500 m on Mt. Sumbing in Central Java 25.5 % of the plants are anemophilous; on the adjacent Mt. Sindoro the proportion is 21 %; on the more easterly Mt. Lawu 23 %; and on Mt. Kawi still further East 25 %. We thus see an increase in the proportion of anemophilous plants as we proceed Eastward. The investigations of

VAN STEENIS [1]) have revealed that the flora of Mt. Papandajan in West Java is a mixture of plants from West and East Java. From the plant-list he presented to me I calculated a percentage of anemophilous plants in this mountain of 30.6 %, a figure which approaches the figures for various parts of the Arctic region.

If regard is paid, not to the number of species, but to that of individuals then the predominance of wind-pollinated flowers, especially on the high volcano-tops in Central and East Java, becomes very conspicuous. In the extensive grass plains entomophilous plants are found scattered only, and in East Java the forest consists chiefly of *Casuarina Junghuhniana*, likewise an anemophilous plant. The proportion would become even more unfavourable for the flowers pollinated by the agency of insects if only such species, in which pollination cannot be effected in another way, were counted. The number of these species is, as we shall see further down, very small.

In the whole area above Kandang Badak there are thus 14.5 % of wind-pollinated plants, but when studying this character in the plants growing in the immediate vicinity of Kandang Badak, in the forest therefore, we find that 11 % only of the plants are anemophilous, and in the forest on the top of Mt. Pangrango 10.4 % also only are wind-pollinated. In the forest the number of grasses and sedges is considerably smaller than in the open parts of the top, and the forests occurring on the top make no exception to this rule. The trees all bear insect-visited flowers, with the exception of *Podocarpus imbricata*, *Rapanea avenis* and *Myrica javanica*. The higher percentage of anemophilous plants on the high volcanos therefore depends on the occurrence of open plains where grasses and sedges occur in larger quantities, as for instance in the Papandajan mountain group; this explains also the increased proportion of anemophilous plants on the mountain-tops of Central and East Java, where large grass-covered stretches are common. This phenomenon is therefore not correlated with the height of the locality. Besides representatives of the grasses and sedges the following species have wind-pollinated flowers: *Podocarpus imbricata*, which occurs up to 2700 m altitude; *Myrica javanica*, a dioecious plant, which does not occur on the Pangrango-top, but which is abundant on Mt. Gedeh; the three *Urticaceae* occurring in this region; two species of *Quercus*; *Thalictrum javanicum*; further in moist open parts *Laurembergia coccinea*, and *Plantago major*; (the latter, however, as has also been observed in other parts of the world, is also frequented by insects); finally *Rapanea avenis*.

All plants whose flowers are not wind-pollinated, are counted as insect flowers, though many species are never visited by insects. In the tropics there is a further difficulty, as a considerable part in pollination is played

[1]) C. G. G. J. VAN STEENIS, Eenige belangrijke plantengeographische vondsten op den Papandajan. De Tropische Natuur, Vol. XIX, 1930, p. 73.

here, by various species of birds. In the high mountains the number of flower-visiting birds is small, and most of the flowers visited by birds, also attract insects: in one species only, a *Loranthacea, Scurrula lepidota,* pollination is effected exclusively by birds. In view of the comparatively slight importance of flower-visiting by birds in these regions, the name insect flowers may be used without inconvenience as a collective appellation.

It is generally known that in the Alps and in the circumpolar regions the flowers are very conspicuous in the landscape. This is partly due to the relatively small size of the vegetative parts of the plants, which causes the flowers to cluster more closely and nearer the ground. The impression made by the flowering plants is further heightened to some extent by the contrast with the bare rocks and with the snow. In the tropics this latter factor does not count, and even on the highest volcano-tops the plants are more in the nature of shrubs or low trees intermixed with but comparatively few low and compact herbs, while genuine cushion-plants are altogether lacking. The flowers with the exception of the large yellow flower of *Hypericum* are not so conspicuous either. Yet these tops are sometimes gayly resplendent in a wealth of colour, chiefly in the months of April and May, when many plants develop young shoots. The young leaves are generally highly coloured in bright reds, browns and purples, and contrast vividly against the vault of dark foliage and especially against the white hue of *Anaphalis javanica*. The flowers themselves are not so intensely coloured. The yellow tint of the *Anaphalis* flowers is masked by the white colour of the involucres and of the leaves of this plant. The dark-purple tone of the flowers of *Vaccinium varingifolium* is dominated by the glaring red of the young leaves. In the tropics, even on the tops of the volcanos one never gets the impression of a lustrous decoration of flowers, such as the Alps afford. *Vaccinium laurifolium* which in its blossoming season is spread all over with pink bells, *Leptospermum,* which at that period looks as if snowed over with thousands of white flowers, and *Hypericum,* are more or less exceptions, and these plants also occur usually mixed with others.

Of the 129 entomophilous plants occurring on Mts. Pangrango-Gedeh above 2400 m the flower colour of 12 is green, of 63 white, of 26 yellow, of 8 pink, of 3 orange, of 5 red, of 6 violet, of 3 dark-purple, and of 3 blue. On the top of Pangrango the flower colour of 2 plants is green, of 23 white, of 11 yellow, of 2 pink, of 2 red, of 4 violet, of 1 dark-purple, and of 1 blue. Above 2400 m there are therefore 112 species with light coloured flowers and 17 with dark flowers, that is 86 % light and 14 % dark. On the top of Pangrango there are 38 plants with lighter and 8 with darker flowers, making 80 % lighter as against 20 % darker ones. In this region also the lighter coloured largely predominate, just as in other vegetative regions. This survey consequently does not teach us much, nor can any relations be established between the colours of the flowers and the species of flower-visitors. The numbers of visitors in these tropical high regions are moreover so small that no general conclusion can be drawn in this respect.

The bumble-bee, the only constant visitor, goes for white, yellow, pink, red, violet and purple flowers, and for all such flowers, when ripe for visiting, with equal frequency. *Apis* visits chiefly a yellow and two white flowers; the syrphus-flies likewise. The flower-visiting birds have no distinct preference either for any particular colour.

In the Alps both the scent and the secretion of nectar are enhanced as compared with those of flowers from the plains. On the Javanese volcano-tops this phenomenon is by no means striking. The flower most assiduously frequented by the bumble-bee, *Hypericum Leschenaultii* does not secrete any nectar and has no scent. The flowers of *Eurya*, much frequented by *Bombus*, *Apis* and hover-flies, have a disagreeable dung-odour. *Lonicera javanica* and *Rhododendron retusum* have scentless flowers; the *Vaccinium* species, however, and *Platanthera Blumei*, smell powerfully, those of *Anaphalis*, *Leptospermum* and *Symplocos* less so.

It is no use cataloguing the classes of flowers to which the high-mountain plants belong in order to find out whether there is any correspondence between these classes and the classes of visiting insects. For such an investigation the number of plant species and the number of visitors are both too small. One insect may moreover visit flowers that belong to different classes; the bumble-bee, for instance, frequents flowers without honey but with pollen as food, such as *Hypericum* and *Plantago*, as well as flowers with an easily accessible honey-supply, such as *Rubus*, *Leptospermum* and *Symplocos*, and flowers with concealed honey, such as *Lonicera*, *Vaccinium*, *Allaeophania* and *Rhododendron*. With regard to the relative importance of the various pollinators, I have come to the conclusions set down below. Details will be found in the specific descriptions of plants in the second part of this book.

The only social insect that is always present, is the bumble-bee, *Bombus rufipes*, var. *obscuripes*, but it is not always present in the same abundance, as this depends a.o. on the number of open flowers, which it frequents. Whether the weather is bright or unfavourable, this creature is always busy and may be watched at work till evening draws on. The number of individuals is never very great, but as each individual visits a large number of flowers, the bumble-bee might still be of great importance as a pollinator. The number of plant species that are constantly visited by the bumble-bee is not so very great. Near Kandang Badak the most assiduously visited flower is *Allaeophania rugosa*, a heterostylous plant, which bears flowers for many months in the year and which regularly attracts the visits of *Bombus*. The flowers are pale-violet, sometimes lilac or almost entirely white. Though it is chiefly honey that is sucked from these flowers, pollen is collected too. The bumble-bees thrust their snouts deep into the tubular corolla, and in doing this their heads and backs are thickly powdered with pollen, and this also comes afterwards into contact with the stigmas. In the vicinity of Kandang Badak the violet-flowered *Disporum chinense* and the

blue-flowered *Dichroa febrifuga* are both visited by *Bombus*, but not so regularly as *Allaeophania*; they look for honey and pollen in these flowers. *Melastoma setigerum* yields chiefly a special kind of pollen, which as in other species of this genus is stored in particular anthers; cf. CAMMERLOHER [1]).

Leptospermum is near Kandang Badak occassionally visited with much assiduity by the bumble-bees, but on the top of Pangrango I have up to the present never observed this; in the highest region of this mountain the importance of this pollinator for this plant is therefore not considerable. *Solanum nigrum* is visited fairly regularly by bumble-bees.

A plant on the top of Pangrango which is diligently visited by the bumble-bee is *Hypericum Leschenaultii*. The flowers of this plant attract its attention perhaps stronger than all others, though it does not find any honey in them. The insects crawl about among the filaments and brush the pollen out of the anthers, and in doing this they also rub the stigmas. See plate XXX A. Flower after flower is explored and the same worker often makes the same journey several times, every time occupying itself for a few moments in each flower; see the description of the bumble-bee visit in the special description of this plant. In *Lonicera javanica* the bumble-bees chiefly suck honey, though pollen is gathered at the same time. The creatures brush against the anthers and the stigmas with their heads and the fore-part of their thoraxes. *Plantago major* is sedulously visited, the insects looking in these anemophilous flowers for pollen only; in their visit the underside of their bodies get sprinkled with pollen, and this may be brushed off on the stigmas of flowers in the female stage lower down.

The visiting of *Rhododendron retusum* is irregular; the bumble-bee is not seen in the neighbourhood of this flower for a long time, after which the flowers of one or more plants are suddenly all visited. The yellow sticky pollen hanging in threads among the anthers, easily gets in contact with the creature's head and thorax, as it works its way far down into the fiery red corolla tube to reach the honey. Very numerous are these insects on the flowers of *Rubus lineatus*, the open blooms of which are searched for honey, pollen being, however, also collected. The stigmas are easily powdered with the pollen brushed from the insect's body. During the brief flowering season of *Swertia javanica*, the flowers of this plant strongly attract the attention of the bumble-bees. A large number of flowers on one plant are visited one after another, and next those of other plants, chiefly for the sake of the honey, though pollen too is carried off. The flowers are protandrous exposing their pollen and their stigmas in two successive days. Fertilization with pollen of the flower itself has thus become more difficult, but, as one part of the flowers on one plant is in the male phase while another part is in the female phase, the bumble-bees frequently effect geitonogamy, which

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[1]) H. CAMMERLOHER, Blütenbiologie I. Berlin, 1931, p. 49.

is essentially the same as self-pollinnation; true cross-pollination or allogamy cannot be brought about untill other plants are visited. *Symplocos sessilifolia* is also a plant whose flowers occur only during a short part of the year, but as long as that season lasts, they are diligently visited by bumble-bees. *Eurya acuminata* also regularly attracts the attention of *Bombus*. *Vaccinium varingifolium* and *V. laurifolium* are not sedulously visited, though the flowers of a few plants especially of the latter species receive sometimes a good deal of attention. JUNGHUHN [1]) allready was struck by this, and wrote that the fragrant flowers of the latter sort are frequented by swarms of bees.

There are a few plants on which *Bombus* but seldom appears. *Gaultheria leucocarpa* and *G. fragrantissima* are occasionally visited by it; I have noticed this in the many years that I have observed these plants three times only. Still less interest is taken by the bumble-bee in *Primula imperialis*; once only on Mt. Pangrango and also once on Mt. Papandajan I observed the creature entering the flower. *Polygonum chinense*, as far as I have observed, is on the top of Pangrango never visited by bumble-bees, whereas on plants growing at Kandang Badak the insects are seen, though as irregular guests. Finally the bumble-bee appears very sporadically on *Viburnum coriaceum* and on *Impatiens javensis*. *Digitalis purpurea* planted near Kandang Badak and near Lebak Saät is more frequently visited.

It is peculiar that some plants are seldom or never visited in the Pangrango-Gedeh mountain, whilst in other mountains they are busily frequented. Thus on Mt. Kawi I often saw *Albizzia montana* visited by a smaller variety *Bombus rufipes* var. *flavipes*, but I have never seen this on Mt. Gedeh. *Leptospermum javanicum* I saw visited by hosts of bumble-bees on Mt. Singgalang in Central Sumatra, and this plant is visited fairly often on Mt. Gedeh, but it is not visited at all on the top of Pangrango.

Bombus lives in Java on many mountains from an altitude of about 1200 m upwards to the summit, either in the variety *rufipes* or in the variety *flavipes*. I noticed that in all more than 50 flower species are visited by bumble-bees; see the list given at the end of this chapter, whilst further particulars will be found in the special part.

If the bumble-bees can be seen at work every day and in all weather, *Apis indica*, the Javanese honey-bee, appears at intervals only; in rainy weather it is hardly ever seen on the top of Pangrango; in the dry season it will appear during a few days in large numbers, after which it will remain absent for a long time. Because of this capriciousness, its importance as a pollinator is indeed very much inferior to that of the bumble-bee.

Sometimes they may be seen at work in large numbers on the capitula of *Anaphalis javanica*, on which they gather nothing but pollen, and fly away laden with heavy orange lumps. On *Allaeophania rugosa* also they

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[1]) FR. JUNGHUHN, Java, Vol. I, p. 581.

are at times busily occupied. With great regularity they appear on fine days on the flowers of *Eurya acuminata* and *Symplocos sessilifolia*, gathering there both honey and pollen. Now and then they are seen on *Cardamine africana*, *Fragaria vesca*, *Lonicera javanica*, *Plantago major* and *Rubus lineatus*, and very rarely on *Hypericum Leschenaultii*.

The wasp *Polistes diabolicus* is on Mt. Pangrango of no importance as a pollinator; I have observed it a few times only on the capitula of *Anaphalis javanica*. ROEPKE [1]) on the other hand reports that during his visit to the top of Merapi in Central Java the flowers of *Vaccinium varingifolium* were sedulously frequented by hundreds of males of this wasp.

Ichneumon flies are seldom to be found on the flowers; though they are occasionally seen on *Anaphalis javanica*, *Leptospermum javanicum* and *Valeriana Hardwickii*, these creatures are not of much importance as pollinators.

Somewhat more important are the various *Diptera*, among which the syrphus-flies are sometimes present in remarkably large numbers; very few plants however are regularly visited by them.

The first plant which should be mentioned here is *Anaphalis javanica*. On sunshiny days in the middle of the year large numbers of *Diptera* swarm on the capitula; I collected no fewer than 22 different species on the flowers of this plant, and their number is no doubt still larger. But in rainy weather and even on days when the sky is overcast, they are all gone. They also swarm in large numbers on *Eurya acuminata* and *Symplocos sessilifolia*. Besides these they occasionally visit a large number of plants, as may be seen in the list appended to this chapter. The only species generally occurring throughout the year is the small dark-coloured hoverfly *Chamaesyrphus nigripes*. This fly I collected on no fewer than 17 plants.

Rhopalocera are very rare on the top of Pangrango, and near Kandang Badak there occur also but few species. On the top a few plant species are visited by species of *Lycaenidae* and *Vanessa*, which are only of slight importance for pollination. The part played in these altitudes by moths is practically unknown; *Noctuidae* and *Geometridae* occur. Of one species only, *Agrotis c-nigrum*, I had evidence that it regularly flies at the flowers of *Platanthera Blumei*. This orchid has green flowers which smell delightfully, especially in the evening; as will be seen in the description of these flowers, the stigma was found covered not only with pollinia but also with moth-scales; I have not been able to observe whether the *Agrotis*-species here referred to is the only visitor of these flowers or whether other moths frequent them as well. The *Microlepidoptera* of which a few species frequent flowers, are also of slight importance in pollination.

Various species of thrips occur in the flowers. In *Polygonum chinense*

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[1]) W. ROEPKE, Ueber den Höhenflug des Männchen von *Polistes diabolicus* Sauss. Tijdschr. v. Entomologie, Vol. LIX, 1916, p. 176.

they can always be found in large numbers and they are always powdered with pollen grains. As the larvae remain inside the flowers, and in any case on the same plant, they transfer however the pollen only from the anthers to the stigmas of the same flowers. The adults, however, at least can fly, and may thus effect cross-pollination. It is remarkable that in the flowers of well-developed specimens of *Swertia javanica* thripses seldom occur, whilst they are found numerously in the flowers of the stunted individuals, growing in the barren crater-valley of Mt. Pangrango.

Representatives of other orders of insects are also of little account as pollinators, the only one worth mentioning is a species of bug: *Nysius*, a small greyish insect, which is always present on the capitula of *Anaphalis*.

In the tropics flowers are visited not only by insects but also by birds, and the latter play a very important part in the pollination of the flowers in the plains as well as in the lower parts of the mountains. Doubts have indeed been entertained as to the question what they are doing there. It has been suggested that what the birds were looking for in flowers, was not honey, but insects. Of late years a great many data have been gathered, especially by PORSCH [1]), which prove incontestably that these birds visit the flowers for the sake of their honey supply. In my paper on the pollination of the species of *Erythrina* [2]) I have gone into more detail on this matter, so that I may refer the reader to that article.

In the high mountains the number of flower-frequenting birds is small, three species only occurring there. They are of importance for a few plants only, and none of these is for its pollination exclusively dependent on them.

The only *Nectariniida* which occurs as far up as the tops of the volcanos is *Aethopyga eximea*, a little bird decked in the hues of precious stones, especially conspicious for the ruby-coloured neck of the male, the female being of a plainer colouring. This bird frequents all sorts of flowers and may be regularly watched busying itself on *Lonicera javanica*, *Rhododendron retusum*, *Scurrula lepidota* and somewhat less frequently on the flowers of *Rubus lineatus*. In the flowers of *Lonicera*, *Rhododendron* and *Scurrula* they push their bills far into the tube, and the root of the bill is in this way thickly powdered with pollen; the *Rubus* flower is however far too shallow so that pollination cannot be brought about by them. The birds may also be observed busy on the flowers of *Vaccinium varingifolium*. All these flower-species also easily set fruit through self-fertilisation. On one occasion I saw the bird active in flowers of the violet *Dendrobium Hasseltii*, a plant in which self-pollination is impossible, and which produces very few fruits. Whether the pollinia were carried off by the little bird, I was unable to see, the orchid being high up in the tree.

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[1]) O. PORSCH, Vogelblumenstudien I. Zeitschr. f. Wiss. Bot. Vol. LXIII, 1924 and many other articles.

[2]) W. M. DOCTERS VAN LEEUWEN, Vogelbesuch an den Blüten von einigen *Erythrina*-Arten auf Java. Ann. d. Jard. Bot. de Buitenzorg, Vol. XLII, 1931, p. 1.

Oreosterops javanica frontalis is quite common in the mountain forests where it flies about in flocks, looking for insects and eating all sorts of fruits, but they do not despise honey either. On the top of Pangrango I observed this little white-eye on the two species of *Vaccinium*, occurring there. Round Kandang Badak it is a regular frequenter of *Scurrula lepidota*. On Mt. Singgalang in Central Sumatra I observed species of *Zosterops* drawing honey from the flowers of a *Rhododendron* and from those of a species of a *Gaultheria* and FORBES [1]) describes the visit of a white-eye (*Zosterops chlorata*) to the flowers of *Vaccinium forbesii* on Mt. Dempo in Sumatra: the little creature's nostrils were covered with pollen. The importance of these little birds in the pollination of flowers is probably greater than appears from the above observations.

The third honey-sucking bird is *Dicaeum trochileum*, generally present wherever *Scurrula* occurs, but absent elsewhere. The importance of this bird lies especially in the dispersal of the seeds of this parasitic plant [2]).

Apart from *Scurrula*, one does not find therefore in this region, as at lower altitudes in tropical regions any plants of which the flowers are visited exclusively by birds. Birds and insects are therefore more or less rivals, as is amusingly illustrated by the following scene, observed in the Singgalang mountain in Central Sumatra. A *Rhododendron*-bush, strewn with flaming red flowers, was being visited by a single black bumble-bee. Then a honey-bird came along, and though many flowers were vacant and only one was occupied by the bee, the bird started by driving away the insect and even chased it a few dozen yards, upon which it returned to the *Rhododendron*-bush. On the top of Pangrango I also witnessed once a similar scene between a bumble-bee and a cock of *Aethopyga*, both wanting to pay at the same moment a visit to the same *Lonicera* plant.

Reviewing the above we find that only one creature, *Bombus rufipes* occurs in the high mountains so regularly and in so many individuals as to be capable of playing an important part in the pollination of flowers. *Aethopyga* might perhaps do so too, but this honey-bird is not so generally present, and visits only very few flower-species, which are also visited by the bumble-bee. In respect of species and individuals the *Diptera* are most numerously represented on the highest tops, but these insects are very sensitive to changes in the weather and are therefore often absent. They are only prevalent on sunshiny days in the dry season. In the wet season they are not so common, not even on dry days, because they fly mainly to the flower-heads of *Anaphalis*, a plant flowering from May to July. That period, accordingly, is the season when the flower-visiting *Diptera* are most numerous on the mountain-tops. The importance of *Apis indica* is not very

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[1]) H. O. FORBES, Wanderungen eines Naturforschers im Malayischen Archipel. Jena, 1886, p. 224.

[2]) W. M. DOCTERS VAN LEEUWEN, Uit het leven van enkele Javaanse *Loranthaceae*. De Tropische Natuur, Vol. XX, 1931, p. 114.

great either, because this insect visits but few flower species and is moreover often absent.

There consequently remains only the bumble-bee, but even by this insect about ten flower species only are visited regularly, others only occasionally. As a result, the plants on the Javanese high-mountains, in the present instance those on Mt. Pangrango, are therefore in a bad condition as regards pollination. There are three plants only, which are entirely dependent on cross-fertilization, as they are dioecious, viz. *Rapanea avenis, Eurya acuminata,* and *Balanophora elongata.* The first-named is an anemophilous plant, and the second one is constantly visited. Of the pollination of *Balanophora* nothing is known; it is perhaps entirely or partially parthenogenous. Heterostylous plants there are but few, viz. *Allaeophania* which is very assiduously visited, and *Polygonum chinense* which draws far fewer insects, only thripses occurring regularly in the flowers. Whether these flowers are able to produce seeds by autogamy is unknown. Over against this it may be stated that flowers, entirely dependent on self-fertilization, are comparatively rare.

Cleistogamous flowers occur in *Viola pilosa,* but this plant also bears chasmogamous flowers, which latter, however, as far as I have seen, are never visited and do not form fruits, whilst the small closed flowers do so regularly. The flowers of *Veronica javanica* are quasi-cleistogamous, i.e. they scarcely open, but are otherwise normally developed. The flowers of *Cerastium* and *Drymaria,* and those of *Gentiana* and *Thelymitra,* generally remain closed in dull weather. Though they are occasionally visited these flowers are all usually self-pollinated.

It is furthermore a remarkable phenomenon, that nearly all plant-species, in spite of the scarcity of pollinators, form fruits from nearly all, or from all flowers. The epiphytic orchids only, on which generally few fruits are found, form an exception to this rule. The terrestrial orchids on the other hand, always form fruits, and special investigation has shown that, perhaps with the exception of *Platanthera Blumei,* they can form fruits autogamously. In *Phajus flavus* and in the two species of *Myrmechis* the pollen germinates in the anthers and the tubes grow from there through the style-tissue to the ovules; this kind of fortilisation is also known in other terrestrial-orchids, cf. FORBES [1]) and SMITH [2]).

My investigations have shown that almost all the Javanese mountain plants are capable of setting fruit without cross-pollination, and that autogamy is in many species the more usual process. In *Lonicera javanica* there even occur forms in which the anthers are adpressed against the stigma; and in the normal form with anthers protruding from the corolla and not touching the stigma, seed can nevertheless also be formed without cross-

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[1]) H. O. FORBES, loc. cit., p. 91 seq.

[2]) J. J. SMITH, Zelfbevruchting bij Orchideeën. Natuurkund. Tijdschrift voor Nederl. Indië, Vol. LXXXVII, 1928, p. 1.

pollination. Flowers enclosed in gauze and thus debarred from insect-visitors, all set fruit. *Swertia javanica*, which is sedulously visited by the bumble-bee, turns its anthers inward on the third flowering day, so that the slit is bent towards the stigma and the pollen easily drops on to it. It is also rather remarkable that the *Primula*-species of this region is homostylous, whilst most species of this extensive genus are heterostylous. The stigma of the Javanese *Primula* is pollinated already in the bud.

In the region investigated there exists consequently a correlation between paucity of insects and autogamy. In the Alps it has also been observed that the chance of cross-fertilisation in the high mountains is less than in the plains. According to GÜNTHART [1]) we should look to the unfavourable weather conditions as an active factor, which drives away the insects and prevents a sufficient procreation of those plants dependent on cross-pollination. The latter will partly be supplanted therefore by species capable of multiplying autogamously. If this explanation is right, one might expect that regions, which share this scarcity of insects with the Alps, will show the same phenomenon; and this in fact is true. The observations on pollination in the Scandinavian high mountains and those in Greenland have shown that there also insects are very scarce and that autogamy is prevalent. WARMING's investigations (cf. GÜNTHART, p. 1094) disclosed moreover that these plants which depend on xenogamy are capable of adapting themselves to vegetative processes of multiplication. In the Javanese high mountains this is, however, by no means so.

As very little is known about the flower-biology of the plants in the Javanese plains, I have not been able to ascertain, whether the proportion of xenogamy to autogamy in plants of the Javanese high mountains differs from that in plants of the plains. I have noticed, however, that several plants, belonging to the undergrowth of the primeval forest show autogamy: see the descriptions in Chapter X. In the primeval forest also the scarcity of pollinating insects is striking. Investigations in the Javanese plains moreover would teach us but little, as the greater part of this region has been put under cultivation and has been robbed of its original vegetation. Particulars as to the pollination of the trees and the lianas of the virgin forest, which develop their flowers high up in the air, are not yet known.

Here follow: 1⁰. a table of some plants in the high mountainous regions with the visitors of their flowers; ++ means: very frequently; + means: frequently; — stands for: occasionally; and [1]) denotes: insect-visit observed once; 2⁰. a list of mountain-plants together with the visitors observed by me on their flowers; 3⁰. a list of the flower-visitors together with the flowers visited by them. This list includes visitors observed on other mountains as well as visits to plants of other high mountains, and of those growing at a lower altitude.

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[1]) A. GÜNTHART, loc. cit., p. 1091.

1. SOME MOUNTAIN-PLANTS WITH THEIR VISITORS.

PLANTS	Aves	Bombas	Apis	Polistes	Ichneumonid.	Diptera	Noctuidae	Lycaenidae	Microlepidopt.	Thysanoptera
Albizzia montana	—	—	....	....	....	....	....	....	....	....
Allaeophania rugosa	....	+ +	+	....	—	—	....	....	....	....
Anaphalis javanica	....	....	+	—	....	+ +	....	—	—	—
Cardamine africana	....	....	—	....	....	—	....	....	....	....
Dendrobium Hasseltii	—[1]	....	....	....	....	....	....	....	....	....
Dichroa febrifuga	....	+	....	....	....	....	....	....	....	....
Dichrocephala chrysanthem.	....	....	....	....	....	....	....	....	....	—
Digitalis purpurea	....	+	....	....	....	....	....	....	....	....
Disporum chinense	....	+	....	....	....	....	....	....	....	....
Eurya acuminata	....	+ +	+ +	....	....	+ +	....	....	....	....
Fragaria vesca	....	....	—	....	....	—	....	....	....	....
Gaultheria fragrantissima	....	—	....	....	....	....	....	....	....	....
Gaultheria leucocarpa	....	—	....	....	....	—	....	....	....	....
Hypericum Leschenaultii	....	+ +	—[1]	....	....	—	....	....	....	—
Impatiens javensis	....	—	—	....	....	—	....	....	....	....
Leptospermum javanicum	....	+	....	....	—	+	....	—	—	....
Lonicera javanica	+ +	+ +	—	....	....	—	....	....	....	....
Melastoma setigerum	....	+ +	....	....	....	....	....	....	....	....
Myriactis nepalensis	....	....	....	....	....	....	....	....	....	—
Photinia Notoniana	....	—	....	....	....	—	....	....	—	....
Plantago major	....	+ +	....	....	....	—	....	....	....	....
Platanthera Blumei	....	....	....	....	....	....	+ +	....	....	....
Polygonum chinense	....	—	—	....	....	—	....	—	....	+
Primula imperialis	....	—[1]	....	....	....	....	....	....	....	....
Rhododendron retusum	+ +	+	....	....	....	....	....	....	....	....
Rubus lineatus	+	+ +	—	....	....	—	....	....	....	....
Scurrula lepidota	+ +	....	....	....	....	....	....	....	....	....
Solanum nigrum	....	+ +	....	....	....	....	....	....	....	....
Sonchus asper	....	....	....	....	....	—	....	....	....	....
Swertia javanica	....	+ +	....	....	....	—	....	....	....	—
Symplocos sessilifolia	....	+ +	+ +	....	....	+ +	....	....	....	....
Thelymitra javanica	....	....	....	....	....	—	....	....	....	....
Vaccinium laurifolium	+	+	....	....	....	....	....	....	....	....
Vaccinium varingifolium	+	+	....	....	....	—	....	....	....	....
Viburnum coriaceum	....	—	....	....	....	....	....	....	....	....
Valeriana Hardwickii	....	....	....	....	....	—	....	....	....	....

2. SYSTEMATIC LIST OF THE MOUNTAIN-PLANTS AND THEIR VISITORS.

Fam. LILIACEAE.

Disporum chinense DON.

1. Bombus rufipes var. obscuripes. Mt. Gedeh, 1700—2400 m.

Fam. ORCHIDACEAE.

Dendrobium Hasseltii LINDL.

1. Aethopyga eximea. Mt. Gedeh, 2400 m.

Platanthera Blumei LINDL.

1. Agrotis c-nigrum. Mt. Pangrango, 3000 m.

Thelymitra javanica BL.

1. Chamaesyrphus nigripes. Mt. Pangrango, 3000 m.

Fam. LORANTHACEAE.

Scurrula lepidota G. DON.

1. Aethopyga eximea. Mt. Gedeh, 2400 m.
2. Dicaeum trochileum. Mt. Gedeh, 2400 m.
3. Oreosterops javanica frontalis. Mt. Gedeh, 2400 m.

Fam. POLYGONACEAE.

Polygonum chinense L.

1. Thysanopteron. Mt. Pangrango, 3000 m.
2. Terias hecabe. Mt. Papandajan, 2200 m.
3. Lycaenida. Mt. Pangrango, 3000 m.
4. Apis indica. Mt. Gedeh, 2400 m.
5. Bombus rufipes var. obscuripes. Tjibodas, 1450 m ; Mt. Gedeh, 2400 m ; Mt. Papandajan, 2200 m ; Mt. Lawu, 3000 m.
6. Syrphus serarius. Mt. Pangrango, 3000 m.
7. Syrphus species. Mt. Lawu, 3300 m.
8. Tachinida. Mt. Pangrango, 3000 m.
9. Calliphora fulviceps. Mt. Pangrango, 3000 m.

Fam. CARYOPHYLLACEAE.

Cerastium caespitosum GILIB.

1. Syrphus koningsbergeri. Mt. Pangrango, 3000 m.

Fam. RANUNCULACEAE.

Ranunculus diffusus DC.

1. Chamaesyrphus nigripes. Mt. Gedeh, 2400 m.
2. Syrphus balteatus. Mt. Gedeh, 2400 m.
3. Syrphus serarioides. Mt. Gedeh, 2400 m.
4. Coenosia anipila. Mt. Gedeh, 2400 m.

Thalictrum javanicum BL.

1. Syrphus species. Mt. Lawu, 2600 m.

Fam. CRUCIFERAE.

Cardamine africana L. var. *borbonica* O. E. SCHULZ.

1. Apis indica. Mt. Gedeh, 2400 m.
2. Chamaesyrphus nigripes. Mt. Gedeh. 2400 m.
3. Rhadinomyia orientalis. Mt. Gedeh, 2400 m.

Fam. ROSACEAE.

Fragaria vesca L.

1. Apis indica. Mt. Pangrango, 3000 m.
2. Syrphus koningsbergeri. Mt. Pangrango, 3000 m.
3. Syrphus serarius. Mt. Pangrango, 3000 m.
4. Syrphus serarioides. Mt. Pangrango, 3000 m.
5. Limnophora prominens. Mt. Pangrango, 3000 m.

Neillia thyrsiflora DON.

1. Bombus rufipes var. obscuripes. Mt. Salak, 2100 m.

Photinia Notoniana W. et A.

1. Microlepidopteron. Mt. Pangrango, 3000 m.
2. Lycaenida. Mt. Pangrango, 3000 m.
3. Coleopteron. Mt. Pangrango, 3000 m.
4. Bombus rufipes var. obscuripes. Mt. Pangrango, 3000 m ; Mt. Sumbing, 3100 m ; Mt. Lawu, 3200 m.
5. Chamaesyrphus nigripes. Mt. Pangrango, 3000 m.
6. Rhadinomyia orientalis. Mt. Pangrango, 3000 m.
7. Tachinida. Mt. Pangrango, 3000 m.
8. Limnophora prominens. Mt. Pangrango, 3000 m.

Rubus fruticosus L.

1. Bombus rufipes var. obscuripes. Mt. Pangrango, 3000 m.

Rubus lineatus REINW.

1. Aethopyga eximea. Mt. Pangrango, 3000 m; Mt. Gedeh, 2400 m.
2. Apis indica. Mt. Papandajan, 2300 m.
3. Bombus rufipes var. obscuripes. Mt. Pangrango, 3000 m ; Mt. Gedeh, 2400 m ; Mt. Tangkuban Prahu, 2100 m ; Mt. Papandajan, 2500 m ; Mt. Salak, 2100 m ; Mt. Lawu, 3100 m.
4. Chamaesyrphus nigripes. Mt. Pangrango, 3000 m.

Fam. SAXIFRAGACEAE.

Astilbe indica BL.

1. Dilophus nigriventris. Mt. Gedeh, 2200 m.
2. Sphegina javanica. Mt. Gedeh, 2200 m.
3. Coenosia anipila. Mt. Gedeh, 2400 m.
4. Limnophora prominens. Mt. Gedeh, 2400 m.

Dichroa febrifuga LOUR.

1. Bombus rufipes var. obscuripes. Mt. Gedeh, 1500—2400 m.

Hydrangea oblongifolia BL.

1. Thysanopteron, Mt. Gedeh, 2300 m.

Fam. LEGUMINOSAE.

Albizzia montana BTH.

1. Aethopyga eximea. Mt. Gedeh, 2400 m.
2. Bombus rufipes var. flavipes. Mt. Kawi, 2500 m.

Fam. BALSAMINACEAE.

Impatiens javensis STEUD.

1. Apis indica. Mt. Gedeh, 2400 m.
2. Bombus rufipes var. obscuripes. Mt. Gedeh, 2400 m.
3. Syrphus balteatus. Mt. Gedeh, 2400 m.

Fam. THEACEAE.

Eurya acuminata DC.

1. Apis indica. Mt. Pangrango, 3000.
2. Bombus rufipes var. obscuripes. Mt. Pangrango, 3000; Mt. Gedeh, 2400 m.
3. Chamaesyrphus nigripes. Mt. Pangrango, 3000 m.
4. Syrphus confrater. Mt. Pangrango, 3000 m.
5. Calliphora fulviceps. Mt. Pangrango, 3000. m.
6. Pegomyia bistriata. Mt. Pangrango, 3000 m.

Fam. GUTTIFERAE.

Hypericum Leschenaultii GAUD.

1. Thysanopteron. Mt. Pangrango, 3000 m.
2. Apis indica. Mt. Pangrango, 3000 m.
3. Bombus rufipes var. obscuripes. Mt. Pangrango, 3000 m; Mt. Gedeh, 2500—2900 m; Mt. Salak, 2100 m; Mt. Papandajan, 2300 m; Mt. Tjikorai, 2700 m; Mt. Sumbing, 2800—3300 m; Mt. Sindoro, 3000 m; Mt. Lawu, 3200 m.
4. Bombus rufipes var. flavipes. Mt. Kawi, 2500 m.

Fam. MYRTACEAE.

Leptospermum javanicum BL.

1. Microlepidopteron, Mt. Pangrango, 3000 m.
2. Dodona adonira windu. Mt. Pangrango, 3000 m.
3. Pterocormus species. Mt. Pangrango, 3000 m.
4. Bombus rufipes var. obscuripes. Mt. Gedeh, 2400, 2700 m; Mt. Singgalang (Sumatra), 2600 m.
5. Chamaesyrphus nigripes. Mt. Pangrango, 3000 m.
6. Syrphus serarioides. Mt. Pangrango, 3000 m.
7. Rhadinomyia orientalis. Mt. Pangrango, 3000 m.
8. Calliphora fulviceps. Mt. Pangrango, 3000 m.
9. Limnocephala boops. Mt. Pangrango, 3000 m.
10. Pegomyia bistriata. Mt. Pangrango, 3000 m.

Fam. MELASTOMATACEAE.

Melastoma setigerum BL.

1. Bombus rufipes var. obscuripes. Mt. Gedeh, 2400 m ; Mt. Salak, 2100 m ; Mt. Papandajan, 2200 m.

Fam. ARALIACEAE.

Schefflera rugosa HARMS.

1. Chamaesyrphus nigripes. Mt. Pangrango, 3000 m.
2. Rhadinomyia orientalis. Mt. Pangrango, 3000 m.
3. Pegomyia bistriata. Mt. Pangrango, 3000 m.

Fam. ERICACEAE.

Gaultheria fragrantissima WALL.

1. Bombus rufipes var. obscuripes. Mt. Gedeh, 2700 m.

Gaultheria leucocarpa BL.

1. Bombus rufipes var. obscuripes. Mt. Pangrango, 3000 m.
2. Chamaesyrphus nigripes. Mt. Pangrango, 3000 m.

Gaultheria species.

1. Zosterops species. Mt. Singgalang (Sumatra), 2400 m.

Rhododendron javanicum BENN.

1. Bombus rufipes var. obscuripes. Tjibodas, 1450 m ; Mt. Gedeh, 2400 m ; Mt. Salak, 2100 m.

Rhododendron retusum BENN.

1. Aethopyga eximea. Mt. Pangrango, 3000 m; Mt. Gedeh, 2400 m.
2. Bombus rufipes var. obscuripes. Mt. Pangrango, 3000 m ; Mt. Gedeh, 2400 m ; Mt. Singgalang (Sumatra), 2700 m.

Vaccinium laurifolium MIQ.

1. Oreosterops javanica frontalis. Mt. Pangrango, 3000 m.

Vaccinium lucidum MIQ.

1. Bombus rufipes var. obscuripes. Mt. Gedeh, 1800 m.

Vaccinium varingifolium MIQ.

1. Oreosterops javanica frontalis. Mt. Pangrango, 3000 m.
2. Bombus rufipes var. flavipes. Mt. Kawi, 2700 m.
3. Bombus rufipes var. obscuripes. Mt. Pangrango, 3000 m ; Mt. Gedeh, 2400 m ; Mt. Sindoro, 3000 m ; Mt. Lawu, 3000 m.
4. Polistes diabolicus. Mt. Merapi, 2500 m.

Fam. PRIMULACEAE.

Primula imperialis JUNGH.

1. Bombus rufipes var. obscuripes. Mt. Pangrango, 3000 m ; Mt. Papandajan, 2500 m.

Fam. SYMPLOCACEAE.

Symplocos sessilifolia GUERCKE.

1. Apis indica. Mt. Pangrango, 3000 m.
2. Bombus rufipes var. obscuripes. Mt. Pangrango, 3000 m.

3. Chamaesyrphus nigripes. Mt. Pangrango, 3000 m.
4. Syrphus confrater. Mt. Pangrango, 3000 m.
5. Syrphus gedehanus. Mt. Pangrango, 3000 m.
6. Syrphus serarioides. Mt. Pangrango, 3000 m.
7. Calliphora fulviceps. Mt. Pangrango, 3000 m.

Fam. GENTIANACEAE.

Gentiana quadrifaria BL.

1. Chamaesyrphus nigripes. Mt. Pangrango, 3000 m.
2. Syrphus serarius. Mt. Pangrango, 3000 m.
3. Syrphus serarioides. Mt. Pangrango, 3000 m.

Swertia javanica BL.

1. Bombus rufipes var. obscuripes. Mt. Pangrango, 3000 m ; Mt. Gedeh, 2400—2800 m ; Mt. Tjikorai, 2700 m.
2. Aethopyga eximea. Mt. Pangrango, 3000 m.
3. Thysanopteron. Mt. Pangrango, 3000 m.
4. Elateride. Mt. Pangrango, 3000 m.
5. Syrphus koningsbergeri. Mt. Pangrango, 3000 m.

Fam. SOLANACEAE.

Solanum nigrum L.

1. Bombus rufipes var. obscuripes. Mt. Gedeh, 2400, 2700 m ; Mt. Papandajan, 2200 m ; Mt. Sindoro, 2200 m.

Fam. PLANTAGINACEAE.

Plantago major L.

1. Halictus monachus. Mt. Lawu, 3100 m.
2. Bombus rufipes var. obscuripes. Mt. Pangrango, 3000 m ; Mt. Lawu, 2900 m.
3. Chamaesyrphus nigripes. Mt. Pangrango, 3000 m.
4. Syrphus species. Mt. Lawu, 3300 m.

Fam. RUBIACEAE.

Allaeophania rugosa HOOK.

1. Bombus rufipes var. obscuripes. Mt. Gedeh, 2400 m ; Mt. Papandajan, 2300 m ; Telaga Bodas (Priangan), 2000 m.
2. Apis indica. Mt. Gedeh, 2400 m ; Telaga Bodas (Priangan), 2000 m.

Ophiorrhiza longiflora BL.

1. Thysanopteron. Mt. Gedeh, 2100—2400 m.

Fam. CAPRIFOLIACEAE.

Lonicera javanica DC.

1. Aethopyga eximea. Mt. Pangrango, 3000 m.
2. Miliona fulgida. Mt. Tjikorai, 2500 m.
3. Apis indica. Mt. Pangrango, 3000 m.
4. Bombus rufipes var. obscuripes. Mt. Pangrango, 3000 m ; Mt Tjikorai, 2700 m ; Mt. Sumbing, 3100 m.

5. Chamaesyrphus nigripes. Mt. Pangrango, 3000 m.
6. Megaspis errans. Mt. Pangrango, 3000 m.
7. Syrphus serarioides. Mt. Pangrango, 3000 m.

Viburnum coriaceum BL.

1. Bombus rufipes var. obscuripes. Mt. Pangrango, 3000 m ; Mt. Tjikorai, 2400 m.

Fam. VALERIANACEAE.

Valeriana Hardwickii WALL.

1. Pterocormus species. Mt. Pangrango, 3000 m.
2. Chamaesyrphus nigripes. Mt. Pangrango, 3000 m.
3. Syrphus koningsbergeri. Mt. Pangrango, 3000 m.
4. Syrphus serarius. Mt. Pangrango, 3000 m.
5. Syrphus serarioides. Mt. Pangrango, 3000 m.
6. Rhadinomyia orientalis. Mt. Pangrango, 3000 m.
7. Servilliopsis buccata. Mt. Pangrango, 3000 m.

Fam. COMPOSITAE.

Anaphalis javanica SCH. BIP.

1. Nysius species. Mt. Pangrango, 3000 m ; Mt. Papandajan, 2400 m.
2. Thysanopteron. Mt. Pangrango, 3000 m.
3. Scoparia murificalis. Mt. Pangrango, 3000 m.
4. Microlepidoptera. Mt. Pangrango, 3000 m.
5. Pyrameis cardui. Mt. Pangrango, 3000 m.
6. Celastrina askasa. Mt. Pangrango, 3000 m.
7. Dodona adonira windu. Mt. Pangrango, 3000 m.
8. Elaterida. Mt. Pangrango, 3000 m.
9. Coleopteron. Mt. Pangrango, 3000 m.
10. Pterocormus species. Mt. Pangrango, 3000 m.
11. Polistes diabolicus. Mt. Pangrango, 3000 m ; Mt. Papandajan, 2300 m.
12. Apis indica. Mt. Pangrango, 3000 m ; Mt. Papandajan, 2300 m.
13. Halictus monachus. Mt. Lawu, 3200 m.
14. Chamaesyrphus nigripes. Mt. Pangrango, 3000 m.
15. Eristalis bicornutus. Mt. Pangrango, 3000 m.
16. Eristalis kobusi. Mt. Pangrango, 3000 m.
17. Megaspis chrysopygus. Mt. Pangrango, 3000 m.
18. Megaspis zonalis. Mt. Pangrango, 3000 m.
19. Syrphus balteatus. Mt. Pangrango, 3000 m.
20. Syrphus confrater. Mt. Pangrango, 3000 m.
21. Syrphus koningsbergeri. Mt. Pangrango, 3000 m.
22. Syrphus latistrigatus. Mt. Pangrango, 3000 m.
23. Syrphus serarius. Mt. Pangrango, 3000 m.
24. Syrphus serarioides. Mt. Pangrango, 3000 m.

25. Rhadinomyia orientalis. Mt. Pangrango, 3000 m.
26. Syrphidae. Mt. Papandajan, 2400 m ; Mt. Sumbing, 3300 m ; Mt. Sindoro, 3100 m ; Mt. Lawu, 3200 m.
27. Echinomyia angulata. Mt. Pangrango, 3000 m.
28. Servillia flavopilosa. Mt. Pangrango, 3000 m.
29. Servilliopsis buccata. Mt. Pangrango, 3000 m.
30. Calliphora fulviceps. Mt. Pangrango, 3000 m.
31. Tephritis montana. Mt. Pangrango, 3000 m.
32. Idiella quadrimaculata. Mt. Pangrango, 3000 m.
33. Idiella unicolor. Mt. Pangrango, 3000 m.
34. Coenosia anipila. Mt. Pangrango, 3000 m.
35. Limnophora prominens. Mt. Pangrango, 3000 m.

Bidens pilosa L.
1. Apis indica. Mt. Gedeh, 2400 m.
2. Syrphus balteatus. Mt. Gedeh, 2400 m.

Dichrocephala chrysanthemifolia DC.
1. Thysanopteron. Mt. Pangrango, 3000 m.

Gnaphalium longifolium BL.
1. Nysius species. Mt. Gedeh, 2400 m.
2. Chamaesyrphus nigripes. Mt. Gedeh, 2400 m.
3. Syrphus koningsbergeri. Mt. Gedeh, 2400 m.

Lactuca rostrata BOERL.
1. Apis indica. Mt. Gedeh, 2200 m.
2. Bombus rufipes var. obscuripes. Mt. Gedeh, 2200 m.

Myriactis nepalensis LESS.
1. Thysanopteron. Mt. Pangrango, 3000 m.
2. Chamaesyrphus nigripes. Mt. Gedeh, 2400 m.

Sonchus asper L.
1. Syrphus koningsbergeri. Mt. Pangrango, 3000 m.
2. Syrphus serarioides. Mt. Pangrango, 3000 m.

3. FLOWER-VISITORS.

AVES.

Fam. NECTARINIIDAE.

Aethopyga eximea HORSF.
1. Albizzia montana. Mt. Gedeh, 2400 m.
2. Bontia daphnoides. Tjibodas, 1450 m.
3. Brachychiton acerifolium. Tjibodas, 1450 m.
4. Cestrum aurantiacum. Tjibodas, 1450 m.
5. Dendrobium Hasseltii. Mt. Gedeh, 2400 m.
6. Erythrina subumbrans. Tjibodas, 1400 m.

7. Eucalyptus species. Tjibodas, 1400 m.
8. Fuchsia species. Tjibodas, 1450 m.
9. Grevillea robusta. Tjibodas, 1450 m.
10. Lonicera javanica. Mt. Pangrango, 3000 m.
11. Maurandia erubescens. Tjibodas, 1450 m.
12. Prunus Puddum. Tjibodas, 1450 m.
13. Rhododendron retusum. Mt. Pangrango, 3000 m; Mt. Gedeh, 2400 m.
14. Rhodoleia Teysmanni. Tjibodas, 1450 m.
15. Rubus lineatus. Mt. Pangrango, 3000 m; Mt. Gedeh, 2400 m.
16. Rubus moluccanus. Mt. Tjikorai, 2800 m.
17. Salvia splendens. Tjibodas, 1450 m.
18. Scurrula lepidota. Mt. Gedeh, 2400 m.
19. Swertia javanica. Mt. Pangrango, 3000 m.
20. Vaccinium varingifolium. Mt. Pangrango, 3000 m.

Fam. DICAEIDAE.

Dicaeum trochileum SPARRM.

1. Scurrula lepidota. Mt. Gedeh, 2400 m.

Oreosterops javanica frontalis REICH.

1. Scurrula lepidota. Mt. Gedeh, 2400 m.
2. Vaccinium laurifolium. Mt. Pangrango, 3000 m.
3. Vaccinium varingifolium. Mt. Pangrango, 3000 m.

Zosterops species.

1. Gaultheria species. Mt. Singgalang (Sumatra), 2400 m.
2. Rhododendron species. Mt. Singgalang, 2200 m.

(Zosterops chlorata)

1. Vaccinium Forbesii. Mt. Dempo, Sumatra.

HEMIPTERA-HETEROPTERA.

Fam. LYGAEIDAE.

Nysius species, (aff. *sundanus* BEDD.)

1. Anaphalis javanica. Mt. Pangrango, 3000 m; Mt. Papandajan, 2400 m.
2. Gnaphalium longifolium. Mt. Gedeh, 2400 m.

THYSANOPTERA.

Species diverses.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.
2. Dichrocephala chrysanthemifolia. Mt. Pangrango, 3000 m.
3. Hydrangea oblongifolia. Mt. Gedeh, 2300 m.
4. Hypericum Leschenaultii. Mt. Pangrango, 3000 m.

5. Myriactis nepalensis. Mt. Pangrango, 3000 m.
6. Ophiorrhiza longifolia. Mt. Gedeh, 2100—2400 m.
7. Polygonum chinense. Mt. Pangrango, 3000 m.
8. Styphelia pungens. Mt. Semeru, 2700 m.
9. Swertia javanica. Mt. Pangrango, 3000 m.

LEPIDOPTERA.

Fam. PYRALIDAE.

Scoparia murificalis WALK.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.

Microlepidopterorum species diverses.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.
2. Leptospermum javanicum. Mt. Pangrango, 3000 m.
3. Photinia Notoniana. Mt. Pangrango, 3000 m.

Fam. NOCTUIDAE.

Agrotis c-nigrum L.

1. Platanthera Blumei. Mt. Pangrango, 3000 m.

Fam. GEOMETRIDAE.

Miliona fulgida SN. V. VOLL.

1. Lonicera javanica. Mt. Tjikorai, 2500 m.

Fam. NYMPHALIDAE.

Pyrameis cardui L.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.

Fam. PIERIDAE.

Terias hecabe L.

1. Polygonum chinense. Mt. Papandajan, 2200 m.

Fam. RIODINIDAE.

Dodona adonira windu FRHST.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.
2. Leptospermum javanicum. Mt. Pangrango, 3000 m.

Fam. LYCAENIDAE.

Celastrina askasa askasa HORSF.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.

Species diverses.

1. Polygonum chinense. Mt. Pangrango, 3000 m.
2. Photinia Notoniana. Mt. Pangrango, 3000 m.

COLEOPTERA.

Fam. ELATERIDAE.

Species dubiae.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.
2. Swertia javanica. Mt. Pangrango, 3000 m.

Fam. IGNOTA.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.
2. Photinia Notoniana. Mt. Pangrango, 3000 m.

HYMENOPTERA.

Fam. ICHNEUMONIDAE.

Pterocormus species.

1. Anaphalis javanica. Mt. Mt. Pangrango, 3000 m.
2. Leptospermum javanicum. Mt. Pangrango, 3000 m.
3. Valeriana Hardwickii. Mt. Pangrango, 3000 m.

Fam. VESPIDAE.

Polistes diabolicus SAUSS.

1. Anaphalis javanica. Mt. Pangrango, 3000 m ; Mt. Papandajan, 2300 m.
2. Vaccinium varingifolium. Mt. Merapi, 2700 m.

Fam. APIDAE.

Apis indica FABR.

1. Allaeophania rugosa. Mt. Gedeh, 2400 m ; Telaga Bodas (Priangan), 2000 m.
2. Anaphalis javanica. Mt. Pangrango, 3000 m ; Mt. Papandajan, 2300 m.
3. Bidens pilosa. Mt. Gedeh, 2400 m.
4. Cardamine africana. Mt. Gedeh, 2400 m.
5. Eurya acuminata. Mt. Pangrango, 3000 m.
6. Fragaria vesca. Mt. Pangrango, 3000 m.
7. Hypericum Leschenaultii. Mt. Pangrango, 3000 m.
8. Impatiens javensis. Mt. Gedeh, 2400 m.
9. Lactuca rostrata. Mt. Gedeh, 2200 m.
10. Lonicera javanica. Mt. Pangrango, 3000 m.
11. Pogostemon menthoides. Mt. Gedeh, 1600—2000 m.
12. Polygonum chinense. Mt. Gedeh, 2400 m.
13. Rubus lineatus. Mt. Papandajan, 2300 m.
14. Salvia splendens. Tjibodas, 1450 m.
15. Spilanthes acmella. Mt. Kawi, 2600 m.

16. Strobilanthes cernuus. Mt. Gedeh, 1700—2000 m.
17. Symplocos sessilifolia. Mt. Pangrango, 3000 m.

Halictus monachus BLTG.

1. Anaphalis javanica. Mt. Lawu, 3200 m.
2. Plantago major. Mt. Lawu, 3100 m.

Bombus rufipes LEP. var. *obscuripes* FRIESE.

1. Allaeophania rugosa. Mt. Gedeh, 2400 m ; Mt. Papandajan, 2300 m ; Telaga Bodas, 2000 m.
2. Begonia species. Tjibodas, 1450 m.
3. Blumea silvatica. Mt. Papandajan, 2200 m.
4. Cestrum aurantiacum. Tjibodas, 1450 m.
5. Cyrtandra picta. Mt. Gedeh, 1600 m.
6. Dahlia hybrida. Tjibodas, 1450 m.
7. Dichroa febrifuga. Mt. Gedeh, 1500—2400 m.
8. Digitalis purpurea. Mt. Gedeh, 2400 m.
9. Disporum chinense. Mt. Gedeh, 1700—2400 m.
10. Elaeocarpus obtusus. Tjibodas, 1500 m.
11. Eurya acuminata. Mt. Pangrango, 3000 m.
12. Fuchsia species. Tjibodas, 1450 m.
13. Gaultheria fragrantissima. Mt. Gedeh, 2700 m.
14. Gaultheria leucocarpa. Mt. Pangrango, 3000 m ; Mt. Papandajan, 2400 m.
15. Helianthus annuus. Tjibodas, 1450 m.
16. Hypericum Leschenaultii. Mt. Pangrango, 3000 m ; Mt. Gedeh, 2500—2900 m ; Mt. Salak, 2100 m ; Mt. Papandajan, 2300 m ; Mt. Tjikorai, 2700 m ; Mt. Sumbing, 2800—3300 m ; Mt. Sindoro, 3000 m ; Mt. Lawu, 3200 m.
17. Impatiens javensis. Mt. Gedeh, 2400 m.
18. Lactuca rostrata. Mt. Gedeh, 2200 m.
19. Lagenaria Patersonii. Tjibodas, 1450 m.
20. Lasianthus purpureus. Tjibodas, 1500 m.
21. Lathyrus odoratus. Tjibodas, 1450 m.
22. Leptospermum javanicum. Mt. Gedeh, 2500—2900 m ; Mt. Singgalang (Sumatra), 2600 m.
23. Lonicera javanica. Mt. Pangrango, 3000 m ; Mt. Tjikorai, 2700 m ; Mt. Sumbing, 3100 m.
24. Medinilla verrucosa. Tjibodas, 1450 m.
25. Melastoma malabathricum. Kamodjan, near Garut, 1400 m.
26. Melastoma setigerum. Mt. Gedeh, 2400 m ; Mt. Salak, 2100 m ; Mt. Papandajan, 2200 m.
27. Melastoma species. Mt. Singgalang (Sumatra), 2400 m.
28. Neillia thyrsiflora. Mt. Salak, 2100 m.
29. Parochetus communis. Mt. Papandajan, 2300 m.

30. Photinia Notoniana. Mt. Pangrango, 3000 m ; Mt. Sumbing, 3100 m ; Mt. Lawu, 3200 m.
31. Plantago major. Mt. Pangrango, 3000 m ; Mt. Lawu, 2900 m.
32. Plectranthus javanicus. Mt. Sumbing, 2200 m.
33. Plectranthus Teijsmanni. Mt. Papandajan, 2200 m.
34. Pogostemon menthoides. Mt. Gedeh, 1900 m.
35. Polygonum chinense. Tjibodas, 1450 m ; Mt. Gedeh, 2400 m ; Mt. Papandajan, 2200 m ; Mt. Lawu, 3000 m.
36. Primula imperialis. Mt. Pangrango, 3000 m ; Mt. Papandajan, 2500 m.
37. Prunus Puddum. Tjibodas, 1450 m.
38. Rosmarinus officinalis. Tjibodas, 1450 m.
39. Rhododendron javanicum. Mt. Gedeh, 2400 m ; Tjibodas, 1450 m ; Mt. Salak, 2100 m.
40. Rhododendron retusum. Mt. Pangrango, 3000 m ; Mt. Gedeh, 2400 m ; Mt. Singgalang, 2700 m.
41. Rhodoleia Teijsmanni. Tjibodas, 1450 m.
42. Rubus lineatus. Mt. Pangrango, 3000 m ; Mt. Gedeh, 2400 m ; Mt. Tangkuban Prahu, 2100 m ; Mt. Papandajan, 2500 m ; Mt. Salak, 2100 m ; Mt. Lawu, 3100 m.
43. Rubus moluccanus. Mt. Gedeh, 1800 m.
44. Saurauja cauliflora. Tjibodas, 1450 m.
45. Saurauja leprosa. Tjibodas, 1400 m.
46. Solanum nigrum. Mt. Gedeh, 2400—2700 m ; Mt. Papandajan, 2200 m ; Mt. Sindoro, 2200 m.
47. Strobilanthes cernuus. Mt. Gedeh, 1700—2000 m ; Mt. Tjikorai, 2300 m.
48. Strobilanthes involucratus. Tjibodas, 1500 m.
49. Swertia javanica. Mt. Pangrango, 3000 m ; Mt. Gedeh, 2400—2800 m ; Mt. Tjikorai, 2700 m.
50. Symplocos sessilifolia. Mt. Pangrango, 3000 m.
51. Vaccinium laurifolium. Mt. Pangrango, 3000 m ; Mt. Gedeh, 2400 m ; Mt. Sindoro, 3000 m ; Mt. Lawu, 3000 m.
52. Vaccinium lucidum. Mt. Gedeh, 1800 m.
53. Vaccinium varingifolium. Mt. Pangrango, 3000 m ; Mt. Gedeh, 2400 m ; Mt. Sindoro, 3000 m ; Mt. Lawu, 3000 m.
54. Viburnum coriaceum. Mt. Pangrango, 3000 m ; Mt. Tjikorai, 2400 m.
55. Xyris melanocephala. Mt. Papandajan, 2200 m.

Bombus rufipes LEP. var. *flavipes* HANDL.

1. Albizzia montana. Mt. Kawi, 2500 m.
2. Hypericum Leschenaultii. Mt. Kawi, 2500 m.
3. Rubus niveus. Mt. Kawi, 2600 m.
4. Styphelia pungens. Mt. Kawi, 2600 m.
5. Vaccinium varingifolium. Mt. Kawi, 2600 m.

Bombus senex SN. V. VOLL.
1. Anemone sumatrana. Mt. Singgalang (Sumatra), 2300 m.
2. Melastoma species. Mt. Singgalang, 2000 m.

DIPTERA.

Fam. BIBIONIDAE.

Dilophus nigriventris DE MEIJ.
1. Astilbe indica. Mt. Gedeh, 2200 m.

Fam. SYRPHIDAE.

Baccha austeni DE MEIJ.
1. Pogostemon menthoides. Mt. Gedeh, 2000 m.

Chamaesyrphus nigripes DE MEIJ.
1. Anaphalis javanica. Mt. Pangrango, 3000 m.
2. Cardamine africana. Mt. Gedeh, 2400 m.
3. Eurya acuminata. Mt. Pangrango, 3000 m.
4. Gaultheria leucocarpa. Mt. Pangrango, 3000 m.
5. Gentiana quadrifaria. Mt. Pangrango, 3000 m.
6. Gnaphalium longifolium. Mt. Gedeh, 2400 m.
7. Hypericum Leschenaultii. Mt. Pangrango, 3000 m.
8. Leptospermum javanicum. Mt. Pangrango, 3000 m.
9. Lonicera javanica. Mt. Pangrango, 3000 m.
10. Myriactis nepalensis. Mt. Gedeh, 2400 m.
11. Photinia Notoniana. Mt. Pangrango, 3000 m.
12. Plantago major. Mt. Pangrango, 3000 m.
13. Rubus lineatus. Mt. Pangrango, 3000 m.
14. Schefflera rugosa. Mt. Pangrango, 3000 m.
15. Symplocos sessilifolia. Mt. Pangrango, 3000 m.
16. Thelymitra javanica. Mt. Pangrango, 3000 m.
17. Valeriana Hardwickii. Mt. Pangrango, 3000 m.

Eristalis bicornutus DE MEIJ.
1. Anaphalis javanica. Mt. Pangrango, 3000 m.

Eristalis kobusi DE MEIJ.
1. Anaphalis javanica. Mt. Pangrango, 3000 m.

Megaspis chrysopygus WIED.
1. Anaphalis javanica. Mt. Pangrango, 3000 m.

Megaspis errans F.
1. Lonicera javanica. Mt. Pangrango, 3000 m.

Megaspis zonalis F.
1. Anaphalis javanica. Mt. Pangrango, 3000 m.

Melanostoma quadrinotatum DE MEIJ.
1. Pogostemon menthoides. Mt. Gedeh, 2000 m.

Rhingia basalis DE MEIJ.
1. Anemone sumatrana. Mt. Singgalang (Sumatra), 2200 m.

Sphegina javana DE MEIJ.
1. Astilbe indica. Mt. Gedeh, 2200 m.

Syrphus balteatus DE G.
1. Bidens pilosa. Mt. Gedeh, 1500 m.
2. Impatiens javensis. Mt. Gedeh, 2000 m.
3. Ranunculus diffusus. Mt. Gedeh, 2400 m.

Syrphus confrater WIED.
1. Anaphalis javanica. Mt. Pangrango, 3000 m.
2. Eurya acuminata. Mt. Pangrango, 3000 m.
3. Symplocos sessilifolia. Mt. Pangrango, 3000 m.

Syrphus gedehanus DE MEIJ.
1. Symplocos sessilifolia. Mt. Pangrango, 3000 m.

Syrphus koningsbergeri DE MEIJ.
1. Anaphalis javanica. Mt. Pangrango, 3000 m.
2. Cerastium caespitosum. Mt. Pangrango, 3000 m.
3. Fragaria vesca. Mt. Pangrango, 3000 m.
4. Gnaphalium longifolium. Mt. Gedeh, 2400 m.
5. Hypericum Leschenaultii. Mt. Pangrango, 3000 m.
6. Sonchus asper. Mt. Pangrango, 3000 m.
7. Swertia javanica. Mt. Pangrango, 3000 m.
8. Valeriana Hardwickii. Mt. Pangrango, 3000 m.

Syrphus latistrigatus DE MEIJ.
1. Anaphalis javanica. Mt. Pangrango, 3000 m.

Syrphus serarius WIED.
1. Anaphalis javanica. Mt. Pangrango, 3000 m.
2. Fragaria vesca. Mt. Pangrango, 3000 m.
3. Gentiana quadrifaria. Mt. Pangrango, 3000 m.
4. Polygonum chinense. Mt. Pangrango, 3000 m.
5. Valeriana Hardwickii. Mt. Pangrango, 3000 m.

Syrphus serarioides DE MEIJ.
1. Anaphalis javanica. Mt. Pangrango, 3000 m.
2. Fragaria vesca. Mt. Pangrango, 3000 m.
3. Gentiana quadrifaria. Mt. Pangrango, 3000 m.
4. Lonicera javanica. Mt. Pangrango, 3000 m.
5. Sonchus asper. Mt. Pangrango, 3000 m.
6. Symplocos sessilifolia. Mt. Pangrango, 3000 m.
7. Valeriana Hardwickii. Mt. Pangrango, 3000 m.

Syrphus, species diverses.
1. Anaphalis javanica. Mt. Papandajan, 2400 m; Mt. Sumbing, 3300 m; Mt. Sindoro, 3000 m; Mt. Lawu, 3200 m.

2. Plantago major. Mt. Lawu, 3300 m.
3. Polygonum chinense. Mt. Lawu, 3300 m.
4. Thalictrum javanicum. Mt. Lawu, 2600 m.

Fam. ORTALIDAE.

Rhadinomyia orientalis SCHINER.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.
2. Cardamine africana. Mt. Gedeh, 2400 m.
3. Leptospermum javanicum. Mt. Pangrango, 3000 m.
4. Photinia Notoniana. Mt. Pangrango, 3000 m.
5. Schefflera rugosa. Mt. Pangrango, 3000 m.
6. Valeriana Hardwickii. Mt. Pangrango, 3000 m.

Fam. TACHINIDAE.

Echinomyia angulata DE MEIJ.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.

Servilliopsis buccata TOWNS.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.
2. Valeriana Hardwickii. Mt. Pangrango, 3000 m.

Servillia flavopilosa BIG.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.

Fam. TRYPETINIDAE.

Tephritis montana DE MEIJ.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.

Fam. MUSCIDAE.

Calliphora fulviceps V. D. W.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.
2. Eurya acuminata. Mt. Pangrango, 3000 m.
3. Leptospermum javanicum. Mt. Pangrango, 3000 m.
4. Polygonum chinense. Mt. Pangrango, 3000 m.
5. Symplocos sessilifolia. Mt. Pangrango, 3000 m.

Idiella quadrimaculata MACQ.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.

Idiella unicolor MACQ.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.

Fam. ANTHOMYIDAE.

Coenosia anipila STEIN.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.
2. Astilbe indica. Mt. Gedeh, 2200 m.
3. Ranunculus diffusus. Mt. Gedeh, 2400 m.

Limnophora prominens STEIN.

1. Anaphalis javanica. Mt. Pangrango, 3000 m.
2. Astilbe indica. Mt. Gedeh, 2200 m.
3. Photinia Notoniana. Mt. Pangrango, 3000 m.

Lispocephala boops THOMS.

1. Leptospermum javanicum. Mt. Pangrango, 3000 m.
2. Valeriana Hardwickii. Mt. Pangrango, 3000 m.

Pegomyia bistriata STEIN.

1. Eurya acuminata. Mt. Pangrango, 3000 m.
2. Leptospermum javanicum. Mt. Pangrango, 3000 m.
3. Schefflera rugosa. Mt. Pangrango, 3000 m.

CHAPTER VIII.

MULTIPLICATION AND DISPERSAL OF THE PLANTS LIVING IN THE HIGHER PARTS OF THE MOUNTAINS.

Multiplication may take place both by a vegetative and by a generative process. In some cases the former manner plays an important part, though the extension of the area is usually slow, but in the course of years plants can nevertheless wander far from their original habitat. By no means all plants, however, possess the faculty of multiplying vegetatively. In the fourth plant zone on Pangrango-Gedeh we find the following examples.

The grasses occurring there grow usually in tussocks, and in that case there is hardly any vegetative extension. The two species of *Isachne*, however, especially the compact creeping *Isachne pangerangensis* which occurs in the crater-valley of Pangrango and in the aloon-aloon of Gedeh, spread more or less along the ground, and may form at length an almost pure community: along the banks of rivulets, in water-courses and in rain-runnels a thick carpet of this grass is sometimes observed.

The species of *Carex* also form large clumps, but offshoots from the short and thick rhizome may form new plants. This, however, happens but rarely. *Gahnia* produces occasionally also offshoots. *Scirpus fluitans*, which grows in and along brooks and pools, ramifies powerfully and may gradually cover large surfaces.

In the *Liliaceae*, *Dianella* and *Disporum* a slowly progressing vegetative development takes place, which is in the first species slightly more rapid than in the second. The epiphytic orchids do not spread vegetatively. *Dendrobium gracile* does form offsets with tubers and roots at the base, and these may occasionally catch on, but they remain on the same tree. In the terrestrial orchids on the other hand vegetative propagation does occur but it proceeds very slowly. *Thelymitra javanica* [1]) forms offsets on which tubers and flowering stalks may grow. The new plants are usually found in the immediate vicinity of the parent plant, but a slow spread is nevertheless possible. *Calanthe abbreviata* and *Phajus flavus* behave in the same way. In *Platanthera Blumei* the rootstock forks and forms new plants alongside of the old one. The old stem eventually dies and in this way new individuals come into existence, standing more or less apart. The two species of *Myrmechis*, especially the smaller one, *Myrmechis gracilis* [2]), creep along the ground and through the moss

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[1]) J. DIETZ, Morphol. anatom. Untersuchungen der unterirdischen Organe tropischer Erdorchideen. Ann. d. Jardin bot. de Buitenzorg, Vol. XLI, 1930, p. 14.

[2]) J. DIETZ, loc. cit., p. 12.

cushions, and the rootstock branches. Ultimately the connecting parts rot away and the shoots become independent individuals, and the plant may spread in this way in course of time.

Elatostema pedunculosum and *Pilea trinervia*, especially the former, rest with the basal part of their shoots in the ground. These procumbent parts branch in the humid soil. Large groups of individuals come in this way into existence, especially in *Elatostema*, which is frequently abundant in marshy places. It also occurs on drier ground in the forest, and then the plants are also forming clumps. The introduced *Rumex alpinus* which occurs exclusively near Kandang Badak beside the lodge and near the new hut of Lebak Saät spreads slowly by vegetative propagation. In *Polygonum paniculatum*, which favours moist localities, vegetative reproduction takes place in the same manner as has been described of *Elatostema*; locally it forms dense communities [1]). *Stellaria media* may spread in the same manner, but *Cerastium caespitosum* and *Drymaria hirsuta* do not behave in this way at least not in this area.

Anemone sumatrana spreads also vegetatively ; on layered inflorescences buds are produced from the involucre beneath the umbel ; and these buds produce roots and grow out into new individuals. But this plant is not indigenous on Mt. Pangrango, it was brought over from Mt. Singgalang in Central Sumatra to the Pangrango top and though it maintains itself there in a few individuals, it hardly spreads. *Thalictrum javanicum* has a branching rhizome but the aerial shoots springing from the branches keep close together and form a single large plant. In the two species of *Ranunculus* vegetative reproduction is a usual phenomenon. The long stolons, which spread in all directions, readily take root, and produce in this way new rosettes which may develop into new individuals. By this means they may come to cover large patches of ground. In a forest-clearing a single individual of *Ranunculus diffusus* covered at the end of one year an extent of about forty square feet. *Cardamine africana* also branches ; layering stems can take root and form small clumps ; but this mode of increase is not of great importance. More effective and generally known is the vegetative spread of *Fragaria vesca*, which emits long runners with a rosette at the end, which may develop into a new plant. Strawberries were planted out by TEYSMANN on the Pangrango top, 90 years ago, and they now occur everywhere both in open patches and in light shadow, but they have not spread beyond the top.

The two species of *Impatiens* form procumbent offshoots rooting at the nodes ; new individuals come into existence, when the connecting parts of the offshoots rot away. *Viola pilosa*, like *Fragaria* forms runners, and a large number of the existing individuals have developed from the rosettes at the end of the shoots. In a comparatively short time open parts

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1) C. G. G. J. VAN STEENIS, *Polygonum* vegetaties in de tropen. De Tropische Natuur, Vol. XX, 1931, p. 163.

of the forest and rotting logs may be covered in this way. *Begonia* roots easily from its procumbent stems.

Laurembergia coccinea, which grows especially in moist open spaces, has creeping shoots which cover the ground with a dense matting plate IX. When the old shoots die off a large number of new individuals is formed. *Sanicula europaea* seldom spreads in this manner, but vegetative spreading is a common feature in *Pimpinella Leeuwenii*. This plant is distinguished from the closely related *Pimpinella pruatjan* by the presence of buds in the bifurcations of the recumbent inflorescences ; these buds can develop into new individuals. Nevertheless it appears that in this mountain the conditions of growth are not very favourable to these plants, for it grows, as far as I know, in an extremely limited area only. In that patch, however, it is found to spread chiefly by the vegetative process. *Primula imperialis* forms side-buds, though infrequently, which may grow into new rosettes, but this development produces dense clumps only, and does not enable the plant to spread. In the three *Gentianaceae* this manner of propagation is also almost negligeable; in *Swertia javanica*, which possesses a branching rhizome, it is of slightly more importance than in the others. *Plantago major* behaves in the same way as *Primula*. *Nertera depressa* on the other hand has long creeping stems, so that it can cover large patches ; new individuals become isolated when older parts of the stems rot away. In *Valeriana Hardwickii* vegetative increase is of slight importance. The same is true of the herbaceous *Compositae* ; to a slight extent it is met with in *Bidens pilosa*, *Gnaphalium luteo-album* and G. *indicum*, to a higher degree in *Artemisia vulgaris*. This latter plant apparently never bears fruit in this region and must spread therefore exclusively in the vegetative way. It is very abundant in the hill-garden of Tjibodas, and it probably got to this top together with other plants transplanted from those gardens on the Pangrango top. *Eupatorium riparium* is an introduced plant, which spreads rapidly by means of branches which grow along the ground and emit rootlets. It has become in this way a troublesome weed, which is hard to eradicate.

The plants dealt with are all herbs ; among the shrubs there are few species only which multiply vegetatively. The species of *Rubus* possess this property, *Rubus fruticosus* having it in a relatively high degree. The European blackberry, which occurs on the top of Pangrango in a few groups, has probably grown there ever since TEYSMANN started his acclimatisation experiments. Fruits are not formed ; consequently the plant can spread only vegetatively, and it does so very slowly indeed. *Hypericum Leschenaultii* increases also vegetatively, but very slowly. This means of spreading is of great importance in *Gaultheria nummularioides*, whose thin branches creep along the soil and take root, new individuals being separated off through the rotting away of parts of the creeping stems ; it enables this plant to occupy large stretches of ground. To *Lonicera javanica* the same applies as to *Hypericum*.

Among the species of trees found on the mountain tops of West Java there is not a single one that reproduces itself vegetatively. This kind of propagation is found however in *Casuarina Junghuhniana* (= C. *montana*) the most common tree on the higher mountain tops of Central and East Java. JUNGHUHN [1]) gives a detailed account of it. It forms easily new stems from adventitious buds on the roots, and old trees are therefore often surrounded by a thick undergrowth of saplings originated in this way. To this faculty the tree owes its resistance to forest-fires, which are of common occurrence in these parts of Java. Fires, which destroy even massive old trees, are unable to kill the roots, and after some time young trees will spring up everywhere in the burnt forest. On Mt. Lawu where severe fires rage every year, the forest consists largely of a dense wilderness of young *Casuarina* trees. These saplings springing from the roots are therefore less important for the extension of the area occupied by the species than for its preservation.

From the above review it may appear that multiplication by vegetative means plays a modest part only in the dispersal of mountain plants, and has practically no importance for their transport from one mountain to another.

The dissemination of tropical mountain-plants by generative processes may be effected in various ways. Extensive evidence on this subject is not as yet available, but on the analogy of what has been observed in other regions, conclusions have been drawn as to the manner in which the dispersal of these plants in the high mountains will take place. A recent work by RIDLEY [2]) which contains a great deal of evidence with regard to the dispersal of plants, is the first general treatment of this subject by a botanist of many years' practical experience in tropical countries. In the following survey I have therefore repeatedly made use of it. The student is likewise referred to it for the literature on the subject.

A few years ago the stomach-contents of a number of fruit-eating birds of Pangrango-Gedeh were examined and described by me [3]). The same work was done for birds of the Sumbing and Sindoro volcanos in Central-Java by my son [4]). With reference to the former article

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[1]) FR. JUNGHUHN, Java. Second Edition, Vol. II, 1853, p. 551. In his description J. says that stems and boughs, covered with an uneven rough and cracked bark, do not bear any epiphytes or parasites. This is not quite correct. The branches are often clothed with thick moss cushions, while certain orchid species also regularly occur. On the older individuals on Mts. Lawu, Kawi and Semeru I observed *Dendrobium Jacobsonii*, with its very conspicuous miniate flowers in dense clusters on the trunks and branches. *Loranthaceae*: *Scurrula Junghuhnii* and *S. montana*, are also often very common, e.g. in the old *Casuarina* forest on the Idjen-Plateau.

[2]) H. N. RIDLEY, The dispersal of plants throughout the world. Ashford, 1930.

[3]) W. M. DOCTERS VAN LEEUWEN, Kleiner Beitrag zur Kenntnis der endozoischen Verbreitung einiger Hochgebirgspflanzen auf Java. Flora, Vol. 118 and 119; 1925, p. 81.

[4]) HANS DOCTERS VAN LEEUWEN, Beitrag zur Kenntnis der Avifauna der Mitteljavanischen Vulkane Soembing und Sindoro. Treubia, Vol. X, Livr. 4; 1929, p. 439.

BACKER [1]) observes that in order to make sure whether a plant can be dispersed by a fruit-eating bird, seeds obtained from the droppings of the bird should be sown. If the seeds germinate the proof would, of course, still be stronger, but in these remote regions, where one can stay for a comparatively short time only and where no people live who could report on the results, it is not possible to see such sowing-tests through. It would moreover be hard to obtain such droppings except from caged birds, which of course are not available. But the results obtained by examination of the contents of the stomach and intestinal tract of birds allow us to draw our conclusions with regard to the significance of fruit-eating birds as dispersers of plants with edible fruits with a fair degree of accuracy.

It is generally accepted that the facilities for the dispersal of seeds play a great part in the distribution of plants. SCHMUCKER [2]), however, argues that although it is true that most plants produce enormous numbers of seeds, we know as yet very little of the result of this seed-production in the natural habitats of the plants. That annual and biennial plants really maintain themselves by means of seeds is obvious enough, and in localities that are not yet completely covered with vegetation, seedlings of all sorts may frequently be observed in large quantities. With regard to perennial plants growing in closed associations, however, one should realize that a species can maintain itself in equal strength if each individual produces during the whole of its life one descendant only. If one considers how many perennial species multiply also vegetatively and how much surer this kind of procreation is than the reproduction through seeds, one is compelled to admit that the chance of reproduction by seeds must be called minimal, and that it is under favourable circumstances only that within the area occupied by the community new individuals can arise from seeds.

SCHMUCKER's remarks certainly deserve our attention. It is indeed obser-

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1) C. A. BACKER, The problem of Krakatau as seen by a botanist, 1929, p. 71. My article was discussed in this book on Krakatau, although not a single plant nor animal of the high mountains of Java occur in that island! Mr. BACKER writes: "In a recent paper on endozoic seed-dispersal DOCTERS VAN LEEUWEN gives a list of fruits and seeds found by him in the intestines of some birds shot, from which he deduces that these birds disseminate the plants. But fruit-eating birds need not necessarily be seed-dispersing birds." None but a tiro in this field would imagine any useful purpose to be served by delivering such a truism, but the contents of his note no. 4 also make his want of knowledge in this matter manifest. There the critic says: "on this point one should consult HANS WINTERSTEIN, Handbuch der Vergleich. Physiologie, II, (1911), p. 1198 seq. "Die Mechanische Funktion des Muskelmagens der Vögel". Mr. BACKER has evidently not read this book properly or he has not understood the matter well, for on p. 1186 he could have read (what indeed may be regarded as a matter of common knowledge) that in those birds who live on juicy fruits the muscular stomach is reduced, whilst on the other hand it is powerfully developed in the genuine seed-eaters such as pigeons and fowls. The chapter quoted by Mr. BACKER happens to treat of the stomach of the real seed-eaters, which in connection with the food they consume is exceptionally developed!

2) TH. SCHMUCKER, Beitrag zur Kenntnis der Hochgebirgsflora Javas und zur Theorie der Pflanzenverbreitung. Beihefte z. Bot. Centralbl., Vol. XLIII, 1926, p. 52.

vable in the high mountains of Java, how few new individuals in untouched forest spring from seeds and succeed in securing a permanent place amongst the other plants; though it should also be borne in mind that tropical regions possess a far larger proportion of trees and shrubs in which vegetative reproduction is exceptional.

But when the association has reached its full development the increase need only take place slowly and occasionally. When an alpinoid forest consists of tree-species that may live a couple of hundred years, then all that is required is one substitute for each existing individual once in all those years. Even in the old forest an enormous number of seeds germinate, but the great majority of the seedlings perish again in a short time. A large proportion of the seeds, however, remains dormant and if from one cause or another an opening is formed in the forest, they germinate and get a chance to grow up. Various examples of this could be cited. When part of the forest is destroyed either by man or by nature, numerous plants spring up and form a new carpet of vegetation.

JUNGHUHN [1]) gives a very telling example of this. When in 1839 he first trod the plateau of Pengalengan near Bandoeng, the ground was covered far and wide with virgin forest. In 1846 he revisited this region and he found that an area of some 5000 acres of forest had been cut down, cleared and planted with coffee-trees, and that the ground was covered by two weeds which do not grow in the shade of the forest, to wit *Ageratum conyzoides* and *Bidens leucantha* (= *B. pilosa*): millions of plants occupied the ground in there plantations. This demonstrates the importance of the dispersal by seeds very convincingly. According to RIDLEY [2]) the dissemination of *Ageratum* is effected not only by wind, but also by man and by animals, as the barbs on the achenes and on the pappus stick easily to clothes and animals' fur. All three means of dispersal may have played a part. The fruits may have been conveyed from other regions by men and horses, and the achenes produced by the plants that have thus developed, could easily have been spread hither and thither by wind. The achenes of *Bidens* are not spread by wind but exclusively by men and animals; the fruits possess hooked appendages by which they readily stick to objects with which they come in contact. A person walking through a field of fruit-bearing *Bidens* soon finds his trouser-legs and putties covered all over with the little dry fruits, which stick so closely that it requires some effort to remove them. To feathers and hairs they do not stick so firmly, and birds and mammals will therefore sooner get rid of them; it is therefore to be presumed that the distribution was effected mainly by these animals.

These two plants, however, are not the only ones which make their appearance suddenly and in great numbers, nor is this phenomenon con-

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1) FR. JUNGHUHN, Java. 2nd. ed., Vol. I, 1863, p. 157.
2) H. N. RIDLEY, loc. cit., p. 569.

fined to annuals. I will now give from my own experience a few examples of perennials behaving in this way.

In 1921 a patch of forest on the slope of the Pangrango-cone at an altitude of about 2800 m was torn open by a gale. Though not all the trees and bushes had been blown down, this patch had become far more accessible to light. In 1925 this patch bore hundreds of individuals of *Primula imperialis,* plants that cannot grow in heavily shaded forest, and which did not occur either in the immediate vicinity of this patch. There were however some flowering and fruit-bearing individuals along the path leading from Kandang Badak to the top of Pangrango, which passes at a distance of some 200 yards by the patch thrown open by the gale. The seeds of this plant do not show any special devices by which dispersal is facilitated, but they must have been present in large numbers in the soil, otherwise they would not have come up plentifully. In 1931 I revisited the same spot and found a dense vegetation of shrubs and bushes, whilst the *Primula* had mostly disappeared.

In the mountains of Central and East Java each year large tracts of forest are destroyed by fires. The next year the seeds of *Albizzia montana* resting in the soil germinate and they do this sometimes in such huge numbers that the young shoots stand close together like culms in a cornfield. This phenomenon struck me especially during an excursion to Mt. Sindoro in Central Java [1]).

After the great fire by which in 1912 the vegetation of the top of Merbabu [2]) was destroyed down to the ground, it also became manifest how many dormant seeds in the soil await their chance. At the end of 1912 *Plantago major* and specifically the form that used to be distinguished as *Plantago Hasskarlii,* which before the fire was found here and there but usually in isolated individuals only, had formed a dense vegetation of robust plants, which were at that time already flowering and fructifying plentifully. A species of *Brassica,* so rare before the fire that it was not collected by me when I visited the mountain a few years earlier, now stood in multitudes among the burnt *Anaphalis* and *Albizzias.* The most remarkable fact was that a terrestrial-orchid, *Habenaria tosariensis* which used to grow sporadically among the tussocks of *Festuca nubigena,* had come up so numerously that in many places the soil was completely covered by it.

Another example is also illuminative. For the building of a mountain bungalow and laboratory a small extent of very dense alpinoid forest near Lebak Saät (2400 m a.s.l.) had been cut down and the ground cleared.

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1) W. DOCTERS VAN LEEUWEN, Beitrag zur Kenntnis der Gipfelvegetation der in Mittel-Java gelegenen Vulkane Soembing und Sindoro. Bull. d. Jardin Bot. de Btz., Serie III, Vol. XI, 1930, p. 35.

2) W. DOCTERS VAN LEEUWEN, Ueber die Erneuerung der verbrannten alpinen Flora des Merbaboe-Gebirges. Zentral-Java. Ber. d. deutschen botan. Gesellsch., Vol. XXXI, 1913, p. 153.

A year later the soil was almost entirely covered with young plants of *Albizzia montana* and *Carex hypsophila*. This *Carex* is present here and there in the forest, but usually not in such dense parts as the patch that was cleared; *Albizzia montana* is also rare there. The latter grows in the aloon-aloon-ketjil (the small one) a few hundred yards from the new locality; the seeds must nevertheless have been disseminated already throughout the forest, for shortly after the clearing of the ground the seedlings were seen to come up in multitudes.

What SCHMUCKER observes as to the slight chance of success of the numberless seeds falling in already fully developed associations, is indubitably true. As soon however as a change occurs, the significance of the seeds becomes evident, and in most cases far more is achieved then by this kind of propagation than by the vegetative process. For plants growing epiphytically and also for parasites the multiplication through seeds is a conditio sine qua non. SCHMUCKER himself however rightly remarks that, though seeds do not achieve much in the near vicinity of their parents, we must not conclude that they are of no importance where longer distances are concerned.

The means of dispersal of the plants of the Javanese high mountains are the same as in other regions, viz.water, wind and animals.

Water plays a modest, but not an entirely unimportant part, as rain water running down the slopes may transport many fruits and seeds. The brooks also, though scarce in these regions, may carry seeds, and accordingly along watercourses plants are met with which are more at home at higher elevations. *Primula imperialis* spreads very probably from the top of Pangrango to Kandang Badak through water transport of the seeds. When in 1854 MOTLEY [1]) visited this mountain he found the *Primula* at the top only. Since that time the plant has probably travelled downwards along the road made a few years before MOTLEY's visit; the majority of them are growing above 2700 m, but some plants occur as far down as Kandang Badak. The seeds of this plant do not possess any special means of dispersal; they usually remain for a long time in the open fruits, and are only shaken out of them by a knock or by a strong squall. During a protracted spell of rainy or misty weather the seeds often germinate already inside the fruits. Finally the inflorescences sink down and the seeds are scattered, but they are not removed very far from the parent plant. This explains why the *Primula's* are usually growing in groups. Nevertheless there must also be other means of dispersal, for isolated individuals are often met with far away from the colonies. I have already pointed out that numerous young individuals have been found in a part of the forest opened up by a storm some hundreds of yards removed from seedbearing individuals. How in this case the dispersal has taken place

1) Letters from J. MOTLEY to W. MITTEN. Hooker's Journal of Botany, Vol. VII, 1855, p. 81.

is entirely unknown. It is hardly probable that the seeds can have been washed down by water through the dense forest tangle. About the distribution of the European species of *Primula* also little is known. The seeds of *Primula acaulis* are according to SERNANDER [1]) spread by ants, but apart from the fact that the seeds of *Primula imperialis* do not possess an elaiosome, ants could not be instrumental in effecting their dispersal, because they are absent in the upper regions of the Javanese mountains.

The dispersal of *Gentiana quadrifaria* may take place in the same way. The little fruits of this plant are born on straight peduncles and dehisce with two valves forming a kind of cup in which the black seeds rest. The latter may be shaken out of the fruits in dry weather by a push, but they may also be driven out by the rain: during a shower the capsule fills with water and the seeds begin to float; they are then easily washed out and they may undoubtedly be dispersed in this way. We shall have to refer to this plant again.

It may be assumed that the seeds of many plants would be dispersed from higher to lower parts by rainwater running down the slopes of the mountain; even where the slope is comparatively unsignificant (perfectly level stretches occur hardly anywhere) heavy rains will cause runlets to be formed, by which seeds may be carried along. The best chance of having their seeds spread by water naturally falls to plants which grow in or along running water. The seeds of *Scirpus fluitans*, which is found in the brook on the Pangrango-top, can be easily carried along by the current, and the same is true of the seeds of *Ranunculus javanicus* whose fruit-bearing stems often overhang the water of the brook. The only plant possessing seeds specially adapted for conveyance by water is *Laurembergia coccinea*. The fruits of this plant, which occurs in Java on some widely distant mountains, possess in their pericarp cavities with air, which make them buoyant. These little fruits are therefore very easily distributed by rainwater, and especially by the running water of brooks. Accordingly this plant generally occurs on the banks of lakes and rivulets and in places which are temporarily flooded.

The seeds of *Thalictrum* also float on water, which explains the occurrence of this plant along runnels; cf. RIDLEY [2]).

Other marsh or waterplants are not met with on Pangrango-Gedeh. On other high summits, for instance on Papandajan and Kawi they are more numerous. The flora of Papandajan has been described by VAN STEENIS [3], who found a large number of marsh-plants, such as *Eriocaulon trilobum*, *Xyris melanocephala*, and several species of *Carex*, which grow in

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[1]) R. SERNANDER, Entwurf einer Monographie der Europäischen Myrmecochoren. Kungl. Svenska Vetenskapsakademiens Handlingar, Bd. XLI, No. 7, 1906, p. 304.

[2]) H. N. RIDLEY, loc. cit., p. 197.

[3]) C. G. G. J. VAN STEENIS, Eenige belangrijke plantengeographische vondsten op den Papandajan. „De Tropische Natuur", 1930, Nos. 5—6.

or along the water and whose seeds of fruits can be transported by water.

A more important factor in the dispersal of fruits and seeds is the wind. Among the plants in these regions there are also species which have very small and light seeds, and others which are adapted for transport by air currents by an extension of their surface. Extraordinarily light are, as is well-known, the seeds of orchids. The many species occurring here undoubtedly owe their dispersal to winds. Of the terrestrial orchids it might still be supposed that the seeds could be distributed by rain and running water, but this is certainly not so with those of the epiphytic ones. For them the conveyance of the seeds by wind is quite indispensable. In this part of the mountain both strong and light winds occur regularly, and even on the ground in the forest there are currents of air strong enough to carry the very light seeds of these orchids. Among the *Ericaceae* are also found some representatives with light seeds, viz. the species of *Rhododendron*. Their seeds are also provided with a narrow wing so that they are easily carried by the wind. *Rhododendron citrinum* and *R. album* occur exclusively as epiphytes; *Rhododendron javanicum* and *R. retusum*, though at this altitude mostly terrestrial, occur nevertheless everywhere epiphytically also, which proves that their seeds are easily carried by winds, since dispersal of these dry fruits and seeds by animals is improbable. The seeds of *Nepenthes gymnamphora* are also very light and this plant too, grows frequently epiphytic.

Graminaceous plants also have small seeds or rather fruits, but in comparison with those of the orchids they may be called heavy. Nevertheless dispersal by winds would appear to play an important part. This is also RIDLEY's [1]) opinion. It is extremely rare to see these plants growing epiphytically in the high mountains, though I know an old individual of *Vaccinium varingifolium* on the top of Pangrango, bearing a number of *Agrostis infirma* plants. But there is a possibility that these seeds were dragged to this place by the mountain-rat *Rattus lepturus*, which is common here. RIDLEY [2]) notes that the seeds of *Poa annua* are easily transported by wind.

The seeds of the *Cyperaceae* are heavier than those of the grasses and probably the wind does not play a part in the dispersal of these herbs, although the possibility should not be entirely excluded. Among *Ranunculaceae*, *Clematis Leschenaultii* has fruits adapted for distribution by wind. The plants climb up into trees and shrubs and the fruits are often high above the ground; they are furnished with a hairy appendage. When a plant bearing ripe fruits is shaken they easily break off and float along on the wind.

I have no knowledge as to the distribution of the fruits of *Ranunculus*. They will easily float on water, but whether they can be disseminated by

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[1]) H. N. RIDLEY, loc. cit., p. 99.
[2]) H. N. RIDLEY, loc. cit., p. 100.

wind I do not know. In RIDLEY's work I have found no information either with regard to the distribution of the fruits of this plant. Fruits of *Thalictrum* are readily dispersed by water in consequence of their easy buoyancy. The species of *Cardamine* have explosive fruits; whether the dispersal of the seeds is further aided by the wind I do not know. The small fruits of *Astilbe indica* are probably disseminated by wind, as portions of the desiccated panicle easily break off. The same probably holds good also of *Hydrangea* as the large desiccated calyces of the barren flowers will very likely help in the dispersal of pieces of the inflorescence by the wind. *Oxalis corniculata* has dehiscent fruits and small seeds which are flung away elastically.

In *Albizzia montana* the seeds remain for a long time attached to the pods and these are easily borne along by the wind; they are accordingly often seen in large quantities in the crater of Gedeh as it were swept together in still spots. The legumes are comparatively large, flat, and when dried out they are very light. The fruits of *Acer niveum* are in possession of a wing such as occurs also in other species of this genus and in this way they are fitted for dispersal by wind. KOORDERS [1]) expresses himself as follows on this: "As a means of dissemination the plant makes use only of its fruits, which is known as a samara, and such fruits are in the main restricted to dispersal by wind, but here they appear also, on the strength of an experiment made by me, to be fit for transport by water. I found at least that when thoroughly dry they will keep-afloat for more than 6 days on a 3½ % solution of salt. In Java they are produced in this species, as far as is known, only once a year, but then in very large numbers. Though the samaras are rather heavy, weighing in dry condition (inclusive of the wings which are usually 5 cm long and 2 cm wide) circa 100 milligrams, and though in Java I was never able to find any indication of a dispersal of the fruits by animals, yet the dispersal is, as the list of localities given above proves, easily effected. The occurrence of this species exclusively in the higher parts of several still active volcanos at points linea recta, 30 miles or more apart and separated from each other by hot plains, where this species has in our days never been found, makes it probable that in Java the strength of the winds in the higher mountainous regions must be sufficient to transport such large samaras as *Acer niveum* possesses over a distance of more than 30 miles."

Both *Balsaminaceae* have explosive fruits which fling their seeds far away; it is not likely that the wind is a factor in the dispersal of these comparatively heavy seeds. I have no data concerning the dissemination of *Hypericum Leschenaultii*, but the seeds are small and dry and the presence

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1) S. H. KOORDERS, Over de geografische Verspreiding, de standplaatsvoorwaarden en de verspreidingsmiddelen der in de hoogste bergstreken van Java wildgroeiende *Aceraceae*. Verslag der gewone Vergaderingen der Wis- en Natuurk. Afdeeling der Kon. Akad. v. Wetenschappen te Amsterdam, Vol. XVI, 1908, p. 806.

of the plant on numerous mountains suggests dispersal by wind, for another way of distribution is hardly thinkable.

The seeds of *Viola pilosa* are comparatively heavy; the plants usually grow on the ground, and the fruits are pressed closely to the soil; nevertheless they occur everywhere. In *Leptospermum* we find comparatively big seeds, but the wind must nevertheless be a factor in its distribution over short distances. *Begonia isoptera* has winged fruits and very small seeds; dispersal by wind of either is therefore quite possible, although they mostly grow in dense parts of the forest.

On *Gentiana quadrifaria* very tiny seeds are found, and dispersal by wind must be assumed for this plant, which is common on all the mountain tops in Java. In *Swertia javanica* the seeds are bigger, but still very light. The little fruits of *Valeriana Hardwickii* are furnished with a pappus consisting of hairs, and one can often observe how the wind blows the little fruits out of the inflorescences and carries them away. With regard to those *Compositae* whose fruits possess a pappus there is no reason to doubt their dispersal by wind.

Recapitulating the above we may say that dispersal by wind occurs certainly either in many or in all representatives of the *Orchidaceae, Ericaceae, Leguminosae, Valerianaceae* and *Compositae*; in the other plants mentioned it is either probable possible, or doubtful. The number of plants whose seeds or fruits are disseminated by wind, is, apart from the *Orchidaceae, Ericaceae* and *Compositae*, not particularly large.

A great many plants possess edible pulpy fruits, and this makes it clear that the distribution by animals must be a very important factor in the dispersal of the mountain-plants. The number of bird species living on fruits is in the highest regions of Pangrango-Gedeh not very large. They are the very common mountain-thrush: *Turdus javanicus fumidus*; the white-eye, i.e. the species without a white ring round the eye: *Oreosterops javanica frontalis*, formerly known by the name of *Zosterops fallax*; *Oreocincla dauma horsfieldii*, a ground thrush; the fruit pigeons: *Sphenurus sphenurus korthalsi* and *Ptilinopus porphureus* = *Ptilinopus roseocollis*, and the pigeon: *Macropygia unchall unchall* = *Macropygia leptogrammica*; *Gallus gallus bankiva* = *Gallus ferrugineus*, the wood-fowl, and *Arborophila javanica*, the wood-partridge are also very common. I have had no opportunity to examine the stomach contents of the latter two birds; but both these gallinaceous birds are true seed eaters and the greater part of the seeds is digested. In RIDLEY's book [1]) however many examples are cited of true seed-eaters in whose droppings undigested seeds have been found, which on being sown proved viable. It is therefore quite probable that these two bird-species also assist in a similar manner in the distribution of plants and especially of *Gramineae* and *Cyperaceae*.

[1]) H. N. RIDLEY, loc. cit., p. 439.

Proofs are however not available. On Mt. Sindoro my son [1]) and I observed the fowl *Gallus varius* feeding on the fruits of *Impatiens platypetala*. When the bird was shot and opened, the stomach proved to be filled with epicarps and seeds, and it is quite possible that some seeds may pass undamaged through the intestine. As these birds are also fond of eating berries and drupes the possibility that they aid in the dispersal of plants is very great. About the other birds mentioned more data are available. JUNGHUHN [2]) already reports that the fleshy fruits of *Vaccinium varingifolium, Gaultheria nummularioides, Myrica javanica* and *Eurya acuminata* are the principal food of the mountain thrushes and fruit-pigeons. KORTHALS [3]) observed how on this mountain the fruits of *Scurrula fusca* were consumed by *Pycnonotus bimaculatus*. WALLACE [4]) states that on the top of Pangrango the mountain thrush ate of the strawberries growing there. ROBINSON, BODEN KLOSS and JACOBSON [5]) report that in the intestines of *Pycnonotus bimaculatus barat* (at 2800 m altitude on Mt. Ophir in West Sumatra) seeds of a species of *Vaccinium* and of *Gahnia javanica* were found.

Personally I have made, unless stated otherwise, on the top of Pangrango the following observations. *Turdus javanicus fumidus* I repeatedly observed eating the fruits of: *Vaccinium varingifolium, V. laurifolium, Photinia Notoniana* and *Rapanea avenis*. Seeds of the last named plant were present in the droppings of these birds which I found on the bank of the brook in which they use to bathe; germinating seeds were also found several times in these excrements. On the oro-oro plateau of Mt. Kawi in East-Java quite large patches are entirely covered with *Styphelia pungens*, which bear orange berries. The mountain thrush which is very common on this mountain is very fond of them; and I have repeatedly found germinating seeds in its droppings. It is obvious therefore that the mountain thrush participates in the dispersal of these plants.

Oreosterops javanica frontalis I watched tasting the fruits of *Rubus lineatus, Rubus Hasskarlii* and *Schefflera lucescens*. *Sphenurus sphenurus korthalsi* was seen eating the fruits of *Vaccinium varingifolium*. In the Tengger mountain I saw flocks of *Pycnonotus bimaculatus* busying themselves everywhere in the bushes of *Rubus niveus* subsp. *Horsfieldii* and feasting on the sweet fruits of those blackberries.

Near Kandang Badak I repeatedly saw *Dicaeum trochileum* eating the drupes of *Scurrula lepidota* which is common there, and dropping the

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1) HANS DOCTERS VAN LEEUWEN, Beitrag zur Kenntnis der Avifauna der Mitteljavanischen Vulkane Soembing und Sindoro. Treubia, Vol. X, 1929, p. 441.

2) FR. JUNGHUHN, Java, Vol. I, 1863, p. 600.

3) P. W. KORTHALS, Waarnemingen omtrent den berg Gedeh op Java. Nederl. Kruidkundig Archief, Vol. I, 1848, p. 125.

4) A. R. WALLACE, The Malay Archipelago, Vol. I, London, 1869, Second Ed., p. 121.

5) H. C. ROBINSON, C. BODEN KLOSS and E. JACOBSON, On a large collection of birds chiefly from West Sumatra. Journ. of the Federated States Museum, Vol. XI, 1924, p. 291.

stones. These birds are the most important dispersers of these semi-parasites [1]).

These field observations may be supplemented with the results which are obtained by examining the contents of the entrails of fruit-eating mountain birds. KOORDERS [2]) in his description of the re-afforestation of Mt. Sindoro reports that the crop and the stomach of the green fruit-pigeon *Sphenurus sphenurus korthalsi* and of a kutilan- species (*Pycnonotus*) probably *Pycnonotus bimaculatus* contained numerous kernels of *Myrica javanica*; those of one green pigeon contained 231 kernels of this plant, of an other one 144 and of a kutilan 4. These seeds were sown out, and all of them, the full 100 %, germinated. Quite rightly KOORDERS concludes that these birds must contribute actively to the dispersal of this mountain plant.

A few years ago I [3]) received the contents of the stomachs and further entrails of birds shot by Mr. BARTELS on the tops of Gedeh and Pangrango. The examination of them proved that *Oreosterops javanica frontalis* had eaten fruits of a species of *Vaccinium*, probably of *V. varingifolium*. The entrails of *Turdus javanicus fumidus* contained seeds of *Vaccinium varingifolium*; those of *Oreocincla dauma horsfieldii* seeds of *Myrica javanica* and those of *Sphenurus sphenurus korthalsi* seeds of species of *Gaultheria*, of *Myrica javanica*, of *Eurya acuminata* and of a plant I did not know at the time but which I have now found to be *Schefflera rugosa*.

By my son [4]) many birds on Mts. Sumbing and Sindoro were shot and the contents of their stomachs examined. The viscera of *Sphenurus sphenurus korthalsi* contained seeds of *Myrica javanica* and "seeds" of a *Ficus*-species. In the intestines of *Xantholaema haemacephala rosea* there were seeds of *Myrica javanica*, in *Pycnonotus bimaculatus* seeds of *Vaccinium varingifolium*, of *Myrica javanica*, and of *Rubus lineatus*. *Turdus javanicus whiteheadi* contained seeds of *Vaccinium varingifolium*, of *Myrica javanica*, and of *Polygonum chinense*. *Aplonis panayensis strigatus* (= *Calornis chalybea*) proved to have eaten fruits of *Myrica javanica*. The entrails of *Oreosterops javanica javanica* contained seeds of *Myrica javanica*, of *Vaccinium varingifolium*, of *Viburnum coriaceum*, of *Polygonum chinense*, and of *Rubus fraxinifolius*. The seeds of *Polygonum*

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1) W. DOCTERS VAN LEEUWEN, Beiträge zur Kenntnis der Javanischen Loranthaceen. Ann. d. jard. bot. de Buitenzorg, Vol. XXXVIII, p. 122.

2) S. H. KOORDERS, Over de standplaatsvoorwaarden, verspreidingsmiddelen en geographische verspreiding van de in Java, vooral in het hooggebergte wildgroeiende soorten der *Myricaceae*. Verslag der gewone vergaderingen der Wis- en Natuurk. Afd. der Kon. Akad. v. Wetenschappen te Amsterdam, Vol. XVI, 1908, p. 651.

3) W. M. DOCTERS VAN LEEUWEN, Kleiner Beitrag z. Kenntnis der endozoischen Verbreitung einiger Hochsgebirgspflanzen auf Java. Flora, Vol. 18 und 19, p. 86.

4) HANS DOCTERS VAN LEEUWEN, Beitrag zur Kenntnis der Avifauna der Mitteljavanischen Vulkane Soembing und Sindoro. Treubia, Vol. X, 1929, p. 439.

chinense, of *Myrica javanica*, and of *Vaccinium varingifolium* were also found in the intestines of *Zosterops palpebrosa sindorensis*.

It may strike the student that seeds of high mountain plants were found in the stomachs of birds which do not live in what are properly high mountainous regions. The seeds of *Myrica javanica* were found in the intestines of *Xantholaema haemacephala rosea* and in those of *Aplonis panayensis strigatus*. In these almost entirely deforested mountains all sorts of plants belonging to the high mountainous regions proper or to craterfields and solfataras, occur very much lower than on less barren mountains. *Vaccinium varingifolium* and *Myrica javanica* on Sumbing and Sindoro occur frequently as low as 1600 m. In accordance with this birds which elsewhere are met with on the highest tops only, e.g. *Sphenurus sphenurus korthalsi*, *Turdus javanicus whiteheadi*, *Oreosterops javanica*, occur here as low down as 1600 m; this proves how completely these birds depend on the fruits of these plants.

From the dates given above it appears that a very large number of fleshy or pulpy fruits of high-mountain plants are eaten by birds. I will give now a complete list of these plants: it contains those of which the fruits were actually seen to be eaten by birds and those of which the seeds were found in the stomach contents.

1. *Gahnia javanica* (Mt. Ophir, Sumatra): *Pycnonotus bimaculatus barat*.
2. *Myrica javanica* (Mts. Gedeh—Pangrango, Sindoro, Sumbing): *Sphenurus sphenurus korthalsi*; *Pycnonotus bimaculatus*; *Oreocincla dauma horsfieldii*; *Xantholaema haemacephala rosea*; *Turdus javanicus whiteheadi*; *Aplonis panayensis strigatus*; *Oreosterops javanica*; *Zosterops palpebrosa sindorensis*.
3. *Scurrula fusca* [1]) (Mt. Gedeh): *Pycnonotus bimaculatus*.
4. *Scurrula lepidota* (Mt. Gedeh): *Dicaeum trochileum*.
5. *Polygonum chinense* (Mts. Sumbing, Sindoro): *Turdus javanicus whiteheadi*, *Oreosterops javanica*; *Zosterops palpebrosa*.
6. *Fragaria vesca*; (Mt. Pangrango): *Turdus javanicus fumidus*.
7. *Photinia Notoniana*; (Mt. Pangrango): *Turdus javanicus fumidus*.
8. *Rubus fraxinifolius*; (Mt. Sindoro): *Oreosterops javanica*.
9. *Rubus Hasskarlii* (Mt. Gedeh): *Oreosterops javanica frontalis*.
10. *Rubus lineatus*; (Mts. Sumbing, Pangrango): *Pycnonotus bimaculatus*, *Oreosterops javanica frontalis*.
11. *Rubus niveus* subspec. *Horsfieldii*; (Mt. Tenger): *Pycnonotus bimaculatus*.
12. *Eurya acuminata*; (Mt. Pangrango): *Sphenurus sphenurus korthalsi*.

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[1]) This plant has not thus far been found by myself on the Gedeh-top, cf. P. W. KORTHALS, Waarnemingen aangaande de berg Gedé op Java. Nederlandsch Kruidkundig Archief, Vol. I, 1848, p. 125.

13. *Schefflera rugosa* (Mt. Pangrango): *Sphenurus sphenurus korthalsi.*
14. *Schefflera lucescens*; (Mt. Gedeh): *Oreosterops javanica frontalis.*
15. *Gaultheria* spec. div.; (Mt. Pangrango): *Sphenurus sphenurus korthalsi.*
16. *Vaccinium laurifolium* (Mt. Pangrango): *Turdus javanicus fumidus.*
17. *Vaccinium varingifolium* (Mts. Pangrango, Sindoro, Sumbing): *Turdus javanicus fumidus* and *whiteheadi, Oreosterops javanica frontalis* and *javanica; Zosterops palpebrosa sindorensis, Pycnonotus bimaculatus, Sphenurus sphenurus korthalsi.*
18. *Styphelia pungens*; (Mt. Kawi): *Turdus javanicus.*
19. *Rapanea avenis*; (Mt. Pangrango): *Turdus javanicus fumidus.*
20. *Viburnum coriaceum*; (Mt. Sindoro): *Oreosterops javanica.*

Of the above listed mountain-plants it is known therefore that their fruits are eaten by birds; of a large number of them the seeds were found in the intestines of birds; and of some of them it was ascertained that the seeds after passing through the bird's intestine were capable of germinating. It may be assumed that the seeds of plants with fleshy or pulpy fruits are as a rule dispersed by birds.

When we study the list of plants with fleshy fruits growing in the upper region of Pangrango-Gedeh, we find that in some families plants with edible fruits predominate, while in other families only few representatives are provided with such fruits. Among the *Cyperaceae Carex baccans* is the only species which has its small hard fruits enclosed in a juicy pericarp. These fleshy pseudocarps are eagerly consumed by forest-fowls and partridges. From an investigation by ROBINSON, BODEN KLOSS and JACOBSON, already quoted before, it appeared that the small fruits of *Gahnia javanica*, which are not very juicy, are also eaten by birds. The two *Liliaceae*: *Dianella javanica* and *Disporum chinense* have big aqueous fruits; the two wild *Polygonaceae*: *Polygonum chinense* and *P. paniculatum* also. The seeds of the former species were also already found in the intestines of birds. The fruits of *Litsea cubeba* are also fed upon by birds. FORBES [1]) writes that these fruits are the favourite food of various bird species. The fruits of *Eugenia jamboloides* are also juicy. Among *Rosaceae* edible fruits are found in *Fragaria vesca*, in *Photinia Notoniana*, and in various species of *Rubus*. Likewise two *Saxifragaceae*, to wit *Dichroa febrifuga* and *Polyosma ilicifolia* are in possession of them. Further *Elaeocarpus acronodia* and *Perrottetia alpestris, Eurya acuminata* and *Melastoma setigerum*. The three *Araliaceae*: *Aralia ferox* and the two species of *Schefflera* are also furnished with them. Of the *Ericaceae* all the species except the representatives of the genus *Rhododendron* are

[1]) H. O. FORBES, Wanderungen eines Naturforschers im Malayischen Archipel (translated by R. TEUSCHER). Jena, 1886, Vol. I, p. 84.

provided with pulpy fruits which are relished by all sorts of mountain birds. Among the *Myrsinaceae* the species belonging to the genera *Ardisia, Embelia* [1]) and *Rapanea* bear edible fruits, *Symplocos sessilifolia* also. The *Loganiacea*: *Geniostoma haematosperma* has a dry pericarp but it possesses a conspicuous red and juicy aril. Of the *Gentianaceae Crawfurdia trinervis* is the only one which has fleshy fruits. We find them too in *Solanum nigrum, Cyrtandra arborescens, Lasianthus lucidus* and *Nertera depressa*. On Tristan d'Acunha, according to MOSELEY, the thrush *Nesocincla eremita* feeds on the berries of this plant, cf. RIDLEY [2]). *Lonicera javanica, Viburnum coriaceum, Pratia montana* and *Melothria punctata* possess also fleshy fruits.

Fructivorous bats which in the tropics contribute largely to the dispersal of various pulpy-fruited plants do not, as far as I am aware, occur in these regions. But there is a species of rat, *Rattus lepturus*, which is of very general occurrence here, and feeds mainly as I found by examination of its stomach-contents on vegetable products. It is a nocturnul creature which spends the daytime in its nest under roots of trees and especially in mossy patches, but comes forth at twilight. In captivity it gladly feeds on the fruits of a variety of plants; I saw it near Kandang Badak eating the small fruits of *Cerastium caespitosum*, and the little animal may often be observed in early morning hours in the branches of *Vaccinium* trees hunting for the fruits. This animal indubitably plays an important part in the dispersal of the seeds of all sorts of mountain plants, though direct observations are scarce as yet.

Birds and mammals may also be instrumental in the distribution of fruits which adhere by means of a sticky layer or by hooked or bent appendages to the fur or coat hairs or in the plumage. The number of plants bearing such fruits is not very large. *Carex hypsophila* has tiny acuminate fruits with strong back-slanting bristles. According to RIDLEY [3]) the fruits of *Peperomia reflexa* are very adhesive and are probably spread by birds. *Drymaria hirsuta* has fruits with viscid hairs and *Sanicula europaea* possesses barbed hooks on the fruits by which they readily fasten themselves. *Dichrocephala chrysanthemifolia* and *Myriactis nepalensis* [4]) produce small sticky fruits, whilst the achenes of *Bidens pilosa* will easily catch on by hooks on the upper edge.

Out of 152 plants represented in the highest regions of Pangrango no fewer than 58 have fruits which are very probably spread by animals.

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1) S. H. KOORDERS, Bijdrage tot de kennis der endozische zaden-verspreiding door vogels. Verslag gewone Vergad. Kon. Akadem. v. Wetensch. Amsterdam, Vol. XVIII, 1909, p. 45. KOORDERS found seeds of *Embelia ribes* in the intestines of *Pycnonotus bimaculatus*.

2) H. N. RIDLEY, loc. cit., p. 395.

3) H. N. RIDLEY, loc. cit., p. 619.

4) Dr. C. G. G. J. VAN STEENIS observed the fruits of this composite attached to the wings of a dragon-fly. See Tropische Natuur, Vol. XXI, 1933, p. 191.

SCHMUCKER [1]) states that out of 172 plants incorporated in his article as occurring in the higher parts of the mountains of Java, 39 possess berries or pulpy fruits as a means of reproduction, and that 2 are in possession of devices for exozoic dispersal. This number is too small. In SCHMUCKER's list of plants occurring above 2500 m, I find 54 species of which dispersal by animals may be assumed. As SCHMUCKER does not give the names of the 39 plants which he considers zoochorous, a further discussion is useless.

Plants whose seeds are very light or which possess special devices for distribution by wind are represented on the part of Pangrango-Gedeh above 2400 m by about forty species.

Of 152 plants found in this area there are 58 which can be spread by animals; the majority of these possess juicy fruits, a smaller number have adhesive or prickly fruits; there are 42 species of which dispersal by wind may be assumed; two species which possess fruits built for distribution by running water; in all therefore 102 forms whose mode of dispersal may be deduced with a high degree of probability. Not everybody, of course, will arrive at exactly the same figures, as in the present state of our knowledge our classification is still somewhat arbitrary, and will remain so for some time to come. Although no one has observed the seeds of a particular plant of the wind dispersed type from the moment that they are blown away, until they come to earth and germinate, yet nobody will doubt that dispersal by wind is of great importance in the dispersal of plants.

In addition to this number of 42 plant species whose fruits or seeds from their structure or lightness may be regarded as distributed by wind, there are several others whose seeds though certainly not so small as those of the Orchids or of *Nepenthes*, which it will be remembered can even be carried along by weak currents of air, are nevertheless light enough to be dispersed by the strong winds prevailing in these high reaches and which may temporarily attain the force of a gale. As examples we mention grasses and *Cyperaceae*, which sometimes have parts of their plumes torn off and carried away by strong winds. The small seeds of *Leptospermum*, *Cerastium*, *Gentiana* and several others are also easily carried along by strong winds. Of such plants 22 may be found in the list of Pangrango-Gedeh plants.

With regard to the dispersal of the remaining species we are still completely in the dark, though some of them are widely distributed. *Balanaphora elongata*, a parasite on the roots of various kinds of trees, occurs from Tjibodas to the tops of Gedeh and Pangrango, the individuals sometimes occurring very far apart. This parasite occurs also on several other javanese mountains separated from each other by wide distances, but we

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[1]) TH. SCHMUCKER, loc. cit., p. 64.

possess no knowledge as to the manner in which the seeds of this plant are dispersed.

It would be very tempting to end this chapter with a discussion of the dispersal of alpine plants generally, a subject of great importance in plant-geography. In broad outline a picture can be drawn of the ways and means by which the alpine plants have reached their present habitats, but as soon as one enters into details one comes upon great difficulties and is landed in speculations which lack firm foundations. Many have already endeavoured to gain an insight into the distribution of plants over long distances. Some of the most important discussions were already produced by BECCARI [1]) and WALLACE [2]), whilst attention may also be drawn to the interesting work of STAPF [3]) and SCHMUCKER [4]). All come to the same conclusion, that the plants which occur on the highest tops of the Indo-Malayan volcanos have arrived partly from lower regions, partly from older less high mountains, and partly from other high tops. The latter are the plants which give the boreal character to this vegetation.

In the western part of this extensive region the plants with Asiatic affinities predominate [5]), while the plants of Australian origin are few in number ; in the eastern part on the other hand, that is in New-Guinea, the proportion is reversed, cf. LAM [6]). This will be readily understood and accepted, but it does not teach us anything definite about the manner by which the plants got there.

The plants living on the tops of Pangrango-Gedeh (apart from a few ubiquitous plants probably dispersed by man) are related or identical with plants of the southern Asiatic mountains, two species only *Leptospermum javanicum* and *Thelymitra javanica* being closely related to Australian plants. The study of the dispersal of the various species is hampered by a lack of data concerning the dispersal over long distances [7]).

With regard to plants which are adapted to dispersal by wind we are better informed than with regard to the others. It is well-known that winds are able to transport grains of sand over long distances ; there is

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1) O. ENGLER, Referat über O. BECCARI, Beitr. zur Pflanzengeografie der malayischen Archipel. Engl. Jahr. f. Syst. Botanik, Bd. I, 1881.

2) A. R. WALLACE, Island Life. London, 3rd. Edition, 1911.

3) O. STAPF, On the flora of Mt. Kinabalu. Transact. Linn. doc. London, Serie II, Botany.

4) TH. SCHMUCKER, loc. cit., p. 56.

5) A. RANT, De Javaansche Gebergteflora als bewijs van een vroegere verbinding van Java met het vasteland van Azië. Natuurk. Tijdschrift v. Ned. Indië, Vol. LXXXIX, p. 1.

6) H. J. LAM, Het Genetisch-plantengeographisch onderzoek van den Indischen Archipel en WEGENER's verschuivingstheorie. Tijdschr. Kon. Aardrijksk. Genootsch., Vol. XLVII, 1930, p. 569.

7) C. G. G. J. VAN STEENIS comes to the same conclusion in his study on the *Styracaceae* of the Netherlands Indies, cf. Bulletin d. Jard. bot. de Buitenzorg. Série III, Vol. XII, 1932, p. 265.

therefore nothing which militates against the assumption that light seeds also may be carried along by winds. Difficulties, however, arise where plants with heavy seeds are concerned, and especially species with edible fruits, which are certainly quite unsuited to dispersal by wind. With regard to these plants we are compelled to assume, 1. that fruit-eating birds migrate from one mountain-top to another, and 2°. that during the transport from mountain to mountain the seeds in the bird's intestine remain viable. The birds feeding on the pulpy fruits of the mountain plants are all sedentary birds, and their migrations from mountain to mountain [1]) have never been observed. To me this appears even highly improbable, because if they did migrate, it would be impossible to explain how on several high volcano tops in Java, which are not so very far apart either, different races of the same bird species could occur. This is usually considered as conclusive evidence of a long separation. LAM in the treatise we quoted points out that in the study of the flora of the high mountains observations on the migrations of birds are of great importance. As a matter of fact very little is known on this subject as regards Java, but as we have said, the fruit-eating birds, (and they are the chief seed-carriers as plant bearing seeds adapted to exozoic dispersal are very rare), are all non-migratory. The study of bird migration, however interesting and important it certainly is, could not therefore be of great consequence for this subject.

As regards the second point, experience teaches that the seeds of fleshy fruits are rarely kept in the bird's intestine longer than half an hour and sometimes not more than a few minutes. BECCARI [2]) has suggested that the juices of fruits might cause constipation in the bowels of birds, but the facts certainly contradict this assumption. As long as more decisive data on both these points are not available, this part of plant-geography will remain a highly speculative subject.

Attempts have been made to use WEGENER's theory of the continental displacements for the elucidation of this problem, see for instance LAM [3]) and DANSER [4]), but apart from the fact that this theory does not rest on a very solid basis and that it has among geophysicists and geologists more opponents than advocates [5]), it should not be forgotten that though the distance between the mountain tops does indeed diminish somewhat, by the displacement of the continents they would not come closer together

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[1]) It is said that these birds, during vulcanic outbursts, seek refuge on other mountains, but this is a mere hypothesis and very improbable.

[2]) O. BECCARI, Malesia, Vol. I, Fasc. III, 1878, p. 218.

[3]) H. J. LAM, loc. cit., p. 566.

[4]) B. H. DANSER, The *Nepenthaceae* of the Netherlands Indies. Bull. du Jard. bot. de Buitenzorg, Série III, Vol. IX, 1928, p. 422.

[5]) On this subject the reader is referred a.o. to CH. SCHUCKERT. The hypothesis of Continental Displacement. Annual Report of the Smithonian Institution 1928. Washington, 1929, p. 249.

than the tops of the volcanos in Java at present are and even these distances are so great, that the explanation of the dispersal of plants from one top to another offers insurmountable difficulties. These problems should not only be studied experimentally, but the historical aspect should also be considered; now of the history of the mountains comparatively little is known, and of the history of the plants and animals [1]) occurring on them we know next to nothing. Lists of plants showing their distribution, may be drawn up with little trouble, and this work is important for the purpose of gaining an insight into their geographical distribution, but apart from the fact that in tropical regions the study of the mountain flora is still in a preparatory stage, so that such lists cannot give more than a rude outline of the areas where the plants occur, they cannot teach us anything about the actual dispersal itself and that after all, is the point.

It is perhaps tempting to draw general conclusions from such fragmentary data as are available, but these conclusions have at present no great value. The consequence is that the various authors constantly repeat the same opinions, but fail in the matter of securely founded explanations.

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[1]) Rhinocerosses used to be common on these high tops and it is well known that these animals will often shift their haunts for long distances. Who shall say what part these animals may have played in the dispersal of plants? It is also well known that in the droppings of elephants large numbers of seeds, a.o. seeds of grasses and *Mangifera* germinate (cf. Flora, Vol. 118—119, 1925, p. 83).

CHAPTER IX.

DESCRIPTIONS OF THE PLANTS OCCURRING ON THE HIGHEST PARTS OF MOUNT PANGRANGO-GEDEH.

MONOCOTYLEDONAE.

FAMILY OF THE GRAMINEAE.

1. AGROSTIS INFIRMA BUESE.

This grass occurs on several mountains from West to East Java. It grows either singly or gregariously, in sunny spots or in light shade, e.g. in open alpinoid woods, and on sandy, as well as on a more stony soil.

The spikelets of this grass show, according to BACKER [1]), every transition from the awned to the awnless form. It is a perennial plant which renovates itself by stools. It often forms big tussocks with stiff erect or slanting culms.

Although this grass occurs plentifully on Mt. Pangrango, it does not form pure communities; in the open crater-valley it occurs but sporadically and its specimens are depauperated and bear narrow panicles. Better developed specimens, sometimes with wide somewhat drooping panicles, are found in shady places. In its young state, the plant is easily recognizable by its dense tufts of greenish-grey culms and leaves, see plate VIII and XVII.

The flowering-time [2]) lasts from January to December, according to BACKER; but on Mt. Pangrango it flowers chiefly in the rainy season, though one may find occasionally a few flowering specimens at other times of the year. Pollination is effected by wind, and takes place early in the morning; I have never observed insects, not even thripses, on its flowers.

2. CALAMAGROSTIS AUSTRALIS BUESE.

This grass is on the Javanese mountains especially common from altitudes of 2000 m up to the summits. It often forms big tussocks, which

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[1]) C. A. BACKER, Handboek voor de Flora van Java, Part II, 1928, p. 208.

[2]) The statements with regard to the flowering-times are valid only for the plants occurring on the top, and in the crater-valley of Mt. Pangrango.

sometimes grow gregariously, forming pure communities, in other cases, however, it occurs scattered in associations consisting mainly of other plants. It is found in sunny or slightly shaded localities, mostly in dry soil, but sometimes also in more or less moist localities. On the sandy flats on the top of Mt. Sindoro it grows even in places where in rainy weather pools are formed, but where such pools regularly occur, it dies off. It may be found also in open alpinoid forests and among shrubs.

In different localities the plant varies greatly in size. On Mt. Pangrango and on Mt. Gedeh it forms dense communities. In the aloon-aloon of Mt. Gedeh it was taken by JUNGHUHN [1]) for *Festuca nubigena*, but as a matter of fact it is mainly *Calamagrostis*, locally also *Agrostis*, which grow in the above mentioned locality. *Festuca nubigena* does not occur there. These dense communities are composed of big tussocks, which, though nearly meeting, still remain separate. The flowering panicles, which reach a height of nearly ¾ m, droop gracefully. In the very infertile spots of the crater-valley the tussocks grow more scattered, they remain small and the panicles do not get higher than 30 to 40 cm. On the stony slopes of the crater of Gedeh the individuals are widely scattered, and most of them are but poorly developed, consisting of a few culms only.

This grass flowers principally in the second part of the rainy season, i.e. in January, February and March; pollination is affected in the morning hours. On the flowers of this species too I have never observed any visiting insect, not even thripses. Like other *Gramineae*, *Calamagrostis australis* is anemophilous. It does not die off in the dry season, but it gets brown, and the empty panicles sink down.

3. ISACHNE PANGERANGENSIS Z. et M.

This grass is common on several mountains of West and East Java. It occurs in various forms differing in habit, in the length of the internodes, and in the size of the inflorescences. On the top of Mt. Pangrango a low, more or less xerophytic form occurs, it is short and compact and bears small inflorescences, figure 15; locally this plant may develop well-nigh pure communities, viz. along the brook in the crater-valley, and in infertile, stony localities in its vicinity, plate VIII. A little glen ending in the valley of the brook is entirely covered with small tussocks of this grass. BACKER's [2]) remark that this plant often occurs in large quantities, but does not form pure communities, does not hold good for Mt. Pangrango. In the above mentioned little glen it forms a dense covering, in which but very few other plants have found a place.

At the end of December the flowering-period begins, and it lasts untill the end of March or early April. Pollination is effected by wind.

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1) FR. JUNGHUHN, Reisen durch Java, 1845, p. 479 and 448.
2) C. A. BACKER, Handboek voor de Flora van Java, Vol. II, 1928, p. 135.

4. POA ANNUA L.

This common European grass has been found also in many places in Java; it occurs here up to the very summits of the mountains. On the top of Mt. Pangrango it occurs locally, on the highest parts as well as in the

Fig. 15. *Isachne pangerangensis* Z. et M. $\times 3/4$.

crater-valley. In the latter it flowers nearly throughout the whole year, though less abundantly in the dry months. Pollination is effected by the agency of the wind.

FAMILY OF THE CYPERACEAE.

1. CAREX HYPSOPHILA MIQ.

This plant is common both on Mt. Pangrango and on Mt. Gedeh. In the Buitenzorg Herbarium it is represented only from few Javanese mountains, viz. from Mt. Papandajan, Mt. Tjerimai, Mt. Slamat, where it grows at an altitude of 3100 m, just below the stony top, and from Mt. Kawi; it is also represented in the Herbarium from the Peak of Korintji in Sumatra, where it was found only on barren slopes at 3750 m and it has also been collected on Mt. Kinabalu in North Borneo. On Mt. Pangrango it grows as well in the poor soil of open stony localities, as in more fertile places; the latter

may be slightly shaded or even overgrown by alpinoid forest. On fertile soil they form large, widely spread tussocks, plate XII. On Mt. Gedeh depauperated individuals occur even on the barren slopes of the top and in the crater. In the Kawah Lanang, an extinct crater, this plant forms a pure community, consisting of old tussocks each raised by a small hillock formed by the older parts of the plants. The flowers are aggregated in spikes, borne at the end of the flowering culm. Flowering takes place principally in the rainy season. At that time of the year in the morning hours dense clouds of pollen are shaken out, pollination being effected by wind. I have never observed insects on the flowers.

2. GAHNIA JAVANICA Z. et M.

In Java this plant has been found chiefly in West Java and on the Dieng-Plateau, in altitudes between 1700 and 3000 m. In Sumatra it has been collected on several mountains between 900 and 3000 m; further it is known from Borneo (Kinabalu) and from Bangka and Riouw, where it grows at an elevation of 10 m only along roads. In Java it grows especially in the neighbourhood of active craters, in sandy and in stony localities, at the margin of crater-lakes and near solfataras. On Mt. Gedeh it is very common on the inner wall of the crater, on stony ground of recent lava currents. Well developed specimens may be found locally in the *Vaccinium* forest. On Mt. Pangrango it is represented by some poor specimens growing at the North East end of the crater-valley. It occurs also on the heaps of stones at the foot of the waterfall of Tjibeureum above Tjibodas. In Sumatra it is found in the margin of the forests, in the undergrowth along rivers and in swamps.

Gahnia forms big tussocks rising from a much-branched rhizome. The aërial shoots are covered at their base with the blackened sheaths of old leaves. There are sterile culms which reach a height of 70 cm and bearing a large number of obliquely ascending linear leaves, and the flowering culms which rise much higher, up to 1 m. The inflorescence is a terminal head of spikelets; it is rather conspicuous when the black fruits have been formed.

As but few specimens occur on the top of Mt. Pangrango I cannot tell much about the flowering time. I found the plants in flower at the end of the rainy season; in April, during the morning hours clouds of pollen were shaken out when the culms were touched.

A good picture of this plant is given by ROCK [1]).

3. SCIRPUS FLUITANS L.

This plant occurs in marshy places, in swamps and pools and in little streams and on moist places on several mountains of Java, viz. Mts. Pang-

[1]) J. F. ROCK, The forest of Mt. Gedeh. The Hawaiian Planters' Record, Vol. XXII, 1920, N°. 2, p. 101.

rango-Gedeh and Papandajan, Dieng, Lawu, Argapura and Hijang. It is also known from Sumatra (Mts. Singgalang and Talamau) and further from Australia, Asia and Europe. On the top of Mt. Pangrango and in the aloon-aloon of the Gedeh it grows along and in the brooks.

The plants show the same habit as in Europe, and they flower regularly. When in the dry season the brook on Mt. Pangrango is quite dried up, they wither more or less. Pollination occurs by the agency of the wind.

FAMILY OF THE LILIACEAE.

1. DISPORUM CHINENSE DON [1]).

This robust herb is frequent in the woods of Mt. Gedeh-Pangrango, growing up to 2500 m altitude. The stems are vertical with more or less drooping tips; they bear alternate or opposite leaves, measuring 6 to 15 cm in length and 1½ to 6 cm in width. The shoot rises from the base of the rhizome and branches only towards the top. The inflorescences are pedunculate drooping umbels consisting of 2 to 8 flowers; they are generally borne at the tip of a lateral branch. The flowers are pedicellate, the purple or greenish-yellow perianth is 6-merous and the segments are free though on first view they appear to form a tube with a fairly narrow mouth. At the base the perianth-segments bear a shallow cavity, which contains nectar. The stamens reach ¾ of the length of the petals and the style projects 1 mm beyond the anthers while the 3 recurved stigmas protrude another 3 mm.

Pollination. The stigmas are already receptive when the flowers open, but the anthers, which have an extrorse dehiscence, are still closed. The flower therefore is protogynous. During the second flowering-day the filaments elongate and the now opened anthers come at the same height with the stigmas. As the anthers can shed their pollen upon the outwardly curved stigmas, self-pollination is possible. The plant is, however, regularly even in rainy weather visited by *Bombus rufipes*, which gets covered with pollen.

Fruits are invariably produced. It are pendulous blue berries, each containing 3 brown seeds.

FAMILY OF THE ORCHIDACEAE.

1. DENDROBIUM HASSELTII LINDL.

A common epiphyte especially in the mossclad forest at altitudes between 2000 to 2800 m. It occurs however also at higher elevations up to the top

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1) syn. *Disporum pullum* SALISB.

of Mt. Pangrango, but not so general as lower down in the forest. The flowering shoots are pendulous and the thick white roots are mostly hidden under moss clumps. I once found some well developed specimens growing on boulders in the dry river bed of the Tji-saät; their stems grew vertical and the roots were only partly covered with moss.

Fig. 16. *Dendrobium Hasseltii* LINDL. $\times$ 3/4.

The shoots are 15 to 20 cm long and bear several leaves. The flowers are arranged in sparse racemes, arising laterally on the old leafless shoots or terminally on the young ones which still bear leaves. The peduncle is 1 to 2 cm long; the splendid violet flowers are more than 2 cm broad, the lip is spathulate with an orange spot in front, figure 16. The spur is conical and about 6 mm long. As the plants are not common on the top of Mt. Pangrango I have with regard to the flowering-times only been able to note, that the plants may be in full flower at the end of the rainy season and in the dry season. I have never observed any insects on the flowers and only once a sunbird, *Aethopyga eximea*. Fruits are seldom produced.

2. MYRMECHIS GLABRA BL.

This small terrestrial orchid has been found only in a few places in Java. In the Herbarium at Buitenzorg it is represented from Mt. Pangrango and Mt. Massigit in West Java and from Mt. Kawi in East Java. On Mt. Pangrango it grows especially at altitudes between 2200 to 2800 m, though it occurs on the top too; one may find it in moss cushions on the ground and on fallen trees; it also grows frequently against the steep walls of hollow roads and epiphytically at the base of trees. The stem is prostrate and often hidden in the moss; it is fleshy and green, and has long internodes[1]). The upper part is ascending and at its end it bears 5 to 10

[1]) H. BURGEFF, Saprophytismus und Symbiose. Jena, 1932, p. 22, Fig. 17.
J. DIETZ, Morphol.-anatomische Untersuchungen der unterirdische Organe tropischer Erdorchideen. Annales du Jardin botanique de Buitenzorg, Vol. XLI, 1930, p. 12.

glabrous leaves. The white petioles are expanded at their base, the blade is triangular-ovate, the margin crenate. The terminal inflorescence consists usually of 3 flowers; at the base it is partly surrounded by the leaves; the peduncle bears one or two nearly subsessile leaflets and higher up the lanceolate bracts. The inflorescence is a short spike, figure 17. The flowers are pure white, about 10 mm long; the ovary is green. The segments of the perianth are connivant, slightly divergent at the top; the sepals and the two lateral petals are more or less similar, the latter however are expanded at the base, embracing the spur. The labellum is narrow; its base is dilated into a spur. The latter bears inside two glands, which excrete much honey. The middle pollen-sacs only are developed, the lateral ones are empty and bladdery. There are 2 pollinia. The rostellum is orange-coloured.

Fig. 17. *Myrmechis glabra*. BL. $\times$ 3/4

Pollination. I have never observed insects on these flowers. In all the flowers examined, young and old, the rostellum was still present. The pollen grains however germinate already in the anther, the tubes growing towards the inner part of the style and the ovules are therefore fertilised by means of self-pollination.

3. MYRMECHIS GRACILIS BL.

This plant has already been found at an altitude between 1600 and 3000 m on numerous mountains in West-Java, and very occasionally in Central and East Java. It is also known from Sumatra: from Mts. Sago, Korintji and Malintang. One can find it in the primeval forest and in alpinoid forests in similar localities as *Myrmechis glabra*. On Mt. Pangrango it is very abundant up to quite near the summit, but especially near Kandang Badak.

This plant is very similar to *Myrmechis glabra*, but its leaves are further apart, the flowers are smaller, and the inflorescence is glabrescent,

Fig. 18. *Myrmechis gracilis* BL. A: with fruits; B: with flowers. $\times$ 3/4.

figure 18. The structure of the flowers and the method of pollination are of the same kind as in *Myrmechis glabra*.

4. PLATANTHERA BLUMEI LINDL.

This plant is only known from Mt. Pangrango-Gedeh; it grows there locally in small groups, from about 1700 m up to the summit of the mountain. It grows in the humus soil of the forest or on fallen trees and in moss,

Fig. 19. *Platanthera Blumei* LINDL. A: inflorescence; B: fruits. $\times 3/4$.

but always in the shade, though often at the edge of the alpinoid forest. The flowering plants reach a height of 60 cm; they consist of a short

rhizome bearing long roots; the rhizome grows vertically and while the aerial part flowers, a new shoot is formed. In one plant we may find shoots past flowering, in the act of flowering, and just sprouting. The leaves are arranged at the base in a kind of radical rosette, but they ascend on the flowering-shoots, and towards the top they become smaller and change into bracts. The flowers are arranged in spikes of 5 to 30 flowers and face in all directions. They are pale-green, figure 19, about 20 mm broad; two of the perianth-segments are recurved and 10 mm long, the others 9 mm; the labellum is about 11 mm long, and bears a long, slender spur, which contains sweetly smelling honey. The flowers open very slowley; first the left and right sepals diverge, and simultaneously the labellum turns downwards; the three remaining perianth-leaves form a hood-like group, vaulting over the gynostemium. Not before the fourth day one of the sepals curves backwards; the rest follow on the fifth day. The spur now straightens forward nearly perpendicular to the flower-axis, the labellum facing straight downwards.

Flowering-time. The number of plants growing on the top is too small to furnish suitable data with regard to the floweringtime. I have found numerous flowering individuals in the months of January, February, March, November; no flowers in June, August, September; so the conclusion may be drawn that these plants flower chiefly in the rainy season.

Pollination. The flowers spread a delicious odour, especially in the evening; in the forest I have never noticed pollinators; still, the flowers are regularly visited. The anthers are generally empty and the pollinia are found not only on the stigma, but on various other parts of the flower. On the stigma I regularly found very numerous scales of a *Noctuine*, but on the flowers of the plants growing in the forest, I have never seen a moth. Once only, in the early evening hours, I observed an *Agrotis c-nigrum* visiting the flowers kept in a jar on a table before my cabin. The flowers regularly set fruit. In Europe and America species of this genus are visited also by *Noctuines* and other moths; cf. KNUTH [1]).

5. TAENIOPHYLLUM GLANDULOSUM BL.

This epiphyte is very common in some parts of Mt. Pangrango-Gedeh. On Mt. Gedeh it occurs between 2400 and 2700 m in the woods of the Gunung Gemuruh and against the slopes of the Gunung Sela. On Mt. Pangrango it is common near Kandang Badak, chiefly at an altitude of 2500 m. On the other side of this mountain it is found also at the same altitude; it grows probably at an altitude of 2500 m in a belt round the

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1) P. KNUTH, Handbuch der Blütenbiologie, Vol. II, Tome II, p. 439 and Vol. III, Tome I, p. 193.

mountain ; however, in 1929 it was discovered on Mt. Kawi in East Java ; at the southern side of the arid Oro-Oro-plain it occurred in abundance in the fringing forest.

This plant grows usually on the trunks or the thicker branches of various trees, once in a while on a slender branch, as seen in figure 20. In the latter

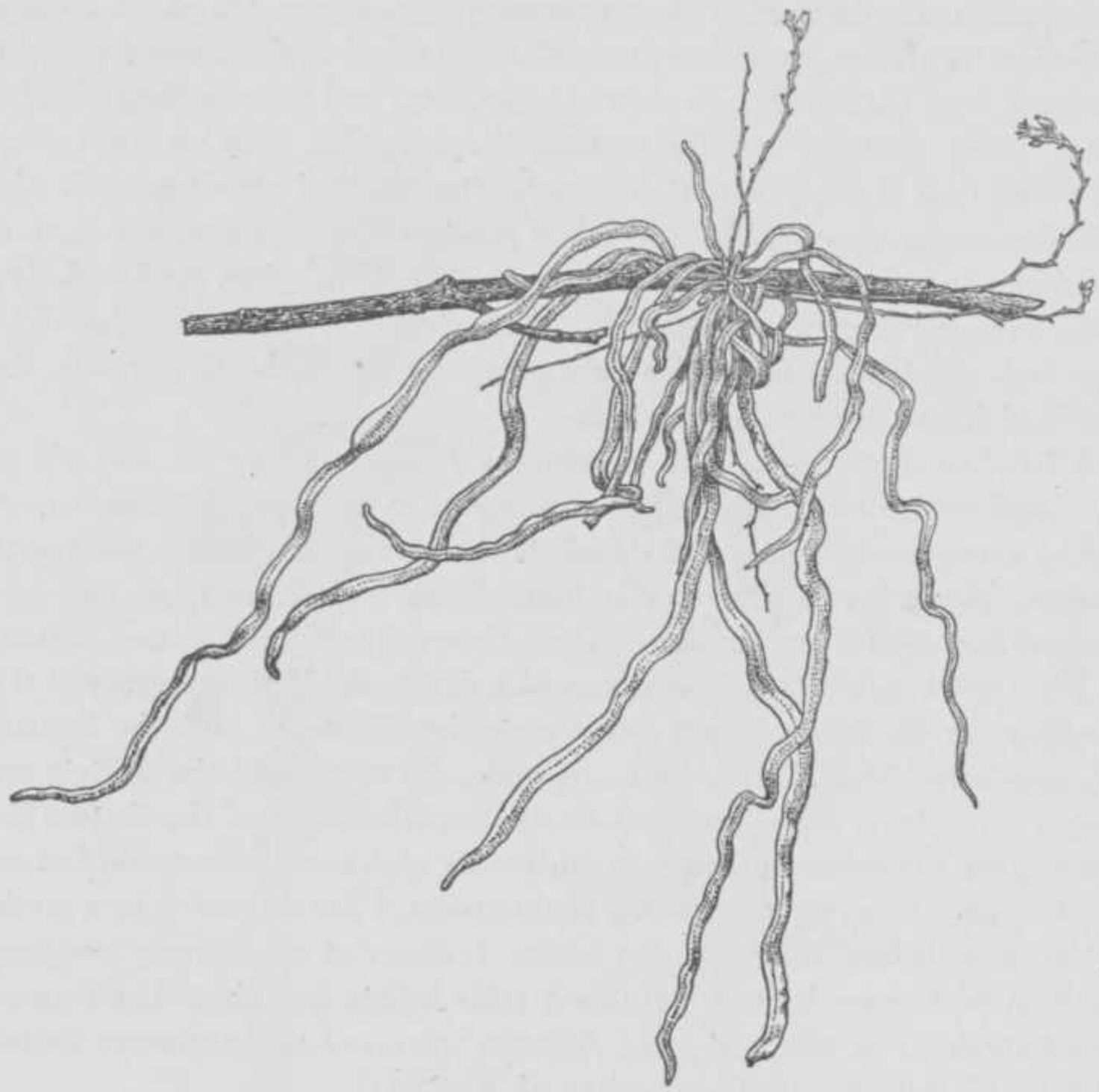

Fig. 20. *Taeniophyllum glandulosum* BL. with drooping roots, $\times 3/4$.

case the roots are mostly free. In plants affixed to the stems, the roots radiate from one point in all directions, growing over and among the moss which covers the bark. On thick branches the roots grow chiefly upwards and downwards, while a few roots encircle the branch. In adult plants the roots are 10 to 20 mm long and 3 to 4 mm broad ; they are flat and dull green.

The short peduncle bears several filiform zigzag inflorescences, in which one flower only opens at a time. The flowers are yellowish green, about 4 mm long and funnelshaped. I have not been able to make observations as to their pollination. The flowers produce relatively few fruits.

The latter are cylindrical, measuring 10 tot 12 mm in length and 3 to 4 mm in width.

The seedlings are dark-green, knife-shaped bodies, fixed at the narrow end; this body represents the elongated hypocotyl, as already described by GOEBEL[1]) in *Taeniophyllum zollingeri* (read *T. Hasseltii)*. At the tip of this organ the stem and the roots originate, see figure 21.

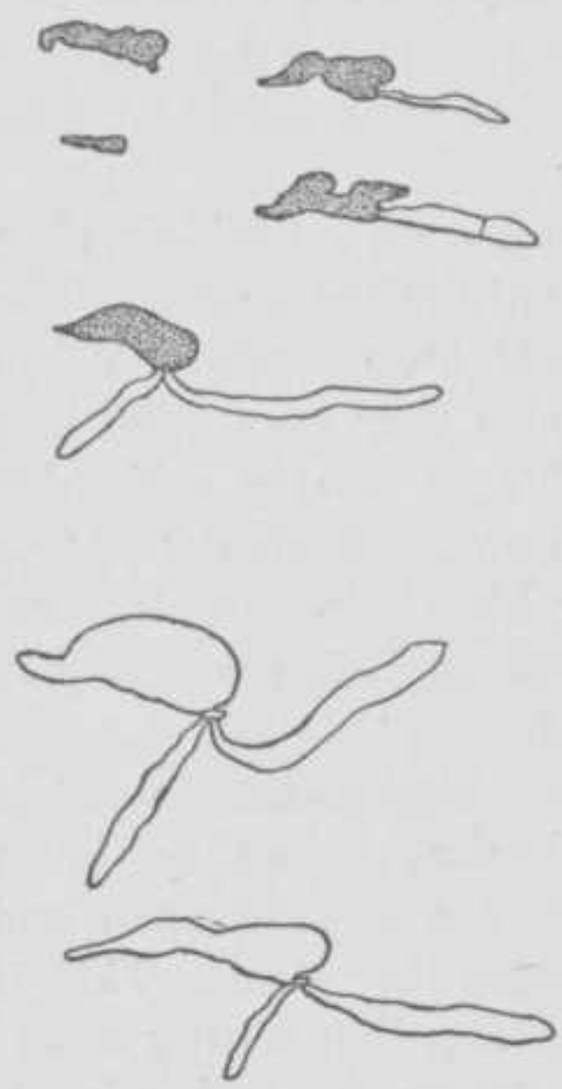

Fig. 21. Young plants of *Taeniophyllum glandulosum* BL. × 1½.

6. THELYMITRA JAVANICA BL.

The representatives of the genus *Thelymitra* are chiefly Australian. The number of species is in Australia very large and some species are apparently very common. In Java there is only one species, which is also known from the Phillippines. It occurs on most of the Javanese mountains especially in the higher areas; on Mt. Telamaja I found it at an altitude of 1400 m. It grows preferably in alpinoid shrubbery and in open alpinoid forest where the undergrowth is sparse, and in grass wildernesses where the ground is not entirely covered. It also does well in sandy, stony localities. On Mt. Pangrango it grows principally in the infertile stony area of the crater-valley; it is found along the brook as well as among the *Anaphalis*-plants; and it grows sporadically among the grass-tussocks and in the open bush wildernesses. The principal condition for a normal development is an ample supply of light.

In the midst of the flowering-season the underground parts of the plant consist of a corm, which is gradually depleted for the sake of the leaf and flowers. At the same time a new corm is formed, which is stored with food and swells in the same measure as the old one shrivels. When the epigeous parts begin to wither the old corm is completely shrivelled, and it has become brown, while the new one is white and succulent. It measures about 20 mm in length and about 8 mm in width. Sometimes two new corms are formed instead of one; in that case next year two plants will spring up closely together. Above the ground the plant develops a ligulate leaf and an inflorescense with small bracts, bearing 3 to 8 flowers. Plate XXXVIII B. The perianth consists of 6 segments of about equal size and shape, violet, purple or pink; the 3 sepals however are marked by a brown median stripe. Sometimes only 5 of the 6 perianth segments are developed, for

1) K. VON GOEBEL, Pflanzenbiologische Schilderungen, Vol. I, Marburg, 1889, p. 195, fig. 88.

instance in the flower reproduced in figure 22. The rostellum is white inside, tapering upwards into a little yellow hood, which bends forward and shows on either side a tuft of white hairs. The ovary matures into a more or less barrel-shaped fruit. After fruiting the inflorescence withers, and the leaf wilts; in the dry season no trace of this orchid is to be found. In November or December the leaf appears above ground followed by the inflorescence. There is a wide range of variability in the time at which the epigeous parts appear; consequently in some months, plants in every stage of development may be found.

Pollination. On Mt. Pangrango the flowers open but seldom, only on very hot days, when the sun shines already early in the morning. The flowerbud requires a high temperature. When transferred to Tjibodas they even open in a room. On Mt. Sumbing I saw on a hot day thousands of open flowers. A similar phenomenon I observed on Mt. Gedeh, on Mt. Kawi and on Mt. Tjikorai. In dull weather they usually remain closed.

Fig. 22. Inflorescence of *Thelymitra javanica* BL. × 3/4.

The pollen of this orchid is not massed in pollinia, but it is granular; before the flower expands the anthers are already open and pollen has fallen upon the stigma. This is rendered easy by the fact that shortly before the opening of the flower the anther bends forward and as a result pollen may readily drop on the stigma which is extremely receptive. Only once I noticed a Syrphid-fly; *Chamaesyrphus nigripes* in the flowers; self-pollination is probably the rule.

The flower biology of some Australian species has been described by CHEESEMAN [1]). He states that these orchids show usually self-pollination. According to him the membraneous margin of the stigma curls backward and in doing so it comes in contact with the pollinia. ROGERS [2]) describes the pollination in various species. In *Thelymitra luteocilium* too the pollen is granular and falls on the stigma by its own weight.

Flowering-time. The plants start their development at the end of the dry season in November and December, and the flowering period begins usually in February. Till June many specimens in flower are to be found,

[1]) R. CHEESEMAN, Fertilisation in *Thelymitra*. Transact. New Zealand Institute, Part XIII, 1881, p. 291.

[2]) R. S. ROGERS, Mechanism of pollination in certain Australian Orchids. Transacts of the Royal Soc. of South Australia, Vol. XXXVII, 1913, p. 57.

then their number diminishes considerably, and from September to January no flowering plants are found; see figure 23 and the table on pag. 88. Leaves, bracts, and flowers but especially the ovaries are subject to fungus

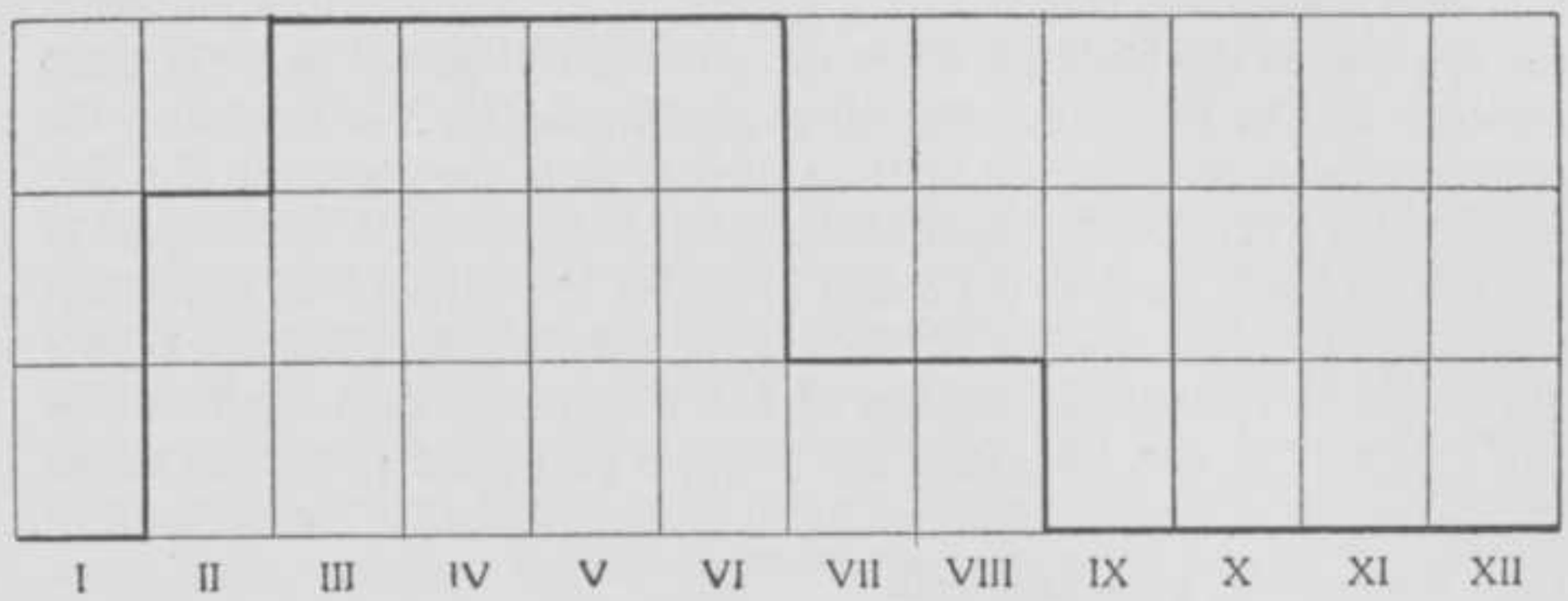

Fig. 23. Flowering-time of *Thelymitra javanica*. BL.

diseases [1]) caused by *Uromyces Thelymitrae* and *Aecidium Thelymitrae*. A strong infection may result in a poor development of the flowers and a reduction in the number of fruits.

DICOTYLEDONAE.

FAMILY OF THE MYRICACEAE.

1. MYRICA JAVANICA BL.

This is a small tree which occurs especially on the mountains of West and Central Java. The Herbarium at Buitenzorg possesses material collected on Mts. Gedeh, Papandajan, Guntur, Patuha, Wajang, Dieng, Tangkuban Prahu, Sindoro, Merbabu, Merapi, Telamaja, Lawu and on some mountains in East Java: Mts. Tengger, Ardjuno, Lamongan and Hijang. It is known further from Celebes and Bali and from the Philippines.

Myrica javanica grows usually above an altitude of 1400 m, but at lower elevations it has also been found, the lowest locality lying at 500 m; on the other hand it may occur up to the summit of the volcanoes, where it grows in alpinoid forest, in sandy and especially in stony places, in grass-fields and near crater-lakes; in lower regions it is also found in the virgin forest. Especially the juvenile-form (see lower) can be found in localities much below the ordinary limit, but no adult plants will be found there. On the top of Mt. Gedeh and in the forest from 1500 m upwards it is common. In the crater of Mt. Gedeh it forms locally a dense shrub; it is particularly notice-

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1) M. RACIBORSKI, Ueber einige javanischen Uredineae. Bull. intern. de l'Acad. d. Sciences de Cracovie, 1909, p. 267.

able how the young plants grow on the debris-cone, plate XXIII. On the rocky edge of the crater the individuals remain very small and they develop into low shrubs only. As this plant may thrive therefore in various habitats, it is very remarkable that it does not occur on the top of Mt. Pangrango, the more so as the birds by which the seeds are dispersed occur in great numbers on Mt. Pangrango as well as on Mt. Gedeh. We meet here the same enigmatic phenomenon which confronts us in the dispersal of a few other plants; *Gaultheria fragrantissima*, for instance, which occurs even in the most infertile parts of the crater of Gedeh is not found on Mt. Pangrango, and the same applies to *Albizzia montana*, whereas *Primula imperialis*, which is common on the top of Mt. Pangrango, does not occur on Mt. Gedeh. The two mountains are however connected at 2400 m across the saddle of Kandang Badak by an uninterrupted forest, where each of these four species grow and fruit.

Myrica attains in the alpine habitat rarely a height of more than 3 m. Its trunk is distorted and branching begins near the ground, and is very irregular; the crown is very dense and more or less globular. The leaves are shortly petiolate, obovate, rounded at the top and decurrent at the base; they are leathery, 4 to 8 cm long, 1.5 to 3 cm broad; the margin is coarsely serrate. In the forest one may often find the juvenile form of this plant, which has generally a slender trunk and is little branched. Its leaves are extraordinarily long and narrow, up to 20 cm long with a width of 3 cm; they are sessile, auriculate and sometimes amplexicaul; the margin is extremely coarsely serrate. These specimens never flower.

Myrica javanica is dioecious (rarely monoecious). The catkins are arranged in axillary inflorescences. The male catkins are arranged in panicles. The flowers sit in the axil of a pilose sessile bract, and consist of 3 or 4 stamens attached to the bract. The stamens have short filaments and globose anthers. These inflorescences are red or green. The female flower consists of a bract with two small scales appressed against the pistil. The ovary is pilose and bears 2 sessile red stigmas, covered with papillae. The little drupes are ovate or spherical, about 4 mm long with fleshy warts, they are dark-purple, resembling a small mulberry. The mesocarp is succulent and sweet, and contains a smooth stone.

Pollination. The pollen is dry, and is scattered by the wind.

Dispersal of the seeds. Several species of mountain-birds are fond of the fruits. The seeds have been found on Mt. Gedeh in the stomachs of *Sphenurus korthalsi*. *Oreocincla dauma horsfieldii* [1]; on Mt. Sindoro they have been found in the stomachs of the first named fruit-pigeon and of *Xantholaema haemacephala rosea*, *Pycnonotus bimaculatus*, *Turdus javanicus whiteheadi*, *Aplonis panayensis strigatus*, *Oreosterops*

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[1]) W. DOCTERS VAN LEEUWEN, Kleiner Beitrag zur Kenntnis der endozoischen Verbreitung einiger Hochgebirgspflanzen auf Java. Flora Vol. 118 and 119, 1925, p. 81.

javanica and *Zosterops palpebrosa sindorensis* [1]). KOORDERS [2]) mentions that he found them in the intestines of *Sphenurus korthalsi* and of *Ixos haemorhoous*.

FAMILY OF THE FAGACEAE.

1. FAGUS SILVATICA L.

In the crater-valley on the top of Mt. Pangrango only one specimen of this plant occurs, probably planted there about 1840 by J. E. TEYSMANN, the well-known curator of the Buitenzorg Gardens. As has been mentioned in one of the preceding chapters TEYSMANN cleared a part of Mt. Pangrango and planted it with European vegetables and fruit-trees. The beech dates probably from that time. It has not developed into a tree, but into a shrub, with spreading branches; much lower than the surrounding shrubs of *Anaphalis javanica*. This beech has been mentioned in various articles and books, and a detailed study of it was published by CH. COSTER [3]), who investigated a.o. the shedding of the leaves and the secundary growth of the stem. It is very remarkable, that both the xylem and the pith contain large quantities of starch and that this amount does not diminish noticeably when the new leaves are unfolded; but in spite of this abundance of stored food, it never flowers. COSTER found also that both "sun" and "shade" leaves are present; they are, however, not more xerophytically built than beech leaves in Europe use to be. Concerning other particulars the reader may be referred to COSTER's article.

As this plant never flowers it has no value for our investigation.

FAMILY OF THE BALANOPHORACEAE.

1. BALANOPHORA ELONGATA BL.

This parasite occurs from Tjibodas up to the top of Mt. Pangrango especially where the forest soil is rich in humus; in a stony soil it is rare.

The plants are monoecious. I have never observed any insects on its flowers, but as the plant is comparatively rare, my observations are too limited in number to draw any conclusions from them.

TREUB [4]) describes the occurrence of apogamy in this plant, but ERNST [5])

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1) HANS DOCTERS VAN LEEUWEN, Beitr. z. Kenntnis der Avifauna der Mittel-javanischen Vulkane Soembing und Sindoro. Treubia, Vol. X, 1929, p. 439.

2) S. H. KOORDERS, Over de standplaatsvoorwaarden, verspreidingsmiddelen van de in Java vooral in het hooggebergte wildgroeiende soorten der *Myricaceae*. Verslag der gewone Vergadering der Wis- en Natuurk. Afd. der Kon. Akad. v. Wetenschappen te Amsterdam, 1908, Vol. XVI, p. 645. (Proceedings 24 April 1908, p. 674).

3) CH. COSTER, Die Buche auf dem Gipfel des Pangerango, Ann. du Jardin bot. de Buitenzorg, Vol. XXXV, 1926, p. 105.

4) M. TREUB, L'Organe femelle et l'apogamie de *Balanophora elongata* BL. Annales d. Jard. bot. de Buitenzorg, Vol. XV, 1898, p. 1.

5) A. ERNST, Embryobildung bei *Balanophora*. Flora, Vol. 106, 1913, p. 129.

in a more recent publication comes to the conclusion that the embryo develops parthenogenetically.

FAMILY OF THE POLYGONACEAE.

1. POLYGONUM CHINENSE L.

This plant occurs quite frequently in Java, especially between 500 and 2000 m, but we can find it up to the highest summits of the volcanoes. The distribution of this plant has been fully described by DANSER [1]), who records it from the Himalayas, South-China, Japan, the Philippine Islands, Malacca, Sumatra, Borneo, Java, Bali, Timor, Celebes, Buru, Ceram and New Guinea.

In the lower regions it is a straggling shrub, whose slender shoots in the midst of other vegetation may ascend to a height of about 6 m, where they ramify freely, the tops of the branches hanging down. On the higher mountain tops, for instance in the Sand-Sea in the Tengger, its habit is more that of a dense bush. On Mt. Pangrango-Gedeh it is also common, the straggling form especially above Tjibodas, while the shrubby form with the larger flowers occurs at higher elevations, i.e. on the top of Mt. Pangrango and especially in the crater of Mt. Gedeh. On the top of Mt. Pangrango, however, both forms growing side by side; the former in open places among the grass, the latter frequently in the fringe of the forest, it does not climb here, however, as high as in lower regions.

For a description of the vegetative parts see DANSER.

The flowers are arranged in much-branched spurious spikes. The latter are highly conspicuous by the white or pink colour of the flowers, plate XXVII. B. The pedicel is as long as the perigone; the latter is pentamerous and nearly free; its segments are rounded and diverge but little, so that at the top only a narrow opening is formed. There are 8 stamens with pink filaments and dark green anthers. The ovary is ovoid with 3 styles, each topped by a capitate stigma.

The flowers are heterostylous. In the short-styled form the stigmas reach to about midway the filaments; in the long-styled form the styles are a little longer than the filaments and project a short distance beyond the perigone.

Flowering-time. On Mt. Pangrango this plant flowers in equal abundance throughout the year, only in the months of September and October the flowering diminishes a little, see figure 24 and the table on pag. 88.

In regions with a drier and more protracted East-Monsoon, for instance

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1) B. H. DANSER, Die Polygonaceen Niederländisch Ost-Indien. Bulletin du Jardin bot. de Buitenzorg, Série III, Vol. VIII, p. 216.

in the Sand-Sea of the Tengger, flowering in the driest months ceases entirely.

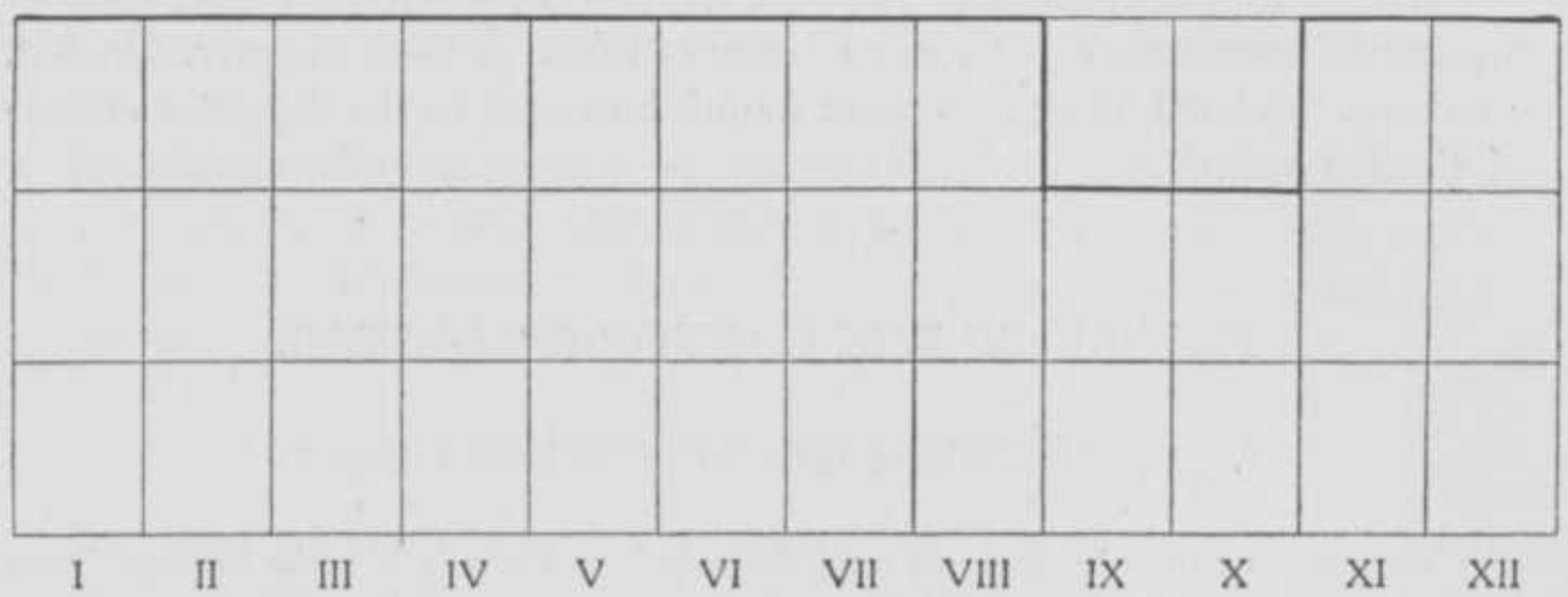

Fig. 24. Flowering-time of *Polygonum chinense* L.

The flowers are often affected by a fungus, which causes large galls. The fungus is *Farysia emodensis* SYD. (better known by the name of *Ustilago Treubia* SOLMS), see ENGLER und PRANTL. (Sec. Edition, Vol. II, p. 3, fig. 1). On Mt. Pangrango I have never found them, but on Mt. Gedeh the galls are common.

Pollination. Sometimes we find specimens which set little fruit, others in which every flower has matured into a fruit. Though I noticed this phenomenon especially in the short-styled form on Mt. Pangrango, it may occur in the long-styled flowers as well.

In the long-styled form the styles often lean against the stamens; when they elongate their stigmas brush past the anthers and get pollinated. On Mt. Pangrango visitors are rare, at Tjibodas *Bombus rufipes* is said to act as pollinator (cf. DANSER); at Kandang Badak and on the top of Mt. Lawu I [1]) also observed that insect, while at Kandang Badak I saw once in a while *Apis indica* on the flowers. Further I observed on the top of Mt. Pangrango a *Lycaenide* and several *Diptera*, viz. an unclassified Tachinid, *Calliphora fulviceps*, *Syrphus serarius* and on Mt. Papandajan I saw *Terias hecabe* busy in the flowers of this plant. On Mt. Lawu and on Mt. Sumbing also I noticed the visits of Syrphids. Thripses, covered with pollen, are moreover regularly found in the flowers. KNUTH [2]) mentions at Buitenzorg the visiting of several insects, generally with short proboscis, chiefly Muscides, but also Syrphids, beetles, *Apis* and digger-wasps. HEIDE [3]) mentions flies and a species of *Syntomis*.

Honey is secreted in small drops at the base of the stamens.

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[1]) W. DOCTERS VAN LEEUWEN, De alpiene vegetatie van de Lawoe-vulkaan. Natuurk. Tijdschrift v. Ned. Indië, Vol. LXXXV, 1925, p. 38.

[2]) P. KNUTH, Handb. d. Blütenbiologie, Vol. III, Tome I, p. 274.

[3]) F. HEIDE, Observations on the pollination of some flowers in the Dutch East-Indies. Danks, Botan. Arkiv, Vol. V, N°. 3, p. 10.

Dispersal of the seeds. The fruits are enveloped by the fleshy, much swollen perigone, which is first white and afterwards black. On Mt. Pangrango I have never seen that the fruits were eaten by animals, but in captivity the mountain-rat *Rattus lepturus* takes to them eagerly. On Mt. Sumbing, the hard black nuts were found, however, in the digestive organs of *Turdus javanicus whiteheadi* and of *Zosterops palpebrosa sindorensis* [1]).

FAMILY OF THE CARYOPHYLLACEAE.

1. CERASTIUM CAESPITOSUM GILIB. [2])

This plant occurs in Europe and Asia but in Java it is only known from Mt. Pangrango and from Lalidjiwo on Mt. Ardjuno. It is very common on the top of Mt. Pangrango, where it occurs in small specimens on the stony ground of the crater-valley and in larger, sometimes huge individuals among open shrubs and between tussocks; especially on the remains of quenched wood-fires this plant may develop richly. In the vicinity of Kandang Badak it grows also abundantly, especially under the moist wall next to the cabin, where the slope has been dug off. When growing in open places this plant mostly has a short ascending stem; in shaded places and between tussocks, however, the plants spread widely in all directions. A big plant developed in a congenial habitat mustered more than 30 flowering branches and its diameter was about 75 cm.

The tomentose stems are often repeatedly branched. The flowers are borne on long pedicels. The latter are when the bud opens about 6 mm long but they elongate still considerably after flowering, so that the fruits protrude a good deal beyond the inflorescence. Five sepals constitute the calyx, they are green and hairy, the apex being glabrous and membranous. The petals are obovate and like the sepals about 6 mm long; the corolla protrudes therefore but little beyond the calyx. There are ten stamens; the ovary is oblong, and bears 5 styles and 5 stigmas.

Pollination. Throughout nearly the whole year the plants flower, only during the dry months of July to October flowering diminishes, besides, the number of plants falls off. The flowers last two days. On the first flowering-day 5 of the 10 stamens are ripe, on the second flowering day the other 5 open, the stigmas being already viscous on the first day. In Europe uni-sexual plants have been found, but I have never noticed them among the plants on Mt. Pangrango. The flowers are homogamous, sometimes faintly protogynous. During the first day the flowers are but half-open and somewhat bell-shaped; the second day they expand further, and towards midday they are widely opened. Already on the first day the

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1) HANS DOCTERS VAN LEEUWEN, Beitr. z. Kenntniss der Avifauna der Mittel-javanischen Vulkanen Soembing und Sindoro. Treubia, Vol. X, p. 439.

2) syn. *Cerastium triviale* LINK.

anthers come in contact with the stigmas and get thickly covered with pollen. The flowers are seldom visited, twice only I observed a Syrphus-fly, viz. *Syrphus koningsbergeri* on them.

In Europe chiefly flies and a single beetle have been noted as visitors, cf. KNUTH [1]).

At Kandang Badak I once saw a mountain-rat, *Rattus lepturus*, sitting quietly among the plants, and drawing down the flowering-stalks to eat the fruits. Yet this animal probably does not effect dispersal, because the seeds serve as food and are digested.

2. DRYMARIA HIRSUTA BARTL.

This herb when growing in a congenial habitat and rising between other plants may reach a height of about 1 meter. It occurs sporadically on the top of Mt. Pangrango on stony open grounds. The individuals are here very small, about 5 cm high and but little branched, figure 25. The plant is especially characterised by the sticky hairs, which occur also on the pedicels and on the calyx of the ripe fruit, enhancing the chances of dispersal.

Fig. 25. Dwarf specimen of *Drymaria hirsuta* BARTL. × 1.

In the so called aloon-aloon of Mt. Gedeh I found plants, the seeds of which had germinated in the bed of the brook, when this contained no water, and the plants consequently were totally submersed during the rainy season but throve quite well. These individuals had developed long internodes and thin leaves but did not bear any flowers.

The flowers are tiny. I have made no observations with regard to pollination, but the flowers are probably autogamous.

FAMILY OF THE RANUNCULACEAE.

1. ANEMONE SUMATRANA DE VRIESE.

This plant is a native of the mountainous districts of Central Sumatra, where it grows between 1800 and 2800 m above sea-level. It occurs either in shady places, rich in humus, or on slightly weathered recent volcanic formations. Sometimes it is also found on poor soils, fully exposed to the sun, in which case the plants are much smaller. In January 1920 I found this plant in great numbers on Mt. Singgalang [2]) in the vicinity of Fort de

1) P. KNUTH, Handbuch der Blütenbiologie, Vol. II, Part I, pag. 199.

2) W. DOCTERS VAN LEEUWEN, Naar de top van de Singgalang bij Fort de Kock. Trop. Natuur. Vol. IX, 1920, p. 97.

Kock, and from there I took a few plants to Java. Some of these were planted out in the Mountain-garden at Tjibodas where they did not thrive, others again on the road to Huis ten Bosch at about 1800 m, while the remainder were planted out on the top of Mt. Pangrango in the little valley of the Tjikuripan. Owing to this circumstance the plant is described here among the Pangrango vegetation, although it is not indigenous.

The axis of this plant is a rhizome with remnants of withered leaves adhering to it and curving upward at the end. The leaves, which are long-petiolate, form a rosette, in whose centre several inflorescences spring up. The leaves are 3-foliolate, the central leaflet which is the largest being shortly petiolulate, while the two lateral leaflets are subsessile. The surface of the leaves is covered with long adpressed hairs.

The peduncle of the inflorescence, measuring from 10 to 30 cm, bears an involucre, which is composed of 5 to 12 well developed leaves. This involucre encloses the flowers, generally numbering up to 4. Seldom one flower only occurs. The flowers have either short or long pedicels; they are generally provided with 5 sepals, elliptical in shape, and either white or very pale lilac on the exterior. These leaves measure from 10 to 16 mm, the breadth being some 8 mm. The flower contains a large number of stamens with white filaments, as well as a great many pistils. These are flattened and oblong, with a short, hooked (sometimes also straight) style. The fruits, although larger and more developed, retain the same shape.

There are two types of reproduction, one by means of fruits, of which large quantities are produced, the other vegetative. After flowering, the inflorescence sinks down, roots are produced in the involucre and young shoots appear in the axils of the involucral bracts. These young plants largely contribute to the formation of groups.

On Mt. Pangrango reproduction occurs in both ways, but up to the present time the plants do not multiply very fast. Yet, although they are rather small, they regularly flower. Many of the fruits, however, are barren.

On Mt. Singgalang the plant occurs in large quantities, the big pure-white or pale lilac flowers forming a striking sight. They were regularly visited by a Syrphid-fly, *Rhingia basalis*, and by a white bumble-bee, *Bombus senex*. Whether this plant is able to develop seed as the result of selffertilisation I have not yet investigated.

In Europe pollination of *Anemone* by *Diptera* and *Hymenoptera* has also been observed, while HERMAN MÜLLER saw a species of *Rhingia*, *Rhingia rostrata*, on *Anemone silvestris*.

2. RANUNCULUS DIFFUSUS DC.

This plant does not occur on the top of Mt. Pangrango, but it is found in the lower parts of this mountain, at altitudes between 1600 and 2600 m.

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1) P. KNUTH, Handb. d. Blütenbiologie, Band II, deel I, 1898, p. 11.

The structure of the flower corresponds to that of *Ranunculus javanicus*, but the plant itself is easily distinguishable by its hairiness and by the incised leaves.

At Kandang Badak I have repeatedly observed *Diptera*, especially syrphids on the flowers. I have noticed the following visitors: the *Anthomyine: Coenosia anipila* and the Syrphids: *Syrphus balteatus* and *serarioides* and *Chamaesyrphus nigripes*.

3. RANUNCULUS JAVANICUS REINW.

In Java this plant is merely known from some widely separated mountains, viz. from Mts. Gedeh-Pangrango and Mt. Papandajan in West-Java, from the Dieng-plateau in Central Java and from the Hijang in East Java. According to KOORDERS [1]) it is identical with *Ranunculus sagittifolius* of Ceylon. In Sumatra it has been found on the Peak of Korintji.

On Mt. Pangrango and on Mt. Gedeh it occurs frequently above 2300 m, and especially near the summit; moreover it has been found underneath the falls of Tjibeureum at 1600 m. On the top of Mt. Pan-

Fig. 26. Flower of *Ranunculus javanicus* REINW. × 3/4

Fig. 27. Fruit of *Ranunculus javanicus* REINW. × 3/4.

grango it grows along the forest path, at the edge of the forest, in the shade of the bushes in the crater-valley and along the brook; it is common also along and in the brook on the aloon-aloon of Mt. Gedeh. Plants

[1]) S. H. KOORDERS, Exkursionsflora von Java. Jena, 1912, Tome II, p. 224.

growing in the water sometimes develop floating leaves. Though seldom, one may see it also among grass-tussocks in the crater-valley.

The plants possess a radical rosette, plate XVIII. The leaves are simple and cordate, the apex obtuse or acute, the margin crenate, they are 20 to 100 mm long and 10 to 60 mm broad; the petiole is very long and sheathing at its base. From these radical rosettes no flowers spring; the latter appear on the runners, which may be formed in great numbers. At their nodes short-petiolate leaves develop; at the end of the runners the latter are sometimes sessile. The runners root at their nodes and form new rosettes. In the axils of the leaves solitary flowers arise; at the end of the shoot they are apparently terminal. These flowering tops rise above the other plants, figures 26 and 27.

At first the calyx is flatly expanded, later on it recurves and soon breaks off. The stamens are numerous; the pistils also: the latter possess short styles.

Flowering-time. Throughout nearly the whole year this plant flowers abundantly; only in the months of August to November the number of flowers is smaller; see figure 28 and the table on pag. 88.

Pollination. The flowers remain open for a considerable time. During the first days the anthers are closed, but the stigmas are already

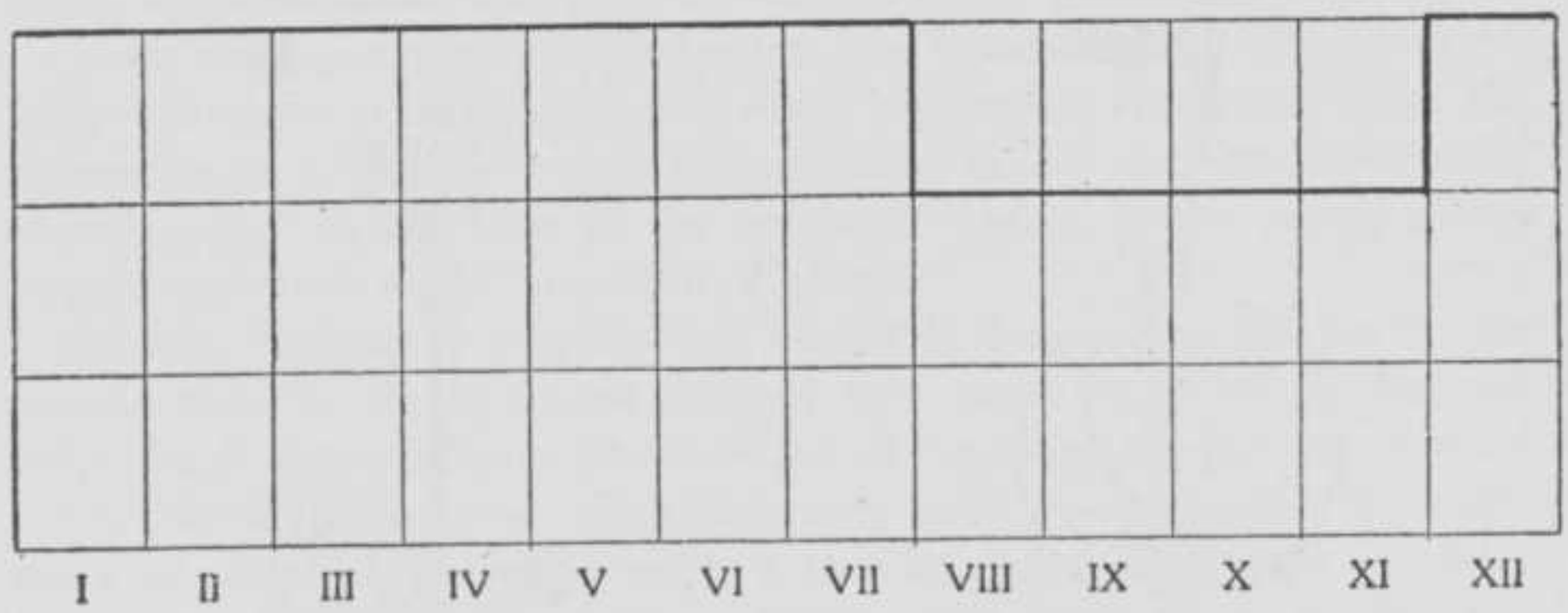

Fig. 28. Flowering-time of *Ranunculus javanicus* REINW.

receptive; the flowers are therefore protogynous. Afterwards the anthers open and directly the ovaries begin to swell.

I have never observed insects on the flowers, self-pollination will therefore be the rule.

4. THALICTRUM JAVANICUM BL.

This plant is represented in the Herbarium at Buitenzorg from several Javanese mountains, from Mt. Pangrango to Mt. Hijang; it has not been

recorded, however, from the many mountains of the Preanger (except from Mt. Papandajan) neither from Mt. Sindoro nor from Mt. Idjen. Outside Java it has been found on Bali (Mt. Agung) and in Sumatra (Peak of Korintji) and in the Himalayas. The lowest finding-place in Java is near the active crater of Mt. Lawu at an altitude of about 1300 m; up to 3300 m, however, it has been found and it is even most common in the highest parts.

The plants grow often gregariously in large numbers, in grass and shrub wildernesses, in open alpinoid forest and in *Casuarina* woods, in shaded places along forest paths, and along little streams.

On the top of Mt. Pangrango I have only once found a specimen among the bushes; it grows however in dense crowds in the narrow, moist gorge of the Tjikuripan at 2950 m altitude.

This perennial herb has a massive rhizome, terminating in a stem branching towards the top and reaching a height up to 60 cm. The stem is sulcate and glabrous, the base clothed with the sheaths of wilted leaves. The lower internodes are stunted, the lower leaves long-petiolate with large sheaths. The upper leaves are pinnate, 3-jugate; the leaflets are obovate or oval with an obtuse or emarginate apex, the margin is towards the apex coarsely toothed; they are borne on a slender petiolule.

The inflorescences are terminal loose corymbs or panicles, figure 29. The flowers are borne on long pedicels; there are 3 to 4 sepals, which are shed when the anthers open; the numerous stamens, radiate in all directions; they possess white filaments which may reach a length of 4 mm. There are 15 pistils each with a hook-shaped stigma.

Pollination. After the calyx has fallen off the anthers open in succession, the outermost maturing earliest; but before all are open the

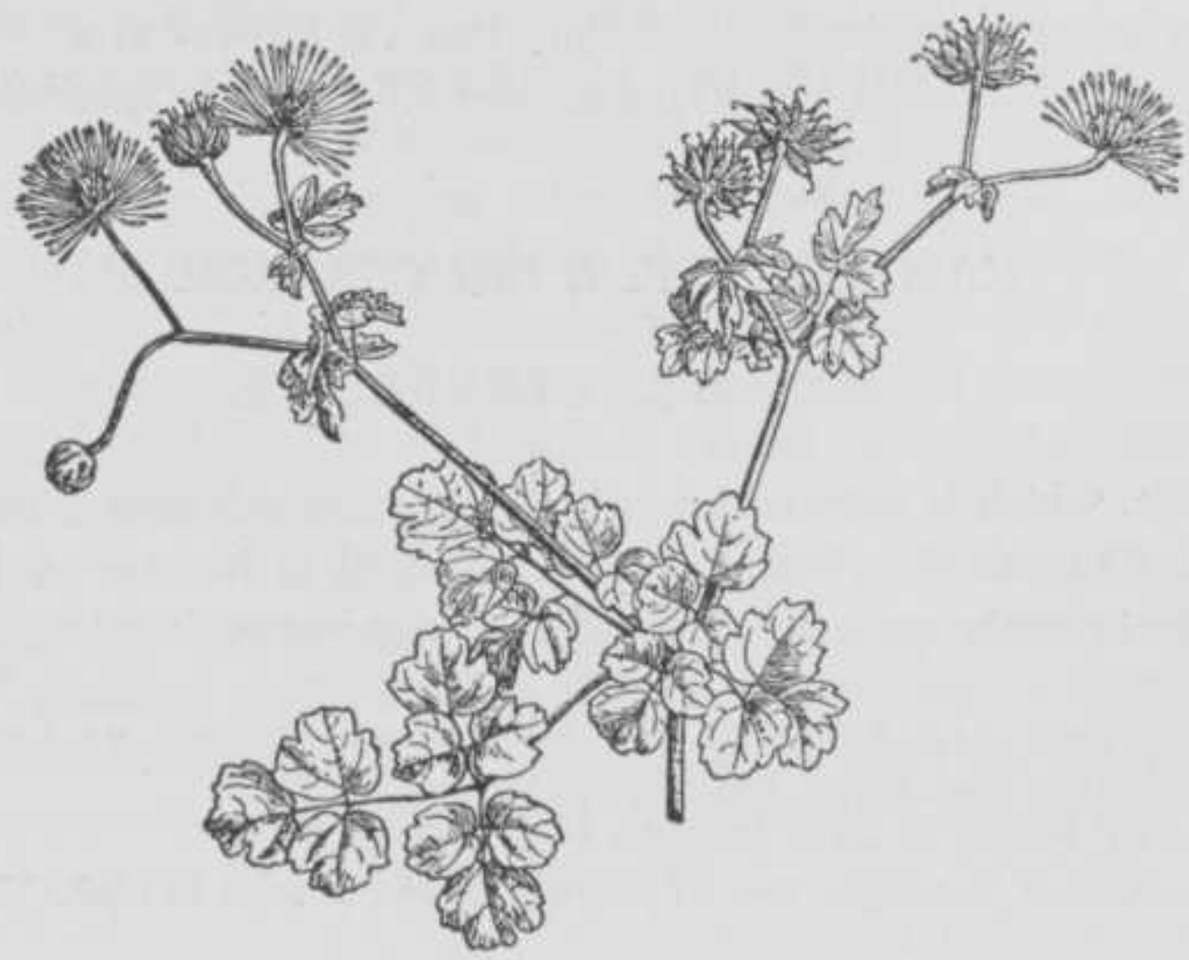

Fig. 29. *Thalictrum javanicum* BL. × 3/4.

stigmas have already turned brown and the ovaries have begun to swell. When the anthers are all open, it is clearly seen that the ovaries have become bigger. The flowers are therefore distinctly protogynous and self-pollination is rendered very difficult, if not impossible.

The pollen is extremely fine and is probably scattered by the wind. On the numerous plants growing on the top of Mt. Pangrango I never saw any pollinators, on Mt. Lawu [1]) I once saw a Syrphid-fly. In Europe many visitors have been observed, especially *Coleoptera, Diptera* and some *Hymenoptera;* protogyny is also reported, cf. KNUTH [2]). From some dioecious species growing in America apogamy has been reported by OVERTON and DAY; but the investigation by KUHN [3]) makes the occurrence of this type of reproduction in this genus highly improbable.

Flowering-time. The plants on the top of Mt. Pangrango flower throughout the year, and fruits are produced in abundance.

FAMILY OF THE LAURACEAE.

1. LITSEA CUBEBA BL. [4])

This small tree is common in mountainous regions; on Mt. Gedeh-Pangrango it occurs up to 2800 m.

Most of the inflorescences spring from the naked basal part of the lateral branches; they consist of a main-axis, bearing small pedunculate umbels, each containing five flowers. Each umbel bears at the base four bracts. The flowers are short-pedicellate, the calyx is pentamerous, connate below. There are ten stamens, arranged in two whorls of five; the ovary bears a style with two stigmas. Nectar is abundantly secreted by yellow disk glands. In spite of the fact that nectar is provided in large quantity, I have thusfar never noticed any visiting insects. However, as the anthers are often pressed against the stigmas self-pollination is possible.

FAMILY OF THE CRUCIFERAE.

1. BRASSICA OLERACEA L.

This plant, which is very common in Europe, occurs sporadically on the top of Mt. Pangrango, where it grows scattered or in groups. It is to be found in the infertile open patches and develops but seldom into big plants.

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1) W. DOCTERS VAN LEEUWEN, De alpiene vegetatie van de Lawoevulkaan. Natuurk. Tijdschr. v. Ned. Indië, Tome LXXXV, 1925, p. 38.

2) P. KNUTH, Handb. d. Blütenbiologie, Vol. II, Tome I, p. 5.

3) E. KUHN, Zur Zytologie von *Thalictrum*. Jahrb. f. wiss. Botanik, Vol. LXVIII, 1928, p. 382.

4) syn. *Litsea citrata* BL.

The structure of the flower and its pollination has been thoroughly examined in Europe and a great number of flower-visitors have been observed, cf. KNUTH [1]). If the pollinators stay away, the long stamens bend and come in contact with the stigma: self-fertilization is therefore possible. As a matter of fact this is the rule on Mt. Pangrango; I have there never noticed visitors on the flowers. All flowers, however, regularly set fruit.

2. CARDAMINE AFRICANA L. subspec. BORBONICA O. E. SCHULZ.

This plant is known from quite a number of Javanese mountains; it grows by preference at an altitude between 1300 and 2700 m. Generally it is found in moist, shaded localities where the soil is rich in humus, though rather in more open parts of the forest. It may also be found in sunny spots, as well as in alpinoid and *Casuarina* forests. On Mt. Gedeh especially it is very common at an elevation of about 1700 m, in the vicinity of Kandang Badak also and in alpinoid forest near the top of Mt. Gedeh where it sometimes grows gregariously. In 1919 and 1920 I found some specimens on the summit of Mt. Pangrango; it has since vanished, but of course it may come back again. The plants grew under shrubs on the highest top, close to the triangulation-post.

It is a herb with an erect, or sometimes decumbent stem bearing a larger or smaller number of leaves. They consist of three leaflets, which are ovate and often more or less oblique, with an acute apex; the margin is serrate, or sometimes lobate. The terminal racemes consist of 3 to 15 flowers borne on short pedicels. The sepals are elliptical, 2 to 3 mm long, the petals are pale-green or yellowish-white, obovate with a short claw, and about 4 mm long. There are 6 stamens; the ovary is globose with a short style and a 2-lobed stigma. The siliquae slant upwards, they are linear with a pointed top, 20 to 40 mm long and 2 to 3 mm broad.

Pollination. All through the year the plants flower, and they are regularly bearing fruit. The flower opens but little; on Mt. Pangrango the stamens were not yet ripe when the flowers opened, and the stigma matured first; these flowers were therefore protogynous. During the process of maturing the anthers open and come in contact with the stigma. Though the flowers are not visited, they all set fruit by means of self-pollination. In the vicinity of Kandang Badak the stamens and the stigma were fully matured when the flowers opened and in the buds the stigma was already covered with pollen. These individuals were therefore homogamous and self-fertilizing. A small quantity of nectar is secreted by two nectaries, situated at the base of the stamens. Once, at Kandang Badak, in June 1920 I observed *Apis indica* on the flowers and later on I noticed on the flowers in the same locality a Syrphid-fly, *Chamaesyrphus nigripes* and an Ortaline: *Rhadinomyia orientalis*.

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[1]) P. KNUTH, Handbuch der Blütenbiologie, Vol. II, Part I, p. 100.

When ripe or when touched the fruits split, the two valves coiling up so quickly that the seeds are flung away. By what agencies the seeds are dispersed over long distances is not known to me.

3. CARDAMINE HIRSUTA L.

Cardamine hirsuta is usually an annual herb, occurring in Java in the mountains chiefly between 1000 m and 2800 m. It grows in moist and fertile sunny places as well as in more infertile stony localities. It may be found also in water and along the water's edge. I found it for instance in the shallow pools in the oro-oro plain of Mt. Kawi in East Java. Here the plants consisted of a slender shoot about 20 cm long, anchored in the mud by means of tiny roots, and bearing at the top one or two leaflets, and some small flowers and fruits only just rising above the water. In the aloon-aloon of Mt. Gedeh at an elevation of 2800 m I found in February 1922 thousands of small plants on the sunny, stony, barren ground, along the bank of the brook, from the middle of the plain to the border of the open alpinoid forest. Later on it became much rarer and in the dry season it is generally quite wanting. I have never found it on Mt. Pangrango.

Pollination. Just as in Europe (cf. KNUTH[1]), the anthers lean against the stigma, and self-pollination is therefore the rule. The flower shows the characteristic structure of the *Cruciferae*. I have never observed any insects on the flowers; KNUTH records from Flanders a bee, a fly and a beetle and from Scotland one beetle, one Syrphid-fly and two Muscides as visitors. But self-pollination is probably the rule in these inconspicuous flowers.

FAMILY OF THE ROSACEAE.

1. COTONEASTER SPECIES.

On the top of Mt. Pangrango grow some small, more or less adpressed shrubs of a species of *Cotoneaster*, mostly hidden under shrubs of *Vaccinium varingifolium*, under grasses and other herbs. The repeatedly branched hypogeous twigs bear epigeous short shoots, which grow more or less erect and bear small leaves. The plants probably are remnants of the individuals grown there by TEYSMANN. They are very slow growing and as they never flower, we need not occupy ourselves with them. It is noteworthy, however, that these plants with no other means of propagation but the hypogeous shoots should have maintained themselves in this locality for so many years; the more remarkable even as they are almost overgrown by other plants.

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1) P. KNUTH, Handbuch der Blütenbiologie, Vol. II, Part I, 1898, p. 91, N°. 194.

2. FRAGARIA VESCA L.

In the garden laid out on the top of Mt. Pangrango by J. E. TEYSMANN, the then curator of the Botanic Gardens at Buitenzorg, strawberry plants were also cultivated. MOTLEY [1]) mentioned the plants and said that the cleared part of the crater-valley was chiefly covered with strawberry plants, "for the apples and other European trees planted there were so covered with foliaceous lichens that they can hardly vegetate".

Up to the present this plant has maintained itself. The leaves and the flowers are smaller, however, than those of the cultivated varieties. One finds these strawberries on the highest part as well as in the crater-valley, always in open localities, among grass tussocks, but never in dense shade. Two types occur, one with smaller, the other with larger leaves and flowers. The flowers of the firstmentioned form measure about 10 mm in diameter, those of the larger type about 13 mm. Whether these types have developed one out of the other, or whether they were present there from the first, cannot be made out at present.

The plants form numerous runners, so that they easily multiply vegetatively; however, fruits are also produced abundantly.

The structure of the flower does not show any particularities. They remain open for four days, on the fifth day the corolla begins to fall off. The anthers open successively from the first till the third flowering-day. I observed but few pollinators, the flowers are therefore probably autogamous. The plant flowers and fruits abundantly throughout the year.

I noticed the following visitors: *Apis indica, Syrphus koningsbergeri, S. serarius,* and *S. serarioides.*

WALLACE [2]) saw that the strawberries were eaten by a mountain-thrush: *Turdus javanicus fumidus.* This bird will therefore aid in the dispersal of the plant.

KNUTH [3]) mentions a large number of flower-visitors from Europe; they belong to *Coleoptera, Diptera* and *Hymenoptera.*

3. NEILLIA THYRSIFLORA DON.

This plant is known from West Java only, from Mts. Salak, Gedeh-Pangrango and Tjikorai. In Sumatra it has been collected on several mountains, viz. on Mts. Talamau, Merapi, Korintji and Malintang. It has also been found in the Himalayas. Near Fort de Kock in West-Sumatra it has been collected as low as 1300 m; generally it occurs above 2000 m, on the top of Mt. Tjikorai it grew at an altitude of 2800 m. On Mt. Pangrango-

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[1]) J. MOTLEY, Letters to W. MITTEN. Hooker's Journal of Botany, Vol. VII, 1855, p. 82.

[2]) A. R. WALLACE, The Malay Archipelago. Macmillan's Colonial Library, Tenth Edition, 1861, p. 91.

[3]) P. KNUTH, Handbuch der Blütenbiologie, Vol. II, Part I, 1898, p. 366.

Gedeh it is nowhere frequent; it occurs scattered among other plants, especially between 2200 and 2500 m. The plant is a sparse shrub, more or less ascendant, recalling some species of *Rubus*, but it is not aculeate. When exposed to the light the branches, the petioles, the mid-ribs and the young leaves become red. Part of the leaves are trilobate, the higher leaves, however, are simple and cordate; the margin is biserrate. The inflorescence is a terminal panicle or sometimes a terminal raceme, the flowers are clustered densely together and shortly pedicellated.

The calyx is 5-toothed, often red-brown, covered, especially near the base, with stipitate glands. The corolla is white and widely open, 10 to 20 stamens are inserted upon the receptacle; they surround the pistil, which consists of a superior ovary, a style and a capitate stigma. The fruit is enclosed within the enlarged calyx.

Pollination. The filaments bend inwards, the anthers curve over the stigma, and often come in contact with it. On Mt. Pangrango I never observed visitors on the flowers; self-pollination is probably the rule. On Mt. Salak the flowers were regularly visited by *Bombus rufipes* var. *obscuripes*.

4. PHOTINIA NOTONIANA W. et A.

This plant is known from several Javanese mountains, especially in West Java, among others Mts. Pangrango-Gedeh, Salak, Tjerimai, Kendeng, Malabar, Papandajan, further from Mts. Sumbing, Sindoro, Merbabu, Slamat, Semeru and Hijang. It has been collected in Sumatra too (Peak of Korintji), in Lombok and Flores, and it is also known from the Himalayas. It prefers open localities, growing in grass wildernesses, on stony ground and in light alpinoid forest; sometimes at altitudes below 1500 m, but usually above 2200 m and up to the very summits of the volcanos. On Mt. Pangrango it is arboreous, and grows among the other trees of the alpinoid forest; when growing in the shrub wildernesses and in the grass associations of the top, it is a shrub. It grows also near the crater of Mt. Gedeh.

This plant grows as a rule solitary, and develops into a densely branched shrub or low tree; on the top of Mt. Pangrango I have never seen specimens higher than 4 m. The leaves are long-petiolated, leathery, broadly-elliptical or oblong, and entire. The young leaves and the tips of the shoots are of a beautiful red. The flowers are arranged in dense corumbs. The latter are usually terminal, but they arise in the axils of the upper leaves. The calyx is pentamerous, gamosepalous with obtuse lobes; the corolla consists of 5 free white petals, about 3 mm large. There are 10 stamens with filaments tipped by pink anthers. The ovary is inferior and the two green styles terminate each in a disk-shaped, yellowish green stigma. Round the base of the style runs a cup-shaped disk, which is yellow, with brown markings. But little nectar is secreted; the scent of the flowers

reminds one of those of the hawthorn. The fruit is dark-purple, and fleshy, and contains 1—2 seeds which are ovate or compressed; the pericarp is hard.

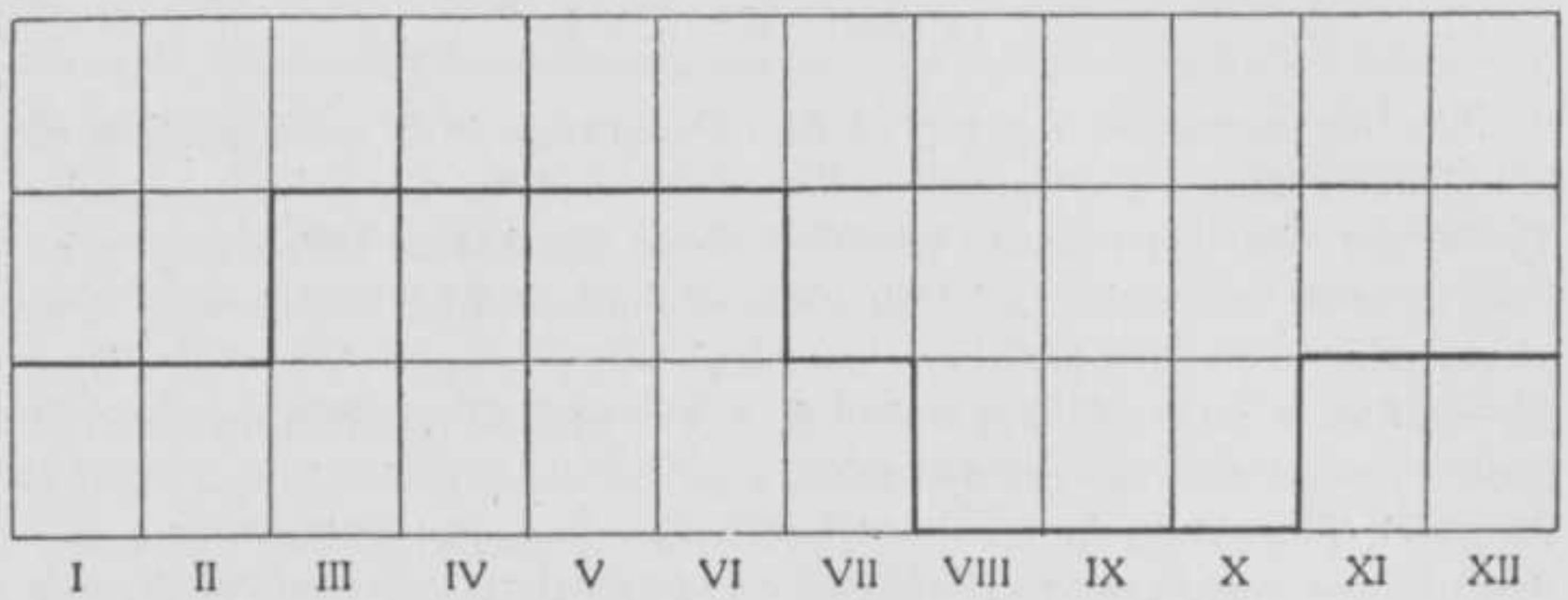

Fig. 30. Flowering-time of *Photinia Notoniana* W. et A.

Pollination. First flowering-day: the stamens are curved inward and pressed against the stigmas which are already receptive. Pollination occurs therefore on the first day and the flowers are homogamous.

Second flowering-day: the stamens are radially spreading, and the anthers are for the greater part empty.

The flowers are not much visited, on Mt. Pangrango once in a while I observed *Bombus rufipes* on the flowers, and on Mt. Lawu I saw[1]) the same. A few times I noticed also flies on the flowers, viz.: *Chamaesyrphus nigripes, Syrphus koningsbergeri, S. serarius* and *S. serarioides*, also the Anthomyine: *Limnophora prominens* and an unclassified Trypetine.

Pollination by the agency of insects is possible therefore, but self-pollination is on Mt. Pangrango the rule; I noticed this on Mt. Sumbing and on Mt. Lawu also; all the normal flowers set fruit.

Flowering-time. According to the table on page 88 and figure 30 the flowering-time is rather capricious: at the end of the dry season, in the months August to October flowering is practically nil; in the months March to June, at the end of the rainy season it is generally fairly abundant. The plants, however, are often effected by psyllids, which form galls[2]) not only on the leaves but also on the flowers, and may prevent a normal development of the flowers. In some years hardly any normal flowers can be found. The irregularity of the flowering, which is clearly shown in the table, may perhaps be explained by this cause

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[1]) W. DOCTERS VAN LEEUWEN, De alpiene vegetatie van de Lawoe-vulkaan. Natuurk. Tijdschrift v. Ned. Indië, Vol. LXXXV, 1925, p. 38.

[2]) Mrs. J. DOCTERS VAN LEEUWEN en W. M. DOCTERS VAN LEEUWEN, The Zoocecidea of the Netherlands East Indies. Batavia, 1926, p. 217. N. 490.

I saw the mountain-thrush : *Turdus javanicus fumidus,* often eat of the fruits ; the mountain-rat : *Rattus lepturus,* is also very fond of them.

I have not yet found the seeds, however, in the stomach contents.

5. PIRUS MALUS L.

This tree occurs on the top of Mt. Pangrango in a small number of individuals ; they were probably planted there about ninety years ago by TEYSMANN, the then curator of the Botanic Garden at Buitenzorg, who tried to grow vegetables and fruit-trees on the top of Mt. Pangrango. The plants grow in a clump in the crater-valley. Ten years ago there were about 10 small trees, none of them higher than 3 m, and all poorly branched and knotty. Some years ago most of them were cut down probably to serve for firewood. The plants do not flourish ; they are poor in leaf but they sometimes flower fairly well, i.e. in March 1920 and February 1921. In the dry season they are mostly bare or the leaves are half-withered, and they do not bear flowers. They never set fruit. The trunks have a diameter of 5 to 8 cm at their base.

6. RUBUS FRUTICOSUS L.

This European *Rubus*-species dates probably also from the time when TEYSMANN tried to grow Dutch fruit-trees and vegetables on the top of Mt. Pangrango. I collected some material there and sent it to the Dutch *Rubus*-specialist, A. DE WEVER, who answered me, that the material could not be identified with any of the Dutch *Rubi,* as the pith is yellow, and such pith is unknown in any of the Dutch species. I will use therefore the old collective name.

It occurs in two places in the crater-valley on Mt. Pangrango ; a large number of individuals form there a compact bush reaching about 1½ m in height and 4 to 5 m in diameter. The branches and the leaves show the characteristic structure. The branches root at the end, forming in this way new plants. The latter, however, remain in the vicinity of the clump, which consequently hardly extends.

The flowers are pink ; they are occasionally visited by *Bombus rufipes,* but they never set fruit ; the reproduction is therefore exclusively vegetative. This has gone on for nearly a century.

During the greater part of the year the plant flowers abundantly, during the dry months, however, the number of flowers is somewhat smaller.

7. RUBUS LINEATUS REINW.

This plant is common everywhere in the mountains of Java, it has also been collected on Bali, Borneo (Mt. Kinabalu) and in Sumatra. It grows from 1600 m up to the very summits of the mountains. In the higher regions

it occurs in the alpinoid forest rich in humus (though preferring the open alpinoid forest), along mountain streams, in alpinoid undergrowth and on the edge of the forest, but it does also well in stony localities. On Mt. Pangrango-Gedeh it grows in the same stations, a few specimens occurring in the grass wildernesses of Mt. Pangrango. When it grows gregariously a tangle is formed which, though the plants are not very prickly, is difficult to penetrate.

It is a stout shrub sometimes supporting itself, but more often straggling among and over other plants. In the rainy-season robust upright or slanting shoots are formed which in the next years ramify profusely; on these lateral branches the terminal or axillary inflorescences are formed. The leaves are palmately compound, 3- to 5-foliolate; the leaflets are lanceolate, often silvergrey pilose or glabrous on the underside; the margin is serrulate. The petiole often bears reflexed prickles. The latter are also but less strongly developed on other parts of the plant.

The buds arise in clusters; at first the pedicels are more or less erect but afterwards the top of the pedicel curves, and the bud becomes cernuous. In this stage the inner parts of the flower are still enclosed in the calyx, the styles are already nearly full-grown, and are pressed against the top of the calyx, the petals are hidden, the short stamens bent inward, figure 31.

Fig. 31. Inflorescence of *Rubus lineatus* REINW. × 1.

Pollination. First flowering-day: The calyx is densely tomentose; it consists of 5 strongly acuminate sepals, which spread star-like. The corolla consists of 5 small, obtuse, white petals, 4 to 6 mm long, erect and pressed against the stamens. The numerous stamens possess a rather broad filament tapering towards the tip and topped with a white anther; they are 2 to 3 mm long and the anthers come at the same level with the tips of the stigmas. The latter are receptive and the outermost are pressed against the anthers. A large number of pistils is inserted on the conical receptacle; the clustered styles diverge, and terminate each in a short, furcate stigma. The anthers open later in the course of the morning, and the flowers are therefore protogynous.

Second flowering-day: The calyx has now curved backwards, the petals

separate slightly, sometimes they have become brown and they are readily shed. The stamens too diverge more; the anthers are for the greater part empty and brown. The styles and the stigmas are in the same condition as on the day before.

The flowers are fairly rich in nectar, which is secreted by a disk at the inside of the calyx.

Third flowering-day. Having regained during the night its original position the calyx once more encloses the petals in the same way as in the bud.

This plant flowers nearly throughout the year in equal abundance, fruits are also produced regularly and in large numbers. The latter are a bright orange and though not very flavorous they have an agreeable sour taste.

On account of the anthers leaning against the outermost stigmas self-pollination is readily effected. The flowers are, however, also frequently visited by *Bombus rufipes*, which are busy in the flowers from early morning until sunset. I observed this pollinator also on Mt. Lawu [1]). The honey-bird: *Aethopyga eximea* I saw also repeatedly on the flowers, quietly searching one open flower after the other; on Mt. Papandajan I noticed *Apis indica* and once I saw a Syrphid-fly: *Chamaesyrphus nigripes* in the flowers.

The number of visitors is scant when compared with the long list which KNUTH [2]) gives of the visitors of the European species of *Rubus*.

The fruits are eaten by animals. The mountain-rat: *Rattus lepturus*, when kept in captivity, is extremely fond of these orange black-berries; on Mt. Pangrango I also saw *Oreosterops javanica frontalis* eat of the fruits and in the stomachs of *Pycnonotus bimaculatus* [3]), shot on mount Sumbing, we found seeds of this plant.

FAMILY OF THE SAXIFRAGACEAE.

1. ASTILBE INDICA BL.

This robust herb which reaches a height of over 2 m, is frequent on the higher parts of the mountains in Java. On Mt. Gedeh it occurs especially from the vicinity of the hot fountains up to Kandang Badak. The strong stem bears a small number of large, bi- to trifoliate leaves with a brown-haired sheath at the base of the petiole. The terminal inflorescences are large, rust-coloured, pubescent panicles, which are highly conspicuous by the white colour of the numerous small flowers. The calyx is poorly

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[1]) W. DOCTERS VAN LEEUWEN, De alpiene vegetatie van de Lawoe-vulkaan. Natuurk. Tijdschr. v. Ned. Indië, Vol. LXXXV, 1925, p. 38.

[2]) P. KNUTH, Handbuch der Blütenbiologie, Vol. II, Tome I, p. 354.

[3]) HANS DOCTERS VAN LEEUWEN, Beitrag zur Kenntnis des Avifauna der Mittel-Javanischen Vulkane Soembing und Sindoro. Treubia, Vol. X, 1929, p. 493.

developed, the corolla is wanting and the 8 to 10 stamens are so short that they hardly project or do not emerge at all beyond the calyx. The two ovaries are ovoid and each bears a short style.

The faintly scented flowers are visited by numerous insects, chiefly by flies. At Kandang Badak I observed Syrphids: *Spegina javana* and other species, among which probably *Chamaesyrphus nigripes*; the Anthomyines: *Limnophora prominens* and *Coenosia anipila* and the Bibionide: *Dilophus nigriventris*.

Small beetles may sometimes be found also in large numbers on the inflorescences, the flowers of which abundantly set fruit.

2. DICHROA FEBRIFUGA Lour.

This shrub is very common on Mt. Pangrango-Gedeh between 1400 and 2600 m, but especially in the lower part of this region. The stems are thick and terete. The opposite, short-petiolate, leaves are ovate and serrate; the thick apex is acute, at the base the lamina tapers into the petiole. The large corymbose inflorescences are found at the tips of the branches and are highly conspicuous by the blue colour of the flowers.

The green calyx consists of 5 to 6 triangular sepals; the 5—6-merous corolla of thick blue petals. The 10 to 12 stamens possess slender filaments and oblong anthers. The ovary is half-inferior, and 4- to 5-capillary; it contains numerous ovules; the 4 to 5 capitate stigmas are closely pressed together.

Pollination. During the first flowering-day the stamens are united in a bundle and stand wellnigh vertical; the anthers are open, producing white, granular, waxy pollen. The stigmas are surrounded by the anthers and at 8 o'clock already they are covered with pollen.

On the second flowering-day the anthers are empty; the styles diverge carrying their stigmas outside the ring of anthers. The amount of nectar secreted in the flowers is but small; the flowers are faintly scented.

On the third flowering-day the perianth-leaves and the stamens are shed.

Bombus rufipes visits the flowers, but otherwise visitors are rare. As, however, all flowers set fruit, self-pollination will be the rule. The fruits are unilocular; they are many-seeded blue berries.

3. HYDRANGEA OBLONGIFOLIA Bl.

An erect shrub with few stems; it occurs everywhere above 1200 m in the mountains of Java, and grows in exposed places, as well as in alpinoid forests. On Mt. Gedeh-Pangrango it is especially found above the hot wells, not higher than 2500 m. The inflorescences are large, terminal panicles, highly conspicuous by the large size of the sterile flowers. These decoy-flowers are borne on long pedicels, and possess 4 large sepals which

are at first pale-yellow and become later-on green or straw-coloured; they measure 5 to 6 cm in diameter. The other flower parts are like those of the fertile flowers: 8 anthers containing pollen and two styles, but the ovary is rudimentary. The 5-merous fertile flowers are borne on short pedicels, the calyx is tubular with 5 small teeth, and yellowish; the corolla is reddish or green outside and light-blue inside, marked with a dark-blue margin. The petals are free and the corolla is caducous. There are 10 stamens; the episepalous ones are shorter than the epipetalous ones; the anthers are blue and contain white pollen. The ovary is inferior and bears 3 to 4 flat blue styles with narrow white stigmas. Nectar is secreted in drops on the flat top of the ovary.

Pollination. The panicles are visited chiefly by small flies; thripses are also common in the flowers. Self-pollination, however, is possible: the anthers often come in contact with the stigmas, and pollen may even be shed upon the stigmas of the neighbouring flowers.

4. POLYOSMA ILICIFOLIA BL.

On Mts. Pangrango-Gedeh this plant is fairly common above Tjibodas; it occurs also above Kandang Badak, where it shows, however, a smaller, stouter habit, a form described as var. *minor*, cf. KOORDERS and VALETON [1]). The flowers of this variety were examined by me.

The inflorescences are short-pedunculate racemes borne at the end of the lateral branches. The perigone is 4-merous with long purple lobes which for the greater part remain erect and form accordingly a tube; at the top only they are reflexed. The 4 stamens are inserted upon the receptacle, the anthers remain a little distance below the tip of the stigma.

The fruit matures to a succulent drupe which is at first white, later on it becomes purple and finally black.

Pollination. The anthers already open introrsely in the bud and the stigma in growing upwards through the tube formed by the thecae is pollinated. The flowers secrete a large quantity of nectar, and they are delicately scented; however, I never saw that they were visited. In many flowers the stamens protrude through gaps between the perigone-segments, which seem to have been forced apart; this was done perhaps by a pollinator, may be by a bird.

FAMILY OF THE LEGUMINOSAE.

1. ALBIZZIA MONTANA BTH.

This plant, belonging to the sub-family of the *Mimosaceae*, occurs on almost every mountain of Java. It is therefore very remarkable that this

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[1]) S. H. KOORDERS and TH. VALETON, De Boomsoorten van Java, Bijdrage no. 5. Batavia, 1900, p. 382.

tree does not grow on the top of Mt. Pangrango. On the top of Mt. Gedeh, especially on the open ground in the crater, it grows abundantly and gregariously. In the vicinity of Kandang Badak and even in lower regions, along streams, one notices its delicate foliage. Concerning its distribution over great distances, nothing, as far as I am aware, is known.

The pods are strap-shaped and light, and the comparatively small seeds remain for a long time attached to the dehisced legumes. Distribution by means of wind is therefore very likely; it is reported by KOORDERS and VALETON [1]). As *Albizzia montana* occurs on almost every mountain in Java, this distribution cannot be very difficult. The reason why this tree does not grow on the top of Mt. Pangrango, so near Mt. Gedeh, is probably that this locality does not suit it. VON FABER [2]) points out that minimal differences in edaphic conditions may for some plants determine the possibility of existence; the nature of these conditions is, however, in this case quite unknown.

Albizzia montana is either a small tree or a large shrub; full-grown individuals attain a height of 8 m, seldom more. The stem is generally curved, and branches already near the base; the crown of the old trees is irregular and open. The young twigs, leaves and petioles are tomentose, but the hairs disappear later on. The rachis of the leaf is provided with a gland, and is 10 to 20 cm long; the leaves are bi-pinnate and 6 to 12-jugate, with small pinnules. The flowers are arranged in dense, axillary spikes, about 10 cm long; the peduncle is ± 3 cm long, and there are one or sometimes two spikes in a leaf-axil. The flowers are sessile, with a small calyx; the corolla is somewhat larger, ± 8 mm long, and the long yellow filaments with their grey anthers protrude from it. The ovary is flattened, red, about 2 mm long and shortly stalked. In the adult buds nothing is to be seen of the stamens; the style, however, already protrudes 5 to 6 mm and is receptive. The flowers are therefore outspoken protogynous; the stamens do not become visible until a few days later. The pods are flat, straight or slightly curved; the unwinged margin is slightly thickened; they are 6 to 10 cm long and ± 15 mm broad and contain 6 to 10 hard black seeds. They dehisce with 2 valves.

This plant occurs more abundantly on the mountains of Central and East Java than on those of West Java. It may be found at an elevation of 1100 m, but it usually grows at considerably greater altitudes. It thrives especially on dry mountain-slopes and flats, for instance round or in craters and in craterfields. In dense forest it is mostly wanting; the findingplaces at Kandang Badak and lower, though on the very wet marshy banks of a brook, are always more or less open. It occurs also on landslips or in parts laid open by a gale. Besides, it is in the higher part of the mountains one of the pioneer-plants which spring up in burned areas. In such circum-

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1) S. H. KOORDERS en TH. VALETON, De Boomsoorten van Java, Vol. I, 1894, p. 292.
2) F. C. VON FABER, Die Kraterpflanzen Javas. Weltevreden, 1927, p. 119.

stances it becomes evident how many viable seeds there are buried in the soil, which do not germinate in the shade of the trees. When the forest is destroyed by a fire the seeds germinate. The seedlings form thick bushes. Later on most of them die.

This phenomenon may be observed on several mountains; I myself have seen it on Mt. Merbabu [1]), Mt. Sumbing, and Mt. Sindoro [2]), and KOORDERS and VALETON [3]) also mention it. JUNGHUHN [4]) describes this tree; especially the description in his famous work "Java" is very detailed.

According to KOORDERS and VALETON it flowers and fruits during the whole east-monsoon. As it does not occur on Mt. Pangrango, I have but few notes about its flowering. In June I saw no flowers on the top of Mt. Gedeh; in February 1922 on the contrary, many trees were covered with flowers. On Mt. Kawi it flowered abundantly in April 1929.

Pollination. Concerning the pollination I possess but few data; I have only observed that on Mt. Kawi the flowers were regularly visited by *Bombus*; at Kandang Badak I noticed visiting by *Aethopyga eximea*.

The plants are often badly infected by a fungus, *Uromycladium Tepperianum*, which forms voluminous galls on the branches and the leaves. Wherever *Albizzia montana* occurs these galls are found. The galls on the leaves are oblong, and not very large; those on the branches are more rounded, and may sometimes reach 10 cm in diameter; but oblong branch-galls occur also. The adult galls are brownish yellow, but often covered with thick layers of dark russet spores. See RACIBORSKI [5]).

Good pictures of the habitat of this species are given by ERNST [6]) and by ROCK [7]).

FAMILY OF THE OXALIDACEAE.

1. OXALIS CORNICULATA L.

Small clumbs of this herb are found now and then on Mt. Pangrango; it may disappear, however, for a long time. The little yellow flowers are

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[1]) W. DOCTERS VAN LEEUWEN, Ueber die Erneuerung der verbrannten alpinen Flora des Merbaboe-Gebirges in Zentral-Java. Ber. d. deutsch. bot. Gesell. 1913, Vol. XXXI, p. 156.

[2]) See p. 181 note 1.

[3]) S. H. KOORDERS en TH. VALETON, Bijdrage No. 1 tot de kennis van de boomsoorten van Java. 1898, p. 294.

[4]) FR. JUNGHUHN, Physiognomie van de Flora der toppen van Javaansche bergen. Natuur- en Geneesk. Archief voor Ned. Indië, Jaarg. II, 1845, p. 22.

[5]) M. RACIBORSKI, Ueber einigen javanischen *Uredineae*. Bull. internat. de l'acad. d. Sciences de Cracovie, 1909, p. 269.

[6]) A. ERNST, Die Besiedlung vulkanischen Bodens auf Java und Sumatra. Vegetationsbilder, Reihe VII, 1 en 2, pl. 4.

[7]) J. F. ROCK, The forest on Mt. Gedeh, West-Java. The Hawaian Planters' Record, Vol. XXII, 2 Febr. 1920, p. 100.

regularly open and produce nectar; but I have never observed insects visiting them; however, they regularly set fruit by means of self-pollination. Concerning the pollination in Europe, cf. KNUTH [1]).

FAMILY OF THE CELASTRACEAE.

1. PERROTTETIA ALPESTRIS LOES.

This is an erect much branched shrub which grows in the primeval forest of Mt. Gedeh-Pangrango; at altitudes between 1500 and 2500 m, preferably in open places and along road-sides.

The inflorescences are axillary repeatedly branched corymbs with green or reddish branchlets.

The pentamerous flowers are greenish-white or reddish, and measure about 2 mm in diameter. The calyx is gamosepalous with 5 acute, red lobes; the petals are more or less triangular, green with red tips. There are 5 stamens facing outwards though not projecting beyond the corolla. The ovary is broadly conical, and bears a short style surrounded at the base by a disk.

Pollination. The flowers close in the evening, the anthers joining above the stigma on which they shed their pollen.

The ovary matures to a berry, measuring 6 to 10 mm. I never saw any visiting insects.

FAMILY OF THE BALSAMINACEAE.

1. IMPATIENS JAVENSIS STEUD.

This plant is especially frequent in moist places in the third belt of JUNGHUHN, and in the lower area of his fourth belt too. At about 2400 m on Mt. Gedeh it is very common. The flowers are not often visited: I observed the following insects on them: *Bombus rufipes, Apis indica,* and *Syrphus balteatus.*

On Mt. Sindoro the fruits of another species, i. e. *I. platypetala* are eaten by the forest-fowl: *Gallus varius* [2]); the seeds, however, are probably not despersed by this bird, as they are digested by it.

FAMILY OF THE THEACEAE.

1. EURYA ACUMINATA DC.

An extremely variable plant which has been described under various names a. o. as *Eurya japonica.* In the virgin forest of the twin mountains

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[1]) P. KNUTH, Handb. d. Blütenbiologie, Tome II, Vol. I, p. 243.

[2]) HANS DOCTERS VAN LEEUWEN, Beitrag zur Kenntnis der Avifauna der Mittel-javanischen Vulkane Sumbing und Sindoro. Treubia, Vol. X, Tome 4, p. 439.

Pangrango-Gedeh it occurs frequently though scattered; it is familiar in the alpinoid forest of both mountains and on the top of Mt. Pangrango it is very common. At this elevation they occur as small crooked trees, up to about 5 m high and richly branched. The bark is grey and rather smooth, and the branches are distributed irregularly around the trunk, the terminal ones being long and thin, and for the greater part bare. The leaves are borne on short petioles; they are oblong or lanceolate and their base is very acute and the apex acuminate; they are 3 to 6 cm long, 1 to 3 cm broad; the margin is serrate.

The plant occurs on all the mountains of Java, and also in Sumatra, Malacca, Ceylon and the Himalayas. On the top of Mt. Pangrango it mostly occurs scattered, but among the shrubs of the crater-valley sometimes in small groups. It is dioecious and the flowers are solitary or rarely in fascicles of two or three in the axils of the leaves on the slender twigs.

Male Flowers. These flowers are borne on a short pedicel; the latter bears two small bracteoles at the top. The calyx is divided in 5 oval, more or less asymmetric lobes; the outer lobes are green, the inner ones greenish-white. The corolla is also 5-merous, more or less campanulate or infundibuliform; the white petals are united at their base only. Generally there are 20 stamens, each consisting of a white filament and an orange anther; the pollen is dry and the anthers are often already emptied at half past nine in the morning. The pistil is rudimentary, green, without stigmas. Nectar is secreted in a small quantity only.

Female flowers. The perianth is like that of the male flowers; in some specimens it remains more or less closed, in others it is more expanded. Stamens are altogether absent, and the pistil consists of a spherical, green ovary and 3 to 4 short sessile stigmas. These flowers produce more nectar. The fruit is a globose, sometimes flattened bluish-black berry.

Pollination. The flowers possess the nauseous scent of skatol, and on warm calm days the neighbourhood of this tree is infected by this penetrating stench. Many insects, however, are attracted by the flowers. In the main flowering-time there is a concert of buzzing *Bombus rufipes*, which visit the flowers for the sake of the honey only, and of *Apis indica*, which collects the pollen as well. Several Syrphid-flies occur also on the flowers, a.o. *Chamaesyrphus nigripes* and *Syrphus confrater*, the Anthomyine: *Pegomyia bistriata* and the Muscide: *Calliphora fulviceps* I observed also on the flowers.

Flowering-time. Throughout the year flowers may be found; in the months of December to February nearly all individuals are in flower, in the other months, however, flowering is generally scanty. However, in the months of July to November one may find in one year many flowers and in a following year but few. On the top sometimes not a single tree flowers, while at a lower elevation flowering is abundant, cf. figure 32.

The fruits are eaten by birds; in the stomach of the mountain-dove:

Sphenurus sphenurus korthalsi, I found seeds and fruits of this tree.

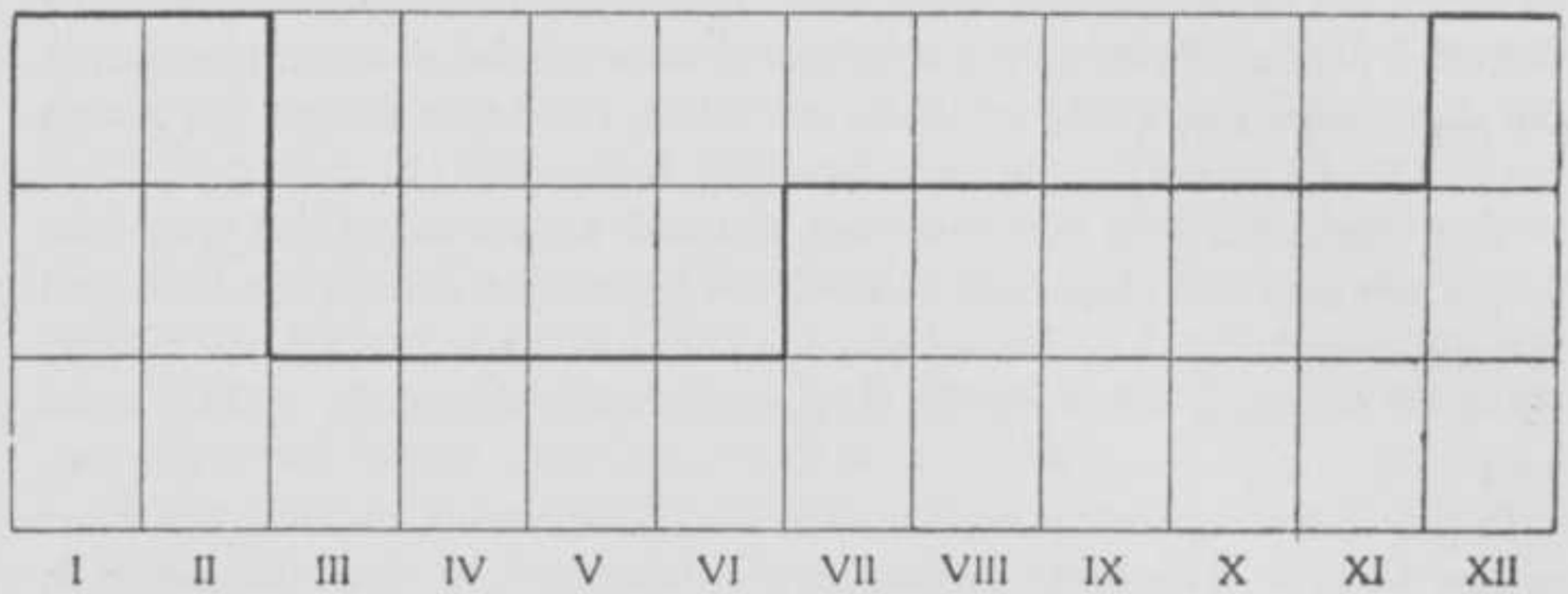

Fig. 32. Flowering-time of *Eurya acuminata* DC.

FAMILY OF THE GUTTIFERAE.

1. HYPERICUM LESCHENAULTII GAUD.

This plant is very common on the higher mountains; in Java it is found on nearly all the volcanoes at an altitude between 1800 and 3300 m; it is known also from Bali and Lombok, from Mt. Lompobatang (South Celebes) and from some volcanos of Sumatra, viz. from the Peak of Korintji and from Mt. Dempo. Further it is also found on the Himalayas. It occurs in many habitats, on bare rocks as well as in alpinoid underwood, in open sandy localities, in grass plains, and sometimes along the margin of swamps. The plant varies in habit according to the nature of the habitat and one may often find the different types growing in each others neighbourhood. In the Sand-Sea (Tengger) and in the so called oro-oro-plain on the top of Mt. Kawi one finds low, dense specimens, which in the dry season are for the greater part leafless; in shaded places the plants are much more slender. On the top of Mt. Pangrango both forms grow, but the former does not show such a remarkably compact habit as in the Sand-Sea and in other open places of the East-Javanese mountains. On Mt. Pangrango *Hypericum* grows abundantly in the alpinoid forest, especially at its edge. It assumes then the habit of a straggling shrub; its twigs are sometimes more or less liana-like and the flowering-shoots hang down from the crowns of the low trees. Such plants may possess stems 3 to 4 m in length. In an open part at the North-East side of the crater-valley there is a patch almost entirely overgrown with a dense tangle of *Hypericum,* which forms here shrubs 1 to 2 m in height. In the grassy plain more compact specimens are found. On Mt. Sumbing they also grow in fissures of a nearly perpendicular wall of rock [1]).

[1]) W. DOCTERS VAN LEEUWEN, Beitrag zur Kenntnis der Gipfelvegetation der in Mittel-Java gelegenen Vulkane Sumbing und Sindoro. Bull. d. Jard. bot. de Buitenzorg, Serie III, Vol. XI, 1930, p. 36.

In the rainy season the plants develop vigorous shoots which flower either in the same year or in the next. In the dry season the leaves grow red, and part of them, in the first place those of the flowering-branches, but sometimes the whole of them, are shed. In the Sand-Sea the plants are in the dry season completely bare, cf. KOORDERS [1]).

The young parts of the plants are covered with a coating of wax; the leaves are opposite subsessile, ovate-oblong, pellucid dotted, the base and the apex are blunt. The leaves of young shoots are sometimes very large, 50 to 80 mm long, those on the flowering shoots are mostly 20 to 30 mm long.

In the flowering-time the plants are extremely conspicuous by the large yellow flowers. The latter are solitary or arranged in terminal, rarely in axillary inflorescenses. The calyx is composed of 5 sepals, which show a considerable range of form, varying from broadly oblong to lanceolate. The corolla consists of 5 rounded brightly yellow clawed petals. The dia-

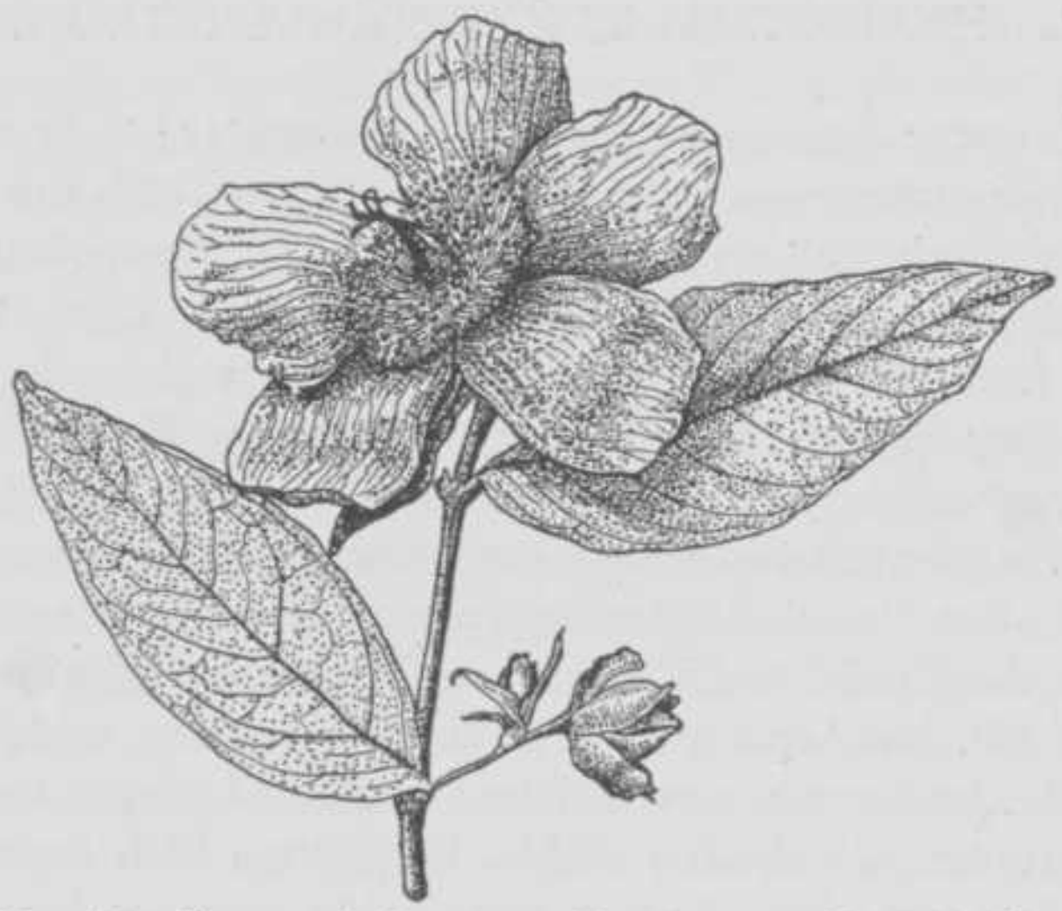

Fig. 33. Flower of *Hypericum Leschenaultii* GAUD. × 3/4.

meter of the flowers is usually 5 to 6 cm; on Mt. Sumbing I noticed on otherwise bare walls of rock small plants with flowers reaching 8 cm in diameter. At first they are more or less urceolate and as the pedicel is curved the opening faces obliquely downwards; later on they expand widely and face upwards, figure 33. The stamens are much shorter than the petals, they are arranged in 5 more or less distinct bundles. The pistil consists of a pyramidal 5-celled ovary and 5-free styles, which taper towards the stigmas, and project a fair distance beyond the stamens. No nectar is secreted.

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1) S. H. KOORDERS, Versuch einer Arten-Aufzählung der Hochgebirgsflora von Tosari und Ngadisari. Natuurk. Tijdschr. v. Nederl. Indië, Vol. LX, p. 259.

Pollination. The aestivation of the petals in the full-grown bud is imbricate; the corolla is still quite closed; in the middle the stamens lie closely appressed against each other; and the stigmas only project beyond them. The stigmas are already viscous, and the flowers are therefore clearly protogynous. In the young, just open flower in which the cup-shaped petals are still bent towards each other, the stamens are pressed against the petals, and the pistil is free and distinctly visible. The filaments are grown out but the anthers are still closed; in some flowers, however, the anthers have already opened at this stage. The stigma is usually soon after the opening of the flower already covered with pollen.

In flowers one day older the anthers are open and the ovary begins to swell already.

The flowers are regularly visited by *Bombus rufipes;* twice only I observed a Syrphid-fly, viz. *Chamaesyrphus nigripes,* in search of pollen, but they are too small to effect pollination except by chance. *Bombus* is the regular customer and it does not miss a single flower. I observed this visitor not only on Mt. Pangrango-Gedeh, but also on Mt. Papandajan, Mt. Tjikorai, Mt. Sumbing, Mt. Sindoro, Mt. Kawi and Mt. Lawu [1]). It already pushes its body into the recently opened flowers when the anthers have not yet opened, and it visits the same open flowers repeatedly. It sweeps the pollen out of the anthers, wallowing round in the flower and in doing so it regularly brushes against the stigmas, which usually become thickly covered with pollen; when the insect flies away, it is laden with thick, yellow lumps of it. That the same bumble-bee repeatedly visits the same flower I managed to observe in the following way. On a small table before my hut I had placed a vase containing some flowers; out of a bush to the left came a bumble-bee; having visited the flowers there, it made for the flowers in the vase, plate XXX A. For a short time it was rummaging about in the flowers and then it flew away towards a shrub to the right. I marked this insect with a spot of white paint, and for many hours I saw it return regularly about every half hour. Later on a second and third insect came to the flowers by the same way. From early in the morning till late in the evening, even in rainy weather these insects are busy in the flowers, which represent their main source of pollen. It is a remarkable fact, that on Mt. Pangrango *Apis indica,* though often present in still larger numbers, hardly ever visits these flowers; I observed them once only on them.

Flowering-time. Flowers of this plant may be met with during the whole year. In the months of January to April their number is but small, in May they are generally more abundant, whereas in June and July all shrubs are in full flower; in August the number of flowers is beginning to diminish, and in the last months of the year it is again very small; see figure 34 and the table on. p. 88. It is not the same every year; in September

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1) W. DOCTERS VAN LEEUWEN, De alpiene vegetatie van de Lawoe-vulkaan. Natuurk. Tijdschrift v. Ned. Indië, Vol. LXXXV, 1925, p. 38.

1927, October 1924, November 1925 and December 1923 hardly any flowers were seen; in September 1921, however, a fairly large number, and

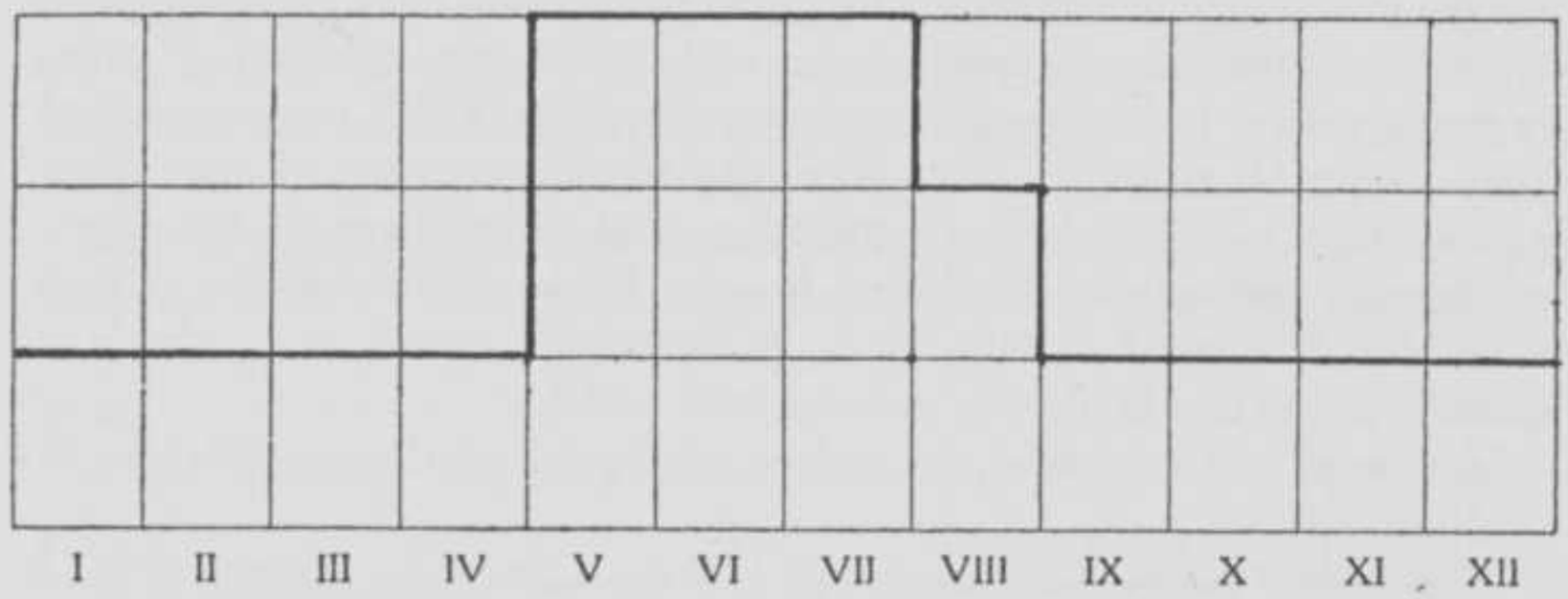

Fig. 34. Flowering-time of *Hypericum Leschenaultii* GAUD.

in the preceding month of August a wealth of flowers were found. In August 1924 the flowering was a great deal less rich, and in October of the same year it had almost entirely ceased.

In the month of November of the year 1925, which was remarkably dry, the shrubs on Mt. Pangrango possessed hardly any leaves or flowers.

The fruits are brown septicidal capsules, containing a large number of brown, more or less kidney-shaped seeds; the latter have no wings, but they are very light. Of the means of dispersal over great distances nothing is known.

A beautifully coloured plate is to be found in CURTIS Botanic Magazine [1]). A short account of the pollination I have given already at an earlier occasion [2]).

FAMILY OF THE VIOLACEAE.

1. VIOLA ODORATA L.

This species of *Viola* is in Java frequently cultivated in the mountains. In 1920 I took a number of plants from Tjibodas to the top of Mt. Pangrango, and planted them out in the alpinoid forest and shrub. Though the plant spread slowly by means of stolons, it does not thrive and it never flowers.

2. VIOLA PILOSA WALL.

This herb is extremely common in Java, where it occurs from an altitude of 1000 m up to the very summits of the volcanoes. It is also known to

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1) CURTIS' Botan. Magazine, Vol. CLII, Part II, 1928, Tab. 9160.

2) W. DOCTERS VAN LEEUWEN, Uit het leven van planten en dieren op de top van de Pangrango. De Tropische Natuur, Vol. XVI, 1927, p. 115, fig. 23 en 24.

occur in Sumatra and in the Himalayas, in Ceylon and in South-China. It may be found in shaded, or in sunny localities, preferably where the soil is rich in humus; but it grows also between stones, and in moss cushions. On Mt. Gedeh-Pangrango it grows from Tjibodas up to and on the top, but especially above 2000 m. On the top of Mt. Pangrango it is common in the alpinoid shrub and especially on the edge of it, further in moss cushions and among the grass, but it is rare in very exposed situations.

The plant consists of a rosette of obliquely spreading leaves, from which sprout long runners which root at the nodes. The leaves are long-petiolate, cordate, and acute. The chasmogamous flowers are borne on long pedicels

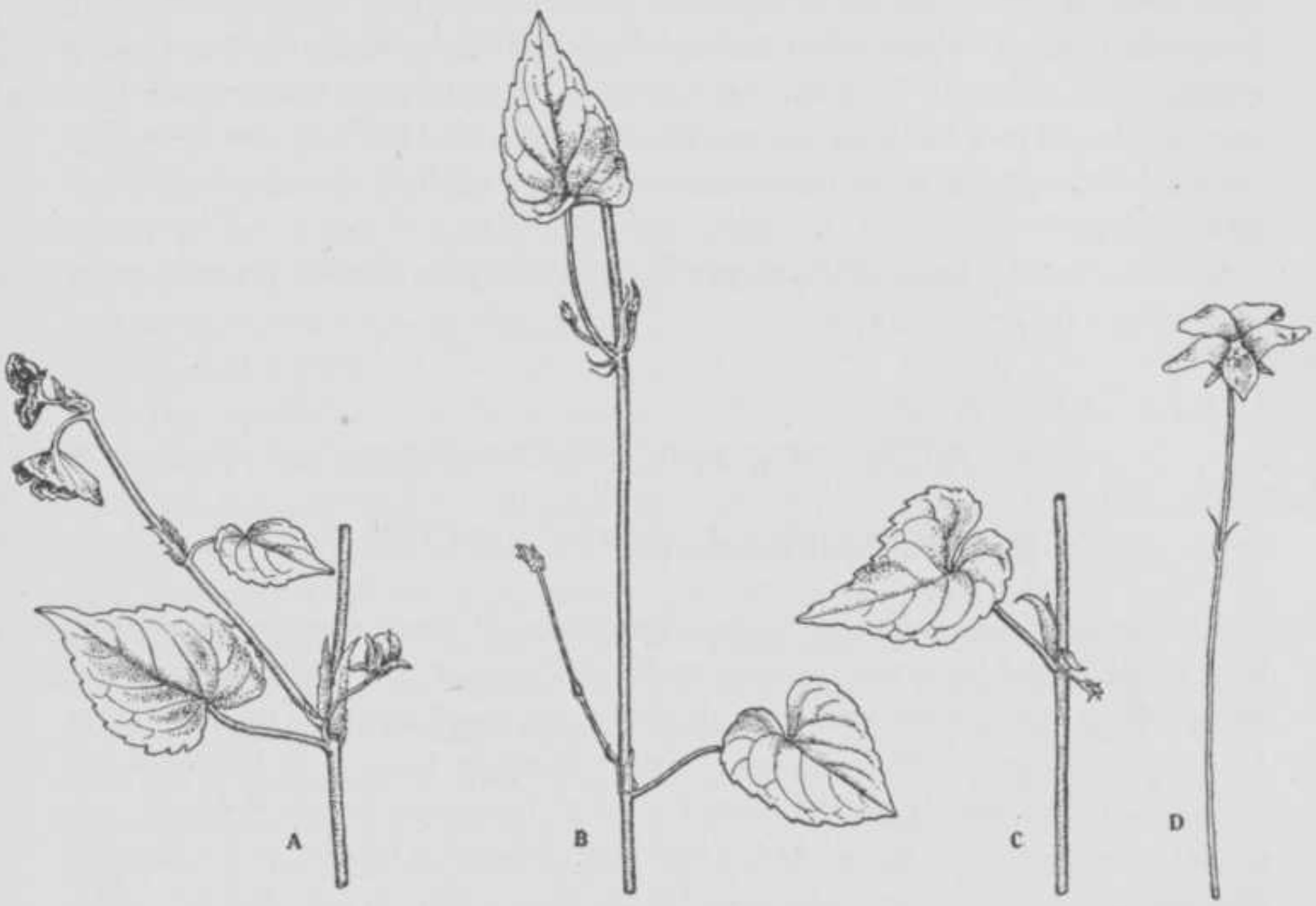

Fig. 35. *Viola pilosa* WALL. A, Runner with fruit; B and C, Runners with cleistogamous flowers. D, Chasmogamous flower. × 3/4.

in the axils of the leaves of the rosette. They are pale-violet or white with dark veins; they have no scent. There are 5 petals, one bearing a short spur and 5 stamens connected with the ovary. Fig. 35 D.

On the runners springing from the rosette small leaves develop; in but little exposed places, under moss for instance, the latter are sometimes rudimentary, but here too a new plant may arise at the end of the stolon. At the nodes cleistogamous flowers are formed, figure 35; when the runners grow in exposed stations chasmogamous flowers may arise, but this happens rarely; cleistogamous flowers, on the other hand, may develop on the rosette, but this is extremely rare.

The plants flower throughout the year, but in the dry months the number of flowers diminishes.

The cleistogamous flowers possess a well-developed calyx enclosing the rudimentary petals which, though minute, are distinctly recognizable. There is a small pistil with a short style and 5 stamens; the anthers form a hood, capping the style.

Pollination. To the best of my knowledge the chasmogamous flowers never fructify. Moreover I have never noticed insects on these flowers; the cleistogamous flowers are regularly fruiting; the pollen in these flowers is granular, it germinates already in the anthers, and the tubes grow from these straight away into the stigma.

The fruits are green or purple capsules, covered with short, white hairs; they contain about ten brown seeds. The stalk curves downwards and hides the capsule among moss and old leaves. Consequently they are easily overlooked; this may be the reason why these cleistogamous flowers are not mentioned in a book on the weeds of Tea lands [1]). They are, however, as we have seen, of more importance to the plant than the chasmogamous flowers.

Concerning the pollination of the European *Viola*-species we may refer to KNUTH [2]).

FAMILY OF THE MYRTACEAE.

1. LEPTOSPERMUM JAVANICUM BL.

The genus *Leptospermum* is represented by a large number of species in Australia and by a few species in New Zealand. Few species only are known from the Netherlands East Indies; the above named *Leptospermum javanicum* occurs in the western islands. Outside Java it is known from Sumatra, (Habinsaran on the East Coast of Sumatra, where it forms, according to a note on one of Mr. LÖRZINGS collecting labels, at an altitude of 1200 m a shrub society of about 60 cm high only, cf. also FREY [3]), Mt. Merapi, Mt. Singgalang [4]) and Mt. Talamau), from Borneo (Mt. Kinabalu) and from South Celebes (Mt. Lompobatang). It is also known from the Malayan Peninsula.

In Java this tree is found on the top of some of the western mountains only. It is commonest on the tops of Mt. Gedeh and Mt. Pangrango, where it has been gathered by several collectors. According to JUNGHUHN [5]) it

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1) C. A. BACKER and D. F. VAN SLOOTEN, Handboek van de Javaansche Theeonkruiden. Batavia, 1924, fig. 180.

2) P. KNUTH, Handbuch der Blütenbiologie, Bd. II, Tome I, 1898, p. 138.

3) A. FREY-WYSSELING, Over de struikwildernis van Habinsaran. De Tropische Natuur. Vol. XX, 1931, p. 194.

4) ED. JACOBSON, *Leptospermum javanicum* BL. De Tropische Natuur, Vol. XVI. 1928, p. 64.

5) FR. JUNGHUHN, Schetsen, ontworpen op een nieuwe reis over Java. Tijdschr. voor Nederl. Indië, Vol. VII, 1845, p. 160.

grows also on Mt. Tjikorai and in the crater of Mt. Salak [1]; from the latter locality it is also reported by ZOLLINGER [2]; afterwards it has been found there again; and it occurs on the top as well. KOORDERS [3] mentions it from Mt. Malabar. It thrives best among other trees, in alpinoid forest where the soil is rich in humus, but it may also be found on crater-fields and in other localities where the soil is poorer in humus; in those cases, however, its habit is chiefly shrubby. The trees on Mt. Singgalang are much bigger than the Javanese ones; those growing on the infertile parts of the Habinsaran plateau, however, are shrubby.

Leptospermum javanicum is therefore a low tree or a shrub. The tallest specimens on Mt. Pangrango attain a height of about 8 m; on Mt. Singgalang in Central-Sumatra I saw trees about 15 m high. On Mt. Gedeh as well as on Mt. Pangrango they grow scattered in the mountain forest, especially above 2400 m.

The best developed specimens are met with on a part of Mt. Gedeh which is but rarely visited, viz. the northern slopes of Gunung Sela. *Leptospermum* reaches there a height of about 10 m, and its trunk-diameter measured breast-high attains 30 cm; it is there the commonest species of the alpinoid forest.

A few individuals occur at lower altitudes and in the rock-garden at Tjibodas (1500 m) it grows well, though slowly. Well-developed trees occur on the top of Mt. Pangrango, especially at the edge of the forest, where their tops often rise above the other trees, plate VII. In the crater-field one may find this plant also, especially young individuals, 1 to 2 m high. These young plants are densely leaved and branched from the base; the lower branches are longer than those produced higher up and ascend at an acute angle; the plant shows therefore the form of a slender pyramid. The lower branches die when the tree grows older. In a full grown tree the first ramification is found about 1 m or higher above the ground; often, however, a few branches are spared, which gives the trees a very irregular shape. As these branches reach about as high as the top of the central axis and the higher ones also attain the same height, the old trees assume the characteristic "umbrella form", described among others by JUNGHUHN [4]; see also SCHIMPER [5]. In very old specimens, for example in the tree growing above the mountain-hut on Mt. Pangrango usually but few lateral branches remain.

The trunk is either fairly straight or curved and knotty; and sometimes

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[1]) FR. JUNGHUHN, Java. Second Edition, Vol. III, p. 576.

[2]) H. ZOLLINGER, Tocht naar den Salak, Nov. 1843. Tijdschr. voor Nederl. Indië, Vol. VI, 1843—1849, Part II, p. 159.

[3]) S. H. KOORDERS, Exkursionsflora von Java, Vol. II, p. 686.

[4]) FR. JUNGHUHN, Physiolognomie van de Flora der toppen van Javaansche bergen, benevens plantbeschrijvingen. Natuur- en Geneesk. Archief voor Nederl. Indië, Jaarg. II, 1845, p. 22.

[5]) A. F. W. SCHIMPER, Pflanzengeographie auf physiologischer Grundlage, IInd. Edition 1908, Jena, p. 761, fig. 421.

more or less spirally twisted; the bark is rough and has deep longitudinal fissures. As usual in the trees of this region the wood is very hard. The phyllotaxis is spiral; the leaves are borne at the top of a thin brown petiole, and are more or less clustered. They are lanceolate 10 to 30 mm long and 4 to 6 mm broad, acute, and narrowed at the base. At their upperside they are shiny and dark-green, at the underside a dull pale-green. The young leaves are yellowish-brown, but they are not so conspicuous as the young leaves of many other trees of this region. The adult leaves are altogether glabrous, but they bear at their tip a small tuft of hairs, which is even more developed on young leaves. The main-nerve is conspicuous, but the two lateral veins ascending from the base are very poorly developed.

The flowers are borne at the end of short lateral branches; they are solitary or arranged in groups of 2 to 4. They are produced during a few weeks only. When in full flower the trees look as if covered with snow; they are then easily recognizable from a great distance, plate XXIX. B. The pedicel is very short and merges gradually into the half-inferior ovary. The calyx is green, but its 5 obtuse triangular lobes are pink, with a white, ciliate margin; they persist during the flowering period, even somewhat longer than the petals. The latter are inserted on the edge of the calyx, they are white, sub-orbicular and shortly clawed. The open flowers reach 10 to 20 mm in diameter. They possess 30, sometimes 33 stamens, which are also inserted on the edge of the calyx. The filaments are filiform and topped by a spherical, greenish connective, which is more or less glandular. In the bud the connective is well developed; later on it shrivels more or less. The two anther-lobes are yellowish brown; they dehisce longitudinally. The lower part of the calyx and the top of the ovary are covered by a bright green disk; in the older flowers its margin becomes more or less reddish. The conical ovary is 5-celled, it rises from the bottom of the calyx-tube; its top bears a short, filiform style, which is usually slightly curved, and topped by a capitate stigma, flattened at the upperside. There are flowers which have a very short style and flowers in which the style is not developed at all; the latter are male and do not set fruit. The fruits are dark-brown or black, half-inferior capsules, 4 to 6 mm in diameter; they contain a large number of oblong, smooth and shiny, black seeds.

BLUME[1]) distinguished a variety *congesta* and a variety *alpestris,* which are not maintained by KOORDERS and VALETON. These varieties are probably nothing but growth forms. The leaves of the variety *alpestris* described by BLUME from Mt. Pangrango are more densely congested and its flowers are mostly solitary. The material has probably been collected on young trees, which up till the present time occur in large numbers at the border of the crater-valley and still show the quoted peculiarities. According

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1) C. L. BLUME, Bijdragen tot de Flora van Nederl. Indië. Batavia, 1826, part 172, p. 1100.

Idem. Museum Botanicum Lugduno-Batavium. Leiden, 1849—1851, Vol. I, p. 68.

to KOORDERS and VALETON [1]) the variety *congesta* mentioned by BLUME from Mt. Pangrango, would be a growth form occurring in particularly dry stations.

Pollination. In the young bud the inward curved stamens cover the pistil; their connectives are visible as green, glandular globuli. In the older buds the stamens have straightened somewhat.

On the first flowering-day the petals are cup-shaped, and more or less erect. The stamens are usually quite straight, but they are still bent over the receptacle, and the anthers are still closed; the connective is fully expanded. The style and the stigma are still hidden between the filaments. The nectar is distinctly visible; it is excreted in fine drops on the whole surface of the disk.

On the second flowering-day the petals have expanded horizontally, the filaments are curved a little more outward, the connective has become brown and the anthers are open. Like the day before nectar is still visible in drops. The style has slightly elongated, the stigma stands eccentrically between the anthers, often leaning against them.

On the third flowering-day the anthers are empty, the excretion of nectar has ceased and the stigma reaches as high as the anthers; the ovary already shows a slight swelling. Pollination occurs therefore on the second day. The flower is homogamous, or sometimes slightly protogynous, flowers of the same plant behaving differently in this respect.

The flowers are sweetly scented, and by no means scentless as they were described by KOORDERS and VALETON, and when the trees are covered with flowers they spread a distinctly noticeable almond fragrance.

The nectar attracts plenty of insects. On Mt. Pangrango I observed some *Microlepidoptera* and Ichneumon-flies, which are not yet identified. The greater part of the visitors are flies. I observed the following species: The Anthomyines: *Lispocephala boops* and *Pegomyia bistriata*; the Ortaline: *Rhadinomyia orientalis*; the Syrphides: *Chamaesyrphus nigripes* and *Syrphus serarioides* and the Muscine: *Calliphora fulviceps*.

Though Syrphid-flies make for the flowers, the most active visitors are a little black fly: *Rhadinomyia orientalis*; a yellow fly with black stripes on the thorax: *Pegomyia bistriata* and a little grey fly: *Lispocephala boops*. To obtain the nectar the insects have to dive deeply into the receptacle; they must push aside the stamens and in doing so, they easily come in contact with the pollen. On Mt. Singgalang also different *Diptera* were busy in the flowers, but there, the flowers were mostly visited by *Bombus rufipes*; the whole environment resounded with the humming of those insects. The white bumble-bee *Bombus senex* also visited the flowers. On Mt. Pangrango I observed but once a bumble-bee on them (27 June 1924); at Kandang Badak at an altitude of 2400 m where in March 1930 the trees were flowering abundantly, numerous bumble-bees were attracted by them.

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[1]) S. H. KOORDERS and TH. VALETON, Bijdrage No. 6 tot de kennis der boomsoorten op Java, 1900, p. 178.

During my visit to Mt. Singgalang besides *Leptospermum* but few plants were flowering, and this tree attracted therefore nearly all the visitors. In the flowering-time May and June there are on Mt. Pangrango plenty of flowers which offer more nectar or pollen to the bumble-bees.

Elsewhere I have already briefly described the pollination [1]). From Australia various visitors on flowers of this genus have been reported, to wit short- and long-tongued bees, beetles and a moth. Visiting by birds has also been noted. See PORSCH [2]). I myself have never seen any visiting birds, neither on Mt. Pangrango nor on Mt. Singgalang. Once I saw the butterfly *Dodona* searching one flower after the other.

Still in the flowering-months many rainy or sunless days occur and on such days the above-mentioned pollinators with the exception of *Bombus* do not fly on Mt. Pangrango. The flowers have to rely then on self-pollination; as the plants are always laden with fruit, the latter must be succesful.

Figure 36 shows that the main flowering-time falls in May and June. During the many years that I have observed this plant, the flowering-time remained constant. The statement of SCHIMPER [3]), that in the month of

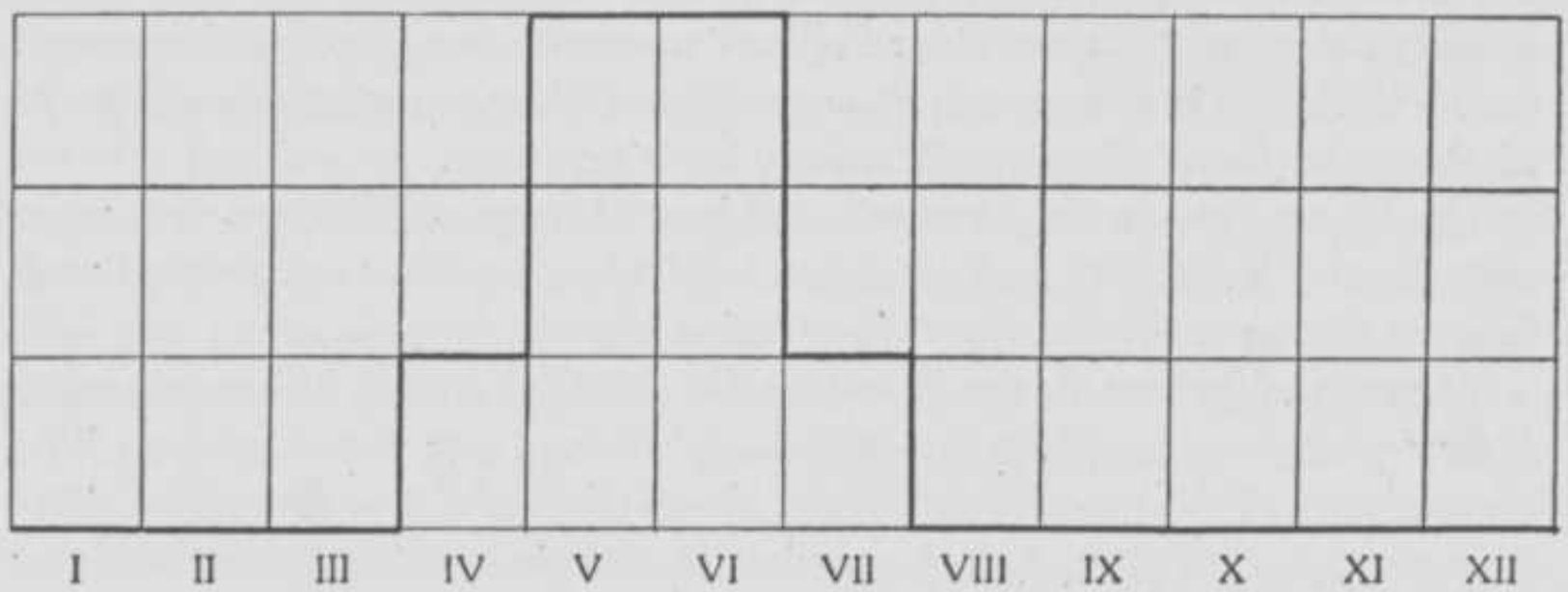

Fig. 36. Flowering-time of *Leptospermum javanicum* BL.

December the trees on Mt. Pangrango were fully covered with white blossoms does not agree with my observations. SCHIMPER's trees probably did not grow on the top; trees growing at a lower altitude flower sooner; in the vicinity of Kandang Badak they do so already abundantly in March. Though the main flowering-time occurs in the above-mentioned months, we find sometimes flowers at an earlier date, especially on young trees; in February and March 1921 for instance I noticed some flowers on young plants; whereas in 1923 and 1924 the old trees did not yet flower in April.

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1) W. DOCTERS VAN LEEUWEN, Uit het leven van planten en dieren op de top van de Pangrango. De Tropische Natuur, Vol. XVI, 1927, p. 185, fig. 29.

2) O. PORSCH, Kritische Quellenstudien über Blumenbesuch durch Vögel. III. Biologia Generalis, Vol. III, 1927, p. 543.

3) A. F. W. SCHIMPER, loc. cit., p. 761 (Also in: Gebirgswälder Javas 3, Forstl. Naturw. Zeitschr. II. 1893, p. 343).

JUNGHUHN [1]) writes, that the trees flower abundantly especially in March and April.

In October 1924 I saw a great number of flowers on the only living branch of an old, nearly decayed tree; probably a final flare-up before its death.

At the end of January 1920 I visited the top of Mt. Singgalang [2]) in West-Sumatra. The fullgrown trees and the shrubby young ones were all in full flower; they looked snow-capped. Whether the trees of this mountain also flower in other months of the year I do not know. It would be interesting to have exact data on that subject.

Dispersal of the seeds. Neither the seeds nor the fruits are provided with any particular adaptation for an easy dispersal. The dehisced fruits remain attached to the branches for a rather long time and the seeds are probably scattered by the wind. Still, one may sometimes find seedlings at a distance of many meters from fruiting trees; the seeds are therefore probably dispersed by the wind, and those fallen on the ground may be carried further by running water. In the crater-valley as a matter of fact young plants are found along the edge of the forest, but also in its centre, near the brook.

Conclusion. Flowering-time falls in the transition period between the rainy and the dry season, in May and June. Cross-pollination is effected especially by *Diptera*, but self-pollination is also possible, as the stigma comes in contact with the anthers.

FAMILY OF THE MELASTOMATACEAE.

1. MELASTOMA SETIGERUM BL.

A shrub with setose leaves; it occurs on Mt. Gedeh-Pangrango in the higher parts, for instance in the neighbourhood of Kandang Badak at an altitude of 2400 m. I observed that the large pale violet flowers are regularly visited by *Bombus rufipes*. When visiting Mt. Singgalang in Sumatra I saw another species of *Melastoma* visited by the white *Bombus senex*.

FAMILY OF THE ONAGRACEAE.

1. OENOTHERA SPECIES.

Seeds of this plant were brought by me from the island of Hawaii, from the slopes of the Heleakala-volcano. They were sown in February 1921 on

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1) FR. JUNGHUHN, Java I, p. 579; Idem, Reisen durch Java, p. 445.

2) W. DOCTERS VAN LEEUWEN, Naar de top van de Singgalang. De Tropische Natuur, Vol. IX, 1920, p. 96, fig. 2 and 3.

the top of Mt. Pangrango. Some plants have come up and their number is slowly increasing. The flowers fruit abundantly by means of self-pollination. Up to the present time I have never observed visiting insects.

FAMILY OF THE HALORRHAGIDACEAE.

1. LAUREMBERGIA COCCINEA KANITZ.

KOORDERS [1]) distinguishes two species of this genus in Java, viz. *Laurembergia coccinea* and *Laurembergia javanica,* the latter is said to differ from the first in its dense growth. BLEY [2]) points out, that the two species are probably identical and that the difference in habit is due to pecularities of the habitat.

This plant occurs locally in West and Central-Java at altitudes between 1600 and 3000 m; in the Herbarium at Buitenzorg it is represented from Mt. Gedeh-Pangrango, Mts. Patuha, Papandajan and from the Dieng-plateau. From Sumatra it is known from Mt. Talang in the Padang-Highlands, where it occurs at an altitude of 1600 m. It grows especially in moist, sunny places, along or in brooks and swamps and on moist, stony grounds.

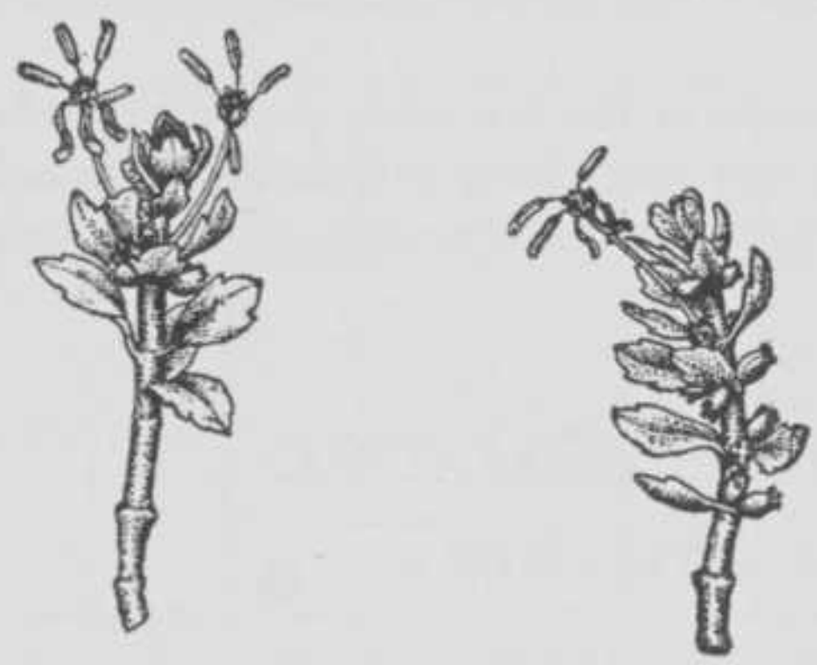

Fig. 37. *Laurembergia coccinea* Kan. Part of the stamens are lost. × 1.

On the top of Mt. Pangrango *Laurembergia coccinea* grows in the crater-valley, especially in and along the brook and in gullies formed by rainwater, it is also very common along the brook in the aloon-aloon of Mt. Gedeh.

The roots are fixed so firmly in the stony ground that it is hardly possible to collect the plants without breaking their shoots. They often grow half-submerged and in the flowering-time the tops only of the shoots are above the water. It forms usually dense mats. The small plants grow also often between the dark-coloured cushions, formed by the moss *Enthostodon Buseanus,* see plate IX; SCHRÖTER [3]) compares this association with those of the so called "Schneetälchen". On first view they may have much in common; essentially, however, they have nothing to do with each other.

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1) S. H. KOORDERS, Exkursionsflora von Java, Vol. II, Jena 1912, p. 706, fig. 89.

2) FR. BLEY, Zur Entwicklung von *Laurembergia javanica* SCHINDL. Arbeiten aus dem Institut der Allg. Botanik der Univers. Zürich, Serie III, No. 6, 1925.

3) C. SCHRÖTER, Exkursionen in Ost-Java. Beiblatt No. 15 zur Vierteljahrsschrift der Naturf. Gesellsch. in Zürich, Vol. LXXIII, 1928, p. 591.

The plant is much branched, the shoots trail along the ground, rooting firmly at the nodes. The shoots and leaves are often dark red. The leaves are opposite, sub-sessile, oblong or oblong-obovate, decurrent at the base, the margin is but seldom entire, mostly coarsely teethed, figure 37. On fully-developed plants three kinds of flowers may be found, viz. male, female and bi-sexual flowers; on Mt. Pangrango, however, I noticed the first two kinds only. They are often arranged in groups of three in the axils of the uppermost leaves; each group consists of a male flower in the middle and a female one on each side. Single flowers occur also.

The male flowers are borne on a pedicel, which is 5 to 15 mm long, and they project therefore beyond the leaves. They possess 4 yellowish-green, erect sepals and 4 spreading afterwards recurved boatshaped petals. There are 8 stamens, each consisting of a long filiform filament and a long, yellow versatile anther. The pistil is rudimentary and bears 4 short, haired stigmas.

The female flowers are borne on a very short pedicel, they possess small sepals, but neither petals nor stamens. The well-developed pistil has 4 stigmas covered with white hairs, and protrudes above the urn-shaped calyx.

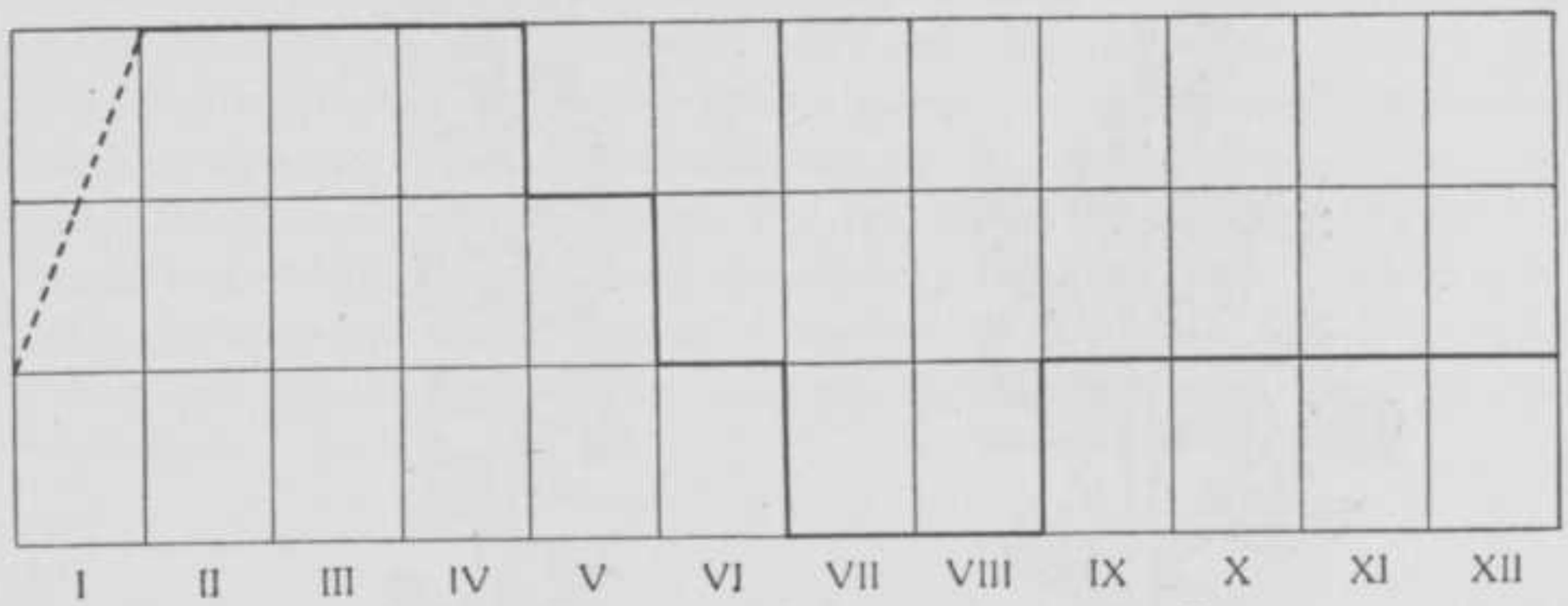

Fig. 38. Flowering-time of *Laurembergia coccinea* KAN.

The fruit is a nut; its pericarp contains cells filled with air. This air gives the fruits buoyancy and they may be dispersed therefore by water.

Pollination. BLEY already pointed out, that this plant is anemophilous; this fact is indicated by the free exposure of the versatile anthers; by the dry powdery pollen; by the feathery stigmas protruding above the calyx; and by the absence of means by which insects are attracted.

It flowers especially at the end of the rainy season, from February to April. In May flowering diminishes in some years, and in July and August flowers are seldom found. In September they reappear; full flowering begins probably in January, but of this month I have no notes; see figure 38 of the flowering-time and the table on page 88.

On Mt. Gedeh the inflorescences and the ends of the stems were attacked by a gall-mite and changed into red galls consisting of a cluster of short branches, figure 39.

FAMILY OF THE ARALIACEAE.

1. SCHEFFLERA RUGOSA HARMS.

This plant has been collected on comparatively few mountains in Java, viz. on Mts. Gedeh-Pangrango, Papandajan, Dieng, Sindoro, Sumbing, Slamat, Tangkuban Prahu in West and Central-Java, and Mts. Kawi and Ardjuno in East-Java; it has also been found on the Peak of Korintji in Sumatra. It grows at altitudes above 2000 m, generally in the highest

Fig. 39. Mite-galls on *Laurembergia coccinea* KAN. × 3

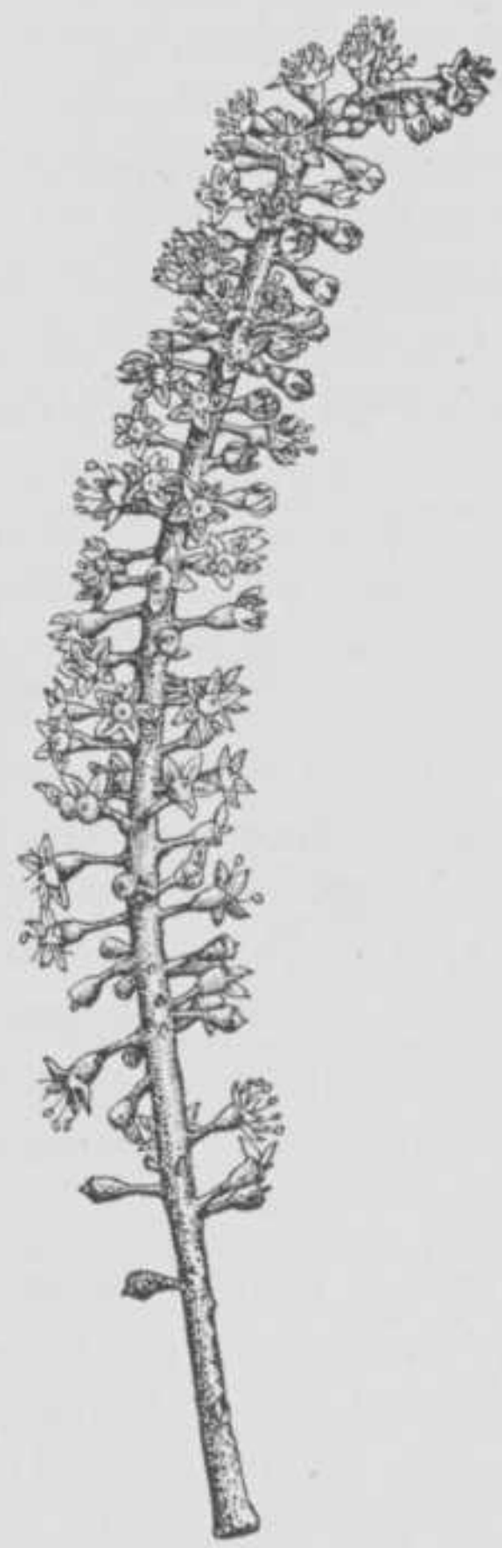

Fig. 40. Inflorescence of *Schefflera rugosa* HARMS × 3/4.

regions, up to the very summits of the volcanos. It occurs in alpinoid forest and also in stony parts, in underwood, and in grass plains; especially, however, on the edge of the forest. Plants scattered among other trees grow to a height of 8 m; they possess ascending flexuous branches; in an open habitat the plant remains lower, reaching a height of 2 to 3 m only, with but few branches, some of the trailing along the ground.

The bark is extremely rough; the young parts are all covered with a dense felt of stellate hairs. The 5—7-merous leaves with their long petioles are congested at the top of the brittle shoots. The leaflets are ovate or ovate-oblong, and obtuse or tapering at the base, 120 to 250 mm long and 60 to 110 mm wide.

The inflorescences are terminal on short lateral branches; they are compound racemes up to 500 mm long, without leaves, and with long lateral axes studded with flowers, which expand for the greater part simultaneously, figure 40. The flowers are borne on a short pedicel in the axil of a minute bract. The tiny calyx is toothed, the corolla is star-shaped, pentapetalous, often reddish. The 5 stamens alternate with the corolla-lobes, they consist of a thin filament and a globose anther. The pistil is, 5-celled, the stigma is sessile. At the base of the filaments a small disk is formed, and nectar is secreted in little drops. The flowers spread the same scent as *Ligustrum*.

Pollination. The stamens open successively, but they do not come in contact with the stigma, except occasionally with the stigmas of neighbouring flowers. Self-pollination therefore is possible though difficult.

Insect visits are rare. I noticed but a few *Diptera* on the flowers, viz. *Pegomyia bistriata, Chamaesyrphus nigripes* and *Rhadinomyia orientalis*.

Flowering-time. As comparatively few plants grow on the top of Mt. Pangrango I could assemble but few data concerning the flowering-time. I have found flowers in all months, but usually in small numbers only. The inflorescences are moreover attacked by a *Psyllid* which changes them into simple galls [1]; as a result the flowers remain small and they do not open.

FAMILY OF THE UMBELLIFERAE.

1. PIMPINELLA LEEUWENII WOLFF.

As Mt. Pangrango has been visited so often, it was a surprise to me to find there a *Pimpinella* which could not be identified with any Javanese species of this genus; WOLFF [2]) has described it as a new species. It is nearly related to *Pimpinella alpina*; a plant which has been found on some mountains of Central and East Java, viz. on Mts. Dieng, Ardjuno, the Tengger-mountains and on Mt. Kawi. On the top of Mt. Tjikorai in West Java and in the aloon-aloon of Mt. Papandajan a plant has been found which may be regarded as a form of *Pimpinella alpina*. It is distin-

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[1]) Mrs. J. DOCTERS VAN LEEUWEN-REIJNVAAN and W. DOCTERS VAN LEEUWEN. The Zoocecidia of the Netherlands East Indies. Batavia, 1926, p. 436, fig. 521.

[2]) H. WOLFF, *Pimpinella Leeuwenii* spec. nov. von Java. Repertorium N. 561—576, 20 Oct. 1924.

guished by limp flowering shoots lying on the ground, while the ordinary *Pimpinella alpina* generally bears more or less stiff, erect flowering shoots [1]). The plants of Mt. Pangrango are most nearly related to those of Mt. Tjikorai and Papandajan, but they have a frailer structure showing a comparatively thin rhizome and sparse flowering shoots trailing over the ground among moss and other plants; in the ramifications of the inflorescence roots and young shoots originate.

The plant occurs sporadically in moist open places, in the shade of *Viola pilosa, Primula imperialis* and *Ranunculus javanicus*. They are screened from view by these plants, but the characteristic *Pimpinella* leaves may still attract the attention.

A fully developed specimen consists of a long tap-root, with about 12 widely spreading radical leaves rising more or less between the surrounding plants; those leaves are unevenly pinnate, 5-jugate. At the short stem below the radical leaves a great number of buds originate, developing into stolons. These runners are united with the mother-plant by a shorter or longer internode; from their nodes new leaf rosettes spring, which in their turn produce new stolons. The latter develop into sometimes much branched inflorescences; in these inflorescences also rosettes are formed. The young rosettes bear simple coarsely serrate leaves; the older ones possess unevenly pinnate 2-3-jugate, lateron multi-jugate leaves. The terminal ramifications consist of little umbellules bearing 5—15 flowers with long pedicels.

The umbels are often partly hidden under leaves and under other plants because they are very limp and lie on the ground; in that case the flowers are pale yellowish green. Flowers exposed to the light are more or less purple. There are 5 small petals and 5 stamens, which do not open simultaneously.

Pollination. The stamens are at first bent inward, afterwards they diverge, but then the pollen has already fallen on the stigmas, which however, do not develop any further until the stamens have spread. All flowers set fruit and self-pollination is the rule with these plants. I have never observed insects on them.

Flowering-time. I have not made regular notes concerning the flowering-time; from June to December I mostly did not find any flowers; many, however, from January to May; they flower therefore chiefly in the wettest part of the year.

2. SANICULA EUROPAEA L.

This plant occurs on all the mountains of Java at altitudes between 700 and 3000 m. It is also found in Celebes and Sumatra, and is widely

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1) See also C. G. G. J. VAN STEENIS, Eenige belangrijke plantengeographische vondsten op den Papandajan. De Tropische Natuur, Vol. XIX, 1930, p. 78 ann. 1.

spread in Europe and Asia. It grows in the rain forest as well as in the alpinoid forest, but it does not thrive in open localities, where it is found only in stunted individuals. On Mt. Gedeh-Pangrango it is common from Tjibodas up to the very summit of Mt. Pangrango, but in the alpinoid forest only, not in the grass lands. On Mt. Gedeh it reaches an altitude of about 2700 m and grows in the alpinoid forest only. In the infertile soil of this open forest they develop into low, more or less spherical, densely leaved plants, see figure 41. In a congenial habitat it is a herb which shoots up to a height of 90 cm. At the base the stem bears large long-petiolate leaves, which are 3-fid, with deeply-lobed leaflets. Towards the top of the flowering shoots the leaves are shorter-petiolate and smaller, and the topmost ones are poorly developed. The flowers are arranged in umbels

Fig. 41. *Sanicula europaea* L. $\times 3/4$.

and the latter form irregularly corymbose inflorescences. Each umbellule contains a small number of bi-sexual flowers surrounded by a zone of male ones.

The bi-sexual flowers open first; they possess 5 white petals, curved inwards at the tip; also 5 stamens and an inferior ovary, with two filiform styles.

The flowers are distinctly protogynous. The two long stigmas project

to a considerable distance beyond the corolla. Finally they bend backwards, and it is not until then that the stamens appear one after an other. The male flowers remain closed until the stamens of the bi-sexual flowers of the umbellule are wilted. Disk-shaped nectaries are found round the styles of the bi-sexual flowers and in the centre of the male-flowers. The petals are white, or sometimes pink.

Pollination. On account of the protogyny of the bi-sexual flowers selfpollination is rendered difficult; still it may take place when the stigmas come in contact with the anthers, which happens often; in other cases the styles may touch the anthers of the male flowers. The pollen, however, is dry and probably dispersed by wind.

I saw but few visiting insects: only some small flies. In Europe flies have also been observed as visitors; and visits by beetles and by a wasp have also been noted; see KNUTH [1]).

All bi-sexual flowers produce fruits. The latter are covered with barbed bristles; dispersal by the agency of animals is therefore probable.

FAMILY OF THE ERICACEAE.

1. GAULTHERIA FRAGRANTISSIMA WALL. var. PUNCTATA J. J. S.

This plant has been collected on a great number of mountains in Java, between 1400 and 3000 m; especially in West Java it is common, for instance on Mts. Gedeh, Papandajan, Tangkuban Prahu and in the Kawah Manuk near Garut, Gegerbintang near Sindanglaja, om Mts. Guntur and Patuha; in Central-Java it occurs on Mts. Sindoro, Slamat, Dieng, Talamaja. From East Java it is represented in the Herbarium only from Mt. Ardjuno. In Sumatra it is also known from several mountains. SMITH [2]) separated the plant occurring in Java and Sumatra as variety *punctata* from the standard type, which grows in British India. It differs from this by glabrous sharply triangular twigs, and glabrous leaves, by terminal inflorescences, and by sparsely pubescent flowers.

This plant occurs mainly on a stony soil, on rock walls, often in the neighbourhood of active craters, and also in open alpinoid forest. VON FABER [3]) reports that it grows also as an epiphyte; but I have never seen any full-grown specimens growing in this way.

I have never noticed this species on Mt. Pangrango although specimens collected by BURCK and DE MONCHY are present in the Herbarium at

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[1]) P. KNUTH, Handbuch der Blütenbiologie, Vol. II, Tome I, p. 466.

[2]) In KOORDERS and VALETON, Bijdrage No. 13 tot de kennis van de boomsoorten op Java. 1914.

[3]) F. C. VON FABER, Die Kraterpflanzen Javas. Weltevreden, 1927, p. 12.

Buitenzorg. The locality is either wrongly given, or the plant has disappeared from the mountain-top since their visit. VON FABER [1]) also mentions the absence of this species on Mt. Pangrango. Why this plant is wanting there, is quite unknown.

Gaultheria fragrantissima is usually a large shrub [2]) with ascending branches; the young shoots are triangular and glabrous. In infertile

Fig. 42. A flowering; B fruiting branch of *Gaultheria fragrantissima* WALL. $\times$ 3/4.

habitats, however, the plants often remain small. The leaves are scattered and subsessile, oblong, acute and callously mucronate, and tapering at the base into the petiole; the margin is coarsely serrate. At their underside the leaves are dotted with glands; the mid-rib is prominent and red or pink. The inflorescences are terminal racemes with white peduncles and red triangular appressed bracts, figure 42. The pendulous flowers are borne on short curved white pedicels, and they are usually turned to one side. The calyx is 5-merous with a white tube and red teeth. The urceolate corolla is also white, and 5-angular with 5 recurved broadly triangular lobes, and a narrow opening. There are 10 stamens inserted at the base of the corolla; the filaments are broad, white in the basal part, reddish towards the top. The anthers are curved towards each other; the pollen-sacs are brown; they dehisce by oval pores and bear a two-lobed appendix. The ovary is superior, globose and 5-sulcate, it is pale-green, 5-celled with projecting placentae and numerous ovules. A 10-lobed disc runs round the base of the ovary. The style is cylindrical, the lower part thinly pilose. The fruit is a

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1) F. C. VON FABER, loc. cit., p. 119.
2) cf. p. 62.

fleshy pseudocarp consisting of the ripened ovary and the swollen calyx and the floral receptacle. Still it dehisces with 5 valves. The minute seeds are triangular or rhomboid. The leaves when brayed or crushed produce an aromatic odour, and especially in Central Java they are collected by the natives, who extract an oil from them. The latter contains methyl-salicylate, which explains its activity in cases of rheumatism. HORSFIELD already mentions its reputation as a liniment against that disease.

As this plant has been systematically collected it has become rare on several mountains; on Mt. Sumbing I did not find one single specimen; and on Mt. Sindoro, quite close to Mt. Sumbing, I noticed a few plants only in a depression near the crater, very difficult to get at.

Pollination. The anthers are already open as soon as the flowers begin to expand and the pollen may easily drop on the stigma, which as a matter of fact is very soon covered with it. In fact all flowers produce fruits, which are red to dark-red. During my different visits to Mt. Gedeh and also to the other mountains, I have observed practically no pollinators, once only a *Bombus rufipes*. The fruits which are sweet tasted are believed to be eaten by birds; in the intestines of a fruit-dove, *Sphennurus sphenurus korthalsi*, shot on Mt. Gedeh, seeds of a *Gaultheria* were found [1]) but of which species of *Gaultheria* could not be determined, as the seeds of the different species are very similar.

Fig. 43. Dwarf specimen of *Gaultheria leucocarpa* BL. × 1.

As this plant does not grow on Mt. Pangrango I cannot give information about the flowering-time.

2. GAULTHERIA LEUCOCARPA BL.

A shrub, which has been found on several Javanese mountains, especially in West and Central Java; in East Java it occurs on Mts. Kawi, Tengger, Lamongan and Idjen. From Sumatra it is also known from several places viz. Mt. Dempo, Lake Toba, the Peak of Korintji, Mts. Sibajak, Talawan, Singgalang, Merapi and Sinabang; and it occurs in the Malayan Peninsula too. Generally this plant is found at altitudes between 1600 to 3000 m, on Mt. Idjen it has been collected at an elevation of 1300 m. It grows on stony grounds as well as in alpinoid underwood and in open forest; on the top of Mt. Ungaran it grew in a thick bed of *Sphagnum* and is occurs sometimes also epiphytically. This species of *Gaultheria* is a shrub

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[1]) W. DOCTERS VAN LEEUWEN, Kleiner Beitrag z. Kenntnis der endozoischen Verbreitung einiger Hochgebirgspflanzen auf Java. Flora, Vol. 118—119, 1925, p. 86.

about 1 to 2 m high, sometimes more or less climbing between other shrubs. In a very infertile habitat, for instance on the hard and but little weathered lava in the crater of Mt. Gedeh they are more or less starved and reach a height of a few cm; only they flower, however, and even bear fruit, see figure 43.

On Mt. Pangrango this plant is common especially at the edge of the forest and among shrubs.

The twigs are often pendulous, bent more or less in zigzag lines and green or dark-red. The leaves are scattered; they are petiolate, cordate or ovate, and gradually narrowing towards the callously mucronate top; the margin is dentate-serrate; the teeth are callously tipped.

The flowers are borne in racemes or in loose panicles or they are solitary or fascicled in the axils of the leaves; but they are seldom terminal. The peduncles are green or at the upperside red; they bear small bracts. The flowers are pedicellate, their opening is turned downwards.

The calyx consists of 5 pale-green or red sepals; they are more or less triangular and erect. The corolla is widely bell-shaped, yellowish-white or pale-green, with 5 obtuse, slightly recurved lobes. The corolla gives a waxy impression and the side exposed to the light often shows a red hue.

There are 10 stamens inserted at the base of the corolla, the filaments are flattened, tapering towards the base and the tip; the anther is dorsifixed and curved, the lower part papillose, orange-brown with recurved margins and two bodkin-shaped appendices projecting upwards.

The ovary is half-inferior, five-celled, and bears a filiform style. At the base of the style runs the hairy disc, which secretes a great quantity of nectar. The fruit is a pseudocarp, as the enlarged fleshy calyx wholly encloses the real fruit. The fruit is white or pale-pink, up to 1 cm in diameter, plate XVI; inside a great number of small triangular brown seeds are found.

Pollination. The anthers open by two extrorse pores; the pollen is dehisced in tetrads; it is sticky, but not coherent in threads. The stigma projects for about 1½ mm above the anthers. Some flowers are protandrous with the stamens ripening on the first day, and the stigma attaining maturity on the next day. On the same plant, however, homogamous flowers can be found. The flowers remain unchanged for up to five days. They are but seldom visited, once a small Syrphus-fly, *Chamaesyrphus nigripes*, was observed by me and twice I saw *Bombus rufipes* visiting the flowers. I observed the same animal busy in the flowers on Mt. Papandajan. The pollen may easily drop on the stigmas because the latter protrude beyond the anthers and because the flowers are pendulous. When the corolla falls off the anthers shove therefore along the stigma. In young flowers, opened but one day, the stigma is already thickly covered with germinating pollen. All flowers set fruit. In December 1919 one branch bearing many flower-buds, was wrapped in gauze, and a month later all flowers had set fruit.

Insect visits occur, though they have but seldom been observed, but self-pollination is the rule.

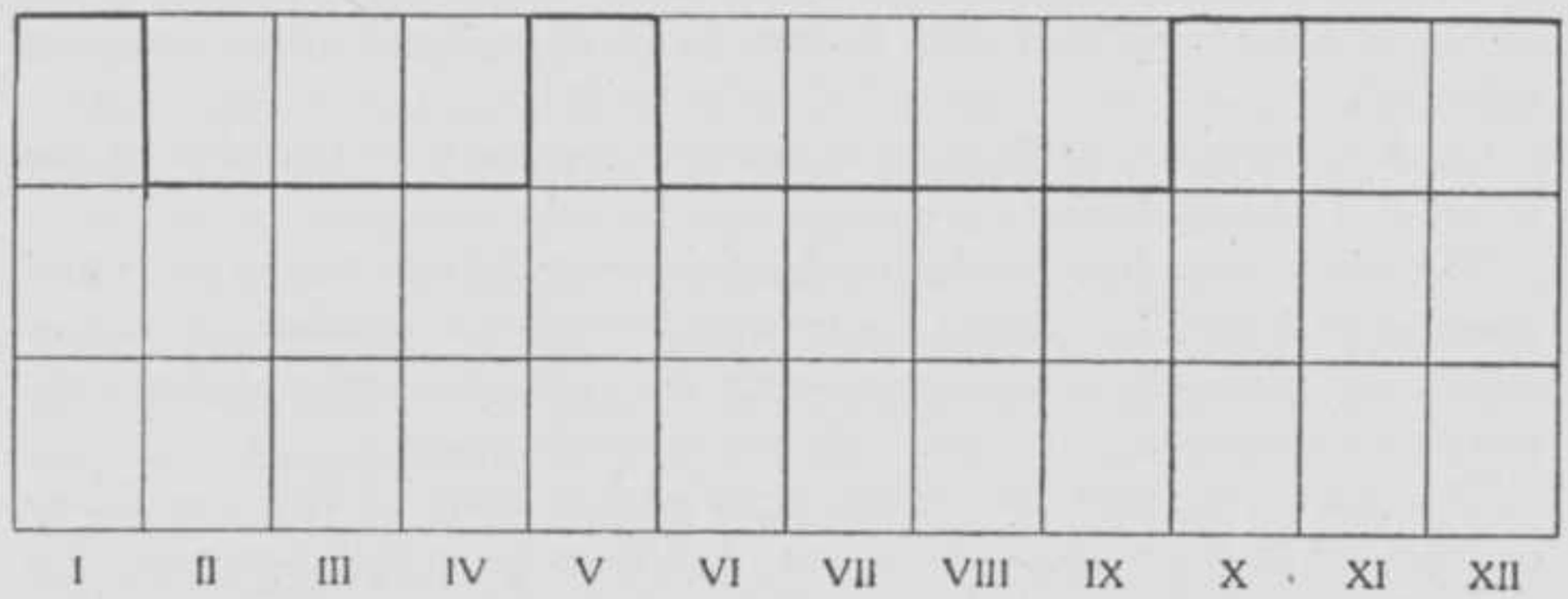

Fig. 44. Flowering-time of *Gaultheria leucocarpa* BL.

Flowering-times. These plants flower throughout the year though somewhat irregularly, one year one may find in a certain month but few flowers, next year in the same month a great number. Flowering alternates more or less with fruiting, that is while a plant is abundantly fruiting, it generally bears but few flowers. Concerning the flowering-time one may compare the table on page 88 and the curve in figure 44; the latter prove that during the rainy season from October to January always many flowers occur, and that thereupon their number diminishes somewhat, and increases in May, but, as mentioned before, there is no constant principal flowering-time.

Dispersal of seeds. The fruits are eaten by birds, and in the intestines of a *Sphenurus sphenurus korthalsi*[1]) shot on Mt. Gedeh, as mentioned before, I found a great number of *Gaultheria*-seeds, but I was unable to identify the species to which they belonged. On Mt. Pangrango I saw *Oreosterops javanicus frontalis* once in a while eat of the fruits.

3. GAULTHERIA NUMMULARIOIDES DON.

This plant is already known from a great number of Javanese mountains, from West Java to East Java; it occurs usually between 2000 and 3300 meter. It has been collected also on some mountains of Sumatra, viz. Mts. Sibajak, Sinabang, Korintji, Talang and Mt. Talamau. Outside the Indo-Malayan region it is known from the Himalayas. The plant grows on open grounds, on stony crater-slopes, in rocky clefts, but also in the alpinoid forest, where it grows sometimes epiphytically in the moss at the base of the trees. On Mt. Pangrango it grows in the crater-valley, especially along the brook, but also in more shaded localities and by preference in the moss

[1]) W. DOCTERS VAN LEEUWEN, Kleiner Beitrag z. Kenntnis der endozoischen Verbreitung einiger Hochsgebirgs-pflanzen auf Java-Flora. Vol. 118—119, 1925, p. 86.

cushions which cover the base of some old plants of *Anaphalis javanica*. On Mt. Gedeh it is found even on the very stony spots of the summit, but

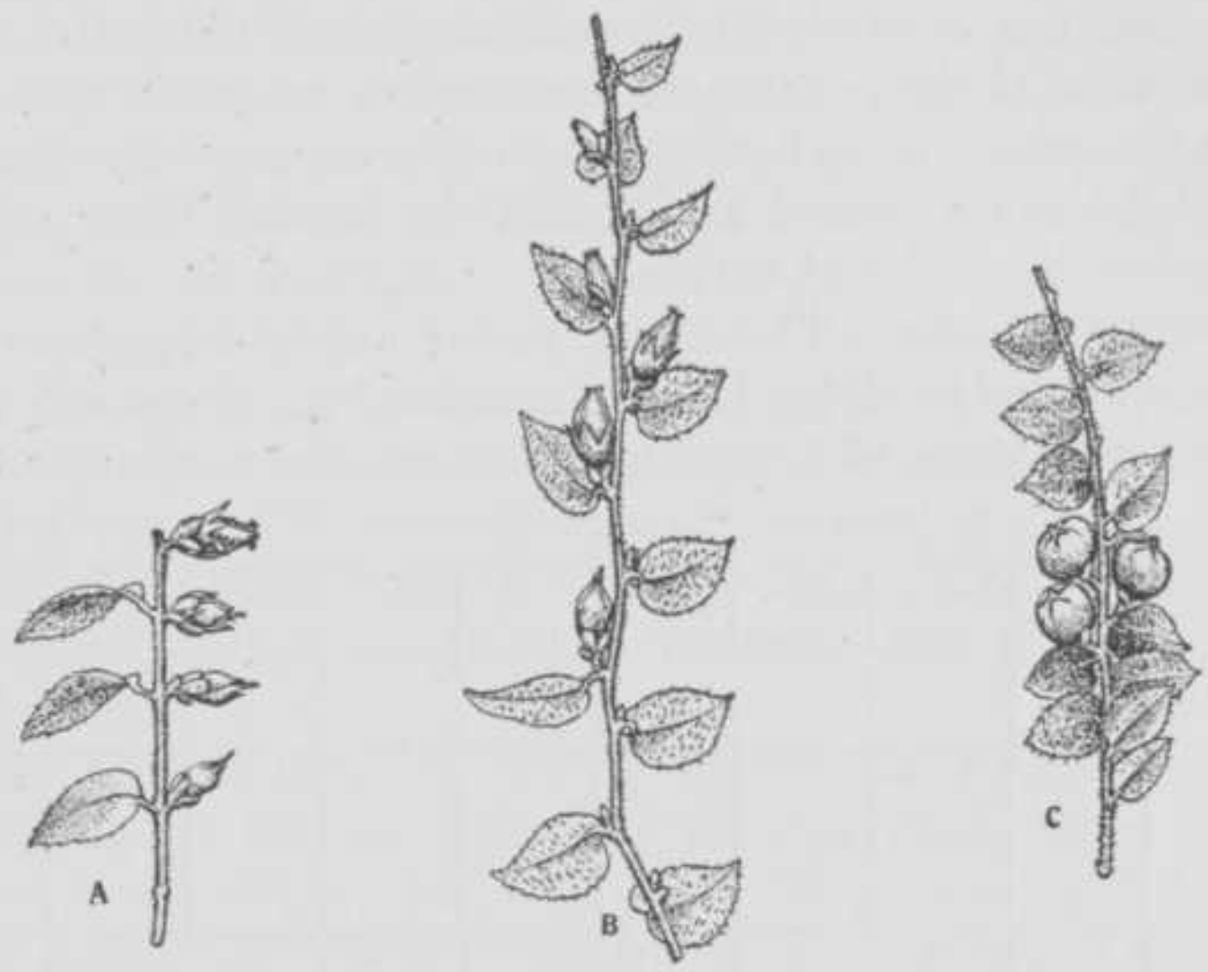

Fig. 45. Flowering and fruiting branches of *Gaultheria nummularioides* DON. × 3/4.

also frequently in the open forest. It is a prostrate much branched shrub which hispid twigs spreading in all directions; they are rooting at the nodes.

The leaves are scattered, about 5 to 6 cm long, sub-sessile, and ovate with an acute apex and a rounded base; the margin is slightly serrate, the teeth tapering into hairs. The leaf is glabrous above, at the underside it is covered with long red or brown bristles, the petioles are often red like the shoots. The axillary flowers are borne on a very short pedicel covered with imbricate triangular bracts. They are found only near the top of the shoot; they face downwards and are often hidden in the moss or between other plants or pressed against the ground, but they may also stand quite free, figure 45. The calyx is connate, 5-merous, seldom 6-merous, with spreading narrowly triangular lobes. The calyx is generally pale-green or white. The corolla too is 5-merous, pure white, urceolate, with a narrow opening, surrounded by the 5 short recurved lobes which are often pink. The 10 stamens are inserted at the base of the corolla, the filaments are slender, somewhat flattened above the base, and glabrescent. The shortly sagittate anther is brown, and attached a short way above its base. The locules dehisce by an oblong pore, and bear at their tops two divergent hornlets. The ovary is superior, spherical, with 5 longitudinal furrows and surrounded by a ring-shaped disk. The style and the stigma are filiform. The fruit is enclosed by the fleshy calyx with which it forms a pseudocarp; red first, it becomes later on dark-blue.

Pollination. The stigma projects slightly beyond the anthers. The

latter are in the old buds still white, but the pores are already open while the stigma is still dry. In that stage the flowers are therefore male. As soon as the flowers open, the anthers shrivel, and the stigma becomes receptive. After one day the corolla falls off, and the anthers slip across the stigma. In consequence of the position of the flowers, especially when they are hidden in the moss, visiting by insects is rendered very difficult; as a matter of fact I have never noticed a visitor on the flowers. They regularly set fruit, however, by means of autogamy.

Flowering-time. The plants flower nearly throughout the year, especially in shaded localities. In more open localities the growth and consequently the production of flowers is all but arrested in the months of June

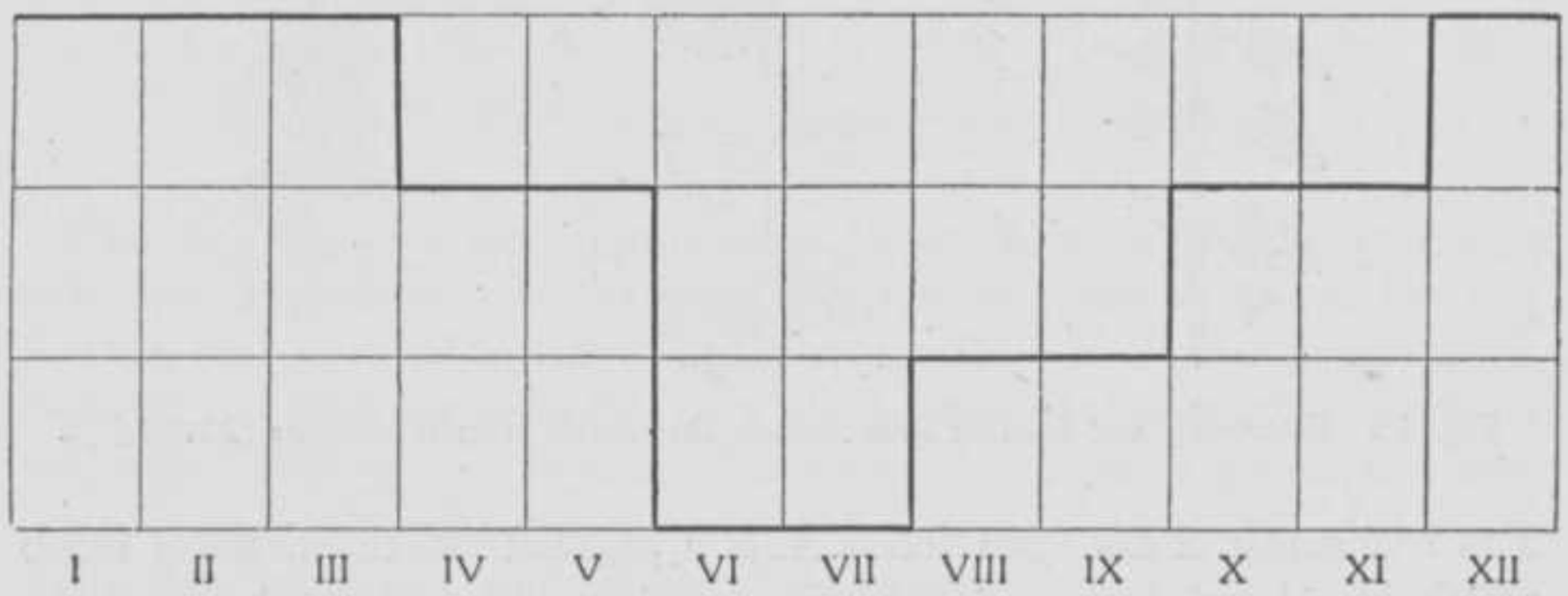

Fig. 46. Flowering-time of *Gaultheria nummularioides* DON.

and July. Especially in the rainy season flowering is abundant. Concerning the flowering-time the reader may compare figure 46 and the table on page 88.

Dispersal of the seeds. The fruits taste sweet and are probably eaten by birds; the rat: *Rattus lepturus* will eat them also, in captivity at least they took the fruit eagerly.

The pollination has also been studied in the American *Gaultheria procumbens*. In this species the flowers also are bent downwards and they are likewise protandrous. Visits of bumble-bees and of the common bee have been observed; see KNUTH [1]).

4. RHODODENDRON RETUSUM BENN.

This plant has the habit of a shrub or of a low tree, reaching rarely over 4 m in height; it seldom occurs epiphytically, though it is found in the moss cushions on old fallen trees. In Java it is chiefly known from West Java, viz. from the Mts. Karang, Salak, Gedeh-Pangrango, Papandajan, Wajang, Buranggrang, Tangkuban Prahu near Bandung, Patuha and

[1]) P. KNUTH, Handbuch d. Blütenbiologie, Vol. III, Tome II, 1905, p. 6.

Tjikorai. From Central Java it is merely known from Mt. Tangkuban Prahu near the Dieng. This plant shows a western distribution: it has also been collected on several mountains in Sumatra, from Mt. Dempo in South Sumatra to Mt. Sibajak in East Sumatra. It thrives in the alpinoid forest in a soil rich in humus as well as on sandy, stony grounds. On Mt. Pangrango-Gedeh it occurs from altitudes of 2200 m up to the very summits. On the stony slopes of the crater of Mt. Gedeh it develops merely into small shrubs, about 30—60 cm high.

The trunk is nodose, dark-brown, and branches irregularly. The young shoots and the leaves are studded with glandular scales. The leaves are congested at the tips of the slender shoots in 4—7-merous spurious whorls; they are shortly petiolate, narrowly obovate, rounded at the top, and acute at the base; the margin is entire. They are leathery, shiny green above, dull, and covered with numerous scales beneath; they are 2 to 5 cm long and 1 to 3 cm broad.

The sessile racemes bear 4 to 10 flowers. The young buds are erect, the older buds and the flowers pendulous, the ripe fruits again erect. The flowers have long pedicels, the latter are red, but covered with white hairs and yellow scales. The small calyx is strongly lepidote. The corolla is trumpet-shaped, plate XXIX A, 2 to 3 cm long, with 5 small lobes. It is adpressedly pilose, and covered with scattered scales, and of a beautiful brick-red [1]). An annular zone at the base of the corolla-tube is widened; in this part nectar is secreted. There are 10 free stamens, inserted at the base of the corolla-tube, 5 longer, and 5 shorter ones (5 + 5); the filaments are filiform, of a pale orange-pink; the anthers are red. The pistil consists of a green, cylindrical, 5-angular, densely scaly ovary, about 4 mm long, and a style which is about 18 mm long and topped by a capitate stigma. The disk is annular, and 10-toothed.

The fruit sits upon the calyx and the disk, and is tipped by the withered style; it is oblong spindle-shaped and opens by 5 valves. There are numerous, minute seeds, about 0.2 mm long, with a narrow membranous wing at both sides.

Pollination. In the adult bud the anthers lie close under the hood formed by the corolla lobes; they are all open, and the pollen hangs in threads from the anthers. In this stage the stigma lies at a distance of about 2 mm below the anthers, and is not yet receptive. The flowers are therefore distinctly protandrous. Not much is changed on the first flowering-day; during the second and the third flowering-day the style elongates, and as the now receptive stigma brushes past the anthers, it will come in contact with the pollen-masses hanging down from the latter. Finally the stigma projects 1 or 2 mm beyond the corolla.

Flowering-time. Because of the scattered situation of the trees it was difficult to collect dates with regard to the flowering-time; the notes

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[1]) Once I found a specimen with orange flowers.

are chiefly based on observations on a number of shrubs, growing along the edge of the forest. In May flowering is fairly abundant, between August and October it ceases usually entirely, whereas during the other months of the year flowers may be found, though in small numbers, see figure 47.

On Mt. Pangrango I have watched several times the honey-bird: *Aethopyga eximea* while it searched, perched upon the flowering shoot, one flower after the other; each time thrusting its head deep into the corolla-tube. The feathers round the root of its bill were in this way powdered

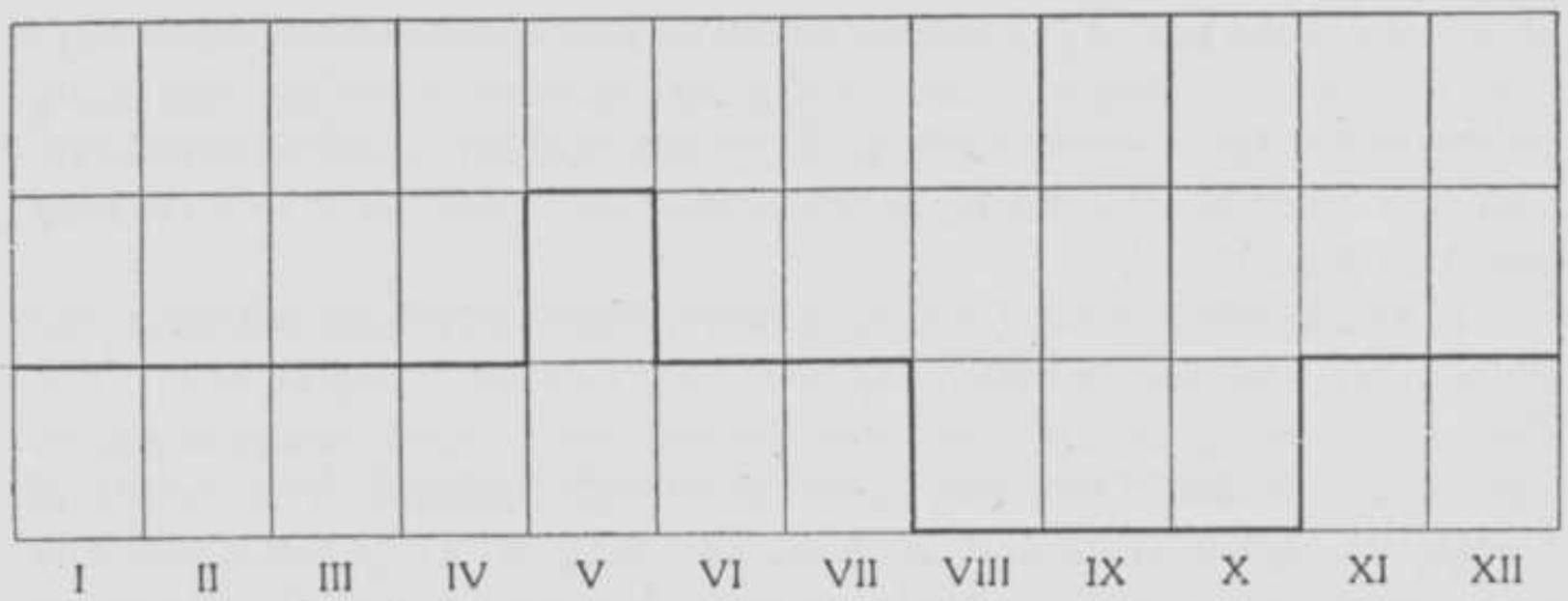

Fig. 47. Flowering-time of *Rhododendron retusum* BENN.

with pollen. For years I had seen no other animals on the flowers, but in February 1927 the bumble-bee: *Bombus rufipes* was a regular visitor on some trees; I have never observed this again. On Mt. Singgalang in Central Sumatra I observed large numbers of the black *Bombus* on the flowers. KARNY [1]) also mentions that *Bombus* visits this plant.

In the Swiss species of *Rhododendron* pollination is chiefly carried out by the agency of bumble-bees; cf. SCHRÖTER [2]).

In another journal I have already published a short description of the pollination of this plant [3]).

5. VACCINIUM LAURIFOLIUM MIQ.

This plant is known from several Javanese mountains, especially in West Java but also in Central and East Java as far as Mt. Hijang. Furthermore it occurs in Bali, Lombok and Sumatra. It grows usually at an altitude above 2000 m, and prefers the highest parts of the mountains; on some mountains, for instance on Mt. Tangkuban Prahu near Bandung and also

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1) H. H. KARNY, Eine Rundfahrt durch Sumatra. Natur, 1927, Heft 14—15, p. 12.

2) C. SCHRÖTER, Das Pflanzenleben der Alpen. Second edition, Zürich, 1923, p. 171.

3) W. DOCTERS VAN LEEUWEN, Planten en dieren op de top van de Pangrango. De Tropische Natuur, 1927, Vol. XVI, p. 190; fig. 33.

near Tjibodas it may be seen already at an altitude of 1400 to 1600 m; at this elevation, however, it rarely or never flowers. On Mt. Gedeh-Pangrango, where it is extremely common, it grows as well in the open parts of the rain-forest as in the alpinoid forest, and in the alpinoid shrub, along the edge of the forest, and in stony ground. In the lower parts it grows either epiphytically, or as a shrub with long branches, which pushes its way upward between other shrubs; sometimes it attains even more or less the habit of a liane. In the higher parts it is almost exclusively terrestrial; the much-branched shrubs with there straggling branches form with the other shrubs a dense tangle.

The branches are a dark red; the bark is coarse and nodose; the shoots more or less angular on account of the decurrent petioles. The leaves are leathery, shortly petiolate, broadly or narrowly elliptical, obtuse or sometimes subacute, and completely glabrous; the margin is entire. At the base of the lamina two small sunken glands are found.

The leaves are at the upperside a shining deep green, the midrib is red, the petiole is often reddish. The young shoots and the newly expanded leaves are a brillant brick-red in contradistinction with the young leaves of *Vaccinium varingifolium*, which are blood-red. The leaves of *Vaccinium laurifolium* are moreover larger, the adult ones measure 5 to 12 cm in length, 3 to 7 cm in width.

The flowers are borne in axillary racemes, accumulated at the tip of the branches, plate XIII. In the flowering-season the plant seems entirely covered with blossoms. The racemes are usually secund; the bracts are caducous. The flowers have short pedicels; the calyx is campanulate, 5-toothed, the erect teeth are pressed against the corolla; the tube is green, the teeth are red. The corolla is urceolate with a wide mouth, surrounded by 5 minute recurved lobes; it measures about 10 mm in length and 6 mm in width; and is usually pink, sometimes almost white. There are 10 stamens inserted at the base of the corolla tube, the basal part of the filaments is red, covered with long white hairs and curved towards the style; the upper part is vertical and parallel to the style. The anther is oblong; the spurs are extremely short, in the bud they are white, maturing they become orange-brown; at the tip they lengthen into two tubes. The ovary is hemi-spherical, the style is stout and tapers towards the tip. The fruit is spherical, deep bluish-purple, and contains numerous small seeds.

Pollination. Nectar is secreted on a yellow disk which runs round the base of the style and rests upon the ovary. The flowers are very fragrant, with a scent like sour apples. When the corolla opens the stigma reaches to about two thirds of the length of the corolla-tube, and the anthers reach somewhat higher. In the bud the pollen, which is rather dry, is shed already, and collects at the bottom of the corolla-tube, and partly also on the stigma. When the corolla falls off another part of the pollen may be shed on the stigma. As a matter of fact self-pollination is readily effected.

I have observed but few visiting insects; *Bombus rufipes* occasionally searches the whole bush very thoroughly. Once in a while I saw *Oreosterops javanica frontalis* on the flowers. All flowers, however, set fruit, and self-pollination will therefore be the common mode of fertilisation in this plant. JUNGHUHN [1]) observed swarms of bees on its flowers (*Agapetes rosea*) which: "adorn in an abundance of drooping racemes and with its beautiful pink colour every branch and branchlet of this tree; they not only

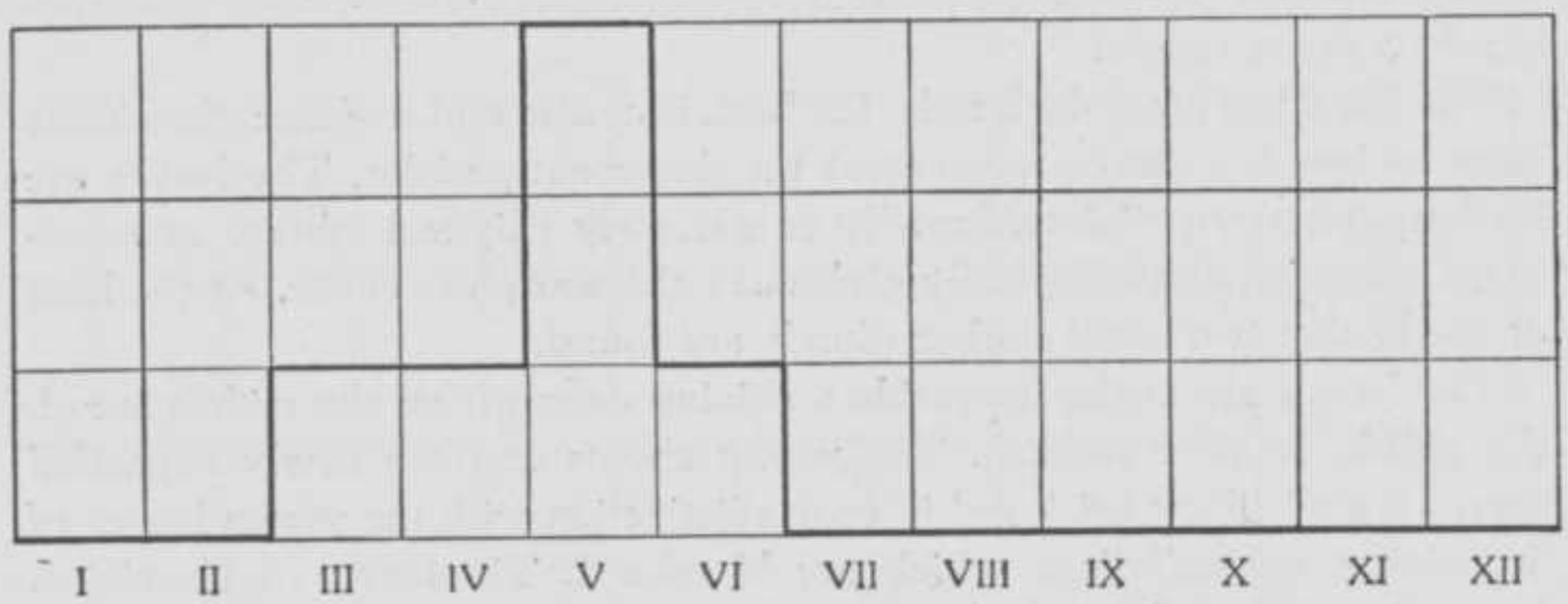

Fig. 48. Flowering-time of *Vaccinium laurifolium* MIQ.

fascinate the eye of the traveller but he may at the same time delight in the sweet fragrance with which these aromatic blossoms scent the air far and wide".

Flowering-time. The plants of Mt. Pangrango have a short flowering-season. From July to February occasionally a plant with one or more flowering shoots may be found and in March and April a somewhat larger number start flowering; in May, however, almost all plants are in full blossom; while in June the number of flowering plants begins to decrease. The fruits begin to swell at the same time, but they do not mature before January, see figure 48.

The fruits as I have observed repeatedly, are greedily eaten by *Turdus javanicus fumidus*. In the stomachs of these birds I have found many *Vaccinium*-seeds [2]), but it could not be determined to which species of *Vaccinium* they belonged; as *Vaccinium varingifolium* was in fruit at the time the birds were bagged, the seeds were probably of this tree.

The young shoots are subject to a fungus-disease; the whole shoot changes into a pink cylindrical gall bearing rudimentary leaves. On the leaves also fungus-galls often develop: at the upper side they appear as round brightly green specks with a pink centre, at the under side the

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1) FR. JUNGHUHN, Java, second edition, Vol. I, 1853, p. 581.

2) W. DOCTERS VAN LEEUWEN, Kleiner Beitrag zur Kenntnis der endozoischen Verbreitung einiger Hochgebirgspflanzen auf Java. Flora, 1925, Vol. 118, 119, p. 86.

black apothecia of the fungus, viz. of *Anhella tristis*, described by RACIBORSKI [1]), are formed.

6. VACCINIUM LUCIDUM MIQ.

This plant is very common in the primeval forest of Mt. Pangrango-Gedeh at altitudes between 1500 and 2500 m, and shows an epiphytical habit. It is recognizable by its small, obovate leaves and the dark red blossoms.

I have noticed repeatedly that the flowers were visited by *Bombus rufipes*.

7. VACCINIUM VARINGIFOLIUM MIQ.

This plant is one of the commonest species on the Javanese mountain tops; it occurs from West to East Java, on every mountain chiefly above 2000 m altitude. In many places it forms the main constituent of the alpinoid vegetation. The crater of Mt. Tangkuban Prahu (near Bandung) for instance is surrounded by a belt of these plants among which but few others have found a place [2]). *Vaccinium varingifolium* is not particular as to soil: it grows in alpinoid forest rich in humus as well as in extremely stony places. It is common in the vicinity of solfataras and hot mud-wells; and in such localities it may occur at much lower altitudes than usually, namely down to 1400 m. In such stations it is a pioneer and, when the solfataras extend its activity, the last survivor; partly burnt they are able to hold out for years the scalding ground [3]). This plant may develop into a low tree, usually not over 8 m high; in the highest regions it grows to 5 m high and in bare rocky localities it remains shrubby. SCHRÖTER [4]) describes a specimen found on the summit of Mt. Weliran at an elevation of 3100 m which grew closely appressed to the ground; this form of growth is according to him caused by the action of strong winds; cf. the note on page 33.

On Mt. Gedeh-Pangrango the tree-form as well as the shrub-form occur, the latter chiefly on the more or less bare slopes of the crater of Mt. Gedeh; the tree-form on the top of Mt. Pangrango. The shrubs occurring there have sprung from the stumps of trees cut down by the men of the triangulation service. SEIFRIZ [5]) states that *Vaccinium varingifolium*

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[1]) M. RACIBORSKI, Parasitische Algen und Pilze Javas, sec. part. Batavia, 1900, p. 10.

[2]) W. M. DOCTERS VAN LEEUWEN, Tangkoeban Prahoe (botany) Excursion-guide for the Fourth Pacific Science Congress, Excursion B 4, 1929, p. 11.

[3]) W. M. DOCTERS VAN LEEUWEN, Beitrag zur Kenntnis der Gipfelvegetation der in Mittel-Java gelegenen Vulkane Sumbing und Sindoro. Bull. d. Jard. de Buitenzorg, Serie III, Vol. XI, p. 28.

[4]) C. SCHRÖTER, Exkursionen in Ost-Java. Beiblatt No. 15 zur Vierteljahrschr. d. Naturfors. Gesell. Zürich, Bd. LXXIII, 1928, p. 584, fig. 7.

[5]) W. SEIFRIZ, The altitudinal distributions of plants on Mt. Gedeh. Java. Bull. of the Torrey botan. club, Vol. I, 1923, p. 300.

is the most polymorphic species of this genus as it is able to grow as a shrub, a tree or a liana, and moreover, in terrestrial as well as in epiphytic form. Epiphytic specimens of this species, however, I have never seen, though in connection with the dispersal of the seeds by birds it is not impossible that young plants might occur in this form. But this species certainly never becomes a liana. It has probably been confused with another species, perhaps with *Vaccinium laurifolium*, which grows sometimes as a liana.

This tree is almost fireproof; even when the whole trunk is charred, buds at the base of the stem may still sprout. It holds its ground therefore even in large numbers on mountains which are continually subject to bushfires, for instance on Mt. Merbabu [1]), Mt. Sumbing and Mt. Sindoro. On these bare mountains small trees can be found already at an elevation of 1600 m, though they are much more common on the top.

The trunk is usually crooked and irregularly branched a little distance above the ground, plate XX; the bark is dark, and shows many cracks. The shoots are more or less angular, grooved, glabrous or slightly hairy, the leaves grow closely together. There is a wide range of difference in the shape of the small leaves, which are oblong, elliptical, rhomboid, obovate or lanceolate and obtuse, or acute; the short petiole is decurrent. At the upper side they are a dark glossy green, at the under side dull and pale-green, the midrib is red. The newly expanded leaves and the shoots are a brillant blood-red, which in the months of April and May, when they are nearly all densely covered with young foliage, contrasts beautifully, with the silvery white of *Anaphalis*. Seen from the top of Mt. Pangrango, the top of Mt. Gedeh looks in this time of the year suffused with a red hue.

The flowers are borne in terminal or axillary racemes with well-developed bracts, which often are so large and so similar to ordinary leaves, that one might take the inflorescence for a shoot bearing axillary flowers. The flowers are short-stalked, turned more or less to one side, and obliquely drooping. The calyx is 5-sepalous, green, the lobes are red; the deep-purple corolla is urn-shaped or conical with 5 small recurved lobes. There are 10 stamens inserted on the base of the corolla-tube, the red filaments are dilated in the basal part and covered with white hairs; the anthers dehisce by two oblique pores; they are not spurred; they are closely pressed against the style, reaching up to about two thirds of its length. The ovary is obconical, and bears a cylindrical style, with a broadened stigma, which lies in the mouth of the corolla. A thick ring-shaped disk secretes almond-scented nectar. The fruit is spherical, flattened, dark-purple, similar to the berries of *Vaccinium myrtyllus* also in taste but harder.

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[1]) W. DOCTERS VAN LEEUWEN, Ueber die Erneuerung der verbrannten alpinen Flora des Merbaboegebirges in Zentral Java. Ber. d. deutschen Bot. Gesell. 1913, Vol. XXXI, p. 156.

Pollination. Before the opening of the flower the pollen is often already shed upon the stigma and on the bottom of the corolla-tube. After flowering the corolla falls away and during this process the anthers and the pollen on the inner side of the tube can come in contact with the stigma. Self-pollination therefore may readily take place. The flowers are not regularly visited, though sometimes *Bombus rufipes* comes to suck the nectar, as I observed also on Mt. Lawu [1]) and on Mt. Kawi. *Oreosterops javanica frontalis* drinks often also of the nectar; this observation agrees with one of FORBES [2]), who relates that on Mt. Dempo in Sumatra a *Zosterops* replaces the honey-birds; the nostrils of this *Zosterops* were found by him to be dusted with pollen.

On Mt. Merapi in Java ROEPKE [3]) observed the yellow wasp, *Polistes diabolicus*, intent upon searching the flowers.

The flowers may be pollinated therefore by the agency of insects and birds, but self-pollination is common; all flowers produce fruits.

In European species of *Vaccinium* self-pollination and pollination by insects are reported, cf. KNUTH [4]).

Flowering-time. Through the whole year flowers may be seen on these trees but the main flowering is limited to a very short time. On Mt. Pangrango flowering starts in April, and culminates in May when

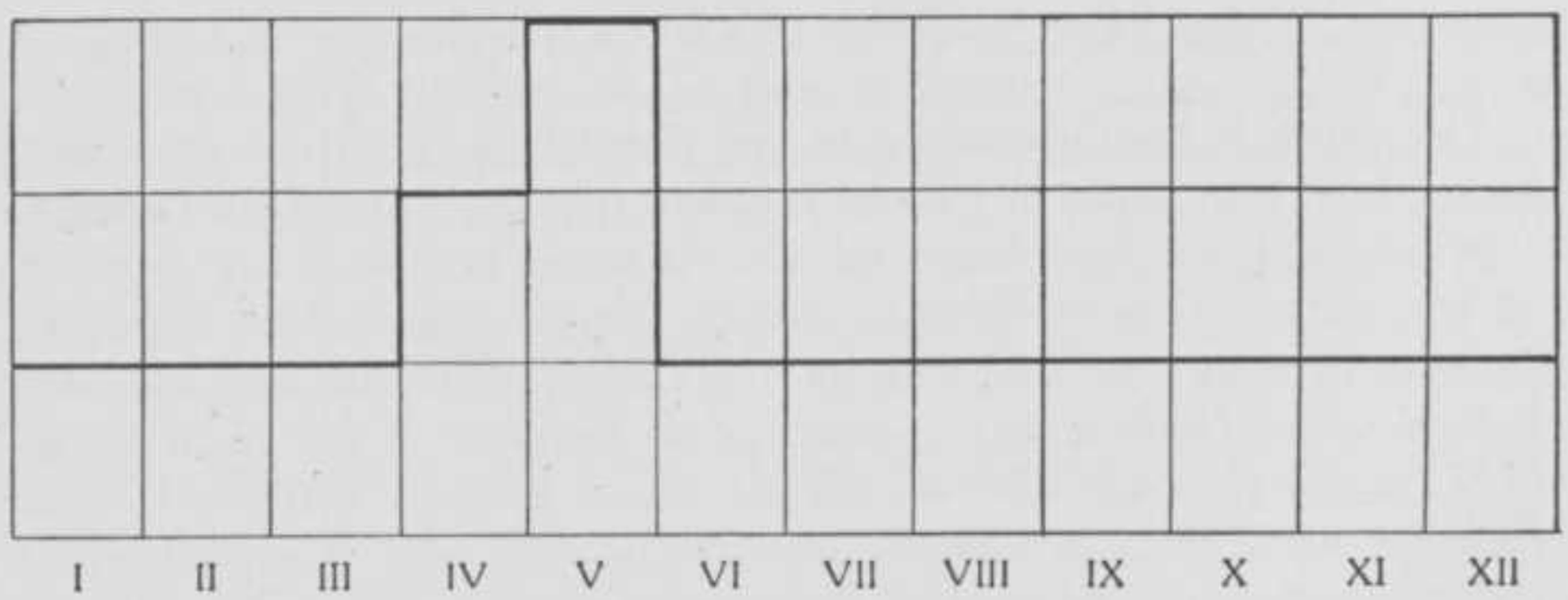

Fig. 49. Flowering-time of *Vaccinium varingifolium* MIQ.

all young shoots are laden with flowers, which scent the air with the fragrance of almond-oil, see figure 49. In every season, however, some individuals show here and there a flowering branch and therefore we find ripe fruit usually throughout the year, and consequently this tree is

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1) W. DOCTERS VAN LEEUWEN, De alpiene vegetatie van de Lawoe-vulkaan in Midden-Java. Nat. Tijdschr. v. Ned. Indië, Vol. LXXXV, 1925, p. 385.

2) H. O. FORBES, Wanderungen eines Naturforschers im Malayischen Archipel, übersetzt von R. Teuscher, Vol. I, Jena, 1886, p. 224.

3) W. ROEPKE, Ueber den Hohenflug von *Polistes diabolicus* Sauss. Tijdschr. v. d. Entomol. Ver., Vol. LIX, 1916, p. 176.

4) P. KNUTH, Handbuch der Blütenbiologie, Vol. LL, Tome II, p. 28.

one of the principal sources of food for the fruit-eating birds of the mountains. On Mts. Pangrango-Gedeh [1]) I have found *Vaccinium*-seeds in the stomachs of *Oreosterops javanica frontalis*, *Turdus javanicus fumidus* and *Sphenurus sphenurus korthalsi*; on Mts. Sumbing and Sindoro [2]) in the stomachs of *Pygnonotus bimaculatus*, of *Turdus javanicus whiteheadi*, and of *Zosterops palpebrosa sindorensis*. Several times I have observed the three first-mentioned birds while they were busy in the trees eating of the fruits. The mountain-rat *Rattus lepturus* also climbs up the trees to eat the fruits; the dispersal may take place therefore by the agency of various animals. JUNGHUHN [3]) relates, that the berries are a delicacy for birds.

The flowers are often liable to attacks by the caterpillar of a *Microlepidopteron*; in that case the corolla does not open and changes into a bulging gall [4]). The plant moreover is subject to a fungus-disease, which results in a deformation of the young shoots and of the fruits into galls.

I have already published elsewhere a short account on the flower-biology [5]).

FAMILY OF THE MYRSINACEAE.

1. ARDISIA JAVANICA DC.

This shrub is locally common in the Western part of Java. It is also known from Mt. Slamat in Central Java and from East Java (Mt. Hijang).

In Borneo it has been found on Mt. Kinabalu, in Bali it was collected on Mt. Batukau and in Sumatra on Mt. Dempo. Generally it occurs at altitudes between 1400 and 2400 m; on the travertine hill Mt. Tjibodas near Tjampea (Buitenzorg) it grows at an elevation of 300 m, while on Mt. Pangrango some specimens occur up to 2800 m altitude. *Ardisia javanica* rarely forms pure associations, but it may occur in large numbers in constantly moist rain forest or in alpinoid forest.

This plant is a large shrub from 1 to 3 m high, bearing an open crown; it is highly conspicuous for the great number of inflorescences collected at the tips of the more or less horizontal lateral branches. The tip of the young shoot is covered with fine brown scales, the older parts are glabr-

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[1]) W. DOCTERS VAN LEEUWEN, Kleiner Beitrag zur Kenntnis der endozoischen Verbreitung einiger Hochgebirgspflanzen auf Java. Flora, Vol. 118—119, 1925, p. 86.

[2]) HANS DOCTERS VAN LEEUWEN, Beitrag zur Kenntnis des Avifauna der Mitteljavanischen Vulkanen Sumbing und Sindoro. Treubia, Vol. X, 1929, p. 439.

[3]) FR. JUNGHUHN, Java, 2nd. Edition, 's-Gravenhage, 1853, Vol. I, p. 580.

[4]) Mrs. J. DOCTERS VAN LEEUWEN-REIJNVAAN and W. DOCTERS VAN LEEUWEN, The Zoocecidia of the Netherlands East-Indies. Batavia, 1926, p. 441, No. 1165, fig. 832.

[5]) W. DOCTERS VAN LEEUWEN, Planten en Dieren op de top v. d. Pangrango. De Tropische Natuur, Vol. XVI, 1927, p. 191, fig. 35.

ous, sometimes brown-red, sometimes greenish. The leaves are elliptical or ovate-elliptical, acute, tapering into the petiole at the base, measuring 70 to 100 mm in length and 20 to 35 mm in width. The axes of the open panicles, which are mostly terminal, but sometimes lateral, are clothed with fine brown scales. The terminal branches, those of the panicle as well as the vegetative ones are curved downward. The calyx is small, pentamerous, green, with ovate overlapping lobes.

The pink corolla is sympetalous, 5-merous, deeply lobed. When newly expanded it is bell-shaped, later it widens.

The 5 stamens consist of very short filaments and ovate, or, more or less triangular, acute anthers which are slightly curved and face each other. The connective is marked at the back by small, round, red spots. The filiform style projects considerably beyond the anthers. The fruits mature as somewhat flattened drupes with a shallow grey depression at the top. They are of a shining purple colour, nearly black when ripe, and measure 7 to 9 mm in diameter and 4 to 5 mm in height. The pulp is succulent, purple-coloured, and encloses a somewhat flattened stone; it is very sweet to the taste.

Pollination. The anthers are already open before the flower expands, and the granular pollen is readily shed upon the stigma and along the style: self-pollination is therefore easily effected, and all flowers in fact regularly set fruit. I have never seen pollinators on the flowers.

Birds feed probably on the succulent, sweet fruits, but I have never observed it. The common mountain-rat, *Rattus lepturus*, when kept in captivity, took the fruits eagerly, gnawing the flesh away and leaving the stones.

2. RAPANEA AVENIS BL.

This tree occurs on several Javanese mountains; KOORDERS and VALETON [1]) distinguish a variety *Rapanea avenis var. venosa*, which later on was separated by MEZ [2]) (see also KOORDERS [3])) as an individual species, viz. *Rapanea affinis*. The difference between the two species is, however, but slight, and as there is a difference in habitat, the possibility exists (see KOORDERS and VALETON) that the plant known as *Rapanea affinis* may be the alpinoid form of *Rapanea avenis*. The trees on Mt. Pangrango belong to this form. Of the plants growing on the top this tree is one of the most common ones. It is conspicuous only for its darkgreen foliage; otherwise it resembles *Vaccinium varingifolium*. It is numerous in the alpinoid forest and on the edge of it, and locally also among the

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1) S. H. KOORDERS and VALETON, Boomsoorten van Java, Bijdrage 5, Batavia, 1900, p. 236.

2) A. MEZ, Monographie der *Myrsinaceae*, Engler Pflanzenreich, IV, 1902, p. 357.

3) S. H. KOORDERS, Exkursionsflora von Java, Vol. III, Jena, 1912, p. 31.

shrub, over which it rises however. One of the largest specimens grows here epiphytically on an old *Vaccinium varingifolium*; VON FABER[1]) mentions this species growing non-epiphytically.

On the top of Mt. Pangrango *Rapanea* develops into a low tree, seldom reaching over 4 m in height. The trunk branches generally already, near the base, and the branches themselves bear numerous slender lateral shoots. The leaves are narrow-elliptical or oblong, obtuse, the margins of the tapering base are revolute. They are leathery, dark blue-green above, with a distinctly projecting midrib and more or less distinct net-veins beneath. They measure 15—35 mm in length and 7—12 mm in width.

The flowers are arranged in short-pedunculate clusters situated in the axils of the leaves or on the bare parts of the shoots. The plants are dioecious, with numerous little red flowers, which especially in the male specimens appear in profusion.

Male flowers, plate XV. The calyx is very small, cup-shaped, 5-toothed and red. The corolla is 4- or 5-merous with broad recurving lobes, dark red on the outside, on the inside pink, and papillose. There are 4 or 5 epipetalous stamens, with purple, short and stout filaments, equal in length with the petals. The pistil is rudimentary; the style has a white tip.

Female flowers. The calyx is 5-toothed and red, the corolla is also 5-merous and deeply lobed; the white, recurved lobes alternate with the sepals; the filaments are inserted on the corolla-lobes, the barren anthers are orange. The pistil consists of an ovate ovary and a large sessile stigma. As in the male flowers, no nectar is secreted.

Pollination. The pollen is dry and the anthers of a large number of flowers open simultaneously. At half past 6 a.m. I saw the pollen being shed at intervals in little showers. When during the morning-hours a flowering tree is shaken showers of pollen are discharged, and drift away on the wind. Pollination is therefore carried out by the agency of the wind and the plants must be described as anemophilous.

The small fruits are spherical, of the size of a peppercorn, and pale- to dark-purple; they have a succulent pericarp and a hard stone. The mountain-blackbird, *Turdus javanicus fumidus* is very keen on them; it may be seen in the trees searching for the fruits. In the stomachs of birds brought down, I have not yet found the stones of this plant. Still we may find them in little heaps in localities where the blackbird is accustomed to bathe. Germinating seeds we can find there also.

Flowering-time. Only few individuals stand free; most of them are scattered in the forest in such a way that it has not been possible to determine the flowering-time with sufficient exactness. In May to July I have usually found flowering individuals, but from August to October none.

The flowers, and sometimes the buds, also are attacked by a gall-mite;

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[1]) F. C. VON FABER, Die Kraterpflanzen Java's. Batavia, 1927, p. 12.

irregular, dark-red or green galls [1]) with a granular surface are produced. Especially the female flowers are as a rule badly attacked.

Elsewhere I [2]) have published already a short description of the pollination.

FAMILY OF THE PRIMULACEAE.

1. PRIMULA IMPERIALIS JUNGH.

JUNGHUHN discovered this plant on his first visit to the top of Mt. Pangrango in April 1839. In Java it was afterwards found on Mt. Hijang too, at altitudes between 2300 to 2600 m, though in a form differing from that of Mt. Pangrango.

J. GRONEMAN [3]) mentions that JUNGHUHN transported this plant to Mt. Malabar and to other mountains of the Preanger, but it has not been found there. Early in 1930 it was discovered in several places on Mt. Papandajan and on the neighbouring mountains; it grows there at altitudes between 2100 to 2400 m.

In Sumatra it is known from the Gaju-lands, from the Peak of Korintji and from Mt. Masurai [4]). It is closely allied to if not identic with *Primula prolifera* of the Himalayas (cf. VAN STEENIS [5]). DE VRIESE [6]) gives a description of this plant, which he calls *Cankriena chrysantha* and quotes some observations of JUNGHUHN. According to DE VRIESE this species was cultivated for years in the Botanic Gardens at Buitenzorg, but this seems improbable to me, as in the much higher mountain-garden at Tjibodas it does not thrive and never flowers. A beautiful figure is added to DE VRIESE's article.

On Mt. Pangrango it occurs in the highest part, where it grows under bushes on the edge of the forest and in alpinoid forest, but hardly ever in grass-lands. At two points on this mountain this plant has descended to lower parts. In the first place along the road leading from Kandang Badak up to the top; where it now occurs as low down as Kandang Badak (at

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1) Mrs. J. DOCTERS VAN LEEUWEN-REIJNVAAN and W. DOCTERS VAN LEEUWEN, The Zoocecidia of the Netherlands East Indies. Batavia, 1926, p. 446, No. 1179, fig. 843.

2) W. DOCTERS VAN LEEUWEN, Planten en Dieren van de top van de Pangrango. De Tropische Natuur, Vol. XVI, p. 189, fig. 32.

3) J. GRONEMAN, Bladen uit het dagboek van een Indisch Geneesheer. Groningen, 1874, p. 338, note 156.

4) VAN BODEGOM, *Primula imperialis* op den Goenoeng Masoerai in Djambi. Tropische Natuur, Vol. XXI, 1932, p. 43, fig. 1.

5) C. C. G. J. VAN STEENIS, Eenige belangrijke plantengeographische vondsten op den Papandajan. Trop. Natuur, Vol. XIX, p. 73.

6) W. H. DE VRIESE, *Cankriena* DE VRIESE, een nieuw geslacht uit de natuurlijke orde der *Primulaceae* op het eiland Java ontdekt door Dr. JUNGHUHN. Jaarb. Nederl. Maatsch. Tuinbouw, 1850.

2400 m); in the lowest part, however, it flowers but seldom. MOTLEY[1]) who visited Mt. Pangrango in 1854, that is 15 years after TEYSMANN laid out the garden on the top of Mt. Pangrango, records that this plant occurs on the top only. 79 Years have passed since, and during these years it has apparently travelled downwards. Below 2400 m I have not yet found it.

In the second place in the ravine of the Tji-Kuripan; where it grows along the brook down to 2700 m. On Mt. Gedeh it does not occur, and plants transferred to Tjibodas, as already mentioned, do not thrive and never produce any flowers.

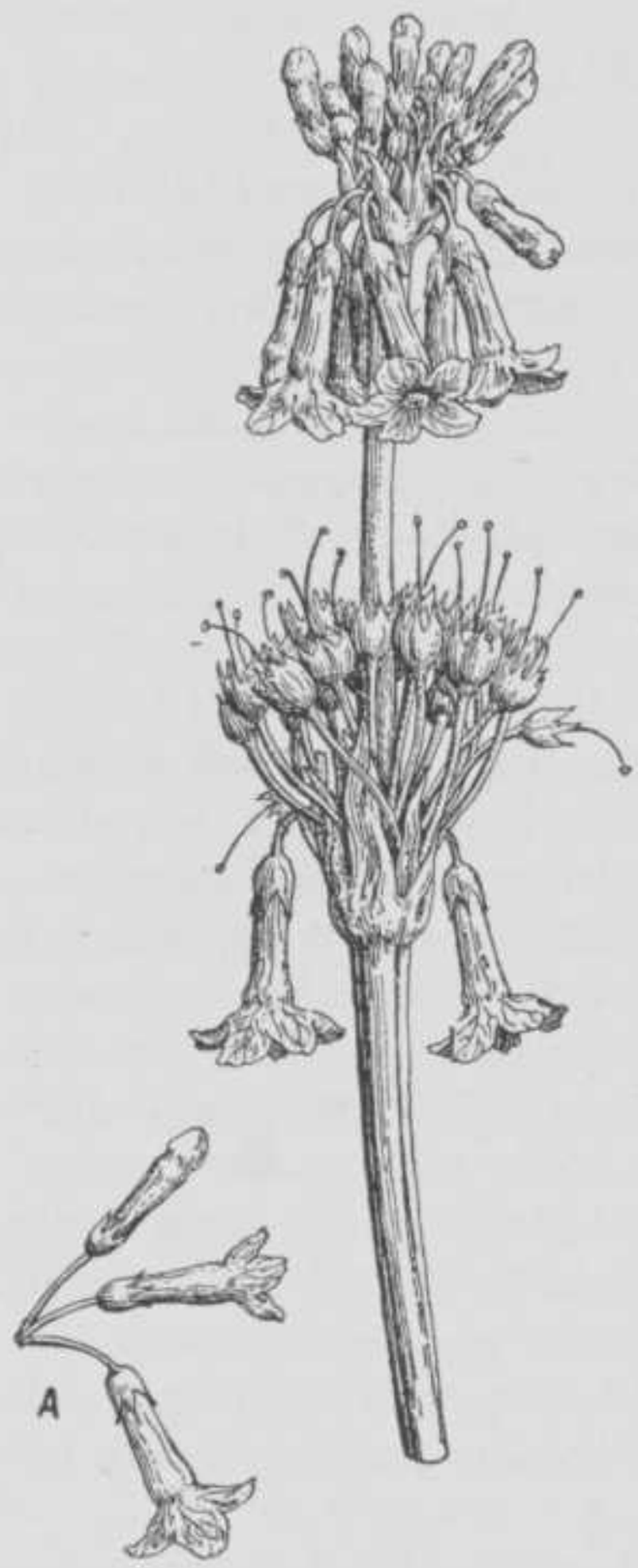

Fig. 50. Inflorescence of *Primula imperialis* JUNGH. × 3/4.

The numerous leaves are arranged in a big rosette, they are more or less horizontally spreading, the innermost ones only rising obliquely, plate XVIII. They are oblong or obovate, gradually tapering into the broad petiole; the margin is serrulate, and when young often curled back. They measure up to 50 cm in length and up to 12 cm in width.

The flowers are collected in tall inflorescences which, rising in the centre of the leaves, may reach up to 1 m in height. On the inflorescence-axis the flowers are arranged in 2 to 5 widely separated whorls; each whorl contains up to 25 flowers and is surrounded by involucial bracts; the bracts are often more or less leaflike at the top. In each whorl the outermost flowers open first. The pre- and postfloration movements are rather interesting. At first the buds are erect, on maturing the peduncles begin to bend, and the open flowers face downwards. After the flowering period the peduncles straighten again, so that the fruits are erect, see figure 50.

In the adult flower the calyx is somewhat bulging; it is connate to the middle, with acute lobes. In the specimens of Mt. Pangrango the outside of the calyx is not waxy, in those of Mt. Hijang and of Sumatra it is covered, however, with a white waxy layer. The corolla is a bright yellow and consists of a nearly cylindrical tube, about 12 mm long, somewhat

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[1]) Letters from JAMES MOTLEY to W. MITTEN, HOOKER's Journal of Botany, Vol. VII, 1855, p. 81.

widened at the insertion of the stamens and with a spreading limb, 8 to 10 mm in diameter with rounded lobes. A short distance from the mouth of the tube the short stamens are inserted on the dilated part; the anthers are included. The pistil consists of a green ovary, a long filiform style topped by a capitate stigma, on the same level as the anthers; this species of *Primula* is therefore homostylous. Nectar is secreted in a small quantity.

In the course of its development the flower shows the following modifications. Bud still erect (just before the peduncle is going to curve). The length of the corolla-tube is about 7 mm, that of the still closed limb about 3.5 mm. The style is nearly as long as the whole corolla and projects beyond the closed anthers.

Bud hanging down, before opening. The corolla-tube is now about 12 mm long, and full-grown, the limb about 5 mm, the stigma is 3 mm away from the hood formed by the folded corolla lobes and on the same level as the anthers; the latter are often open.

Open flower: see above. The corolla-tube continues to elongate slightly, and the anthers project somewhat beyond the stigma.

At the end of the flowering period the corolla falls away, but the calyx persists, and encloses the swelling fruit. The latter contains numerous seeds.

Pollination. In the adult bud and in the open flower the stigma generally comes in contact with one of the anthers, and self-pollination can therefore easily occur. Visiting insects are very rare; in all these years I observed but once *Bombus rufipes* visiting the flowers, on Mt. Papandajan I also saw once a *Bombus* in the flowers.

KNUTH [1]) describes the pollination of this flower, and mentions the possibility of self-pollination, but he thinks intercrossing might be carried out by the agency of long-tongued bees. As the flowers are so conspicuous, he considers cross-pollination obviously certain, though he never observed a single insect on the flowers. According to this investigator nectar is secreted in abundance, in reality it is scanty.

MASSART [2]) refers also shortly to the pollination of these flowers. According to him the stigma lies somewhat lower than the anthers, and in consequence of the pendulous position of the flowers self-pollination is therefore impossible. He has probably examined old flowers that were already pollinated, and where (through the elongating of the corolla-tube) the stigma had been surpassed by the anthers.

Flowering-time. Notwithstanding the fact that we can find flowering plants throughout the year, its flowering shows a distinct periodicity. It flowers abundantly in the middle of the rainy-season, from December to February; during the other months flowering is considerably less rich. This holds good with regard to the plants growing on the top; the plants along the road are already in full flower in November See the

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1) P. KNUTH, Handb. d. Blütenbiologie, Vol. III, Tome II, p. 12, fig. 146.

2) J. MASSART, Un botaniste en Malaisie. Gand, 1895, p. 116.

curve in figure 51 and the table. The seeds remain enclosed in the fruit for a long time, so long that in rainy months they may often germinate already

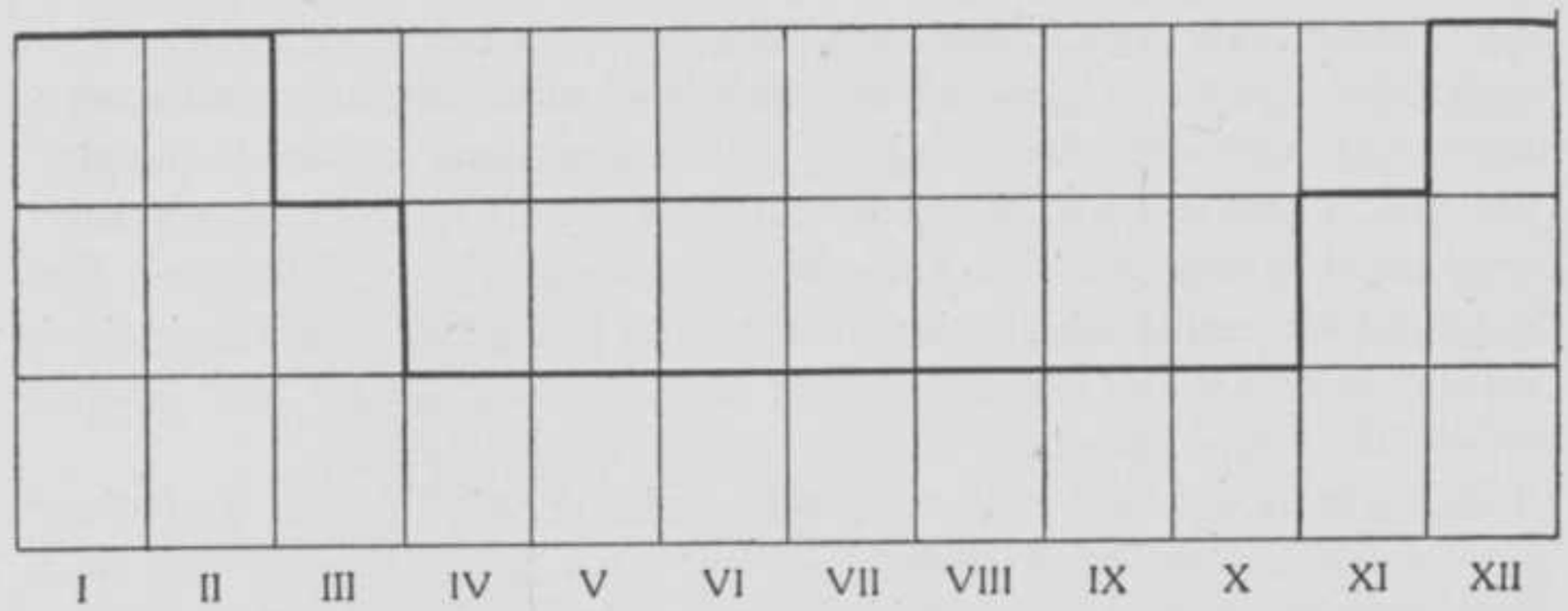

Fig. 51. Flowering-time of *Primula imperialis* JUNGH.

before they are scattered; finally when the old stalks sink down they drop on the soil. The seeds are not provided with any special means of dispersal.

VON FABER [1]) draws the attention to the important part which is played by temperature in the germination of the seeds of *Primula* and refers to the investigations of KINZEL [2]), who, however, does not mention this species.

Primula imperialis has been repeatedly described by visitors to Mt. Pangrango, but the description given by JUNGHUHN [3]), especially the one in his "Reisen" is unsurpassed. Excellent photographs are given by ERNST [4]) and DOMIN [5]).

Elsewhere I have already published a short account of the biology of this plant [6]).

FAMILY OF THE SYMPLOCACEAE.

1. SYMPLOCOS SESSILIFOLIA GÜRKE.

This plant is only known from a small number of Javanese mountains, viz. from Mts. Gedeh-Pangrango, Salak, Patuha, Papandajan, Tangkuban Prahu, Dieng; in East Java it has not been collected up to the present time.

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[1]) F. C. VON FABER, Die Kraterpflanzen Javas. Weltevreden, 1927, see p. 119.

[2]) W. KINZEL, Frost und Licht als beeinflüssende Kräfte der Samenkeimung. Stuttgart, 1912.

[3]) FR. JUNGHUHN, Wiss. Reisen durch Java. Magdenburg, 1845, p. 445.

[4]) A. ERNST, Vegetationsbilder, Reihe VII, Plate 3a. (The incised leaves shown in this photograph are not of *Ranunculus diffusus*, but of *Sanicula europaea*).

[5]) K. DOMIN, Vegetationsbilder, Reihe No. XI, 1913, Plate 28.

[6]) W. DOCTERS VAN LEEUWEN, Planten en dieren op de top van de Pangrango. De Tropische Natuur, Tome XVI, 1927, p. 118, fig. 6 and 7.

It grows equally well in rain forest, in alpinoid forest, in alpinoid shrub and in grass-fields. When growing in the last-mentioned habitat it does not develop beyond the size of a small shrub. On Mt. Gedeh-Pangrango individuals over 8 m high are rare, and in alpinoid forest they are usually not more than 5 m in height. On the top of Mt. Pangrango we find shrubby specimens which, however, are adult and flower abundantly. The trunk is usually crooked, and branches irregularly. The leaves are crowded, elliptical or narrower, subsessile, with an acute apex and base, and serrulate. Newly expanded leaves are a beautiful violet, which changes afterwards into violet-brown.

The plant flowers already when 1 m high. at least this is the rule with the individuals on the top. The flowers are borne in spikes which are aggregated in the axils of the crowded leaves at the tops of the branches, and give the impression of compound inflorescences. The flowers appear usually simultaneously in great numbers; and the whole crown is at such a time gay with the white blossoms; the flowers are deliciously scented, like hawthorn.

The flowers are sessile with three small, triangular, brown-haired bracts. The calyx is pentamerous, free, and covered with purple-brown hairs. The

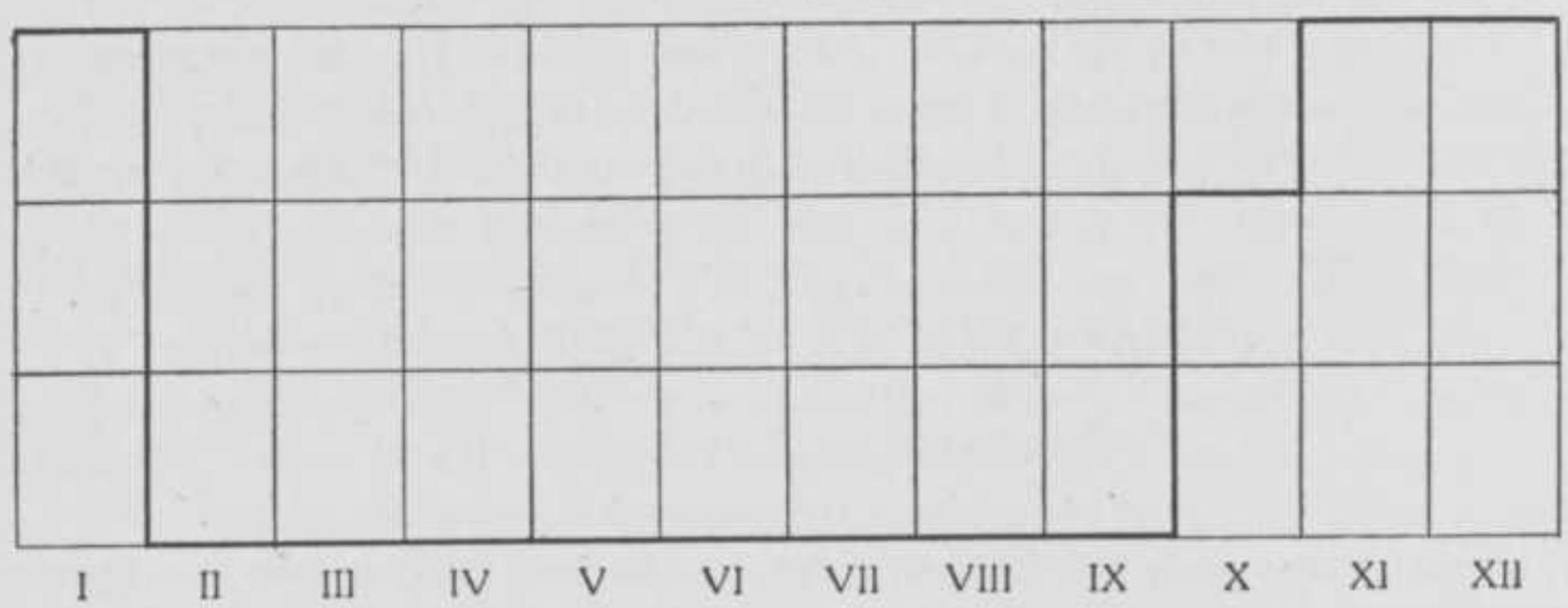

Fig. 52. Flowering-time of *Symplocos sessilifolia* GK.

corolla too is pentamerous, incised to a short distance from the base, white, the base of the lobes is violet. There are about forty stamens inserted on the corolla-tube, which produce a sticky pollen. The ovary is inferior and bears a white style topped by a yellow, capitate stigma. There is a white pentagonal disk which does not produce much nectar.

Pollination. First flowering-day. Early in the morning the corolla begins to expand, but it opens only halfway; it remains bent over the sexual organs; at 8 o'clock the anthers are already open and they often touch the stigma, on which the sticky pollen readily falls.

Second flowering-day. The corolla is widely open, the anthers are empty, and the stigma is always pollinated.

Self-pollination is therefore certain, but the flowers are visited freely by various insects, not in the first place for nectar, which is secreted in small quantities only, but for pollen. *Bombus rufipes* and *Apis indica* are regular visitors and also 4 species of Syrphids: *Chamaesyrphus nigripes, Syrphus gedehanus, serarioides* and *confrater*, besides *Calliphora fulviceps* and a number of small *Diptera*, which have not been collected.

Fig. 53. Psyllid-galls of *Symplocos sessilifolia* GK. × 3/4.

Flowering-time. In the months of February to September hardly any flowers are to be found. Flowering starts in October and keeps on till January, and the flowering-season is therefore limited to the rainy monsoon, figure 32.

Psyllids live on the leaves, and change them into galls. This infection keeps the leaf small. The two halves of the lamina curve upwards till the margins touch and a narrow cavity is formed, in which the larvae of the insects live, figure 53. The galled leaves are white or purple.

The larvae are sucked out by the larva of a Syrphid, probably of *Chamaesyrphus nigripes*, which I have noticed repeatedly on the galls.

The fruits are at first green, later white with violet; the mesocarp is succulent, and surrounds a hard stone; they are probably dispersed by animals, but I have not yet found them in the stomachs of fruit-eating birds.

FAMILY OF THE GENTIANACEAE.

1. CRAWFURDIA TRINERVIS HASSK.

This plant is known only from a few mountains of West Java, i.e. from Mt. Gedeh-Pangrango, Mt. Salak and Mt. Patuha, where it grows in forests rich in humus at altitudes above 2000 m. On the top of Mt. Pangrango it occurs also in the moss-clad forest and a few individuals grow at the edge of the crater-valley, though always in the shade of the *Vaccinium*-forest. As the number of plants was very small, conclusions about the flowering-time could not be made. Once, in March 1921, I found only withered stalks without flowers and young shoots, but generally flowers may be found at all seasons. It is a dextrorse herbaceous climber, working its way through the shrubs up to the lower branches of the trees, but seldom reaching a height of more than 3 meters.

The shoots are about 1 to 2 mm thick, and reddish-violet. The opposite leaves are green, but when exposed to strong light, they become dark-red, almost black. They are subsessile, ovate with an acute apex and tapering at the base into the petiole, and trinerved.

The pendulous flowers are borne on a peduncle, which is about 10 to 20 mm long; they are sometimes terminal, but mostly axillary. The peduncle bears often one or more bracts, in the axil of which often a second flower, or sometimes a pedicel only develops. The full-grown bud is about 20 mm long and sharp pointed. In that stage the corolla protrudes a long way beyond the calyx; it is white at its base and tinged with violet towards the top. The anthers are tightly packed in the upper part of the corolla. The two stigmas, still lying against one another, lie somewhat lower than the anthers.

In the open flower the calyx is dark bronze-green, 10 to 15 mm long, with filiform lobes. The narrowly campanulate corolla is 20 to 25 mm long, violet outside, pale-pink inside; the small opening is surrounded by 5 short teeth. The 5 stamens are free; the ovary is spindle-shaped, and bears a short pink style, and two stigmas which curl backwards. Occasionally 3 stigmas are developed.

Pollination. When the flowers expand the lobes of the stigmas are already receptive and curl backwards, and the anthers dehisce simultaneously; the flower is therefore homogamous. The style now elongates, and as the filaments, on the other hand, contract, the stigmas come in contact with the open anthers and self-pollination is effected.

I have never observed any visitors; but nectar is secreted in inconsiderable quantities.

When the ovary begins to swell the pedicel elongates simultaneously. At first the swelling ovary is surrounded by the corolla, which becomes brown and withers, and splits at one side, but which further remains unchanged till the fruit is ripe. The latter is ovoid and acute, 15 to 30 mm long and about 10 mm thick; its colour is dark-violet; the pericarp is succulent and spongy. The fruit is one-celled and contains a large number of small, brown seeds. The latter are flat, and very narrowly winged.

The flowers all set fruit by means of autogamy; by what agencies the seeds are dispersed is unknown. In view of the succulent pericarp birds may be expected to eat the fruit, but I have never found seeds either in their intestinal canal, or in their excrements.

2. GENTIANA QUADRIFARIA BL.

This is one of the smallest plants of the Javanese high mountains, conspicuous in the flowering-time by its bright blue flowers. It has been collected on many mountains of West to East Java, viz. on Mts. Pangrango, Gedeh, Papandajan, Dieng and on Mts. Tangkuban Prahu, Sumbing, Merbabu, Lawu, Kawi, Ardjuno, Tengger and Hijang.

In Sumatra it has been found on the Karo-plateau near Brastagi, near Lake Toba, and further it is known from Ceylon and the Himalayas. It occurs in Java upwards of 1800 m (in Sumatra between 1200 and

1300 m). It grows by preference in the highest parts in open localities, though it may occur also in light shade. One can find it in the grass, when this does not form too dense mats; in open patches in the alpinoid shrub, in sandy plains, on stony slopes, in tjemara forests and on thinly shaded forest paths.

It is common in the crater-valley and on the highest part of Mt. Pangrango and also in the aloon-aloon of Mt. Gedeh. It occurs moreover over a short distance along the edge of the path a little way below Kandang Badak, where it shows a habit intermediary between the sun-form and the shade-form.

ZOLLINGER has described from Java a second species, which he calls *Gentiana laxicaulis*, and which is supposed to be distinguished by its laxer growth, thinner twigs, widely scattered narrower leaves.

SCHIMPER [1]) regards this species as a mere shade-form and gives figures of both forms; KOORDERS [2]) maintains it as a species and presumes, on what grounds is not stated, that it is a mutation of *Gentiana quadrifaria*. There is, however, no reason to maintain both species, as the so-called *G. laxicaulis* is in fact nothing but a shade-form of *G. quadrifaria*; sometimes one may find plants which possess shoots with short internodes and shoots with long internodes. The difference was very striking in the big form, which I found on Mt. Sumbing; the sun-forms nearly globular, the shade-form widely spreading [3]).

The same phenomenon may be observed in *Gentiana singalangensis* (see Chapter X). In this plant, as in the Javanese species, the flowers of both forms are alike; and the differences are evidently determined by pecularities of the habitat.

The plants are partly annual and then generally but small, but one may come also upon individuals which persist for many years, and develop into big plants. The specimen, shown in plate XXVII. A., I have known for more than 3 years, then it was unfortunately trampled upon by visitors and died. Many individuals are unbranched, others, however, show a great number of branches.

A big plant consists of a short main-axis with a poorly-developed root-system. Sometimes a rosette of leaves may be found at the base of the main shoot; these leaves are triangular and larger than the other ones. Near the base a number of short lateral branches grow out which in their turn bear lateral branches at their base. The internodes are short, the leaves decussate, small and more or less imbricate and at their base the two opposite leaves form a short sheath. They are ovate or obovate-

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[1]) A. F. W. SCHIMPER, Pflanzengeografie, Zweite Auflage 1908, Jena, p. 766, fig. 425.

[2]) S. H. KOORDERS, Exkursionsflora von Java, Vol. III, Jena, 1912, p. 64, fig. 7.

[3]) W. M. DOCTERS VAN LEEUWEN, Beitrag zur Kenntnis der Gipfelvegetation der in Mittel-Java gelegenen Vulkane Sumbing und Sindoro. Bull. d. Jard. bot. de Buitenzorg, Série III, Vol. XI, p. 38, fig. 1.

elliptical, with a narrowed base and terminate in a small mucro. In the annual plants the main-stalk is either branched or unbranched, but the lower parts are like those mentioned above; in the shade plants the internodes are long and the leaflets are narrower. One might compare the short, compact sun plants with the cushion plants so common in alpine areas. The specimens of Mt. Sumbing were hemi-spherical, but they were not nearly so much-branched and the sods were not so dense as these of real cushion plants. The lateral branches terminate in a single, 5-merous, seldom 4-merous flower, borne on a very short pedicel. The calyx is campanulate, outside pale-green, with some violet stripes and with 5 green teeth. The corolla is more or less funnel-shaped, beautifully blue, occasionally violet; it is inserted upon the edge of the calyx. The edge is but little incised, the lobes are acute, with folds prominent on the inside, each lobe showing a pale and a dark-blue half. There are 5 epipetalous stamens, each with a short filament and a small anther. The pistil consists of a cylindrical ovary, a very short style, and two nearly sessile stigmas. The flowers are 6 to 8 mm in diameter. Generally the whole plant is but a few centimeters, it seldom reaches 10 cm in diameter.

As mentioned before, I found in the crater of Mt. Sumbing at an elevation of about 3100 m, especially along the foot of rocks, a very large form showing the same habit as that described above, but in every respect bigger. Shoots, leaves and flowers, all had developed into almost double the ordinary size. On Mt. Merbabu I collected also such a strongly developed specimen.

Pollination. For three consecutive days the flowers are open in the morning, showing successive stages of development; in the afternoon they close.

First flowering-day. The anthers, which are filling up the entrance of the corolla-tube, open, and white pollen is produced in great quantities. The two stigmas are not yet receptive, and are closely pressed together. As they are surrounded by the anthers, they get on the outside thickly covered with pollen. The flowers are therefore protandrous.

Second flowering-day. The anthers are shrivelled, and contracted in the corolla-tube; they have become red. The stigmas recurve and remove the pollen.

Third flowering-day. The flowers are in the same condition as on the preceding day.

The flowers do not open before 9 o'clock in the morning and only, when the sun is shining. First the flowers of the 2nd. and 3rd. flowering-day open, somewhat later those which open for the first time; they are all closing in the afternoon.

Self-pollination is a rule with these plants. Syrphid-flies may be observed on the flowers, but exceptionally only; they dive into the corolla-tube and their heads get powdered with pollen. The common small Syrphid-fly:

Chamaesyrphus nigripes, and once in a while, *Syrphus serarius* and *S. serarioides*, are for a long time actively engaged in the flowers. I have never observed larger species at work in them. Nectar-secretion is but scant.

In SCHRÖTER's [1]) book about alpine flowers many data concerning the biology of the *Gentianaceae* are found and *Gentiana quadrifaria* is mentioned there also. MÜLLER [2]) especially made elaborate investigations about the pollination of the flowers of *Gentiana*; among the visitors he mentions chiefly bumble-bees and butterflies, though Syrphid-flies occur also; see KNUTH [3]). SCHRÖTER reports self-pollination of *Gentiana tenella*. WARMING [4]) noticed in individuals of this small species in Greenland, that the anthers and the stigma cohered by means of pollen-tubes.

Before, during and after the flowering period the shoots show interesting movements. So long as the flower buds are small, the shoots of larger plants are well-nigh horizontal; towards the flowering-time they rise vertically, and afterwards they bend down again to make place for new flowers. The shoots are horizontal therefore during the maturing of the fruit, but they stand up again vertically as soon as the fruit is ripe. A big specimen showed non-flowering shoots of about 12 mm length, the flowering shoots on the contrary were 15 mm long, the vertical shoots with open fruits were 20 to 25 mm long; the fruits rise therefore high above the flowers. The movements are accompanied by growth.

Another interesting fact is that the flowers are remarkably sensitive to mechanical stimuli, especially during the first flowering-day. When the flowers are touched, they close; the flowers visited by Syrphid-flies close also afterwards. Flowers submerged in boiling water or put in weak alcohol also close. But when immersed in absolute alcohol they remain open, nay, closed specimens reopen.

SEEGER [5]) found this sensitivity in *Gentiana prostrata*, but BREMEKAMP [6]) was the first to describe the sensitivity in the Javanese species. A detailed account of the various sensitivities is given by CLAUS [7]). CLAUS draws the conclusion that in the greater part of the species the flowers are extremely sensitive to changes of temperature, as differences of a fraction of 1° C may sometimes lead to a reaction. The minima of temperature required for the opening of the flowers vary for the different species and with respect to the European species they range from 8.5 to 20° C. Many species are

1) C. SCHRÖTER, Das Pflanzenleben der Alpen. Zürich, Second edition, 1923, p. 528.

2) H. MÜLLER, Alpenblumen. Leipzig, 1881, p. 329.

3) P. KNUTH, Handbuch der Blütenbiologie. Leipzig, 1899, Vol. II, Tome II, p. 75.

4) E. WARMING, Om nogle Arktiske Vaexters Biologi. Bihang till U. Svenska Vet. Akad. Handlingar, Vol. XII, Part III, No. 2, 1886, p. 9.

5) R. SEEGER, Über einen neuen Fall von Reizbarkeit der Blumenkrone durch Berührung. Sitz. Ber. d. math. naturw. Klasse d. Wiener Akad. d. Wiss., Bd. CXXI, 1912.

6) C. E. B. BREMEKAMP, Stossreizbarkeit der Blumenkrone bei *Gentiana quadrifaria* BL. Receuil d. trav. Neerlandais, Vol. XII, 1915, p. 26.

7) G. CLAUS, Die Blütenbewegungen des *Gentianaceen*. Flora, Bd. CXX, 1925, p. 198.

sensitive to a mechanical stimulus. *Gentiana quadrifaria* also shows an extreme sensitivity to changes in temperature; on sunless days the flowers do not open at all or much later than when the sun is shining. See also CZECH [1]).

SEEGER saw in the sensitivity of the *Gentiana* flowers a biological function; GOEBEL [2]) justly points out that this is but a supposition, which he thinks but little plausible.

The flowers of *Gentiana quadrifaria* even close after the visits of insects and I consider it very improbable that this could be of any advantage to the plants.

Flowering-time. According to BREMEKAMP [3]) *Gentiana quadrifaria* flowers in the dry season and dies off afterwards. This may be true concerning a part of East Java where his observations were made, but it certainly does not hold good for all localities. On Mt. Kawi I saw flowers in April, on Mt. Lawu in November, on Mt. Merbabu in December and the generalisation does not hold good at all with regard to Mt. Pangrango. The majority of the individuals are not annual, but perennial and flowers may be found in every month. Still there is a great difference in the abundance of flowers in the various parts of the year; see figure 54.

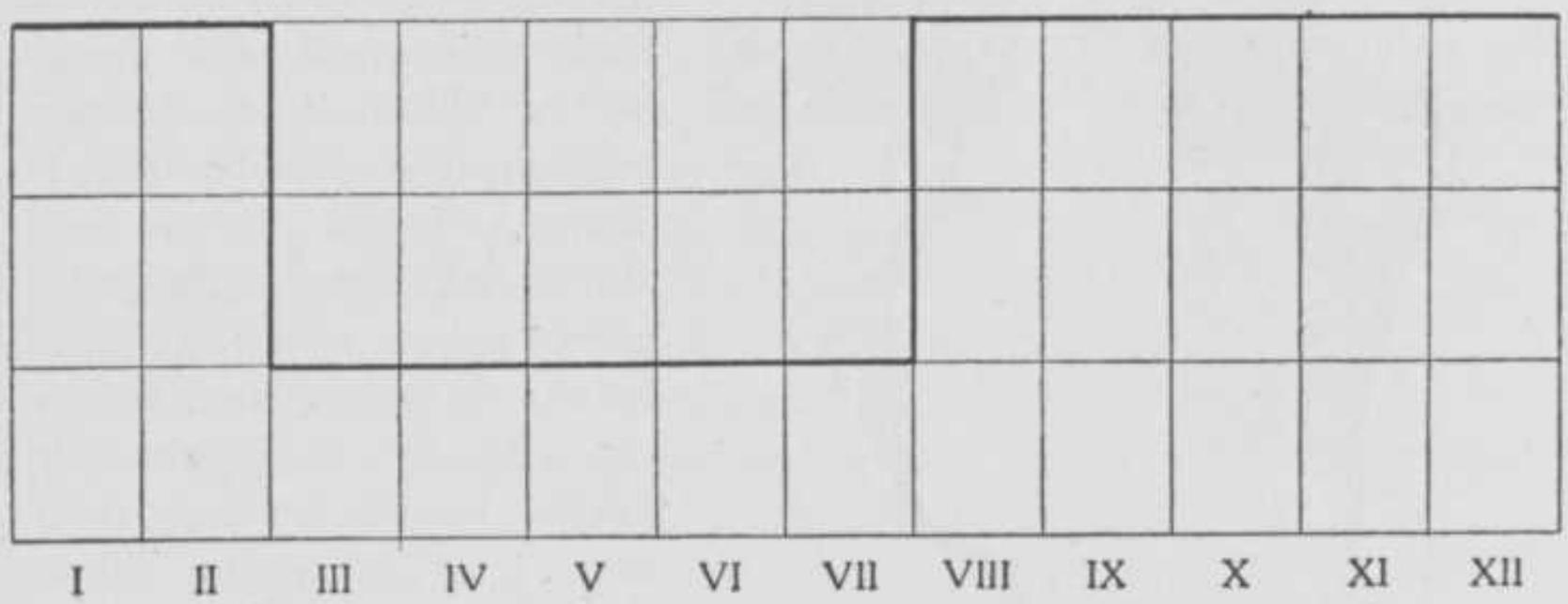

Fig. 54. Flowering-time of *Gentiana quadrifaria* BL.

The majority flowers from August till in February, chiefly therefore in the rainy season, while the number of flowers diminishes during the driest months, June and July. This difference is all the more striking because in the dry months all the flowers are open, and on cold, rainy days in the principal flowering-time sometimes no flowers will open, and one has to look carefully to ascertain if there are any flowers or not.

The growing fruit is at first hidden in the withered corolla; finally it

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1) H. CZECH, Quelques observations sur les mouvements floraux du *Gentiana Freyniana*. Trav. d. Jard. et Lab. alpins de la Linnaea. Bull. d. 1. Soc. bot. de Genève, Vol. XXIII, 1930, 1931, p. 25.

2) K. GOEBEL, Die Entfaltungsbewegungen der Pflanzen. Jena, 1924, second edition.

3) C. E. B. BREMEKAMP, loc. cit., p. 28.

protrudes from the latter, and the shoot rises at the same time until it reaches a vertical position and the fruit opens. It is a unilocular capsule, dehiscing by two valves, which remain connected at their base and spread outwards at the top. Thus a cup is formed in which lie the small black seeds. When it rains the cup fills, the seeds begin to float and the raindrops wash them out of the fruit. By what agent the seeds are dispersed from mountain to mountain is unknown to me, but the transport cannot be very difficult, as the plant occurs from British-India to East Java. The seeds are very light and perhaps dissemination is effected by wind; neither means of attachment to animals, nor parachutes are provided. A short account of the pollination was given by me at an earlier opportunity [1]).

3. SWERTIA JAVANICA BL.

This perennial herb has been found on several Javanese mountains, viz. on Mts. Pangrango-Gedeh, Tjikorai, Papandajan, Malabar, Tjerimai, Slamat, Sumbing, Sindoro, Kawi, Ardjuno and Hijang; KOORDERS [2]) mentions it also from Mt. Wilis; it has been collected moreover on the Peak of Korintji in Sumatra. It grows in the fourth belt of JUNGHUHN, at altitudes between 2300 and 3300 m, in alpinoid forest, in alpinoid shrub and in grass fields, on open stony grounds, along brooks, in moist places and on the edge of the forest. In shaded localities it may reach over 1 m in height. Huge, much-branched specimens more than 1½ m high I collected in an extremely moist alpinoid forest in a ravine on the top of Mt. Kawi at an elevation of 2600 m. When growing in stony localities the plants remain very small; in the crater-valley of Mt. Pangrango I found specimens of a few centimeters only, though all were in flower, see figure 55. KORTHALS [3]) mentions such

Fig. 55. Dwarf specimens of *Swertia javanica* BL. × 1.

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[1]) a. W. DOCTERS VAN LEEUWEN, Naar de top van de Singgalang. De Tropische Natuur, Vol. IX, 1920, p. 95, fig. 4.

b. Idem, Uit het leven van planten en dieren op de top van de Pangrango. De Tropische Natuur, Vol. XVI, 1927, p. 185, fig. 28.

[2]) S. H. KOORDERS, Exkursionsflora von Java. Jena, 1912, Vol. III, p. 66.

[3]) P. W. KORTHALS, Waarnemingen aangaande den berg Gedeh op Java. Nederl. Kruidkundig Archief, Vol. I, 1848, p. 123.

dwarfed plants in his description of the aloon-aloon of Mt. Gedeh. On Mt. Pangrango-Gedeh this plant is extremely common, it grows from a little way below Kandang Badak up to the highest summits. On the top of Mt. Pangrango it occurs in a few individuals in the crater-valley, but very abundantly on the edge of the forest and in the alpinoid forest itself, but not among the grass.

Its habit is that of a robust herb with a massive upright root-stock, from which springs the erect stem, which is usually repeatedly branched. Up to the flowering-time the lowest withered leaves remain attached to the basal part of the stem. The seedling develops into a rosette which after several years produces a flowering-shoot. The leaves are opposite, sessile, glabrous, narrow lanceolate, with an acute apex and tapering towards the base; the margin is entire. The flowers are solitary or stand in pairs in the axils of the upper leaves, plate XXVIII A, which are much smaller than the lower ones, figure 56.

In the bud the anthers and the stigmas are as yet closed, the latter project somewhat above the anthers. The calyx is completely glabrous, equal in length to or somewhat shorter than the corolla, free, pentamerous; the segments are pointed. The pentamerous corolla is bell-shaped with a wide opening, it is white with violet, and marked by 2 green patches above the nectary. The 5 stamens are inserted on the mouth of the corolla; their filaments are dilated in the basal part.

The pistil consists of a uni-locular ovary with marginal placentation, and a very short style with two stigmas.

Fig. 56 Flowering shoot of *Swertia javanica* BL. $\times$ 3/4.

Pollination. First flowering-day. Already early in the morning the corolla opens, and three of the five anthers are open and turned outward; later the two other anthers open; the stigmas are still closed.

Second flowering-day. All anthers are open, and turned inward, so that they may readily come in contact with the now receptive stigmas; the short style elongates slightly.

Third flowering-day. The pollinated stigmas project beyond the quite empty anthers and spread apart.

Fourth flowering-day. The anthers have dropped off; the corolla is withered; the calyx encloses the swelling ovary.

When the flowers are not pollinated by insects, self-pollination may take place during the second flowering-day. But the flowers are frequently visited by *Bombus rufipes*. The insects penetrate deeply into the flowers

where a good deal of nectar is produced and they get thickly powdered with pollen. Generally the bumble-bee visits one open flower after the other of the same plant.

On Mt. Tjikorai too I saw *Bombus* busy. Besides this insect, which visits the flowers regularly, I have once observed the visit of a Syrphid-fly viz. *Syrphus koningsbergeri* and sometimes visits of the honey-bird: *Aethopyga eximea*. Numerous thripses in all stages of development live moreover in the flowers. In those of the dwarfed individuals in the crater-valley I once found a great number of small Elaterids.

In America ROBERTSON observed on *Swertia carolinensis* chiefly the visits of two species of bumble-bees and of the honey-bee, see KNUTH [1]).

Flowering-time. This plant shows a strictly limited flowering-time. Between May and July nearly all specimens are in flower; the main flowering-time falls in June. During the other months of the year flowering

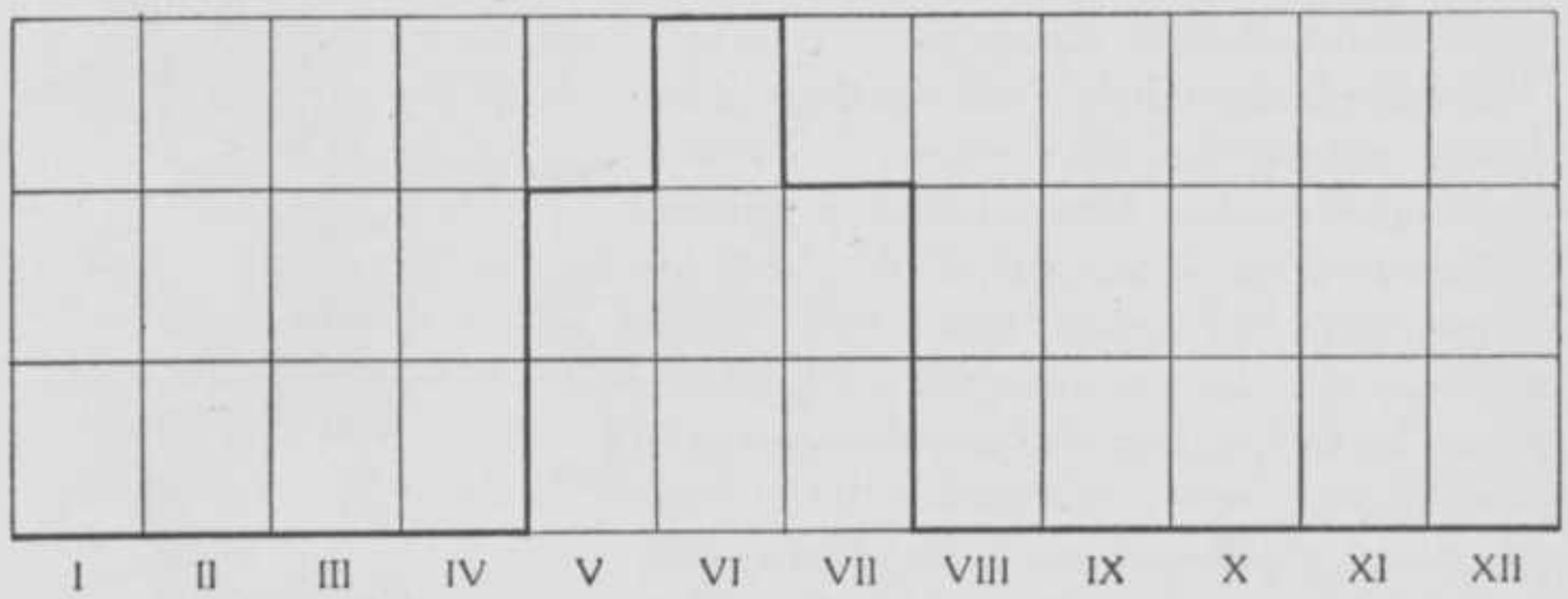

Fig. 57. Flowering-time of *Swertia javanica* BL.

in the plants growing on the top of Mt. Pangrango is practically nil, figure 57.

I [2]) have published already elsewhere a short account of the pollination.

FAMILY OF THE SOLANACEAE.

1. SOLANUM NIGRUM L.

This plant occurs in Java from the lowland up to an altitude of 3000 m. I have found it on Mt. Gedeh for instance in large numbers on rubble just below the active crater. In that locality the flowers were visited regularly by *Bombus rufipes*. On Mt. Sindora I observed the same insect and VAN STEENIS saw it also on Mt. Papandajan.

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1) P. KNUTH, Handbuch d. Blütenbiologie, Vol. III, Tome II, p. 28.

2) W. DOCTERS VAN LEEUWEN, Planten en dieren op de top van de Pangrango. De Tropische Natuur, Vol. XVI, 1927, p. 117, fig. 25.

In Europe the flowers are visited bij bees, bumble-bees and Syrphid-flies, see KNUTH [1]).

FAMILY OF THE SCROPHULARIACEAE.

1. DIGITALIS PURPUREA L.

Years ago this plant was cultivated in the mountain gardens at Tjibodas, but it did not flower there, though it formed large rosettes. Specimens planted out at about 2400 m elevation in forest clearings near Kandang Badak and Lebak Saät, however, flower regularly. Its habit and floral structure are the same as of the European specimens, see KNUTH [2]). In Europe the visitors of the flowers are chiefly bumble-bees, and at Kandang Badak it is *Bombus rufipes* which visits the blossoms. Fruits are regularly produced and at the present time the plant is slowly commencing to spread along the forest-path.

2. VERONICA JAVANICA BL.

This small herb has been found in numerous places in Java, at altitudes between 1000 and 3000 m. It is known also from the Himalayas, Japan, Formosa and tropical Africa. It does not appear to be particular as to its habitat as it occurs in sunny or slightly shaded localities, which may be dry or moist, on fields, in gardens, along roadsides and in the grass. On Mt. Pangrango-Gedeh it is very common in the garden of Tjibodas and further on the tops of both mountains, where it grows in bare stony places as well as among the tussocks of *Calamagrostis australis*. The plants growing in the grass are considerably better developed than those of the bare patches, figure 58.

Fig. 58. Flowering shoot of *Veronica javanica* BL. × 3/4.

LEHMANN [3]) discusses the dispersal of this plant and draws the conclusion that it is a weed on abundantly irrigated grounds in tropical and subtropical countries. In Java, however, it grows sometimes in very arid localities.

The flowers are borne in lax, axillary, racemes. The caylx is 4-merous, deeply pinnatifid, about

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[1]) P. KNUTH, Handbuch d. Blütenbiologie, Vol. II, Tom. II, p. 129.

[2]) P. KNUTH, Handbuch d. Blütenbiologie, Vol. II, Tome II, p. 157, fig. 274 and 275.

[3]) E. LEHMANN, *Veronica javanica* BL., ein Ubiquist tropischer und subtropischer Gebirge. Ann. d. Jardin botan. de Buitenzorg, Bd. XXV, 1912, p. 189.

2½ mm high, and 4-lobed. The corolla is white or violet with a white base, about 2 mm high with 4 erect lobes. There are 2 stamens which do not appear outside the corolla. The ovary bears a short style.

The fruit is broad, obovate and flattened, surrounded by the enlarged calyx which is now 4 to 5 mm long.

Pollination. Sometimes the flowers do not open at all and are shed very early; or they open slightly towards midday and remain attached a little longer. The anthers lean against the stigma and self-pollination is the rule. I have never observed flower visitors.

FAMILY OF THE GESNERIACEAE.

1. CYRTANDRA ARBORESCENS BL.

This little-branched shrub occurs on Mt. Gedeh-Pangrango from 1400 m up to 2700 m altitude in moist, densely shaded localities. Its strong branches may reach a height of about 2 m. The flowers are grouped in shortly pedunculate inflorescences which arise in the axils of the higher leaves and are each surrounded by two connate bracts. One flower only of the inflorescence is open at a time. The flowers are white, and more or less laterally flattened. The calyx-tube is green, funnel-shaped, with appressed hairs; the positions of the stamens and of the stigma are similar to those described of the flowers of *Cyrtandra coccinea*, (see Chapter X). The stigma is very broad. Cf. VON GUTTENBERG[1]).

Pollination. In all flowers examined mites lived, which crawled in and out of the opened anthers; the animals were powdered with pollen, and deposited it chiefly over the innerside of the corrolla, and on the strongly pilose part of the corolla-tube above the anthers. When on the second flowering-day the style elongates, the stigma may consequently come in contact with the pollen. At noon of the second flowering-day the anthers have sunk upon the bottom of the corolla-tube and the stigma is pollinated. I have never noticed insects on the flowers. All parts of the flower, the corolla also, which does not fall away, decay into a pulp in which the fruit matures. All flowers produce fruit.

FAMILY OF THE PLANTAGINACEAE.

1. PLANTAGO MAJOR L.

This plant occurs in Java in many places, in the mountains as well as in the plains. Several species have been described from there, e.g. *Plantago Harskarlii* and *Plantago incisa*; BACKER and VAN SLOOTEN[2]), however,

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[1]) H. VON GUTTENBERG. Ann. d. Jard. bot. de Buitenzorg. Vol. XLVIII. 1933. p. 14.

[2]) C. A. BACKER and D. F. VAN SLOOTEN, Javaansche Theeonkruiden. Batavia, 1924, fig. 200.

have united all these species under the name of *Plantago major*.

The plant grows in various localities, along roads and tracks in grass-fields, in *Casuarina* forests, in shrub and in alpinoid woods; also on hard and stony grounds. In the last mentioned places the rosettes are sometimes very small. On Mts. Pangrango-Gedeh it is found in the vicinity of Tjibodas and further above Kandang Badak; on the forest-path leading to the top of Mt. Pangrango it is very common, it grows there among the grass together with *Primula imperialis* in very large specimens: it is no rare thing to find rosettes with a diameter of 50 cm and more. On the top of Mt. Pangrango and of Mt. Gedeh it occurs also, in the highest part for instance along the border of the shrub; in the crater valley a few specimens only grow.

This plant is so well-known from Europe, that it seems unnecessary to give a detailed description.

Pollination. The flowers of Mt. Pangrango are strongly protogynous: in older spikes we find at the bottom flowers in the male stage and at the top those in the female stage. The anthers are versatile, and they are affixed to long filaments which project far beyond the corolla tube; pollination by means of the wind has been recorded. The spikes,

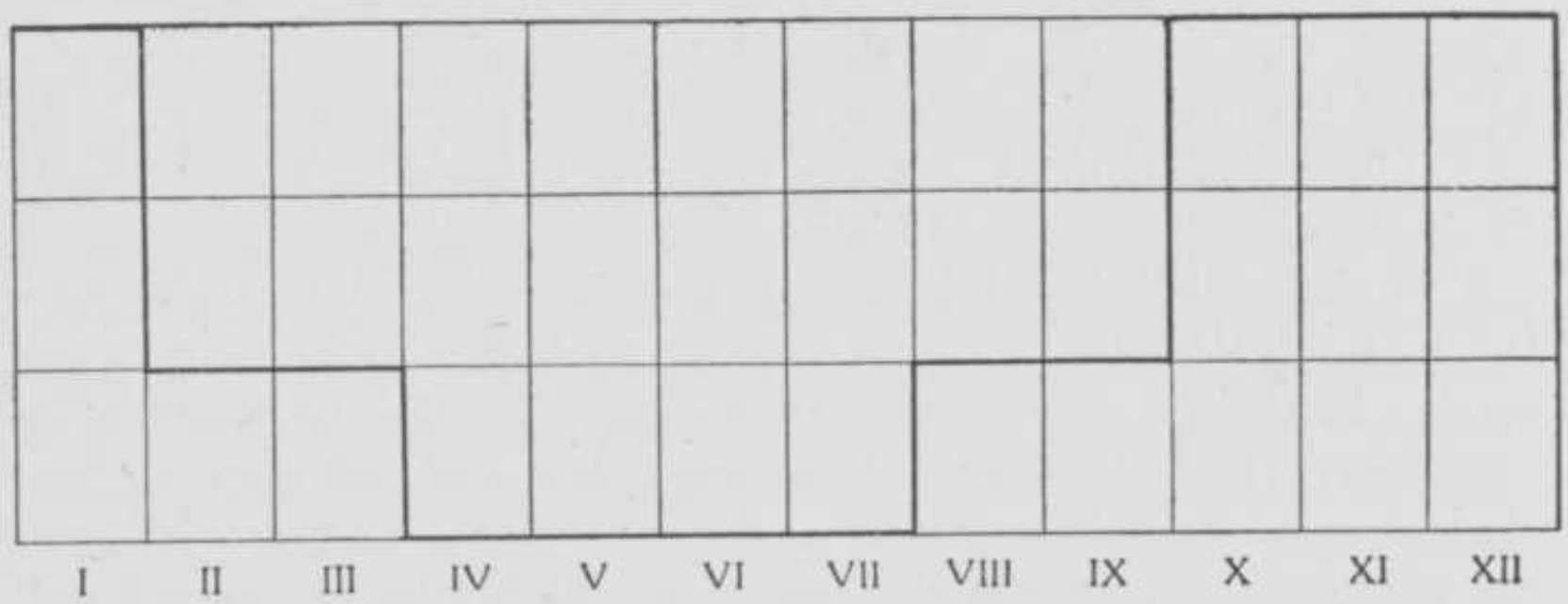

Fig. 59. Flowering-time of *Plantago major* L.

however, are regularly and freely visited by *Bombus rufipes*; they avoid the young spikes, which only show stigmas and they visit exclusively the flowers in the male stage. Doing so they circle round the spike, brushing the pollen out of the anthers, and shattering showers of it. Beside *Bombus* I saw once in a while *Apis indica* and a Syrphid-fly: viz. *Chamaesyrphus nigripes* on the spikes. On Mt. Lawu [1]) it was frequently visited by *Bombus* and besides by a little black bee, *Halictus monachus* and by Syrphid-flies.

It is known that in Europe too the inflorescences are frequented by

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[1]) W. DOCTERS VAN LEEUWEN, De alpiene vegetatie van de Lawu-vulkaan. Natuurk. Tijdschrift v. Ned. Indië, Vol. LXXXV, 1925, p. 38.

various insects. See KNUTH [1]). I [2]) have published already elsewhere a short description of the pollination.

Flowering-time. The plants on the top show a distinct periodicity in flowering; those along the forest-path also, but on the top they flower earlier and finish later. The flowering-time of the plants run from October to January, in February and March the flowering diminishes considerably from April to July it practically ceases, in August some individuals start flowering again; see the curve in figure 59 and the schema on page 88.

FAMILY OF THE RUBIACEAE.

1. ALLAEOPHANIA RUGOSA HOOK.

This plant is known from Java as well as from Sumatra. In Java it occurs chiefly in the western parts of the island, but also on Mt. Dieng and Mt. Sumbing in Central Java. In Sumatra it has been found on several mountains, i.e. Mts. Talang, Merapi, Singgalang, Korintji, Kaba and Dempo. It grows mostly above 1700 m and reaches an altitude of 2800 m; on the top of Mt. Pangrango it does not occur, but it is very common near Kandang Badak and in the alpinoid forests that cover the slopes of Mt. Gedeh. It occurs chiefly in open parts in the forest, along forest-tracks and in light alpinoid shrub; it grows moreover in marshy places and along the banks of small streams and lakes.

This plant is mostly a low strongly branched shrub, 1 to 1½ m high, but in shrub thickets, the stems may go up between other shrubs and reach a length of 2 m. The stems are quadrangular. The decussate leaves are elliptic to lanceolate with a short petiole, 6 cm long and 2½ cm broad; the nerves are strongly prominent on the under side. The bisexual flowers are arranged in clusters in the axils of the higher leaves. They are of two forms, each plant bearing one kind only.

1. Short-styled form. The calyx is tubular with 4 filiform teeth, the corolla is also tubular with 4 recurved short lobes, white or pale-lilac. The stamens are inserted in the corolla tube and are thrust forth about 1 mm above the throat. In this form the style is short and the 4 stigmata are spread in the throat.

2. Long-styled form. The calyx and the corolla are of the same shape as described in the short-styled form, except that the calyx is a little shorter. The style is longer than the tube and the 4 stigmas are spread out about 1 mm above the throat of the corolla tube.

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[1]) P. KNUTH, Handb. d. Blütenbiologie, Vol. II, Tome II, p. 330.

[2]) W. DOCTERS VAN LEEUWEN, Planten en Dieren op de top van de Pangrango. De Tropische Natuur, Tome XVI, p. 191; fig. 34.

Pollination. Only once, in March 1921, I did not see insects on the flowers, but on every other occasion I noticed that numerous individuals of *Bombus rufipes* collected, from early morning till sunset, pollen and nectar. *Apis indica* is also a visitor, but not such a regular one as *Bombus*. LEEFMANS, who found the plant near Telaga Bodas in the Preanger Regencies, noted on his collecting label, that he saw the flowers regularly visited by *Bombus* and *Apis*. On Mt. Papandajan the flowers were regularly visited by the first named insect.

Cross-fertilisation is of common occurrence in these plants; self-pollination must be very difficult, especially in the long-styled form.

Flowering-time. During a great part of the year the plants are loaded with flowers; in the neighbourhood of Kandang Badak flowering stops partly or entirely from July till September, but starts again from October till May and June. In March 1921 flowers were abundant near Kandang Badak, but higher up, on the slopes of Mt. Gedeh, there were no flowers at all.

2. NERTERA DEPRESSA BANKS ET SOL.

This widely distributed herb is common on the mountains of Java. On Mt. Pangrango-Gedeh it occurs also from Tjibodas upwards to the very summits of both mountains. It prefers moist, shaded localities, where it grows on the ground, on moss-cushions, on decaying trunks and on stones, which it covers with dense mats. It grows also epiphytically, especially on the stems of *Alsophila*.

The shoots are about 1 mm thick, at their upper side they are often red-brown. The leaves are opposite, broadly triangular or heart-shaped; the petiole is about 10 mm long. In the axils of the leaves of the horizontally growing shoots short ascending branches are formed; they have short internodes, and the leaves are smaller than those of the prostrate shoots. The two upper leaves fit with their base against each other, and hide the bud. When the flower opens, only the corolla-lobes and the sexual organs appear above the leaves. The calyx remains hidden; it is tubular, green with a red margin, and truncate. The corolla is trumpet-shaped, the pink lobes are flatly expanded. There are 4 stamens with long filaments; they project far beyond the corolla.

The pistil consists of a green inferior ovary and 2 long, widely expanding, hairy stigmas. The fruit is an orange-red or red berry, containing 2 hemispherical seeds, with the flattened sides turned towards each other.

Pollination. In the older bud, while the corolla is still hidden between the apical-leaves, the two stigmas already stick out, and they develop still further, curving outwards; after that the flower opens. The flowers are therefore strongly protogynous.

The pollen grains are fine and it is very probable that pollination is carried out by the agency of the wind. But especially in the rainy season

the flowers may be very moist, sometimes a drop of water lies between the upper leaves and the sexual organs, and pollination by wind is rendered more difficult.

In the further course of the development of the flower, part of the anthers may come in contact with the styles; in the older flowers the stigmas were covered with pollen, whereas in the younger flowers I have never seen any pollen on the stigmas.

Though pollination by wind is possible, self-pollination is on Mt. Pangrango the rule, in fact all flowers set fruit.

According to FRANCHE [1]) this plant is protogynous and autogamy would be impossible. According to DELPINO the species of this genus are anemophilous. The various New-Zealand species, and among them *Nertera depressa* too, are (according to THOMSON [2])), protogynous and anemophilous.

Dispersal of the seeds. By what means the distribution is effected. I do not know. The fruits are very watery, and have not much taste; I have never seen that they were eaten by birds, neither did I find seeds in their stomachs. Still, dispersal by animals is highly probably; the mountain-rat: *Rattus lepturus*, when kept in captivity, is very keen on the fruits.

3. OPHIORRHIZA LONGIFLORA BL.

This stout herb is very common along the path leading to Kandang Badak, between 1700 and 2400 m. It has a strong rhizome and a succulent vertical shoot. Its snow-white flowers are very conspicuous.

The corolla tube is narrow; at the base it shows a spherical swelling. Towards the mouth the tube widens slightly, diverging into 5 spreading lobes. The tube is white or sometimes light-pink; at the inside it is covered with tiny hairs. The stamens possess short filaments and are inserted about half-way in the corolla tube. The style projects considerably beyond the anthers and the two stigmas lie in the entrance of the tube; they are long, broad and mostly obliquely spreading. At both sides of the base of the style a flat scale appears, which probably secretes the nectar which is present in the bottom of the tube.

I have never observed pollinators; thripses and their pink larvae, however, live in the flowers and even in the adult buds. These animals probably transport the pollen from the anthers to the stigmas. The stigmas of all the flowers which I examined were already pollinated, even those in adult, yet closed buds. The delicately scented flowers face obliquely downwards; they all set fruit.

Specimens with much smaller flowers also occur, viz. var. *minor*. The

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1) See P. KNUTH, Handb. d. Blütenbiologie, Vol. II, Tome I, p. 549.

2) See P. KNUTH, Handb. d. Blütenbiologie, Vol. III, Tome II, p. 183, fig. 185.

flowers show the same structure as those of the type, only all parts are much smaller, the tube measures ½ to 1 cm in length. The base of the corolla tube is also swollen and surrounds the nectar glands. The stamens are inserted in the lower part of the corolla tube, the filaments are pressed against the style, which projects beyond them; and the two broad and rounded stigmas reach somewhat higher than midway the tube. They are open and nearly fill up the lumen of the tube. Up to the present time I found no thripses in these flowers and no pollen on the stigmas. The plants are not so common as the first mentioned, and all parts are smaller.

FAMILY OF THE CAPRIFOLIACEAE.

1. LONICERA JAVANICA DC.

KOORDERS [1]) distinguishes two species of this genus, viz. *Lonicera javanica* and *Lonicera Loureiri*. The distinctive marks mentioned by him, however, are but little characteristic: one may find on the same branch leaves with a cordate base and a short acute apex, and others with a rounded or tapering base, and a caudate top. KOORDERS reports that the first-mentioned species occurs at altitudes from 1700 to 2800 m; and the second from 2000 to 3300 m. The form with the extremely hairy young branches known as *Lonicera Loureiri*, is very probably peculiar to the higher stations. KOORDERS mentions *L. Loureiri* from the top of Mt. Pangrango, but the plants of this locality vary in habit, in pubescence and in the size of the flowers and of the fruits. I think therefore that it is better to treat them, in this present book, as a single species.

Fig. 60. Flowering branch of *Lonicera javanica* DC. × 3/4.

The plant is common on all Javanese mountains; it has been found locally at elevations of 1300 to 1400 m, but most of the finding places lie above 2000 m. In the Herbarium at Buitenzorg it is represented also from Sumatra namely from Habinsaran, 850 m, and from the Peak of Korintji. From the Himalayas it is known too (*Lonicera Loureiri*). One will

[1]) S. H. KOORDERS, Exkursionsflora von Java, Vol. III, 1912, p. 286.

find it as a straggling shrub in the rain forest or as a slender liana ascending in the trees in the underwood, on the slopes of ravines, in young forest, on rocks and in grass-land, but chiefly in alpinoid forest and in alpinoid shrub. In the rain forest and on its outskirts and in alpinoid forest it grows as a liana, which may climb 10 m and more into the trees; in bare places and in shrub close by one may find it as a shrub; when they grow, however, in the neighbourhood of a tree or of a shrub providing sufficient shade, they may develop twining shoots. This plant is very sensitive to light, and turns its leaves and flowers as much as possible towards it.

The branches with their abundance of flowers often cover the top of the supporting tree and hang down in festoons. On the top of Mt. Pangrango it grows gregariously in alpinoid forest, in shrub and in grass-land. In the last named locality the plants have short internodes and densely pubescent, sometimes rust-coloured branches. We may consider them as the alpinoid form and not as a separate species, as they merge gradually in the forms occurring in other localities. The shoots are dextrorsely twining; in older specimens they become 1 cm thick, and show an exfoliating bark. The young shoots are sometimes collected in bundles at the end of the main branches; they are glabrous or variously pubescent. The leaves have shorter or longer petioles; sometimes, especially in the upper part of the shoots, they are subsessile; on the flowering part of the shoot they become smaller and change more or less into bracts. The young leaves are often a beautiful purple-brown.

The flowers occur in axillary pairs, which are congested at the end of short shoots. They have a short peduncle (in the form growing in lower regions one often finds the flowers grouped in long-pedunculate axillary inflorescences; here, however, only the forms occurring on the top of Mt. Pangrango will be described). With the ripening of the fruits the shoots stop growing. The two flowers arising in the same axil, expand simultaneously. The description of the flowers causes some difficulties because they vary greatly in form and size; I will describe therefore some of the more common variations; they are, however, all connected by intermediate forms.

The female form. The calyx is 5-toothed. The inconspicuous corolla, first pale-yellow, later dark-yellow, is 5-petalous, and trumpet-shaped. There are 4 short lobes at the upper side grouped so as to form a small hood and a larger broader lobe, curved downwards and often more or less rolled up. In the nearly adult bud the anthers of the 5 epipetalous stamens are as yet pale-green and closed. The style is of the same length as the corolla and bears a capitate stigma, which is already somewhat sticky. When the flowers begin to expand, the large inferior lobe curves outward and downwards, but the anthers still remain pressed against each other. The flower now elongates still further, and the upper half of the limb expands more or less horizontally and the inferior lobe curls still more. Three of the five stamens remain enclosed within the hood, formed by the

upper part of the limb, while the lower pair turn somewhat outwards. The style, which was also at first hidden under the hood, now points straight forwards and the thick, shortly 3-lobed stigma is exposed. The basal parts of the style and of the filaments are covered with hairs which obstruct the entrance to the lower part of the corolla tube. In the anthers, which remain closed, no pollen is present. The dimensions of the various parts are: tube 9 mm, limb 9 mm, anther 2 mm, style plus stigma 18 mm.

The bisexual form. In other plants the flowers are much larger, see figure 60. The tube is wider, the limb broader, the stamens especially the two inferior ones are longer and project further outwards, and the style too is considerably longer. The uppermost stamen is the only one which lies with its anther under the hood. The dimensions of the various parts are here: tube 22 mm, limb 14 mm, anther 6 mm, style plus stigma 39 mm. The anthers contain much pollen. This second form is homogamous or slightly protandrous.

Fig. 61. Galled branch of *Lonicera javanica* DC. $\times 3/4$.

Both kinds regularly set fruit. There exists a considerable range of intermediates between the two forms. During the morning-hours both produce nectar.

In some years on Mt. Pangrango a great number of misshapen flowers may be found; on Mt. Sumbing I found them also. The most thoroughly deformed ones remain very small, they do not open and form dense clumps, more or less hidden between the upper leaves, figure 61. Other flowers open more or less, but of the normal structure not much is left. The stigma and the stamens, which still may produce pollen, remain hidden. The flowers are moreover often red, and the perianth is sometimes spirally twisted, not only the tube but the lobes also. In some cases the number of the stamens is reduced to two. It is therefore clear that the youngest flowers suffer most from the affection. What the cause of the deformation is I cannot tell, though there are indications pointing towards gall-forming, effected by an Aphid or gall-mite. I have not been able, however, to discover the animals, nor did I find any fungi.

The fruits are first green and crowned by the small calyx; on maturing they become darkblue to black. They contain a big stone, figure 62. In the stomachs of the animals examined I did not find these stones, so I cannot tell anything about the dispersal, though it is probably effected by animals.

Pollination. The flowers are frequented by *Bombus rufipes*; one may often observe, that the bumble-bees which visit this plant, avoid the flowers of *Hypericum* and vice versa. On Mt. Sumbing and Mt. Tjikorai I saw this insect also on *Lonicera*. Generally nectar but no pollen is

Fig. 62. Fruits of *Lonicera javanica* DC. $\times$ 3/4.

collected. On Mt. Tjikorai I observed also a *Geometrid*: *Milionia fulgida*, and several times Syrphid-flies which, however, do not occur regularly on the flowers. I noticed: *Chamaesyrphus nigripes*; *Syrphus serarioides*, *Megaspis errans*. *Apis* visits the flowers also once in a while.

In addition to insects these flowers are fairly regularly visited by the common honey-bird of Mt. Pangrango: *Aethopyga eximea*; this lovely bird clings in the strangest poises to the branches, and thrusts its bill deep into the corolla tube. The parts round the nose get sometimes thickly powdered with pollen, as I have repeatedly observed; this little bird is by no means shy.

On several American species of *Lonicera* humming birds (Colibris) but also bumble-bees, butterflies and Syrphid-flies have been observed as visitors; cf KNUTH [1]).

Flowering-time. This plant flowers nearly the whole year abundantly or fairly much. Differences exist in so far that in one month of a particular year flowering may be luxuriant, while in the same month of another year but few flowers occur; this may be easily seen in the table on page 88, and this is the reason why the curve has become irregular, figure 63. The cause of this phenomenon in not clear to me; in the moist year 1921 flowering was abundant in November, while in the abnormally dry year 1925 in that same month very few flowering plants

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[1]) P. KNUTH, Handb. d. Blütenbiologie, Tome II, Vol. II, p. 191.

occurred. Abundant fruit-bearing alternates often with a rich blossoming. It may also happen that at one time a great number of plants are in full flower and others not at all.

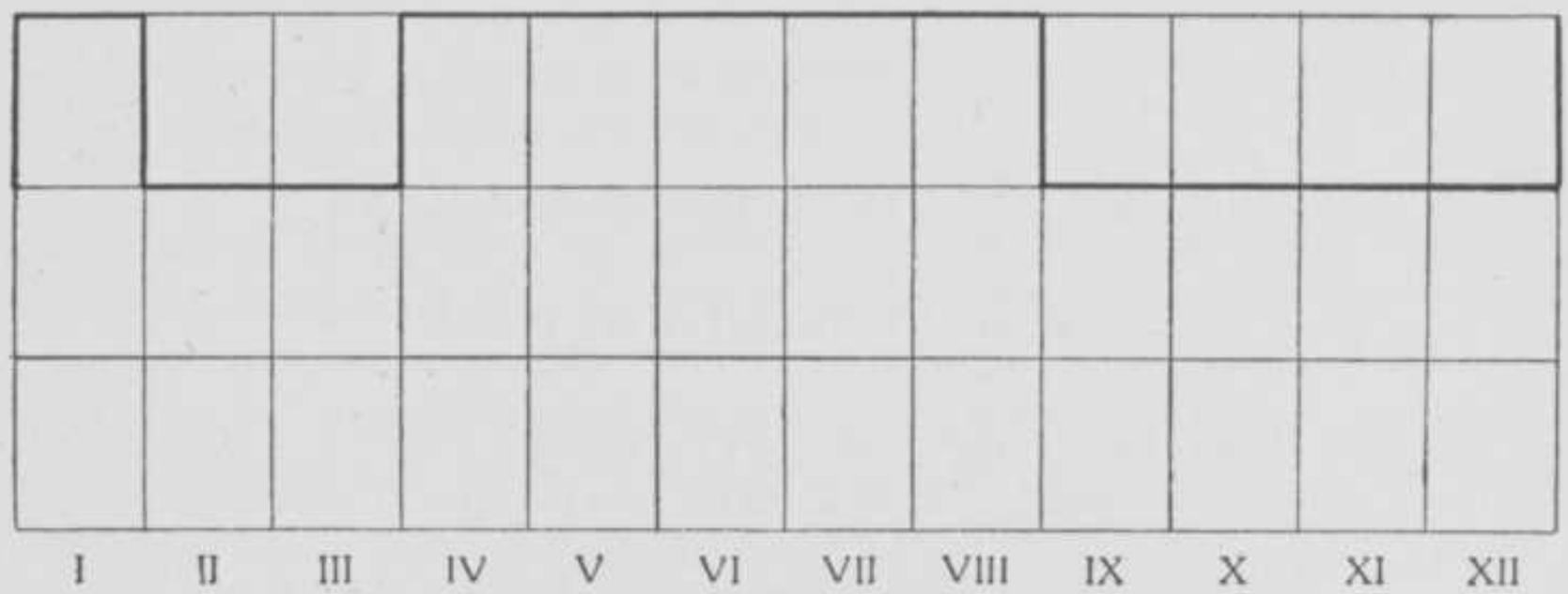

Fig. 63. Flowering-time of *Lonicera javanica* DC.

2. VIBURNUM CORIACEUM BL.

This tree is known from Mt. Salak, Mt. Gedeh-Pangrango, Mt. Papandajan and Mt. Patuha in West Java, and it has further been collected on many mountains in Central and East Java. It has also been found in Bali, in Sumatra, and moreover on the Himalayas. One finds the plant at high altitudes in the rain forest, in alpinoid forests, in tjemara forests and in grass wildernesses, though not generally. On Mts. Pangrango-Gedeh, above Kandang Badak, it is locally very common, on the top of Mt. Pangrango I know but a single individual, which grows in the northeastern part of crater valley among *Hypericum* shrubs.

The plant develops into a shrub or a low tree. The trunk is erect cylindrical and often nodose and it bears a fairly dense crown. The young parts are covered with stellate hairs. The leaves are ovate-lanceolate, tapering into a long point, the margin is acutely dentate; at the upper side they are a deep green, the under side is covered with fine scales. They measure 100 to 250 mm in length and 20 to 50 mm in width. The shoots which do not flower bear large leaves; those on the flowering shoots are smaller.

The flowers are arranged in terminal corymbs. The minute calyx is denticulate; the white or purple corrolla is tubular, it is about 4 to 5 mm long, and 1½ mm wide, and shows an upright limb. There are 5 stamens, and a small pistil with a short stigma.

Pollination. When the flower opens, the anthers are still closely appressed against each other, and appear at the mouth of the corrolla tube; then the stamens develop considerably until they project about 1 mm beyond the flower. Before the bud opens the anthers have usually dehisced already and pollen has fallen upon the stigma. Self-pollination therefore

takes place regularly in these flowers. I have only once observed a *Bombus* on a flower of the tree on the top of Mt. Pangrango. On Mt. Tjikorai I also saw *Bombus* on the flowers.

The drupes are eaten by birds; on Mt. Sindoro we found the stones in the intestines of *Zosterops palpebrosa sindorensis* [1]).

FAMILY OF THE CAMPANULACEAE.

1. PRATIA MONTANA HASSK.

On Mts. Pangrango-Gedeh this plant is frequent above Tjibodas, especially at altitudes between 2200 to 2500 m. It is an erect or ascending herb. The axillary flowers are borne on long pedicels; the flowers are zygomorphous. The calyx is green, and provided with 5 filiform, spreading lobes. The corolla is pentamerous and purple. In the bud it is gamopetalous and curved, during the process of maturing the corolla splits at the top and curves downward; the 3 inferior lobes are alike, with white hairs along the margin, the 2 superior lobes are narrower and of a darker colour.

The sexual organs are directed upwards and the top crooked downwards, the 5 filaments are united into a tube except at the apex. The anthers are also connate. The three upper anthers are somewhat longer than the 2 lower ones; the latter are provided with some stiff, white hairs. The ovary is inferior, barrel-shaped; the style is hidden in the filament-tube.

Pollination. In the adult bud pollen is shed into the cavity formed by the anthers, and on the first flowering-day this space is filled with pollen; the apex of the stigma lies at the base of this cavity and it is already covered with pollen.

On the second flowering-day the style elongates until the stigma finally projects beyond the anthers; the stigma expands now its two lobes. Self-pollination is the rule with these flowers. I never saw visiting insects, but all flowers set fruit, which matures as a dark-purple, glossy berry.

FAMILY OF THE VALERIANACEAE.

1. VALERIANA HARDWICKII WALL.

This stout herb has been found on several Javanese mountains and also is known from Sumatra (Mt. Korintji), from Ceylon, and from the Himalayas. In Java it prefers altitudes above 2000 m, and grows up to the very summit of the mountains, but it has also been collected in localities

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1) HANS DOCTERS VAN LEEUWEN, Beitrag zur Kenntnis der Avifauna der Mitteljavanischen Vulkane Soembing und Sindoro. Treubia, Bd. X, 1929, p. 445.

down to 1400 m. One finds the plant in moist places clothed with vegetation, in grass wildernesses, in alpinoid shrub, in Tjemara forests, on the edge of the forest ; also on stony slopes and at the border of grass plains ; when growing in high grass the plant may reach a height of over 1½ m. On Mt. Pangrango it grows along the forest-path leading to the summit ; on the top itself it occurs in an open patch, though always more or less in the vicinity of and among the bushes.

The plant has a stout ascending rhizome, from which the stem arises. The leaves are pinnate, the leaflets lanceolate and acute ; the leaves at the base of the stem are often simple ; they soon wither. The flowers are borne in terminal compound corymbs. The calyx is 10- (sometimes 11- of 12-) toothed, green, sometimes brownish. The corolla is pentamerous, funnel-shaped and white. There are 3 epipetalous stamens ; the pistil consists of an inferior ovary, and a style terminating into 3 stigmas.

Pollination. The flowers remain open during 3 days.

First flowering-day. The anthers are open but the stigma lobes do not diverge as yet, and the flowers are therefore strongly protandrous.

Second flowering-day. The anthers are open, and the stigmas diverge ; they are mostly propped against the anthers and get pollinated.

Third flowering-day. The anthers have fallen off, the stigmas are expanded.

In the bottom of the corolla tube some nectar is secreted by a small gland. I did not observe many visitors on the flowers ; once I saw a little black Ichneumon-fly : *Pterocormus* species, and further I observed several *Diptera*, viz. *Rhadinomyia orientalis, Lispocephala boops, Servilliopsis buccata, Chamaesyrphus nigripes, Syrphus koningsbergeri, S. serarius* and *S. serarioides*. Self-pollination would be the rule with these flowers.

In Europe many visitors have been observed on the flowers of *Valeriana*-species, chiefly *Diptera*, but also *Coleoptera*, see KNUTH.

Flowering-time. The plants are throughout the year in full flower, only in the driest months of the year the number of flowers diminishes slightly.

After flowering the calyx lobes develop into thin, feathery appendices, which form a whorl below the top of the fruit and support it when it floats on the air. The wind has thus a chance of scattering them.

FAMILY OF THE COMPOSITAE.

1. ANAPHALIS JAVANICA SCH. BIP.

The so-called Javanese "Edelweisz" is probably one of the best-known plants of the high mountain tops, and every tourist is sure to have noticed it. But it is not so common as one might expect, and it is not found on every

Javanese mountain. Two nearly allied species occur in Java, *Anaphalis javanica* and *A. viscida*.

In the Herbarium at Buitenzorg both species are represented by a large number of specimens. In the fresh state they are easily distinguishable, as the colour of *Anaphalis javanica* is light to grey-green in consequence of a dense tomentum, and that of *A. viscida* is darker green, and as the leaves of the first-mentioned species are, as a rule, broader and flatter than those of the second-named plant. In dried material these differences are by no means striking. The dark colour of the discoloured mesophyll appears through the tomentum and *Anaphalis javanica* becomes in this way often very similar to *A. viscida*. The main difference between the leaves of the two species is that those of *A. javanica* are tomentose on both sides, and possess no glandular hairs, whereas the indumentum of *A. viscida* is much less dense and its leaves are provided with glands. The latter, however, are not easily visible. Magnification with a hand lens is not sufficient ; it is necessary to boil sections of the leaves and to examine them with the aid of the microscope. All the available herbarium material I have examined in that way. It is questionable, however, whether conclusive discrimination of the two species by that character is practicable. For that purpose a detailed investigation of all characters would be required. The results of the leaves examined in the manner described guarantee, however, sufficient certainty for my purpose, that is, for the identification of herbarium material, which on account of bad drying is not at once recognizable.

We have two species therefore, which are distinguishable by the characters of the leaf.

I. One with a very dense, woolly indumentum on both sides of the leaf, and without glandular hairs: *Anaphalis javanica*.

II. One with a thin indumentum and with a great many glands: *Anaphalis viscida*.

There are also intermediate forms, more densely tomentose than the typical *A. viscida*, but provided with far less glands.

Both species can often be found on one and the same mountain, for instance on Mt. Merapi (Idjen) and on Mt. Ardjuno. Sometimes all available material, collected on one mountain, for instance on Mt. Slamat, belongs to the more or less intermediary form. It is unknown whether hybrids between both species of *Anaphalis* occur, but it is desirable that this problem should be investigated.

Here I have reckoned all plants with glands to *Anaphalis viscida* and the remainder to *A. javanica*.

All specimens from Sumatra, from Mts. Talamau, Merapi, Singgalang and Korintji are densely tomentose and not glandular, and are consequently *Anaphalis javanica*. Material from Mt. Agung in Bali belongs also to this species.

I will now give a summary of my observations on the two species in Java.

Mountains where exclusively *Anaphalis javanica* has been collected are: Mts. Pangrango-Gedeh, Mt. Papandajan, Mt. Sumbing and Mt. Sindoro, and the Dieng-Plateau.

Mountains where *Anaphalis viscida* only has been collected are: the Mts. Slamat, Hijang, and Tengger.

Both species are represented on the mountains: Tjerimai, Merbabu, Lawu, Kawi, Ardjuno, and Merapi (Idjen).

Anaphalis javanica occurs therefore from West to East Java, whereas *A. viscida* is more frequently represented on the eastern mountains. Its most western locality being Mt. Tjerimai (where the leaves show very few glands). On the mountains in East Java, i.e. Mts. Lawu, Kawi, Ardjuno, and Semeru *Anaphalis viscida* predominates, which gives the landscape by its dark colour a quite different aspect from that produced by the white *Anaphalis javanica*, for instance on Mt. Pangrango.

A fine description of *Anaphalis javanica* is found in "Junghuhn" [1]), who uses De Candolle's name: *Antennaria javanica* for it, and tells that the natives call it Sendoro. One of the mountains of Central Java, Mt. Sindoro owes its name to this plant.

It occurs up to the highest summits and is confined as a rule to the fourth belt of JUNGHUHN. On several sparsely wooded mountains, such as Mt. Sumbing and Mt. Merbabu, it can be found however at considerably lower altitudes (± 1600 m). The principal requirement for its existence is a large amount of light. In dense alpinoid forest it occurs but seldom and then usually in young or poorly developed specimens. Ordinarily it thrives best where this kind of forest borders on open spaces. Besides, it is to be found on open grounds, such as crater-fields, but then, generally in small, low specimens. They grow but slowly; on Mt. Pangrango seedlings were observed in 1919; they grew next to my hut and year by year I have observed them, and up to the present (1932) they have reached a height of about 20 cm, only consequently they have grown but a few centimeters a year. On more fertile soil, growth, however, is much quicker, as soon as they begin to branch. Tall specimens with stems of 15 cm diameter, must be at least a hundred years old. I found the largest specimens on Mt. Sumbing, growing on the tholoid in a sheltered spot, secure from fire [2]). A number of plants were united into a bush; they were well-developed trees about 6 m high; the base of their trunk was about 50 cm in diameter. On Pangrango some old and tall specimens grow also densely together. Where they form a border along the dark *Vaccinium*-forest, they are very conspicuous by their showy white leaves and flowers. In contrast with old specimens clumped together, the stem of which does not branch before a

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1) FR. JUNGHUHN, Java I, p. 581.

2) W. M. DOCTERS VAN LEEUWEN, Beitrag zur Kenntnis der Gipfel-vegetation der in Mitten-Java gelegenen Vulkane Soembing and Sindoro. Bull. d. Jard. Bot. de Buitenzorg, Série III, Vol. XI, 1930, p. 38.

certain height is reached, old isolated specimens, which receive light from all directions, develop more or less hemispherically.

Fine fotos of the habit and habitat are to be found in SCHIMPER [1]) and ERNST [2]), a detailed description is given by KOORDERS and VALETON [3]). About the distribution of both species not much was known till now; at any rate these authors indicated the whole of Java for *Anaphalis javanica*, especially East and Central Java.

The root-system of this plant grows for the greater part horizontally. VON FABER [4]) considers this phenomenon in relation to the presence of mycorrhiza. Mycorrhiza, according to him, prefers the upper layer, because the fungus is very much in need of oxygen. Partly it may be explained, however, by the fact that the plants often grow in very poor rocky ground, where it is difficult for the roots to force their way down.

The stem is covered with a rough longitudinally fissured bark. The rough fissures are likely to retain a large amount of water and accordingly they offer an excellent station for mosses and lichens, which may be collected on them in great variety.

The following species of lichens I found on them on the top of Mt. Pangrango *Anaptychia speciosa* var. *sorediata*, *Cetraria sanguinea*, *Cladonia calycantha*, *Cladonia coccifera*, *Cladonia deformis*, *Cladonia Floerkiana*, *Cladonia pityrea*. In the crater valley very big thalli of *Cetraria sanguinea* creep up against the stems of *Anaphalis*. Small individuals may be smothered by them or may sink down under their weight.

The leaves are congested at the ends of the branches, they are sessile, linear, and acuminate, tomentose with white, woolly hairs, 4 to 6 cm long, and ± 0.5 cm broad, and obliquely ascending. The old withered leaves remain for a long time on the branches, surrounding them like a mantle. As a result the shade of the older, well-developed specimens is dense, as is already mentioned by JUNGHUHN l.c. The shortly pedunculate capitula are arranged in compact, terminal corymbs. Seen from above the latter are surrounded by the tops of the leaves on the axis. The florets are developed on a flat receptacle and their golden hue is due to the orange-yellow anthers. They diffuse a fresh and aromatic scent.

Each head is surrounded by an involucre of strawy bracts, which are white; the outer ones are covered with white hairs, the inner ones are glabrous.

Pollination. The florets of a capitulum are all tubular. The corolla tube bears 5 teeth and is a pale yellow. The anthers are united into a tube and dehisce in the morning, producing the orange-coloured pollen. The stigmas are then still hidden in the anther-tube. In the afternoon the style elongates and the stigmas get covered with pollen, but they are still

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1) A. F. W. SCHIMPER, Pflanzengeographie, p. 760, fig. 419 and 420.
2) A. ERNST, Vegetationsbilder, Reihe 7, Heft 1 and 2, pl. 2 and 36.
3) S. H. KOORDERS and TH. VALETON, Boomsoorten op Java, Part V, 1900, p. 56.
4) F. C. VON FABER, Die Kraterpflanzen Javas. Weltevreden, 1927, p. 71, fig. 7.

closed. Next day the stamens shrivel up and part of the style and the stigmas are liberated. In some cases the stigmas expand.

Self-pollination is therefore possible, but the flowers are regularly and frequently visited, the capitula keeping open table for the insects of the mountain-tops. Many visitors can be found on this plant; *Bombus rufipes*, however, I observed only once. The other insects, however, are very sensitive to cold and wet, and on cloudy days, (and the latter are frequent even in the flowering-time of this plant), one does not see a single visitor. Under these circumstances self-pollination must take place.

On Mt. Pangrango I noticed the following visitors.

1. *Hemiptera*; a small, grey *Hemipteron*, viz. a species of *Nysius* is very common on the capitula.

2. *Thripsidae*; thripses often occur on the heads.

3. *Lepidoptera*; several *Microlepidoptera*: *Scoparia murificalis* and others, and some *Rhopalocera*, viz. *Celastrina askasa* and *Dodona adonira windu*; once I saw *Pyrameis cardui* on the flowers.

4. *Hymenoptera*; several small, black Ichneumon flies, *Pterocormus* spec. and others visit this plant, but not regularly and only in small numbers. *Apis indica* behaves in a very remarkable way. For days and even for weeks one does not see a single individual on *Anaphalis*, though they hover about on the mountain-top. Then suddenly the plants are favoured with the sympathy of large numbers of them, and they carry off thick orange clots of pollen. On Mt. Lawu the flowers were visited and their pollen collected by *Halictus monachus*; on Mt. Papandajan I saw *Polistes diabiolicus* on the flowers.

5. *Diptera*. Many sorts of flies are attracted by the flowers; especially Syrphid-flies are very common visitors. Several species are not yet identified. Of the other species I observed: *Syrphidae*; *Chamaesyrphus nigripes*, *Eristalis kobusi*, *Syrphus confrater* and *S. serarioides* numerous; less numerous: *Eristalis bicornutus*, *Megaspis chrysopygus* and *M. zonalis*, *Syrphus latistrigatus* and *S. koningsbergeri*; *Calliphorinae*: *Calliphora fulviceps*, *Idiella quadrimaculata* and *I. unicolor*; *Anthomyinae*: *Coenosia aniphila*, *Limnophora prominens* and *L.* species; *Ortalinae*: *Rhadinomyia orientalis*; *Tachinidae*; *Echinomyia angulata*, *Servilliopsis buccata* and *Servillia flavopillosa*; *Trypetinae*: *Tephritis montana*. On other mountains I noticed on this plant and on *Anaphalis viscida* also several *Diptera*, but never as many as on Mt. Pangrango and Mt. Gedeh. BECCARI [1]) already noticed, when climbing Mt. Pangrango, that *Anaphalis javanica* was visited by a large number of flies.

Flowering-time. Though plants in flower may be found nearly the whole year through, the main flowering-time is rather short; it is restricted to June and July, the time when there is a good chance of sunny days and when the pollinating *Diptera* therefore get the best opportunities for

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[1]) O. BECCARI, Malesia, 1878, Vol. I, Fasc. III, p. 221.

visiting the flowers. In January the buds swell, and flowering begins here and there. In February, March and April the number of flowering plants is still very small; in May the number varies somewhat: in one year there are but few, the next year some more. In June and July almost all plants

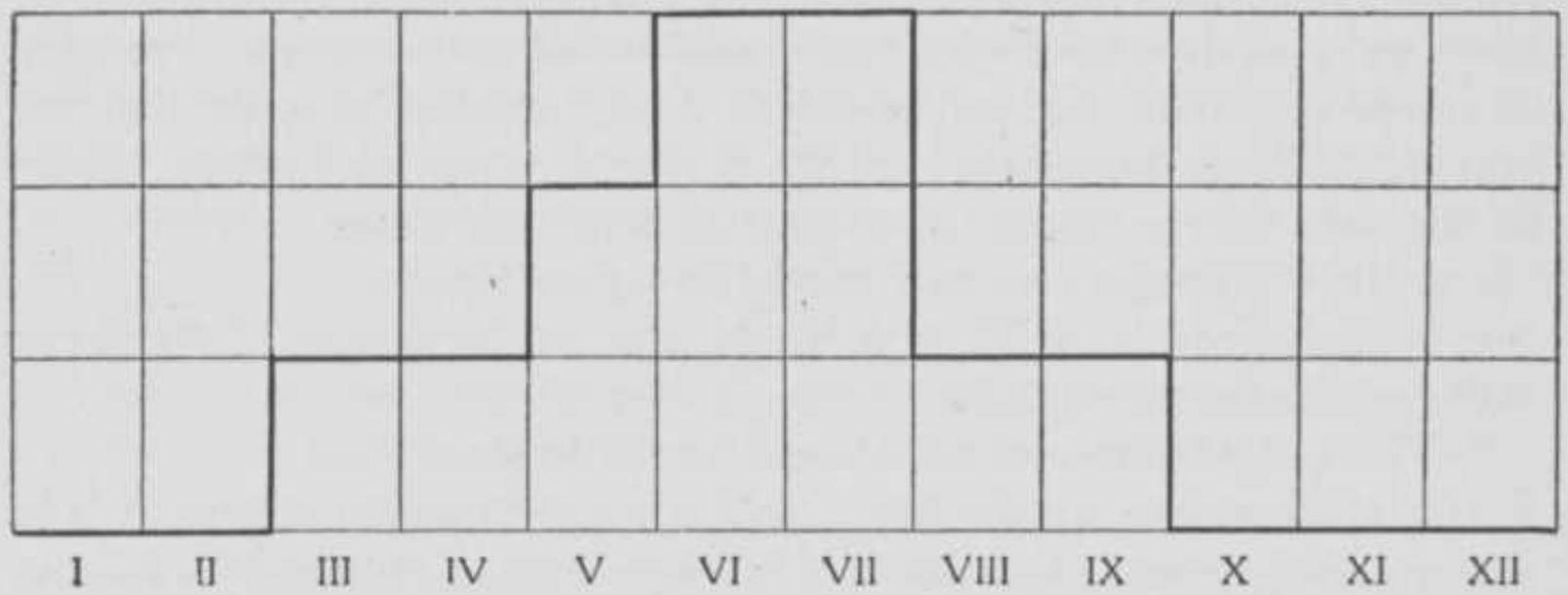

Fig. 64. Flowering-time of *Anaphalis javanica* SCH. BIP.

are in full flower. In August and September the number falls off considerably and in the closing months of the year flowering is reduced to a minimum. See figure 64. After the flowering the small fruits develop, the inflorescences because of the expanding fluff becoming woolly and loose. The fruits are small, black, sub-cylindrical achenes. They bear on their upper side a pappus, formed by a single row of soft hairs. The fruits are easily detached and dispersed by the wind. Seedlings and young plants germinate in many places, also on spots where the plants do not thrive, for instance in the forest around the mountain-top. On landslides at a high altitude this plant is one of the first pioneers. *Gnaphalium longifolium* is a pioneer at lower levels, as I noticed once at Kandang Badak at an altitude of about 2500 m.

I have published already elsewhere a short description of the pollination[1]). Self-pollination is possible, but because of the great number of regularly visiting insects cross-pollination will be the rule. Pollination is mainly effected by *Diptera* and *Apis;* not by *Bombus*. On this plant occurs a thrips-gall. The thripses live in compactly growing, more or less rudimentary leaves of the sterile branches, where they propagate too[2]).

2. ARTEMISIA VULGARIS L.

This wide spread plant also occurs frequently in Java. It is found usually at elevations between 600 and 1400 m, along roads, on the little dikes of

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[1]) W. DOCTERS VAN LEEUWEN, Uit het leven van planten en dieren op de top van de Pangrango. De Tropische Natuur, Vol. XVI, 1927, p. 188, fig. 30 and 31.

[2]) Mrs. J. DOCTERS VAN LEEUWEN-REIJNVAAN and W. DOCTERS VAN LEEUWEN, The Zoocecidia of the Netherlands East Indies. Batavia, 1926, p. 553, No. 1505, fig. 1065.

the sawahs, in fields, in shrub, but exclusively in more or less open localities. Locally it may be found at lower elevations but it has also been noted on several mountain-tops, for instance on Mt. Ardjuno at an altitude of 2500 m, in the "Sandsea" (Tengger-mountains) at 2200 m, and on the top of Mt. Pangrango at 3000 m. Between Tjipanas and Tjibodas and also in the garden itself this plant is exceedingly common but in the forest it is quite absent. In barren, stony parts of the top of Mt. Pangrango and at the border of the alpinoid underwood it grows gregariously. The plants flower but seldom and then generally a few old bushes only. I have never observed any insects visiting the flowers; according to some investigators many species of the genus *Artemisia* are anemophilous, see KNUTH [1]). They multiply easily by means of offshoots of the rhizome, and, once established in a certain locality, they form dense group.

According to BACKER and VAN SLOOTEN [2]) fruits never develop in Java.

3. BIDENS PILOSA L.

This composite is a frequent weed in many stations; along the forest-path at Kandang Badak it grows in small groups. Once in a while I observed there *Apis indica* on the flowers, sometimes also Syrphid-flies.

At Tjibodas the capitula were visited by *Syrphus balteatus*.

4. DICHROCEPHALA CHRYSANTHEMIFOLIA DC.

This herb is common in Java, it may be found in the mountains from altitudes of 1700 m upwards, though it occurs mostly in the fourth belt of JUNGHUHN and also on several high tops. It grows in moist stations as well as in dry localities, on sandy plains, in craters, among shrubs and in grass wildernesses, even in very stony places and on barren rocks. It has also been found on the Peak of Bonthain in South Celebes, on the top of Mt. Agung in Bali and it occurs further in the Philippine Islands and in the Himalayas.

On Mt. Pangrango it occurs frequently in open stations along the forest trails on the top; in especially dense groups under low shrubs. Large specimens are repeatedly branched, but those growing on poor soil generally bear but few lateral branches, and only in the upper leafless part of the stem. The leaves are oblong, and mostly deeply incised; they are best developed at the base of the stem, towards the top of which they merge into bracts and bracteoles. The latter are lanceolate or linear, and bear

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1) P. KNUTH, Handbuch der Blütenbiologie, Vol. II, Part I, p. 605.

2) C. A. BACKER and D. F. VAN SLOOTEN, Javaansche Teeonkruiden. Batavia, 1924, p. and pl. 231.

a few coarse teeth. The capitula are borne on the end of slender stems, they are cylindrical, rounded at their top and consist exclusively of actinomorphous flowers. The peripheral part consists of a large number of white (sometimes purple) florets with a filiform corolla. These florets are all female; the two widely expanded stigmas protrude beyond the corolla. The central part of the capitulum is violet (sometimes sallow); here somewhat larger florets are found, which are bisexual and show the usual structure of the composite flower.

Pollination. Already early in the morning the peripheral florets open; all the stigmas are widely expanded; these florets remain for days unchanged. The bisexual florets open later in the day; the anthers dehisce first, and the stigmas brush subsequently the pollen out of the tube, and in doing so they may get pollinated; they do not expand in these florets.

I have never observed insects visiting these flowers. Thripses, however, often occur in them, and they might effect self-pollination. The achenes are oblong, without a pappus, but very sticky, consequently they may easily stick to passing animals.

The plants flower chiefly in the rainy season; in the dry months they may wither altogether.

On Mt. Lawu I noticed a virescence of the flowers, caused by gall-mites [1]). It was remarkable that while the ordinary flowers were quite withered, the mite-galls had remained green throughout the east-monsoon; the animals accordingly were able to survive the dry months.

Fig. 65. Dwarf specimen of *Erigeron linifolius* WILLD. ×1.

5. ERIGERON LINIFOLIUS WILLD.

This weed of American origin is spread over the whole of Java and occurs from the low-lying plains up to the top of several mountains. On the top of Mt. Pangrango this plant is but a passing stranger, it appears now and then and disappears again. The plants are but seldom well-developed. In the crater-valley on the stony ground specimens may sometimes occur which reach a height of a few centimeters only; they bear but few leaves, but they produce a few capitula, see figure 65, and fruit abundantly.

The achenes are easily dispersed by the agency of the wind.

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[1]) Mrs. J. DOCTERS VAN LEEUWEN-REIJNVAAN and W. DOCTERS VAN LEEUWEN, The Zoocecidia of the Netherlands East Indies. Batavia, 1926, p. 555, No. 1509.

W. DOCTERS VAN LEEUWEN, De alpiene vegetatie van de Lawoe vulkaan in Midden-Java. Natuurkundig Tijdschrift v. Ned. Indië, Deel LXXXV, 1925, p. 39.

6. GNAPHALIUM LONGIFOLIUM Bl.

This plant does not occur on the tops of Mt. Pangrango and Mt. Gedeh, but in lower regions, near Kandang Badak for instance it grows along open forest-paths and on land-slides and acts often as a pioneer. The plant does not form such big shrubs as *Anaphalis javanica*, but the branches are longer and the inflorescences larger, the upperside of the leaves moreover is but little haired, and in sicco the leaves are therefore black.

At Kandang Badak I saw the same little Hemipteron: *Nysius* spec. which is so common an *Anaphalis javanica* on the capitula, also some Syrphid-flies e.g. *Chamaesyrphus nigripes* and *Syrphus koningsbergeri*.

7. GNAPHALIUM SPECIES.

In some places of the top of Mt. Pangrango a small *Gnaphalium* occurs which in many respects closely resembles *Gnaphalium Reinwardtianum* but is somewhat bigger. Generally the plants flower in the rainy monsoon; in the dry season they are mostly withered and the fruits are shaken out. Because of the small number of individuals I am not able to mention any particulars about pollination or flowering-times.

8. MYRIACTIS NEPALENSIS Less.

The *Myriactis* which grows in Java is sometimes distinguished from the one occurring in British India and Ceylon as a separate species, called *Myriactis javanica*. According to KOORDERS [1]) the Javanese plants however are identical with those from the Himalayas. In Java this plant has been collected on several mountains from the West to the East, rarely in altitudes below 2000 m, more frequently in higher elevations. It may occur in various habitats, and it grows sometimes gregariously, and often solitary. It occurs in alpinoid forest, along roadsides, in fields, in grassland, occasionally along the water's edge, also on sandy plains, and in stony localities. On Mt. Pangrango it grows especially at altitudes between 2200 and 3000 m, in the alpinoid forest, locally among the shrub, but not in the crater-valley. From Sumatra it is represented in the Herbarium from several mountains (Mts. Korintji, Talamau, Singgalang and Merapi). It has also been collected on Mt. Lompobatang in South Celebes.

This herb occurs in various forms. Sometimes it is but slightly branched with large leaves and rather few large capitula, and sometimes it is strongly ramified with small leaves and many small heads. On Mt. Pangrango the former kind occurs almost exclusively. The plants may reach a height

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[1]) S. H. KOORDERS, Exkursionsflora von Java, Vol. III, p. 320.

of 75 cm, but they often remain much lower. The flattened capitula bear several whorls of ray-florets. The latter are unisexual and strap-shaped. The corolla has a linear lobe, which faces outwards and it is first white, later on often violet. Stamens are not present in these florets, only a long style with two short stigmas closely appressed against each other.

The disk florets are bisexual. They have a green or yellowish corolla. Before the latter expands, the 5 anthers have already opened, and produced their bright yellow pollen. In the second stage, later in the day, the 5 corolla-lobes spread star-like, and the two stigmas appear above the anther-tube; they are covered with pollen and spread but little apart.

Pollination. On Mt. Pangrango I have never observed visitors on the flowers, but thripses may occur in them. In the vicinity of Kandang Badak I often saw Syrphid-flies, chiefly *Chamaesyrphus nigripes* on the flowers. Self-pollination would be the rule.

The little fruits are provided with a sticky ring, by means of which they easily adhere to passing animals. VAN STEENIS [1]) found them attached to the wings of a dragon-flie (*Procordulia sumbawana*).

9. SONCHUS ASPER L.

This plant grows in small groups on the top of Mt. Pangrango, in open localities, on stony grounds or among the grass. In Java it is found chiefly in West Java, but also on Mts. Dieng and Idjen.

The plants are somewhat smaller than the European specimens, but otherwise they do not show any peculiarities. Self-pollination is the rule; visits of insects I have seldom observed, except those of *Syrphus koningsbergeri* and *S. serarioides*.

10. TARAXACUM OFFICINALE L.

In Java this plant is naturalised in but few localities, all in the vicinity of Garut. On Mt. Pangrango it did formerly not grow. In 1920 I collected seeds of this plant on the slopes of Mt. Heleakala on the Island of Hawaii at an altitude of about 2000 m, where the plants were similar in habit to European ones, though they were somewhat smaller, and had more open rosettes. These seeds were sown on the top of Mt. Pangrango, and at present they are growing on the bare stony (and but sparsely covered) part of the top. They thrive better near the cabin, Lebak Saät. The individuals are dwarfish 4 to 6 cm only in diameter; their leaves are pressed against the ground, and they bear as a rule only one or a few capitula each. The latter are in proportion to the plant abnormally large: 2 cm.

Insects I have never observed on the flowers.

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[1]) C. G. G. J. VAN STEENIS, Verspreiding van *Myriactis javanica* door libellen. Tropische Natuur, Vol. XXI, 1932, p. 191.

CHAPTER X.

PLANTS FROM OTHER MOUNTAIN-TOPS AND FROM THE NEIGHBOURHOOD OF TJIBODAS.

FAMILY OF THE LILIACEAE.

1. ALETRIS FOLIOSA STAPF.

This perennial herb is represented in our herbarium from few localities only ; it has been collected on Mt. Kinabalu in North Borneo, the highest peak of these regions, and on Mt. Singgalang and Mt. Malintang in the western part of Sumatra. I myself saw it in great numbers near the crater-lake near the top of Mt. Singgalang, where it grows in moss cushions in boggy places, near the border of the lake, but also on stony ground.

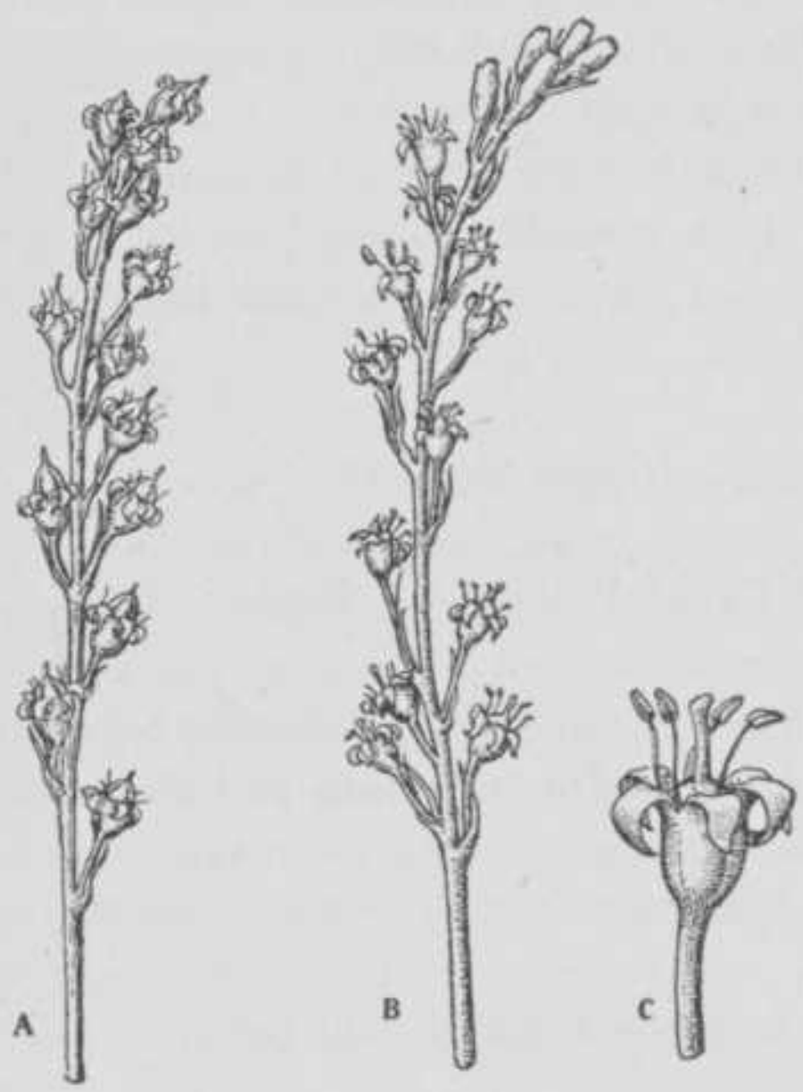

Fig. 66. A. fruiting; B. flowering shoot; C. flower of *Aletris foliosa* STAPF. A and B × 3/4; C × 2.

It has a short rhizome which ends in a rosette consisting of numerous linear leaves each tapering into an acuminate tip. Out of this rosette emerge one or more long-stalked spikes with small bracts and flowers. The latter have a 6-partite perianth with white or pink reflexed lobes, figure 66. The anthers and the pollengrains are orange-coloured and the superior ovary bears 3 short stigmas.

Pollination. The flowers of a spike may differ in the state of development of their sexual organs. In the early hours of the morning the anthers are in some flowers still closed while the stigmas though viscous are not yet pollinated ; in other flowers, however, the anthers are already dehisced, and leaning against the stigmas, they have effected pollination in the bud already. As the stigmas are always already viscous in the full-grown buds, the flowers are in the first instance proterogynous and in the second one homogamous. In the flowers which open with closed anthers, the stamens grow and curve in the course

of the day till they reach the stigmas. Self-pollination is therefore of common occurrence in this plant, and all the flowers set fruit.

During a 3-days' stay on the above mentioned mountain I have not seen a single insect on its flowers.

2. OPHIOPOGON CAULESCENS Back.

This plant, which is known from the whole of Java, occurs on Mts. Gedeh-Pangrango in the primeval forest especially at an altitude of 1300 to 1400 m. It is a herb with a long rhizome which often protrudes above the soil so that its roots assume more or less the character of stilt roots.

At the tip of the rhizome a large number of slanting, linear leaves arise. The inflorescences are simple axillary racemes. The flowers face mostly in one direction ; they are short-pedicellate. The pedicels and the main-rachis are white with a slight purple hue.

The perigone is bell-shaped, white and at the base violet or purple ; its 6 segments are connate at the base. There are 6 stamens with green basifixed anthers on short, stout filaments. The anthers open with slits which at their tip widen into a pore ; the slits face inwards. The ovary is half-inferior, 6-locular, it bears a filiform style which merges imperceptibly in the stigma and projects about 3 mm beyond the anthers.

Pollination. The flowers excrete but little nectar, and are scent-less ; self-pollination readily takes place through the anthers shedding their granular pollen upon the stigma. I have never noticed insects on the flowers.

FAMILY OF THE ZINGIBERACEAE.

1. AMOMUM COCCINEUM Benth and Hook.

This plant is common in open parts of the forest near Tjibodas between 1400 and 1700 m. The rhizome runs horizontally in the soil and two sorts of lateral branches appear above ground :

1°. sterile branches which bear the leaves ; they reach a height of 3 to 4 m ;

2°. flowering shoots ; they sometimes remain in the soil for more than a meter before they emerge.

The flowers are collected in a capitulum which remains with its basal part in the ground ; the perianths only are visible. The latter decay afterwards, the fruits developing in the ground. In the decaying parts of the inflorescences many detritus animals such as ear-wigs, fly-larvae etc. may be found.

The base of the perigone is enveloped in a membranous sheath ; the perigone-leaves are connate, and form a long tube ; the lip faces downwards and is of a brillant red colour marked with a yellow median stripe.

Opposite this lip is a red lobe, which forms a hood-like enclosure for the sexual organs, These organs consist of a broad filament inserted at the base of the perigone-tube and tipped by two long and broad anthers, which dehisce below by a slit. The filiform style lies with its upper part embedded in the narrow groove between the base of the anthers and with its basal part free in the perigone tube. The tips of the anthers leave a triangular space in which in the first stage of the development of the flower the stigma fits nicely. The stigma is club-shaped, at the front-side with a furrow-like hollowing, the margin of which is covered with white hairs. This is the structure of the flower when in bud.

Pollination. When the flower opens, both anthers which were originally parallel to the tube bend downward, and become now more or less perpendicular to the filament, exposing the stigma, which in this stage lies about 1 mm above the anthers. Moreover the flattened part of the stigma rises upward, and the furrow is turned forward filling the entrance to the perigone-tube.

Pollination without the agency of animals is now rendered impossible. The pollen is very sticky and clotty. The next day the flower closes, the flower-segments twisting spirally.

KNUTH [1]) also discusses the structure of this flower, but the figure added to his description certainly does not belong to this plant, but probably to *Phaeomeria solaris*, which is also very common in Tjibodas, where KNUTH made his observations. However, the insects, he mentions, can not effect pollination. Intercrossing would be possible by the agency of insects provided with a long proboscis or of sun-birds. But neither one nor the other were ever seen by me on its flowers.

In the tube of the perigone, however, there often crawl little dark brown beetles: *Onthophagus deflexicollis*, which get dusted with pollen, and when entering and leaving the flower, may readily effect pollination.

Between the bases of the flowers often large, yellow Curculionids: *Rhabdocnemis dehaani*, which bore into the ovaries are to be found. These weevils do not play a part in pollination, no more than the above-mentioned animals living in the decaying flowers.

FAMILY OF THE ORCHIDACEAE.

1. CALANTHE CECILIAE RCHB. F.

This terrestrial orchid grows scattered in the forest of Mt. Gedeh above Tjibodas, especially at an altitude of 1500 m. The highest specimens I found at an elevation of 2000 m. The plant consists of a number of small spurious tubers with 4 to 5 leaves, which are long-petiolate, erect and oblong, up to

[1]) P. KNUTH, Handbuch d. Blütenbiologie, Vol. III, Tome I, p. 180, fig. 30.

40 cm long, and 15 cm broad. The inflorescence reaches a height of nearly 75 cm ; at the end it bears numerous purple flowers. The pedicel is about 2 cm, the ovary about 1 cm long and curved, so that the perianth shows a vertical position. The perianth consists of 5 equal, purple segments and a broad labellum which is dilated downwards into a spur of 2½ to 3¼ cm, containing much nectar.

Pollination. When the flower has been open for some days, the perianth assumes a similar position as in the bud stage ; at the same time it becomes more or less orange-coloured. The pollinia which are still present in the anther become mucilaginous and the pollen germinates ; the pollen-tubes growing downwards in the tissue of the gynostemium. This plant is therefore a characteristic self-pollinator ; in fact all flowers set fruit. The pendulous fruits are purple. FORBES [1]) discusses the pollination of *Calanthe veratrifolia*, and describes autogamy in the flowers of various other orchids.

FAMILY OF THE ROSACEAE.

1. RUBUS MOLUCCANUS L.

This plant is very frequent in Java, and occurs in various forms. At Tjibodas in the swamp below Tjibeureum the flowers showed the following peculiarities, which, however, vary somewhat. As I examined but few plants I will not go into details.

First flowering-day. The numerous stigmas project beyond the more or less inwardly folded petals ; the stamens are bent inwards and the anthers are still closed.

Second flowering-day. The stamens are straighter and the anthers are open ; the stigmas curve slightly outwards.

Pollination. The flowers are visited regularly by *Bombus rufipes* and the stigmas are already pollinated on the first flowering-day. On Mt. Tjikorai I have repeatedly observed the beautiful honeybird *Aethopyga eximea*, visiting the flowers.

2. RUBUS NIVEUS THUNB. subspec. HORSFIELDII FOCKE.

This plant occurs in the higher parts of the mountains of Central and East Java and on Mt. Papandajan in W. Java. On Mts. Sumbing and Sindoro I found it already at an altitude of 1700 m. This plant is recognizable by the white under surface of the leaves. The inflorescences are axillary or terminal. The flowers are smaller than those of *Rubus lineatus*

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[1]) O. FORBES, Wanderungen eines Naturforschers im Malayischen Archipel von 1878—1883, übersetzt von R. TEUSCHER. Jena, 1886, Vol. I, p. 90.

and they do not expand fully. The calyx consists of lobes measuring from 5 to 8 mm, and the corolla is formed of 5 pink petals, which are bent inwards, and hide the stamens ; the styles only protrude.

The anthers are closely pressed against the styles and are shorter than these ; as the flowers however are drooping, pollen is readily dropped upon the stigmas, and self-pollination easily takes place with this species.

Ultimately the sepals spread and the corolla is shed ; the pruinose fruits are at first red, afterwards they become dark blue. On Mt. Semeru I noticed that *Pycnonotus bimaculatus* ate the fruits with avidity.

FAMILY OF THE GERANIACEAE.

1. GERANIUM NEPALENSE SWEET.

In Java two species of the genus *Geranium* occur, viz. *G. nepalense* and *G. ardjunense*. They are closely related and differ in a few characteristics only. KOORDERS [1]) unites both species under the name of *Geranium nepalense*. The differences however are so constant that the two species are easily distinguished. Both species occur on several mountains of Central and East Java, though but rarely together on one and the same mountain. *Geranium nepalense* occurs on Mt. Lawu, *Geranium ardjunense* on Mt. Merbabu, Mts. Kawi and Ardjuno, both species on the Tengger. On Mt. Lawu I had the opportunity to examine the flowers of *Geranium nepalense*. The flowers are pendulous ; the calyx is 5-sepalous, green and persistent ; the corolla is also 5-merous ; the pink petals show fine lines. On the first flowering-day the flowers are but little expanded.

There are 10 stamens with large anthers which are already open at 9 in the morning ; they contain big pollen-grains. The ovary bears a style which terminates into 5 thick stigmas. In most flowers one or two anthers lean against the stigmas ; consequently self-pollination takes place readily. I have never observed insects on the flowers. On the second flowering-day the flowers are more open, the anthers are empty, while the stigmas are in the same condition as the previous day.

FAMILY OF THE ELAEOCARPACEAE.

1. ELAEOCARPUS OBTUSA BL.

This tree has been found over the whole of Java at elevations above 1200 m ; at Tjibodas it is not rare, but the individuals grow scattered in the forest, often a long way apart from each other. The trees flower but

[1]) S. H. KOORDERS, Exkursionsflora von Java, Vol. II, Jena, 1912, p. 410.

seldom, but when they do, they are loaded with flowers. I found the tree in flower in November and December.

The flowers are borne in racemes. The latter contain 8 to 15 white, strongly vanilla-scented flowers. The calyx consists of narrow softly pubescent sepals, which are white inside and cream-coloured on the outside. The clawed petals are longer than the sepals, and glossy white; they dilate towards the fringed tip; the claw is narrow and thickened, with long hairs inside. There are numerous stamens bearing appendices of about 0.6 mm length and short acute anthers, with terminal dehiscence. The pistil is light-green; it consists of a hairy ovary and a slender style, projecting slightly above the anthers. The disk is densely pilose, orange-coloured and lobate.

Pollination. The flowers are pendulous and fall off the second day, covering the ground under the tree with a white carpet. Self-pollination may easily take place in these flowers because the dry pollen falls upon the stigma. But at 7 o'clock in the morning *Bombus rufipes* already is busy in the flowers; these insects are so numerous that the humming is heard at a distance. There is a high probability that pollination is chiefly carried out by the agency of these visitors, but as no other flowering individuals occurred in the neighbourhood it is geitonogamy. However, in one spot of the forest I found two individuals growing closely together. But this is an exception. On these trees the bumble-bees were also busily engaged.

The fruit is a more or less spherical drupe, with a flattened stone. The mesocarp is probably eaten by bats and squirrels, but I have not been able to make observations on them.

FAMILY OF THE DILLENIACEAE.

1. SAURAUJA BRACTEOSA DC.

At Tjibodas this tree occurs chiefly on the outskirts of the forest. The flowers are grouped in long-pedunculate inflorescences. The calyx is free, pentamerous, at the outside covered with rigid scaly hairs. The corolla is white, pentamerous, with an imbricate aestivation; it is bell-shaped or widely funnel-shaped. The numerous stamens are inserted upon the base of the corolla. The pistil consists of a densely pubescent ovary and of 5 filiform styles which are connate at the base.

Pollination. The flowers are open during one day only, though the petals have separated the preceding day already slightly, but neither the stamens nor the pistils were at that time matured. Early in the morning, however, all organs have attained maturity; at about 3 p.m. the corolla together with the stamens fall off.

The flowers are visited freely by *Bombus rufipes*; self-pollination is

however rendered possible : as the flowers are pendulous pollen is readily discharged upon the stigmas. The stigmas of most flowers were already pollinated before they were visited by the bumble-bees. All flowers set fruit.

FAMILY OF THE MELASTOMATACEAE.

1. MEDINILLA VERRUCOSA BL.

This is a very common epiphyte in the rain forest above Tjibodas at altitudes up to about 2000 m. Its flowers are white and its fruits are at first orange and afterwards black. The flowers are often visited by *Bombus rufipes*.

FAMILY OF THE UMBELLIFERAE.

1. PIMPINELLA JAVANA DC.

This plant has not been found in West Java, but it occurs in Central and East Java, on Mts. Sindoro, Merbabu, Wilis, Kawi and Hijang. On Mt. Kawi I noticed in April 1929 some species of flies which visited the flowers of the numerous umbels regularly and frequently.

FAMILY OF THE ERICACEAE.

1. VACCINIUM CORIACEUM MIQ.

This plant grows exclusively epiphytically. It is common in the lower parts of the primeval forest on Mts. Gedeh-Pangrango above Tjibodas at an altitude of 1400 m, where it grows high up in the trees. The branches are pendulous and are conspicuous by the pink colour of the young leaves.

The flowers are grouped in secund terminal or axillary racemes with small caducous bracts. The buds are pointed, at first pink and afterwards white. The calyx is pink ; the corolla is oblong urn-shaped with a narrow mouth.

The sexual organs are similar in structure to those of the other species of *Vaccinium* ; in the adult bud, one day before the opening of the flower, the anthers are already open and discharge their pollen ; the following day, when the flowers are open, the stigma is already pollinated ; these flowers are fertilized therefore by means of self-pollination. In fact all flowers set fruit.

FAMILY OF THE EPACRIDACEAE.

1. STYPHELIA PUNGENS KDS.

This representative of an Australian family does not occur on Mts. Gedeh-Pangrango. Seeds brought from Mt. Kawi were sown by TEYSMANN [1]) on Mts. Gedeh-Pangrango, but no plant has ever been found there. It is common, however, on some mountains in East Java, viz. on Mts. Kawi, Ardjuno, Welirang, Penanggungan, Tengger and Argapura. It grows at elevations between 1700 and 3300 m on dry, sandy or stony, and sunny localities, especially in stations where other plants cannot thrive and where even *Festuca nubigena* does not grow. Sometimes it occurs between or at the base of the tussocks of that grass.

Styphelia pungens is a much-branched low-growing small shrub; the leaves are densely aggregated; they are hard and terminate in a sharp cusp. The axillary flowers have a short pedicel; they are highly conspi-

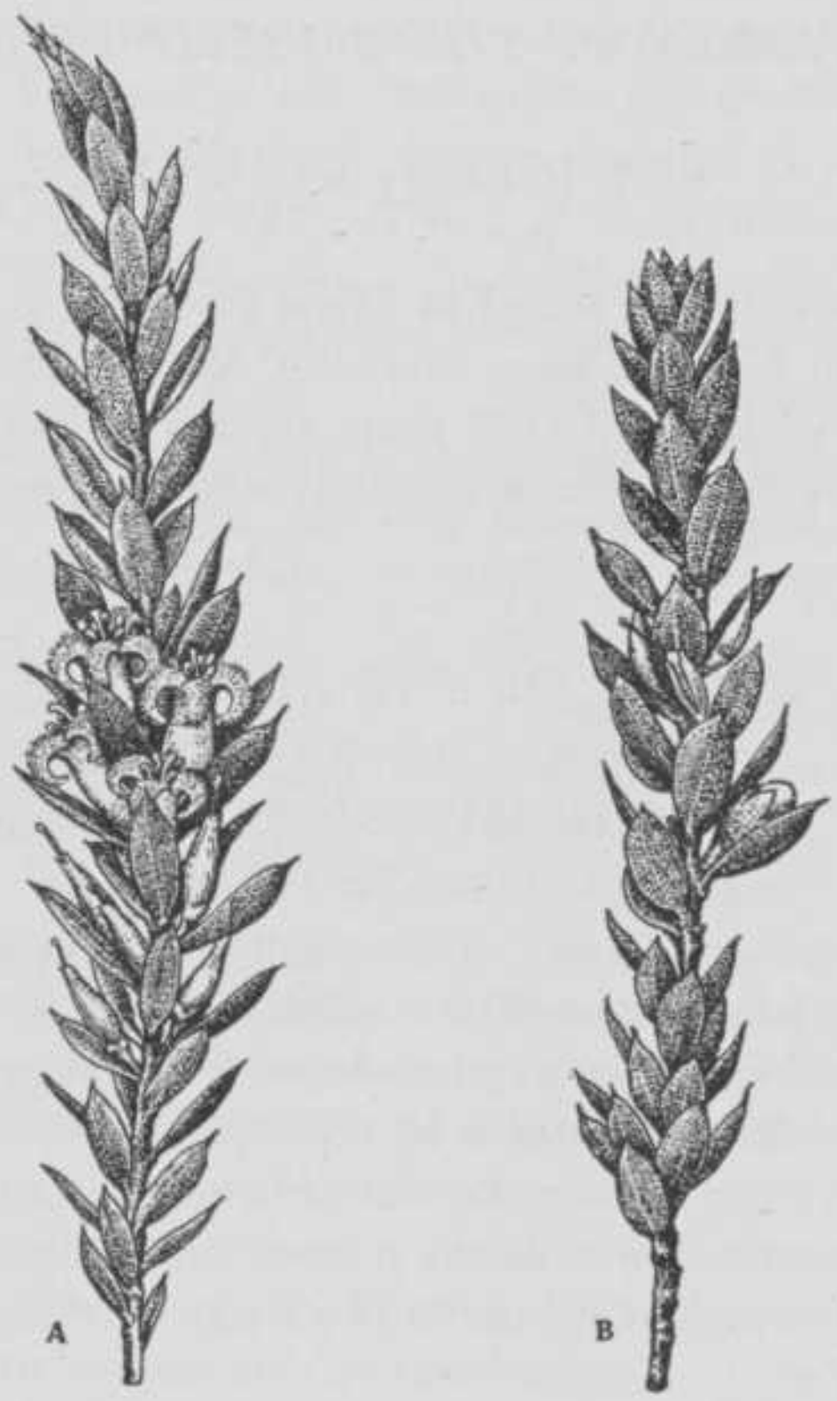

Fig. 67. Flowering and fruiting branches of *Styphelia pungens* KDS. × 2.

cuous by their white colour, which contrasts strongly with the dark-green leaves, figure 67. The calyx is 3 to 4 mm long and consists of 4 pointed

[1]) J. E. TEYSMANN, Uittreksel uit het dagverhaal eener reis door Oost-Java, Karimon Java en Bali Boeleleng. Natuurk. Tijdschr. v. Ned. Indië, Tom. XI, 1854, p. 150.

sepals. The white corolla is usually longer than the calyx tube; it is 4-merous, with reflexed lobes which are inside densely pubescent with long hairs. The stamens are inserted in the throat of the corolla and the dark-brown anthers protrude slightly from the tube. The ovary is ovoid; it bears a long red style topped by a capitate stigma. The base of the pistil is surrounded by a fleshy disk, which produces much nectar. The fruit is an orange drupe.

Pollination. The stigma leans often against the anthers, and this renders self-pollination possible. On Mt. Semeru I did not notice any visiting insects; I found, however, thripses in the flowers. On Mt. Kawi the sweetly scented flowers were visited from morning till night by numerous individuals of *Bombus rufipes* var. *flavipes*. This *Bombus* is smaller than the western bumble-blee: *Bombus rufipes* var. *obscuripes*, and the lower end of the abdomen is surrounded by red-brown hairs.

Dispersal of the seeds. On Mt. Kawi I observed that the fruits were regularly eaten by the thrush: *Turdus javanicus whiteheadi* and everywhere I found stones and seedlings in the excrements of these birds.

FAMILY OF THE GENTIANACEAE.

1. GENTIANA SINGGALANGENSIS BACK.

According to BACKER [1]) this species was collected for the first time by BECCARI on Mt. Singgalang in Sumatra and identified by BOERLAGE [2]), as the British Indian *Gentiana recurvata*, but afterwards it proved to be an undescribed species. It was known only from the Sumatran mountains Singgalang, Malintang, Talamau and the Peak of Korintji, where it grows at altitudes between 2000 and 3300 m. LAM [3]) discovered this plant between 2600 and 3580 m on the top of Mt. Doorman in Central New Guinea. It occurs along river banks, in alpinoid shrub and among moss, doing especially well in open localities. On Mt. Singgalang where I could study it myself, it is very common at an elevation of about 2600 m, where I found it round the crater-lake in sunny stony places as well as in swampy shaded stations. Its range of variability is correlated with differences in habitat: there is a sun-form which is extremely compact, forming small clumps of 5 to 10 cm in diameter; and a shade-form which bears long, soft shoots, which may attain a length of 25 cm. This plant shows therefore the same range of variability as *Gentiana quadrifaria*, and LAM found the same variability also in the specimens collected in New Guinea.

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1) C. A. BACKER, Contributiones ad cognitionem Florae indiae Bataviae. Bull. du Jard. Bot. de Buitenzorg, Serie III, Vol. III, 1920, p. 326.

2) J. C. BOERLAGE, Flora van Nederl. Indië, Vol. II, p. 470.

3) H. J. LAM, Fragmenta papuana VI. Natuurkund. Tijdschr. v. Ned. Indië, Vol. LXXXIX, 1929, p. 73 and 131.

The flowers are arranged in terminal cymes, overtopped by lateral shoots arising directly under the inflorescences. The buds are blue, while the open flower is blue outside and white or very light-blue inside. The green calyx is about 5 mm long ; the lobes are pressed against the corolla. The funnel-shaped corolla is about 12 mm in diameter, and has 5 blunt lobes. The latter bear at their inside a dense tuft of clavate hairs ; one half of this fringe points upwards, the other half downwards. The 5 stamens are epipetalous ; the anthers lie under or in the lower part of the fringe. The pistil consists of an ovoid ovary and a short style with two stigmas.

Pollination. For 3 consecutive days the flowers are found open in the morning and every afternoon they close.

First flowering-day. The anthers are open and the white pollen bulges out of the sacks, but stigmas are still closed ; they are 2 mm below the anthers. The flowers are therefore distinctly protandrous.

Second flowering-day. When closing in the afternoon of the first day, much pollen is caught in the fringe and next morning we may find it there in large quantity. The anthers are partly empty and the style has elongated and the stigmas, though still closed, are nearer to the anthers.

Third flowering-day. Now the anthers are almost empty and have become brown ; much pollen is left between the hairs of the fringe. The stigmas are carried upwards, and as they curl outwards, they brush the pollen off the fringes. All stigmas in fact are pollinated and all flowers set fruit. I have hardly noticed any visitors on the thousands of open flowers, twice I observed a small, black fly. Nectar is however, secreted rather plentifully by an S-shaped yellow protuberance at the base of the stamens ; and nectar is also found between the filaments. *Bombus* which might have acted as a pollinator, was too busily engaged on the flowers of the abundantly flowering *Leptospermum javanicum* (see the description of this plant on p. 189). It is not improbable that in another season this *Gentiana* may be visited more frequently by insects.

The peduncles perform here the same movements as the whole shoot of *Gentiana quadrifaria* (see p. 224), the buds are pendulous, but the flowers are erect ; when they are pollinated their peduncles bend again and when the fruit is ripe they become again erect. These movements are also accompanied by a considerable elongation. The fruits show the same structure as those of *Gentiana quadrifaria* ; and after a heavy rain-shower not a single seed was left in the open fruits.

The flowers are extremely sensitive to differences in temperature. On January 28th. 1920 a rainy day, the flowers opened only at 12 o'clock, on the following day, which was sunny, they opened already at 8.

I have published already elsewhere [1]) a short description of the pollination of this plant.

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[1]) W. DOCTERS VAN LEEUWEN, Naar de top van de Singgalang bij Fort de Kock. De Tropische Natuur, Vol. IX, 1920, p. 4.

FAMILY OF THE LABIATAE.

1. PLECTRANTHUS JAVANICUS BTH.

This high, much-branched herb is extremely common on the slopes of Mt. Sumbing at an altitude of about 2000 m. It was frequently visited by *Bombus rufipes.*

2. POGOSTEMON MENTHOIDES BL.

This erect herb grows abundantly on Mts. Gedeh-Pangrango along the road between Tjibeureum and the hot wells. It reaches a height of about 60 to 100 cm, and bears at the tip of the branches dense cylindrical spurious spikes, with small violet flowers.

Pollination. The flowers are but rarely visited by *Bombus rufipes,* but regularly by *Apis indica* and by some species of *Diptera,* viz. especially *Baccha austeni, Bucentes nigripalpis,* and *Melanostoma quadrinotatum.*

FAMILY OF THE SOLANACEAE.

1. CESTRUM AURANTIACUM LINDL.

This shrub is cultivated in the garden of Tjibodas and has run wild in the forest in the neighbourhood, where it occurs now frequently. The orange flowers are more or less pendulous. They are regularly visited by *Bombus rufipes* and fruit abundantly. Sun-birds visit the flowers also.

FAMILY OF THE GESNERIACEAE.

1. CYRTANDRA COCCINEA BL.

A common shrub in the virgin forest of Mt. Gedeh-Pangrango at altitudes of 1400 to 1800 m, especially under the waterfalls of Tjibeureum.

The flowers are arranged in axillary inflorescences; they are light-red, or sometimes pale-yellow, the young flowers as well as the old ones.

The calyx is narrowly campanulate and marked by red longitudinal lines (the latter are in the yellow specimens light-green), and bears short triangular lobes; it has already grown out to its full size when the corolla is still minute, and it is always filled with water. Very young buds with still closed lobes are already filled with water. The latter is quite clear and tasteless. This flower is therefore provided with a water-calyx. At the base the corolla is tubular, towards the top it widens into trumpet-shape with a bulge. This part with its widely gaping mouth projects beyond the

calyx. The two stamens are bent towards each other and their anthers adhere to each other and lie appressed against the upper part of the throat. The pollen is white.

Pollination. First flowering-day. The anthers dehisce introrsely, the pollen is white and sticky. The closed stigma lies about 3 mm below the anthers. The style and the stigma are pressed against the upper part of the corolla-tube.

Second flowering-day. The style elongates and the stigma opens out into two broad lobes, brushing at the same time the pollen out of the anthers which are now separated.

Third flowering-day. The stigmas spread widely at the level occupied first by the anthers, which have now decayed and lie on the bottom of the corolla tube. The corolla is partly wilted and soon falls off. The calyx enlarges and encloses the fruit for a long time, but before the fruit has fully matured it decays.

All flowers set fruit. As I have never noticed visiting insects, self-pollination must be the rule.

2. CYRTANDRA PICTA BL.

This is an extremely frequent herb in the virgin forest of Mts. Pangrango-Gedeh, where it occurs between 1400 and 2400 m. The large white flowers develop a short way above the ground. They are visited regularly by *Bombus rufipes*. When this animal leaves the flower, its back is dusted with pollen, and as the stigma is receptive, the flower gets readily pollinated.

3. CYRTANDRA SANDEI DE VRIESE.

This shrub is especially common in the virgin-forest above Tjibodas at altitudes between 1400 and 1500 m. The white flowers are grouped in bundles in the axils of the higher leaves.

The calyx is persistent, the pentamerous corolla is trumpet-shaped with a narrowed tube and recurved lobes ; it is white and on the outside covered with brown hairs. On the inside towards the mouth it shows a round, red-brown spot.

The two stamens are inserted on the corolla ; the anthers touch each other in the centre of the red spot. The day before the flower expands, the anther-lobes are already open. The stigma lies also in the throat of the corolla tube, but about 1 mm lower and is not yet receptive. The flowers are therefore protandrous. The disk is yellowish, one-sided, and toothed. After pollination the corolla becomes mucilaginous, but for some days it still encloses the swelling ovary.

Pollination. First day. The corolla is open ; the anthers are filled with white, sticky pollen ; the stigma lies still somewhat below the anthers.

Second day. The style elongates, and carries the stigmas up to the anthers.

Third day. The stamens wilt and droop, the stigmas have expanded and diverge slightly from the corolla.

All flowers set fruit ; I have never observed visiting insects ; self-pollination is the rule.

The ovaries are often attacked by small weevils, which change them in succulent, green galls [1]).

FAMILY OF THE ACANTHACEAE.

1. STROBILANTHES CERNUUS BL.

This plant occurs especially on some mountains of West Java, generally at altitudes between 1400 and 2200 m. There is in the Herbarium at Buitenzorg also material from Mt. Slamat, and it is also common on Mt. Papandajan. When in flower it is a robust much branched herb which reaches a height of up to 3 m. After flowering the plant dies, and new individuals arise from the numerous seeds fallen on the forest-soil. It is especially frequent at 1700 m altitude in the high-stemmed forest, where it constitutes nearly the whole undergrowth. It is highly remarkable that in particular years almost all the plants flower simultanously; the forest looks then as if covered with snow; for some years afterwards hardly any flowering plants can be found. During the period in which I studied the plants on Mts. Gedeh-Pangrango, such a general flowering took place twice, viz. in 1920 and in 1929. Though a few plants may flower in the years before and after, this number does not count in comparison with the thousands of plants which flowered in the years just mentioned. KOORDERS [2]) mentions a general flowering in 1902, and on the labels of material collected on Mt. Salak in 1911 "many specimens in flower" is mentioned. The labels of material collected in November 1911 on Mt. Gedeh report : "flowering locally". As in November, however, the flowering season is nearly over for these plants, this statement does not afford sufficient certainty. BARTELS records general flowering on Mt. Gedeh in 1902 and 1911 [3]). Specimens gathered on the same mountain in May and August 1914 bear the statement : "one group in flower". On the label of material from Mt. Mandalagiri near Garoet, collected in 1919, is stated by LAM : "one flowering specimen". From these as yet somewhat scant data we may conclude that an abundant flowering occurs once in every nine years.

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[1]) Mrs. J. DOCTERS VAN LEEUWEN-REIJNVAAN and W. DOCTERS VAN LEEUWEN. The Zoocecidia of the Netherlands East Indies. Batavia, 1926, p. 506, fig. 962.

[2]) S. H. KOORDERS, Flora van Tjibodas, Vol. III, Part I, 1918, p. 130.

[3]) C. A. B., Medewerking verzocht. De Tropische Natuur, Vol. VII, 1918, p. 21.

In the year after a general flowering seedlings spring up everywhere among the withered stalks. The leaves of these young plants show sometimes silvery spots, especially when they grow in dense shade. KOORDERS [1]) described this youth form as a new species, which he named *Strobilanthes pictus* nov. spec., "Flores cum fructibus adhuc ingnoti", he wrote, which is quite conceivable with juvenile plants.

From a species of *Strobilanthes* occurring in Ceylon a similar periodical flowering has been reported, see for instance GUENTHER [2]), according to whom this Ceylon plant flowers once in every 12 years. From British India also, periodical flowering of different species of *Strobilanthes* has been described. The term of *Str. Wallichii* is 12 years [3]), that of *Str. callosus* is 8 years [4]), and that of *Str. sessilis* is 7 years [4]).

The flowers are borne in the axil of white-rimmed bracts and collected in oblong spikes resembling the female inflorescences ("cones") of the hop. The small white flowers project considerably beyond the bracts.

Pollination. The flowers are visited freely by *Bombus rufipes* as well as by *Apis indica*, as I noted also on Mt. Tjikorai. *Apis* first brushes the pollen out of the anthers afterwards sucking the nectar.

The roots, which arise partly as stilt-roots from the lower part of the shoot frequently bear large dark-brown, hairy galls, caused by a gall-midge: *Asphondylia strobilanthi* [5]).

A finch, *Serinus estherae*, which eats the seeds of this plant, has been discovered by BARTELS [6]) on Mt. Gedeh.

2. STROBILANTHES INVOLUCRATUS BL.

An irregularly branched herb which may reach a height of 1½ m; the lateral branches bear terminal capitate inflorescences, which are enclosed in large bracts, between which a considerable amount of water is held. The plants occur at about 1500 m in the primeval forest of Tjibodas, where they are locally numerous. In every inflorescence only one large flower opens at a time. The calyx is 4-merous, connate and pale-green; the corolla is tubular at first, afterwards widely bell-shaped with 5 to 6 reflexed, rounded lobes. The tube is 20 mm, long and widens till it reaches 15 mm in diameter. The anthers of the 4 stamens lie near the entrance of

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[1]) S. H. KOORDERS, loc. cit., p. 132.

[2]) K. GUENTHER, Einführung in die Tropenwelt Ceylon. Leipzig, 1911, p. 206, fig. 47.

[3]) A. S. Flowering of *Strobilanthes* in Jaunsar. The Indian Forester, Vol. XXIII, 1896, p. 182.

[4]) HUGH MURRAY. Flowering of *Strobilanthes* in Bombay. The Indian Forester. Vol. XXIII, 1896, p. 262.

[5]) Mrs. J. DOCTERS VAN LEEUWEN-REIJNVAAN and W. DOCTERS VAN LEEUWEN, The Zoocecidia of the Netherlands East Indies. Batavia, 1926, p. 516, fig. 985.

[6]) C. A. B., loc. cit., p. 21.

the tube, and the yellowish white pollen appears at the upper side. The ovary is oblong, quadrangular, and surrounded at the base by the orange disk. The style is filiform and partly embedded in a slit of the corolla; at the free end the stigma curves upwards. Self-pollination is rendered highly difficult, if not impossible.

The flowers are regularly visited by *Bombus rufipes*, which dive to the bottom of the flower-tube and get dusted with pollen. Often we find flowers with a hole in the tube; whether this is effected by the bumble-bee or by a sun-bird I do not know.

FAMILY OF THE RUBIACEAE.

1. CHASALIA CURVIFLORA THW.

A low shrub, about 1¼ m high which occurs chiefly in the neighbourhood of the garden at Tjibodas, in the virgin forest. The terminal inflorescences, show pale-violet branchlets. The flowers are white. The calyx is very small. The corolla consists of a recurved violet tube about 14 mm long, with a vertical white limb. The anthers, which lie just below the entrance of the tube, surround the 2-lobed stigma. They dehisce inwardly, and pollen is readily shed upon the stigmas. At half past seven in the morning the stigmas are already pollinated. Insects have never been observed on the flowers, and self-pollination will therefore be the rule; all flowers set fruit.

In the forest at Dèpok near Batavia at an altitude of about 100 m this plant occurs also. The flowers show there distyly and pollination may be effected differently. I have not been able, however, to study it there.

2. GALIUM ROTUNDIFOLIUM L.

This plant occurs in West Java on Mt. Papandajan only. To the East the first mountain, where it grows, is Mt. Dieng. On Mt. Sumbing it is highly common, but on Mt. Sindoro, the twin mountain of Mt. Sumbing, it does not grow. Further it is found on nearly all the mountains of Central and East Java. In Celebes, Lombok, Flores and Timor it is also present, and then it is known from Yunnan in China and from the Himalayas. MIQUEL distinguishes a variety *leiocarpum* which has glabrous fruits, and grows on several mountains as Mts. Idjen, Ardjuno, Wilis, Lawu, Merbabu and in Timor; in numerous localities the variety occurs together with the species itself. This plant grows usually at altitudes between 2000 and 3200 m; on the top of Mt. Muriah it occurs at 1500 m, and on Mt. Wilis at the same altitude.

It is a prostrate herb or it ascends among the shrubs; in the latter case

the shoots may reach a height of 2 m, as I saw on Mt. Kawi in dense *Albizzia*-bushes. It may be found in alpinoid shrub, among grass, on low mounds, on the steep banks of roads and on ravine slopes ; it occurs also in Tjemara forests, and on Mt. Wilis it has been collected in an alang-alang (*Imperata*)-field.

The stem is slender and quadrangular, with opposite leaves, generally measuring ½ to 1 cm in length, ½ to ¾ cm in width. Specimens with extremely large leaves have been collected on Mt. Tengger (1½ to 2 cm long and 1 to 1½ cm wide) and a very small form was found on Mt. Lompobatang in South-Celebes.

The small yellow flowers are collected in panicles ; they are 4-merous, the anthers are yellow because the pollen is of this colour. The style bears two stigmas, which are below the anthers. The pollen is shed upon the corolla-lobes and on the stigmas. I have not observed any pollinators on these flowers. The flower is very probably autogamous.

3. LASIANTHUS GLABER Scheff.

This is a straggling shrub with long and slender, drooping branches ; all parts when crushed, emit a smell like skatol.

The flowers are short-pedicellate ; they are grouped in the axils of the leaves.

The calyx is 5-toothed, dark-purple ; the corolla is trumpet-shaped ; the tube, which is light-purple at the base, shows a white limb formed by 4 lobes, which diverge widely, and are strongly pubescent on their inner side. The 4 stamens are inserted on the corolla, and the anthers are on the same level with the 4 stigmas. The flowers open, already at six a.m. at half past six the anthers dehisce and the stigmas are pollinated, because the anthers are pressed against them. As a matter of fact all flowers produce fruits. The latter are globose and crowned by the calyx-lobes ; the ripe ones are yellow. In each inflorescence only 1 to 3 flowers open at the same time ; consequently the fruits do not ripen simultaneously. I have never observed pollinators on the flowers ; self-pollination is the rule.

4. LASIANTHUS STERCORARIUS Bl.

This is above Tjibodas the most common species of this genus. It occurs in the forest up to an altitude of 2200 m. It is a small tree with a vertical, slender stem and pendulous branches. Generally the flowers are grouped in fours in the leaf-axils ; they are sessile. On each branch usually only one flower opens at a time.

The calyx is cupular and more or less truncate ; the corolla-tube is about 3 mm long, its 7 to 8 lobes form a yellow-white star-shaped limb.

The throat bears numerous long, white hairs, by which the sexual organs are hidden.

The 4 epipetalous stamens are very small ; the anthers are quite hidden among the hairs of the corolla throat. The stigma shows 3 to 5 branches, which are on the same level as the anthers and are pressed against them. At half past six in the morning the stigmas are already pollinated. Nectar secretion is very scarce. I never saw any visitors on this plant. Self-pollination is in fact the rule and all flowers produce fruits. The latter are black and glossy.

5. MYCETIA LATERIFOLIA KORTH.

This is a shrub, conspicuous by its bright yellow blossoms and snow-white fruits. It is frequent in the primeval forest above Tjibodas, especially between 1400 and 1700 m. The flowers are arranged in pendulous racemes; the calyx is 5-toothed and green; the bright yellow corolla is pentamerous, trumpet-shaped, with rounded, recurved lobes. The stamens are inserted upon the corolla ; the filaments, are short and the anthers lie just below the entrance of the tube. The ovary is inferior and bears a long style, with two branches beginning somewhat lower than the anthers, but longer, and therefore projecting beyond them.

Pollination. The day before the buds open the anthers are still closed, but when the flower opens the anthers do so too. During the flowering-time, which lasts only one day, the elongated stigmas brush past the anthers and get pollinated ; at 8 a.m. this has already taken place. Nectar secretion is but scant and the flowers are scentless.

Self-pollination is therefore the rule with this plant ; I never saw insects on them, and all flowers set fruit.

FAMILY OF THE CAMPANULACEAE.

1. WAHLENBERGIA MARGINATA DC.

In West Java this plant occurs on Mt. Papandajan only ; it is frequent, however, in Central and East Java at altitudes between 1000 and 3200 m. It is especially common in sunny or slightly shaded localities, in grass wildernesses, along roadsides, on small mounds, in open alpinoid forests and in Tjemara forests.

The stem is repeatedly branched, and bears narrow leaves, the higher branches end into one or two flowers. The calyx is epigynous, bell-shaped with narrow lobes standing out at an oblique angle ; the violet corolla is at first bell-shaped, afterwards it becomes more funnel-shaped ; it bears 5 oblong lobes. There are 5 stamens, with the filaments fused into a

single slender stalk pressed against the style; the anthers are long, and introrse. The style is pubescent towards the tip, and it terminates into 3 stigmas.

Pollination. First flowering-day. The anthers are packed against the outside of the still closed stigmas. In the bud stage the anthers have already opened and the pollen is shed between the hairs on the stigmas.

Second flowering-day. The stamens shrivel and sink on the bottom of the corolla-tube; the 3 stigmas curl backwards; they are dusted with pollen. Self-pollination is therefore the rule. I have never observed visitors on the flowers.

FAMILY OF THE COMPOSITAE.

1. SPILANTHES ACMELLA L.

This herb shows a wide range of variety; a form bearing extremely large capitula has been described as *Spilanthes grandiflora*. On some mountains this form is extremely common; I saw it for instance in great numbers on the slopes of Mt. Sumbing and of Mt. Kawi; on the last-named mountain it grows in dense clumps in the *Casuarina*-forest which cover the dry ridges. On Mt. Sumbing I observed a number of flies and a small grey *Hemipteron* on the flowers; on Mt. Kawi I noticed numerous *Apis indica* and several *Diptera* belonging, however, to few species.

INDEX.

Note: Bold face figures refer to main discussions of or points of special interest.

A

Acanthaceae 263
Aceraceae 67
Acer niveum BL. 50, 67, **132**
Adinatia 77
Aecidium Thelymitrae RAC. 155
Aethopyga eximea HORSF. 75, **101**, 102, 112, 148, 174, 178, 206, 228, 238, 254
Agapetes rosea JUNGH. 208
Agapetes vulgaris JUNGH. 69
Ageratum conyzoides L. 68, 127
Agrostis 6
Agrostis infirma BUESE. 55, 56, 69, 62, 63, 65, 66, 131, **143**, pl. VIII, X, XII, XVII
Agrotis c-nigrum L. 79, 100, 114, **151**
Albizzia 10
Albizzia montana BTH. 7, 9, 15, 17, 19, 46, 47, 49, 53, 58, 59, 60, 62, 63, 65, 67, 99, 105, 108, 128, 129, 132, 156, **176**
Aletris foliosa STAPF. **251**
Allaeophania rugosa HOOK. 51, 58, 68, 97, 99, 103, 105, 110, **232**
Alsophila 14, 233
Amomum coccineum B. et H. **252**
Amphibia 18
Anaphalis 7, 16, 17, 20, 33, 47, 75, 81, 83, 128
Anaphalis javanica SCH. BIP. 3, 4, 6, 8, 10, 12, 13, 14, 15, 19, 25, 48, 50, 53, 55, 56, 57, 58, 59, 61, 62, 63, 65, 68, 76, 77, 80, 82, 84, 87, 92, 96, 97, 99, 100, 101, 102, 105, 111, 203, **241**, 249, pl. IV, V, VI, VII, VIII, XI, XII, XXV, XXX A
Anaphalis viscida DC. **242**
Anaptychia speciosa 247
Anemone silvestris L. 162
Anemone sumatrana DE VRIESE 46, 67, 94, 118, 123, **161**
Anhella tristis 209
Antennaria javanica DC. 243
Anthomyiidae 82, 120
Ants 20, 79
Apidae 115, 237
Apis indica F. 80, 97, **99**, 102, 115, 159, 167, 169, 174, 179, 180, 183, 220, 231, 233, 238, 245, 247, 264, 268
Aplonis panayensis strigatus HORSF 135
Apples 11
Aptera 83
Arachnoidea 27, 83
Araliaceae 14, 68, 109, 194
Aralia ferox MIQ. 14, 51, 58, 68 137
Arboricola javanica GM. 74
Arborophila javanica GM. 74, 133
Arcta coerulea GUEN. 79
Ardisia 14
Ardisia javanica DC. 51, 53, 61, 68, **212**
Arenaria biflora L. 56
Argostemma montanum BL. 52, 68
Artemisia 12, 78
Artemisia vulgaris L. 46, 68, 124, **246**
Asphondylia strobilanthi FELT 264
Asplenium praemorsum SW. 54
Astilbe indica Bl..... 67, 107, 132, **174**
Astronia 10
Astronia spectabilis BL. 50

B

Baccha austeni DE MEIJ 118, 261
BACKER, C. A. 4, **17**, 84, **126**, 143, 186, 230, 247, 259
Badger 72
Balanophora 8, 52, 71
Balanophoraceae 66, 157
Balanophora elongata BL. 14, 54, 57, 66, 103 139, **157**
Balsaminaceae 67, 108, 132, 179
BARTELS, M. A. 75, 135, 263
Bats 73
BECCARI, O. **13**, 81, 92, 140, 141, 245, 259
Beech 45, 55, **157**
Begonia 53, 116
Begoniaceae 67
Begonia isoptera BRYAND 67, 133
Begonia robusta BL. 67
Bellis 3
BENTHEM, CT. VAN 8

BENTHEM JUTTING, W. VAN 83
Bibionidae 83, 118
Bidens leucantha WILLD. 127
Bidens pilosa L. 46, 68, 112, 124, 127, 138, **247**
Birds 74
BLAAUW, A. H. 18
Blechnum orientale L. 7
BLEY, F. 192
Blue-bottles 83
BLUME, C. L. **3**, 4, 9, 118
Blumea silvatica DC. 68
Boars 71
BODEGOM, J. VAN 215
BODEN KLOSS, C. 134
BOEREMA, J. 44
Bombus rufipes LEP. 89, 97, 102, 147, 159, 175, 179, 183, 189, 191, 200, 201, 206, 208, 209, 211, 220, 227, 231, 233, 238, 246, 254, 256, 257, 261, 262, 264, pl. XXX A
Bombus rufipes LEP. var. flavipes FR. 81, 117, 259
Bombus rufipes LEP. var. obscuripes FR. **80**, **97**, 116, 170, 171, 172, 174
BREMEKAMP, C. E. B. 224, 225
BROCKMANN-JEROSH, H. 48
BRUGGEMAN, M. L. A. 26
Bryum leucophyllum MOLK. 16
Bucentes nigripalpes DE MEIJ 82, 261
Bulbul 74
BURCK, M. W. 198
BURGEFF, H. 148

C

Calamagrostis australis BUESE 8, 55, 56, 62, 63, 65, 66, **143**, 229
Calanthe abbreviata LINDL. 52, 66, 122
Calanthe ceciliae RCHB. F. **253**
Calanthe veratrifolia R. BR. 254
Calliphora fulviceps V. D. W. 83, 120, 159, 180, 189, 220, 245
Calliphorine 82
Calornis chalybea HORSF. 135
CAMMERLOHER, H. 98
Campanulaceae 68, 240, 267
Cankriena chrysantha DE VRIESE ... 215
Caprifoliaceae 68, 110, 235
Carabidae 83
Cardamine africana L. 52, 54, 61, 67, 100, 105, 107, 123, 132, **167**
Cardamine hirsuta L. 46, 67, **168**
Carex 6, 53, 61, 70, 74, 120
Carex baccans NEES. 66
Carex hypsophila MIQ. 6, 16, 54, 46, 57, 59, 62, 63, 65, 66, 85, 129, 138, **145**, pl. VIII, IX, XII, XVII B
Carex longebracteata STEUD. 66
Carychium javanum MOELL. 83
Caryophyllaceae 67, 106, 160
Casuarina 7, 47
Casuarina Junghuhniana MIQ. 43, 95, **125**
Celastraceae 67, 179
Celastrina askasa HORSF. 78, 114, 245
Celastrina ceyx ceyx FRHST. 78
Celastrina dilecta paradilecta FRHST. 78
Celastrina lavendularis floresina COURV. 78
Celastrina singalensis astarga FRHST. 78
Cerastium caespitosum GILIB. 46, 56, 57, 67, 74, 87, 103, 106, 123, 138, **160**
Cerastium triviale LINK. 160
Ceratodon purpureus BRID. 16
Ceratostylis latifolia BL. 10, 66
Ceratostylis simplex BL. 66
Cervus hippelaphus CUV. 70
Cestrum aurantiacum LINDL. 46, 116, 261
Cetraria sanguinea SCHAER. ... 56, 244
Cettia montana HORSF. 75
Chamaesyrphus nigripes DE MEIJ. 79, 82, 100, 118, 154, 163, 167, 171, 174, 175, 180, 183, 189, 195, 201, 220, 224, 231, 238, 241, 245, 249
Chasalia curviflora THW. 265
CHEESEMAN, R. 154
Cinchona 12
Cladonia 56
Cladonia calycantha DEL. 244
Cladonia coccifera L. 16, 244
Cladonia deformis L. 244
Cladonia Floerkiana FR. 244
Cladonia pityrea FLK. 244
CLAUS, G. 244
Clausilia 83
Clematis Leschenaultiana DC. 51, 67, 131
Coelogyne miniata LINDL. 66
Coenosia anipila STEIN. 83, 120, 163, 175, 245
Coleoptera 21, 76, 115, 165
Colibri 238
Collocalia brevirostris vulcanorum STRES. 75
Columba oxyura TEMM. 69
Columba porphurea TEMM. 69
Compositae 13, 68, 111, 241, 268
Cosmolyce beatica L. 78
COSTER, CH. 45, 157
Cotoneaster species 45, 67, 94, **168**

Crawfurdia trinervis HASSK. 14, 51, 54, 60, 68, 138, **220**
Crocias guttatus TEMM. 74
Crocidura orientalis JENT. 74
CROISET VAN UCHELEN, C. E. 19
Crucifera 67, 107, 166
Crustaceae 21
Cryptolopha trivirgata STRICKL. ... 75
Cucurbitaceae 68
Cuon javanicus DESM. 73
Cupressus sempervirens L. 45, 66, 94
Cyathea 14
Cyathea crenulata BL. 6, 31
Cyathea oligocarpa JUNGH. 6
Cyperaceae 16, 66, 94, 133, 145
Cypholophus lutescens WEDD. 51, 66
Cyrtandra arborescens BL. 51, 68, 138, **230**
Cyrtandra coccinea BL. 230, **261**
Cyrtandra picta BL. 116, 262
Cyrtandra Sandei DE VRIESE. 262
CZECH, H. 225

D

Dahlia hybrida 116
DAMMERMAN, K. W. **20**, 22, 45, 71, 73, 83
Danais albata ZINK. 79
DANSER, B. H. 141, 158
Daphniphyllum glaucescens BL. 50, 67
DE CANDOLLE 243
Deer 70
Dendrobiastes hyperythra vulcani ROB. 75
Dendrobium cymbidioides LINDL. 11, 66
Dendrobium gracile LINDL. 66, 122
Dendrobium Hasseltii LINDL. 11, 14, 54, 60, 66, 101, 105, 106, **147**
Dendrobium Jacobsonii J. J. S. 46, 66, 94, 125
Dendrobium Kuhlii LINDL. 10, 66
Dendrochilium cornutum J. J. S. 66
Dianella javanica KUNTH. 4, 7, 10, 52, 60, 62, 66, 122, 137
Dianella vulcanica BL. 4
DIARD, A. 64
Dicaeidae 113
Dicaeum flammeum SPARRM. 74
Dicaeum trochileum SPARRM. 74, 102, 113, 134
Dichroa febrifuga LOUR. 51, 67, 98, 105, 107, **175**
Dichrocephala chrysanthemifolia DC. 52, 54, 68, 77, 105, 112, 138, **247**
Dicotyledonae 66, 155
Didymochlaena lunulata DESV. **73**
Digitalis purpurea L. 45, 68, 94, 99, 105, **229**
DIETZ, J. 122, 148
Dilleniaceae 256
Dilophus nigriventris DE MEIJ. 83, 118, 175
Diplomaturina 83
Diplycosia heterophylla BL. 52, 68
Diptera 13, 76, 81, 83, 92, **100**, 102, 118, 159, 162, 166, 191, 220, 268
Disporum chinense DON. 18, 52, 97, 105, 106, 122, 137, **147**
Disporum pullum SALISB. 147
Djamoer Badak 7
DOCTERS VAN LEEUWEN, HANS 71, 125, 134, 135, 157, 160, 174, 179, 212, 240
Dodona adonira windu FHRST. 19, **77**, 114, 190, 245
Dodona aponata vanleeuwenii ROEPKE. 78
Dog, wild 73
DOMIN, K. 218
Dragon-flies 76
Drymaria hirsuta BARTL. 46, 67, 103, 123, 138, **161**
Dryopteris adnata v. A. v. R. 54
Dryopteris filix mas SCHOTT. 54

E

Echinomyia angulata DE MEIJ. 82, 120, 245
Edelweiss 22
Elaeocarpaceae 62, 255
Elaeocarpus 50
Elaeocarpus acronodia MAST. 22, 64, 67
Elaeocarpus angustifolia BL. 22
Elaeocarpus obtusa BL. 116, **255**
Elaeocarpus punctata HASSK. 67
Elaphoglossum angulatum MOORE. ... 22
Elateridae 115
Elatostema pedunculosum MIQ. 52, 66, 123
Embelia pergamacea DC. 51, 58
ENGLER, O. 140
Enicurus leschenaulti VIEILL. 75
Enthostodon Buseanus BRID. 56, 192, pl. IX
Epacridaceae 258
Eria appendiculata LINDL. 66
Eria floribunda LINDL. 66
Eria multiflora LINDL. 66
Ericaceae 2, 10, 11, 13, 68, 109, 131, 133, 198, 257
Erigeron linifolius WILLD. 46, 68, **248**
Eriocaulon trilobum B. H. 130
Eristalis bicornutus DE MEIJ. 81, 82, 118, 245
Eristalis kobusi DE MEIJ. 118, 245
ERNST, A. **16**, 157, 178, 218, 244
Erythrina 101

Erythrina subumbrans MERR. 112
Eucalyptus species 113
Eugenia jamboloides K. et V. 50, 67, 137
Eupatorium janthinum HEMSL. 46
Eupatorium pallescens DC. 46, 68
Eupatorium riparium ENGL. 46, 68, 124
Euphorbiaceae 67
Eurya 15
Eurya acuminata DC. 6, 46, 50, 54, 67, 69, 80, 88, 97, 100, 103, 105, 108, 134, 137, **179**
Eurya japonica THBG. 179
Eurya tristyla JUNGH. 69

F

FABER, F. C. VON **21**, 28, 30, 31, 34, 37, **44**, 48, 75, 177, 198, 214, 218, 247
Fagaceae 66, 157
Fagus silvatica L. 66, 94, **157**
Falco severus HORSF. 69
Fan-tail 74
Farysia emodensis SYD. 58, 159
Felis pardus L. 72
Festuca nubigena JUNGH. 6, 7, 8, 43, 71, 128 ,144, 258
Ficus diversifolia BL. 3, 22
Fishes 76
Fly-catcher 75
FORBES, H. O. 102, 103, 137, 211, 254
FORSTER, J. 5
Fragaria vesca L. 45, 57, 67, 80, 100, 107, 123, 137, **169**
Frasera, see Swertia
FREY-WYSSELING, A. 186
Fuchsia species 113, 116
Funaria hygrometrica SIBTH. 57

G

Gahnia javanica Z. et M. 19, 52, 56, 59, 60, 62, 65, 66, 122, 134, **146**
Galathea species 46
Galeopterus variegatus CUV. 74
Galium rotundifolium L. 265
Galinsoga parviflora CAV. 46, 68
Galls 58, 77, 159, 171, 178, 195, 208, 212, 215, 220, 237, 246, 248, 263, 264
Gallus bankiva TEMM. 74, 133
Gallus ferrugineus GM. 74, 133
Gallus varius SHAW et NODD. 134, 179
Gaultheria 8, 13, 102, 109
Gaultheria fragrantissima WALL. 4, 7, 15, 51, 58, 59, 60, 62, 68, 99, 105, **198**, pl. XXIV
Gaultheria leucocarpa BL. 4, 6, 51, 54, 58, 59, 60, 61, 68, 89, 99, 105, 109, 156, **200**, pl. XVI
Gaultheria nummularioides DON. 3, 4, 10, 15, 47, 51, 53, 56, 57, 58, 62, 68, 69, 88, 124, 134, **202**
Gaultheria procumbens L. 204
Gautiera repens BL. 69
Geniostoma haematosperma STEUD. 51, 68, 138
Gentiana 3
Gentianaceae 68, 110, 259
Gentiana Freyniana 225
Gentiana laxicaulis ZOLL. 223
Gentiana prostrata HAENKE. 224
Gentiana quadrifaria BL. 4, 10, 13, 15, 19, 38, 47, 56, 63, 65, 68, 103, 110, 130, 133, **221**, 259, pl. XXVII A
Gentiana recurvata CLARKE 259
Gentiana singgalangensis BACK ... 222, **259**
Gentiana tenella ROTTB. 224
Geometridae 100, 114
Geraniaceae 255
Geranium ardjunense ZOLL. 255
Geranium nepalense SWEET. **255**
Gesneriaceae 68, 230, 267
Gibbon 70
GIESENHAGEN, K. 16
Gleichenia 14
Gleichenia vestita BL. 6, 57
Gleichenia vulcanica BL. 6, 16, 56, pl. XI
Gnaphalium 3, 4, 8, 249
Gnaphalium arboreum 12
Gnaphalium indicum L. 68, 124
Gnaphalium javanicum REINW. 6
Gnaphalium longifolium BL. 10, 51, 68, 112, **249**
Gnaphalium luteo-album L. 8, 124
Gnaphalium Reinwardtianum MIQ. ... 249
GOEBEL, K. VON 225
Goniophoma braueri DE MEIJ. 82
Goodyera bifida BL. 52, 66
Gramineae 66, 94, 133, 143
Grevillea robusta A. CUNN. 113
GRONEMAN, J. 215
GUENTHART, A. 92, 104
GUENTHER, K. 264
Guttiferae 67, 108, 181
Gynura aurantiaca DC. 68
Gymnospermae 66

H

Habenaria tosariensis J. SM. 128
HABERLANDT, G. 14, 46

Halictus monachus BLTG. 116, 231, 245
Halorrhagidaceae 68, 192
Haplozia javanica SCHFFN. 58, 60
HARDWICK, E. 3
HASSELT, J. C. VAN 1, 2, 4, 5, 10
Hedera squarrosa JUNGH. 6
Helianthus annuus L. 116
Hemiptera 76, 83, 113, 268
Hepaticeae 49, 61
Heterocera 21
Hirundo rustica gutturalis SCOP. 75
Hogs 71
HOLTERMANN, C. 30
HORNER, L. 4
HORSFIELD, TH. 2, 3, 200
Hover-flies 97
Hydnum 7
Hydrangea oblongifolia BL. 51, 67, 107, 132, **175**
Hylobates leuciscus GEOFR. 70
Hymenolepis spicata PR. 59
Hymenophyllaceae 14, 60
Hymenophyllum paniculiflorum PR. ... 54
Hymenoptera 76, **79**, 115, 162, 166
Hypericum 3, 6, 10, 19, 51, 238, 239
Hypericum Leschenaultii GAUD. 14, 53, 55, 57, 67, 77, 87, 96, 97, 98, 100, 105, 108, 124, 132, **181**, pl. XXVII B, XXX A

I

Ichneumon 79, 100, 189
Ichneumonidae 115
Idiella quadrimaculata MACK. 83, 120, 245
Idiella unicolor MACK. 120, 245
Impatiens 11, 46, 53
Impatiens cyclocoma MIQ. 6, 52, 67, 123
Impatiens javensis STEUD. 52, 67, 99, 105, 108, 123, **179**
Impatiens platypetala LINDL. ... 134, 179
Imperata cylindrica BEAUV. 71
Inga montana JUNGH. 7
Insects 76
Isachne albens TRIN. 52, 66
Isachne pangerangensis Z. et M. 15, 16, 55, 57, 66, 122, **144**, pl. VIII, X
Ixalus pallidipes BARB. 76
Ixos bimaculatus 11

J

JACOBSON, E. 134, 186
JUNGHUHN, FR. 1, 2, 4, 8, 9, 10, 11, 17, 18, 24, 25, 28, 29, 32, 38, 40, 46, 48, 50, 55, 58, 64, 66, 69, 72, 75, 92, 99, 125, 127, 134, 144, 178, 186, 191, 208, 212, 215, 243

K

Kadsura scandens BL. 14, 51, 67
KARNY, H. H. **19**, 77, 206
KINDER, A. 7
KINZEL, W. 218
KNUTH, P. 92, 151, 159, 161, 166, 167, 168, 174, 179, 186, 198, 204, 211, 217, 224, 228, 232, 234, 238, 247, 253
KONINGSBERGER, J. C. **18**, 69, 71, 79, 81, 82
KOORDERS, S. H. 15, 17, 26, 65, 84, 132, 135, 138, 157, 163, 176, 177, 182, 188, 192, 214, 222, 226, 235, 244, 249, 263
KORTHALS, P. W. 4, **10**, 134, 226
KUHL, H. **1**, 2, 4, 5, 10
KUHN, E. 166
Kutilan 74

L

Labiatae 260
Lactuca rostrata BOERL. 68, 112
Lagunaria Patersonii G. DON. 116
LAM, H. J. 140, 141, 259, 263
Lamprocystis 83
Laniellus leucogrammicus SWAINS. ... 74
Lasianthus glaber SCHEFF. 266
Lasianthus lucidus BL. 51, 68, 138
Lasianthus purpureus BL. 116
Lasianthus stercorarius BL. 266
Lathyrus odoratus L. 116
Lauraceae 2, 14, 67, 166
Laurembergia coccinea KANITZ. 54, 64, 68, 88, 95, 124, 130, **192**, pl. IX
Laurembergia javanica SCHINDL. 192
LEEFMANS, S. 78, 238
Leguminosae 67, 108, 133, 176
LEHMAN, E. 229
Lemur, flying 74
Lepidoptera 19, 76, **77**, 113
Leptospermum 3, 8, 10, 49
Leptospermum javanicum BL. 5, 6, 8, 10, 11, 14, 15, 50, 54, 59, 60, 65, 67, 87, 99, 100, 105, 108, 133, 140, **186**, 260, pl. VII, XXIX B
Libellulidae 76
Lichens 6, 10, 11, 20
LIEFTINCK, M. A. 76
Ligustrum 195
Liliaceae 66, 106, 122, 147, 251
Limnophora prominens STEIN. 82, 121, 171, 175, 245

Lispocephala boops THOMS. 82, 121, 189, 241
Litsea citrata BL. 166
Litsea cubeba PERS. 6, 50, 67, 137, **166**
Litsea javanica BL. 50, 67
LOEW, H. 94
Loganiaceae 68
Lomaria pycnophylla KZE. 16
Lomaria vestita BL. 11, 70
Lonicera 3, 6
Lonicera javanica DC. 4, 14, 51, 57, 68, 75, 80, 89, 97, 98, 100, 101, 102, 103, 105, 110, 124, 138, **235**
Lonicera Loureiri DC. 235
Loranthaceae 66, 96, 106, 125
LOERZING, H. 186
Lycaenidae 77, 100, 114, 159
Lycopodium clavatum L. 58, 59, 60, 64, 65
Lycopodium miniatum SPRING. 6, 53, 58
Lycopodium rigidulum JUNGH. 6
Lycopodium rigidum BL. 6
Lycopodium volubile FORST. ... 14, 60
Lycopodium Wightianum WALL. 56, 59, 65, pl. XVII
Lygaeidae 113

M

Macropygia leptogrammica TEMM. ... 74
Macropygia unchall WAGL. 74
Maesa indica WALL. 78
Magnoliaceae 67
Mammals **70**
Marica coerulea KER. GAWL. 45
Marsupiella vulcanica SCHFFN. 58
MASSART, J. **14**, 46, 217
Mastigophora diclados NEES. 60
Maurandia erubescens A. GRAY 113
Medinilla verrucosa BL. 116, **257**
Megaspis chrysopygus WIED. 82, 118, 245
Megaspis errans F. 118, 238
Megaspis zonalis F. 20, 82, 118, 245
MEIJERE, J. C. DE 76, 81
Melanostoma quadrinotatum DE MEIJ 118, 261
Melastoma 116
Melastomataceae 67, 109, 191, 257
Melastoma malabathricum L. 116
Melastoma setigerum BL. 51, 67, 98, 105, 109, 137, **191**
Melothria punctata COGN. 52, 68, 138
MEZ, A. 213
Microlepidoptera ... 79, 100, 189, 212
MIEHE, H. 17
Miliona fulgida SN. V. VOLL. 114, 238
Mimosaceae 176
MITTEN, W. 11
Mocking-bird 74
Molluscs 21, 83
MONCHY, DE 198
Monkeys 70
Monocotyledonae 66, 143
MOSELEY, H. N. 138
MOTLEY, J. 11, 12, 129, 169, 216
MUELLER, H. 162, 224
MUELLER, S. 4, 72
Muntjakus muntjak ZIMM. 70
MURRAY, H. 264
Musci frondosi 49, 61
Muscicapula hyperytha BLYTH. 75
Muscidae 83, 120
Mustela flavigula BODD. 70, 72
Mycetia laterifolia KORTH. 267
Mydaus javanicus DESM. **72**
Mydaus meliceps HORSF. 72
Myriactis javanica DC. 249, 250
Myriactis nepalensis LESS. 3, 52, 54, 58, 60, 61, 63, 65, 68, 77, 105, 112, 138, **245**
Myriapoda 21, 83
Myrica 3, 10
Myrica javanica BL. 4, 16, 17, 46, 50, 59, 60, 62, 66, 69, 75, 95, 134, 135, 136, **155**, pl. XXIII
Myrmechis 52, 53
Myrmechis glabra BL. 52, 54, 66, 103, **148**, 150
Myrmechis gracilis BL. 66, 103, 122, **149**
Myrsinaceae 68, 78, 138, 212
Myrtaceae 5, 67, 108, 186

N

Nasturtium officinale R. BR. 14
Nectariniidae 101, 112
Neillia thyrsiflora DON. 51, 67, 107, **169**
Nepenthaceae 67
Nepenthes gymnamphora NEES. 51, 59, 67, 131
Nertera depressa B. et S. 14, 52, 53, 54, 58, 61, 68, 124, 138, **233**
Nesocincla eremita 138
NIERMEIJER, J. F. 17
Nymphalidae 114
Nysius (aff. sundanus BEDD.) 76, 101, 113, 245

O

Oberonia Costeriana J. J. S. 66

Oenothera species ... 46, 54, 67, **191**
Onagraceae 67, 191
Oniscoidea 83
Onthophagus deflexicollis DEG. 253
Ophiopogon caulescens BACK. **252**
Ophiorrhiza longiflora BL. 52, 68, 110, **234**
Orchidaceae 66, 106, 133, 147, 253
Oreocincla dauma horsfieldi BP. 75, 133, 135, 156
Oreosterops javanica frontalis REICHB. 70, 76, **102**, 113, 133, 134, 135, 136, 156, 174, 202, 208, 211, 212
Ortalinae 83, 120
Orthotrichum 7
Oxalidaceae 67, 178
Oxalis corniculata L. 46, 67, 132, **178**
Oxycoccus 3

P

Paku sigoeng 73
Palavicinia 54
Panther 72
Parmarion 83
Parochetus communis HAM. 116
Partridge 74
Pegomyia bistriata STEIN. 80, 82, 121, 180, 189, 195
Peperomia reflexa DIETR. 52, 53, 66, 138
Perrottetia alpestris LOES. 51, 67, 137, **179**
Phaeomeria solaris SCHUM. 253
Phajus flavus LINDL. 52, 66, 103, 122
Pholidota globosa LINDL. 66
Photinia integrifolia LINDL. 6
Photinia Notoniana W. et A. 6, 54, 67, 77, 89, 105, 107, 134, 137, **170**
Pieridae 114
Pigeon 3, 74
Pigs 71
Pilea trinervia WIGHT. 52, 66, 123
Pimpinella alpina KDS. 195
Pimpinella javana DC. 257
Pimpinella Leeuwenii WOLFF. 57, 68, 124, **195**
Pimpinella pruatjan MOLK. 124
Piperaceae 66
Piper arcuatum BL. 51, 66
Pirus malus L. 45, 67, 94, **172**
Pithecus aygula L. **70**
Pithecus maurus CUV. 70
Pithecus mitratus ESCHH. 70
Pithecus pyrrhus sondaicus R. et KL. **70**
Plagiogyria glauca METT. 65, pl. XIX
Plagiogyria pycnophylla METT. 7, 54, 63, 65
Plantaginaceae 68, 110, 230
Plantago 7
Plantago Hasskarlii DECNE. ... 128, 230
Plantago incisa HASSK. 230
Plantago major L. 6, 16, 52, 53, 68, 88, 95, 97, 98, 100, 105, 110, 124, 128, **230**
Platanthera Blumei LINDL. 52, 53, 54, 66, 79, 97, 100, 103, 105, 116, 122, **150**
Plectranthus javanicus BTH. 117, 261
Plectranthus Teijsmanni MIQ. 117
Pleopeltis feei METT. 11, 17, 22, 46, 58, 59, pl. XXIV
Pleopeltis triquetra BL. 11, 22, pl. XIX
Poa annua L. 46, 66, 131, **145**
Poa pratensis L. 14
Poa trivialis L. 45, 66
Podocarpus 20
Podocarpus imbricata BL. 16, 18, 19, 47, 49, 53, 66, 95
Pogostemon menthoides BL. 117, 261
Polistes diabolicus SAUSS. 79, 100, 115, 211
Polygonaceae 67, 106, 158
Polygonum chinense L. 52, 54, 58, 59, 62, 67, 77, 87, 99, 100, 103, 105, 106, 135, **157**, pl. XXVII B
Polygonum longisetum DE BR. 67
Polygonum paniculatum BL. 52, 67, 123, 137
Polyosma ilicifolia BL. 50, 67, 137, **176**, pl. XIX
Polypodium fasciatum PR. 54
Polypodium nutans BL. .....
Polystictum aculeatum SCHOTT. 54
Polytrichum 56
Pomatorrhinus montanus HORSF. 74
PORSCH, O. 101, 190
Pratia montana HASSK. 52, 68, 138, **240**
Primulaceae 68, 109, 215
Primula acaulis L. 130
Primula imperialis JUNGH. 2, 5, 8, 11, 12, 13, 14, 15, 17, 43, 52, 53, 56, 57, 63, 68, 78, 85, 88, 99, 104, 105, 109, 124, 128, 129, 156, 196, **215**, 231, pl. XVIII
Primula prolifera HOOK. 215
Procordulia sumbawana FOERST. 76
Prunus Puddum ROXB. 117
Psyllidae 76, **77**, 82, 89
Pterocormus 79, 115, 241, 245
Pteris incisa THB. 16
Ptilinopus roseicollis WAGL. ... 13, 133
Ptilinopus porphureus TEMM. 13, 69, 133
Pycnonotus bimaculatus barat R. et KL. 11, 74, 134, 156, 174, 212, 255
Pyralidae 79, 114

Pyrameis cardui L. 78, 114, 245

Q

Quercus 19, 47
Quercus pallida BL. 50, 66
Quercus pseudo-molucca MIQ. 10
Quercus spicata SM. 50, 66

R

RACIBORSCI, M. 155, 178, 209
RAFFLES, S. 1, 2
RANT, A. 140
Ranunculaceae 67, 106, 131, 161
Ranunculus 10, 11, 52, 131
Ranunculus diffusus DC. 13, 14, 17, 18, 46, 53, 58, 67, 106, **192**
Ranunculus javanicus REINW. 6, 13, 14, 17, 18, 56, 63, 64, 67, 87, 130, **163**, 196, pl. XVIII
Ranunculus sagittifolius HOOK. 163
Rapanea 14, 15
Rapanea affinis MEZ. 213
Rapanea avenis BL. 6, 17, 22, 50, 54, 60, 68, 78, 95, 103, 134, **213**, pl. XV
Rattus lepturus JENT. **73**, 100, 131, 138, 161, 174, 204, 212, 213, 234
REINWARDT, C. C. G. 2, 3
Reptiles 3, 18, 75
RESVOLL, TH. R. 22
Rhabdocnemis dehaanii CYRL. 253
Rhacomitrium 16
Rhacomitrium lanuginosum BRID. 16, 55, 56, 57, 63, 65, pl. XI, XVII, XXX B
Rhadinomyia orientalis SCHIN. 83, 120, 167, 189, 195, 241, 245
Rhaebothrips 83
Rhingia basalis DE MEIJ. 119, 162
Rhingia rostrata L. 162
Rhinoceros 1, 3, 5, 24, 69, 74, 142
Rhiphidura phoenicura S. MUELL. ... 74
Rhododendron 14, 102
Rhododendron album BL. 131
Rhododendron citrinum HASSK. 131
Rhododendron javanicum BENN. 51, 68, 109, 117, 131
Rhododendron retusum BENN. 3, 4, 6, 11, 15, 50, 54, 58, 60, 61, 62, 68, 75, 89, 97, 98, 101, 105, 109, 131, **204**, pl. XI, XXIX A
Rhodoleia Teijsmanni MIQ. 113, 117
Rhopalocera 100
RIDLEY, H. N. 125, 130, 132, 133, 138
Riodinidae 114
ROBINSON, H. C. 134
ROCK, J. F. **19**, 178
ROEPKE, W. 18, 76, 77, 80, 100, 211
ROGERS, R. S. 154
Rosaceae 67, 107, 168, 254
Rosa canina L. 45, 67, 94
Rosa rubiginosa L. 45, 67, 94
Rosmarinus officinalis L. 117
Rubiaceae 68, 110, 232, 265
Rubus 10, 14, 15, 51, 97, 170
Rubus alpestris BL. 67
Rubus fraxinifolius POIR. 135
Rubus fruticosus L. 45, 67, 107, 124, **172**
Rubus Hasskarlii MIQ. 67, 134
Rubus lineatus REINW. 51, 54, 57, 58, 59, 60, 67, 75, 87, 98, 100, 101, 105, 107, 134, 135, **172**, 254
Rubus moluccanus L. **254**
Rubus niveus THUNB. 117, 134, **254**
Rumex alpinus L. 45, 67, 94, 123

S

Salvia splendens KER. GAWL. 113, 115
Sanicula 6
Sanicula europaea L. 17, 52, 53, 54, 58, 61, 68, 87, 124, 139, **196**, 218, pl. XVIII
Sastragala 77
Saurauja bracteosa DC. **256**
Saurauja cauliflora DC. 117
Saurauja leprosa KORTH. 117
Saxifragaceae 67, 107, 137, 174
Schefflera lucescens KOORD. 51, 60, 68, 134
Schefflera rugosa HARMS. 6, 50, 54, 68, 89, 109, 135, **194**, pl. XIV
Schima Noronhae REINW. 19, 50
SCHIMPER, A. F. W. **15**, 30, 187, 190, 222, 244
SCHMUCKER, TH. 21, 30, 43, 47, **126**, 129, 139
SCHROETER, C. 19, 22, 31, 32, 47, 56, 92, 94, 192, 206, 209, 224
SCHUCKERT, CH. 141
Sciara 18
Sciara heteroptera DE MEIJ. 76
Scimitar-babbler 74
Scirpus fluitans L. 56, 64, 66, 122, 130, **146**
Scoparia murificalis WALK. 79, 229, 245
Scrophulariaceae 68, 229
Scurrula 74
Scurrula fusca DON. 11
Scurrula Junghuhnii DANS. 125
Scurrula lepidota G. DON. 52, 60, 66, 96, 101, 102, 105, 106, 134
Scurrula montana DANS. 125
SEEGER, R. 224

SEIFRITZ, W. **20**, 209
Serinus estherae FINSCH. 264
SERNANDER, R. 130
Servillia flavopilosa BIG. 82, 120, 245
Servilliopsis buccata TOMS. 82, 120, 241, 245
Shrew 74
Shrike 74
Sigung 73
Silk-worm 64
Skunk 72
SLOOTEN, D. F. VAN ... 186, 230, 247
SMITH, J. J. 103, 198
Solanaceae 68, 110, 261
Solanum nigrum L. 52, 68, 98, 105, 110, 138, **228**
Solanum tuberosum L. 46, 68, 94
Sonchus asper L. 46, 57, 68, 105, 112, **250**
Sphegina javana DE MEIJ. 119
Sphenurus sphenurus korthalsi BP. 75, 131, 134, 135, 181, 200, 202, 212
Spilanthes acmella L. 115, 268
Spilanthes grandiflora TURCZ. 268
Spirogyra 56
STAPF, O. 140
Staphilinidae 83
STEENIS, C. G. G. J. VAN 95, 123, 130, 138, 140, 196, 215, 250
Stellaria media L. ... 14, 46, 67, 123
Stereocaulon graminosum SCHAER. 16, 20, 56, 58, 59, 62, 63, 65
Stinking badger 72
STOMPS, TH. J. **21**, **48**
Straw-berries 11, 12
Strobilanthes callosus NEES. 264
Strobilanthes cernuus BL. 85, 93, 263
Strobilanthes involucratus BL. ... 117, **264**
Strobilanthes pictus KOORD. 264
Strobilanthes sessilis NEES. 264
Strobilanthes Wallichii NEES. 264
Styphelia pungens KOORD. ... 117, 134, **258**
Styracaceae 140
Styrax 15
Sus verrucosus TEMM. **71**
Sus vittatus TEMM. **71**
Swertia 6, 10
Swertia carolinensis BAILL. 228
Swertia javanica BL. 4, 13, 18, 52, 54, 55, 57, 58, 59, 61, 65, 68, 77, 85, 87, 98, 101, 104, 105, 110, 124, 133, **226**, pl. XXVIIII A
Swift 69, 75
Symplocaceae 68, 109, 218
Symplocos 14
Symplocos sessilifolia GUERKE. 50, 54, 59, 60, 61, 68, 77, 80, 82, 88, 97, 100, 105, 109, 138, **218**
Symplocos spicata ROXB. 22, 68
Syntomis 159
Syrphidae **82**, 118
Syrphus balteatus DE G. 119, 163, 179, 247
Syrphus confrater WIED. 82, 119, 180, 220 245
Syrphus gedehanus DE MEIJ. ... 119, 220
Syrphus koningsbergeri DE MEIJ. 82, 119, 161, 169, 228, 241, 245, 249, 250.
Syrphus latistrigatus DE MEIJ, 82, 111, 245
Syrphus serarioides DE MEIJ. 82, 119, 169, 171, 189, 220, 224, 238, 241, 250.
Syrphus serarius WIED. 82, 119, 159, 169, 171, 224, 241, 245

T

Tachinidae 82, 120
Taeniophyllum glandulosum BL. 66, **151**
Taeniophyllum Hasseltii RCHB. F. ... 153
Taeniophyllum tjibodasanum J. J. S.... 66
Taeniophyllum Zollingeri RCHB. F. 153
Taraxacum officinale L.... 46, 54, 68, **250**
TAVERNE, N. J. M. **23**, 24, 25
TEIJSMANN, J. E. **9**, **11** 12, 18, 26, 30, 45, 55, 123, 124, 157, 168, 169, 172, 216, 258
Tephritis montana DE MEIJ. 83, 120, 245
Terias hecabe L. 114, 159
Thalictrum 5
Thalictrum javanicum BL. 57, 67, 85, 87, 95, 106, 123, 130, 132, **164**
Theaceae 67, 108, 179
Thelymitra javanica BL. 4, 10, 38, 56, 59, 63, 65, 66, 88, 103, 105, 106, 122, 140, **153**, pl. XXVIII B
Thibaudia 8
Thibaudia rosea JUNGH. 6
Thibaudia vulgaris JUNGH. 6
Thripses..... 77, 159, 234
Thrush 3, 12
Thysanoptera 77, 113
Tigers 71
Toads 76
Tortricidae 79
TOXOPEUS, L. J. 78, 81
TREUB, M. 157
Tropeolum 9
Trypetinae 83, 120, 171
Turdus 11

300 302

Turdus javanicus fumidus S. MUELL. 13, 69, 72, **75**, 133, 134, 135, 156, 169, 208, 212, 214.
Turdus javanicus whitehaedi SEEB. 135, 160, 212, 259

U

Umbelliferae 68, 195, 257
Uromyces Thelymitrae RAC. 155
Uromycladium Tepperianum MAC. ALP. 58, 178
Urticacae 66
Usnea ..... 2, 7, 62, pl. VII
Ustilago Treubii SOLMS. 159

V

Vaccinium 3, 8, 11, 13, 20, 80, pl. V, VI, XXI, XXV
Vaccinium coriaceum MIQ. 257
Vaccinium ferratum JUNGH. 3
Vaccinium Forbesii FAWC. 102
Vaccinium laurifolium MIQ. 6, 14, 15, 20, 46, 50, 51, 54, 68, 87, 96, 99, 102, 105, 109, 134, **206**, 210, 243, pl. XIII
Vaccinium lucidum MIQ. 21, 68, 109, 117, **209**
Vaccinium myrtillus L. 210
Vaccinium varingifolium MIQ. 4, 5, 6, 7, 9, 14, 15, 17, 19, 20, 22, 32, 47, 50, 54, 58, 59, 60, 61, 62, 68, 69, 73, 75, 86, 96, 99, 100, 101, 102, 105, 109, 131, 134, 135, 136, 207, **209**, 213, pl. XX
Valerianaceae 68, 111, 133, 134, 240
Valeriana 3, 6
Valeriana Hardwickii WALL. 6, 13, 52, 61, 63, 68, 100, 105, 111, 124, 133, **240**
Valeriana officinalis L. 6
VALETON, TH..... 176, 177, 188, 213, 244
Vanessa canace javanica FRHST. 78
Vanessa cardui L. 18, 78
VERMEULEN, J. 8
Veronica javanica BL. 68, 103, **229**
Vespa velutina F. 79, 115
Vespidae 79, 115
VETH, P. J. 13
Viburnum coriaceum BL. 50, 54, 68, 69, 105, 111, 135, 138, **239**.
Violaceae 67, 184
Viola 11
Viola odorata L. 67, 94, **184**
Viola pilosa WALL. 6, 52, 54, 57, 58, 63, 67, 87, 103, 123, **184**, 196
Vireya 8
Vireya retusa BL. 6
VRIESE, W. H. DE 215
VRIJ, M. P. **44**

W

Wahlenbergia marginata DC. 267
WALLACE, A. R. **12**, 13, 134, 140
Warbler 74, 74
WARMING, E. 104, 224
WEEVER, A. DE 172
WEGENER, A. 141
WHITE-eye 75
WINTERSTEIN, H. 126
WOLFF, H. 195
WUELLERSTORF—URBAIN, B. VON 12

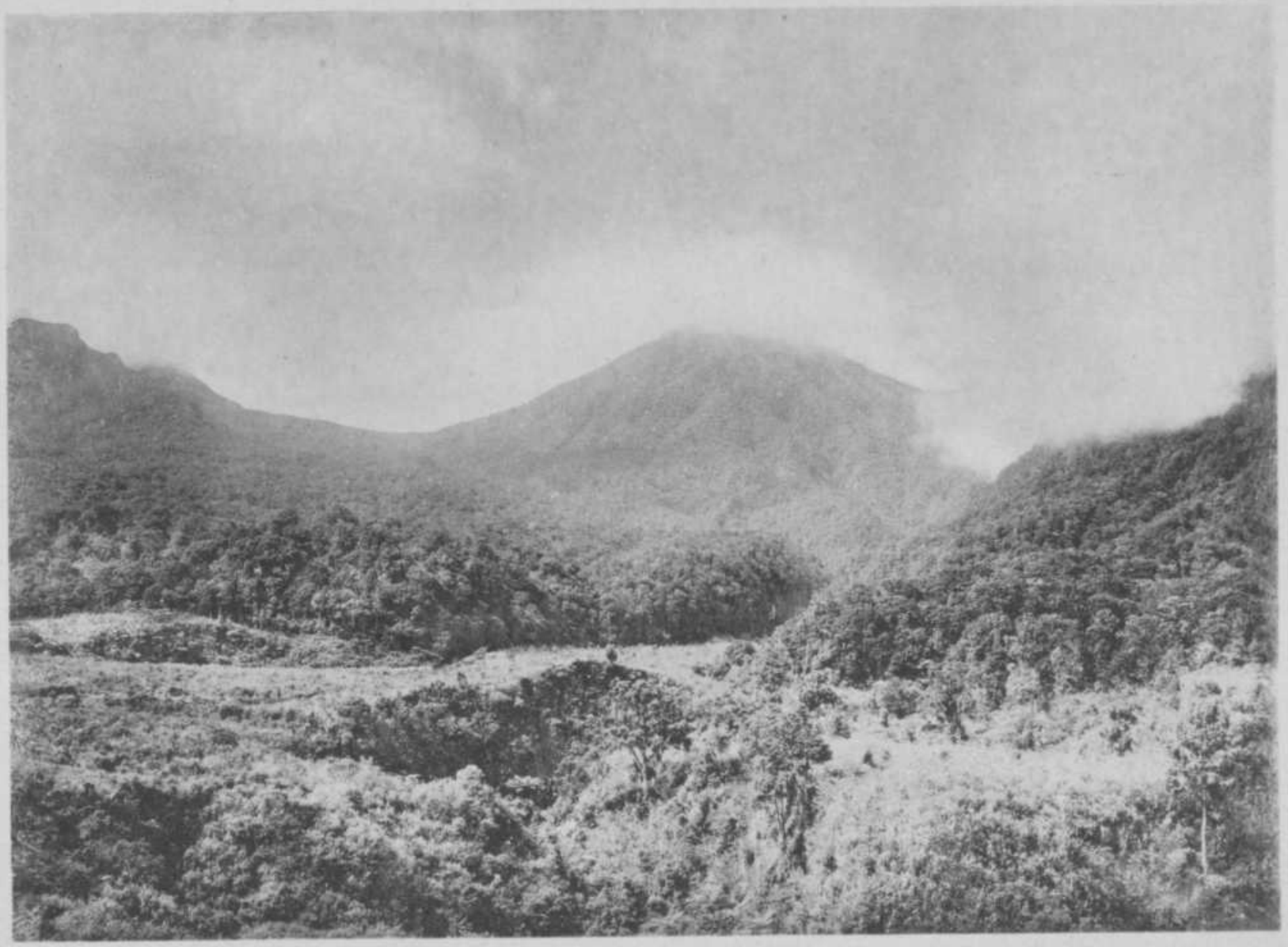
X

Xantholaema haemacephala rosea DUM. 135, 136, 156
Xylocopa 81
Xyris melanocephala MIQ. 117, 130

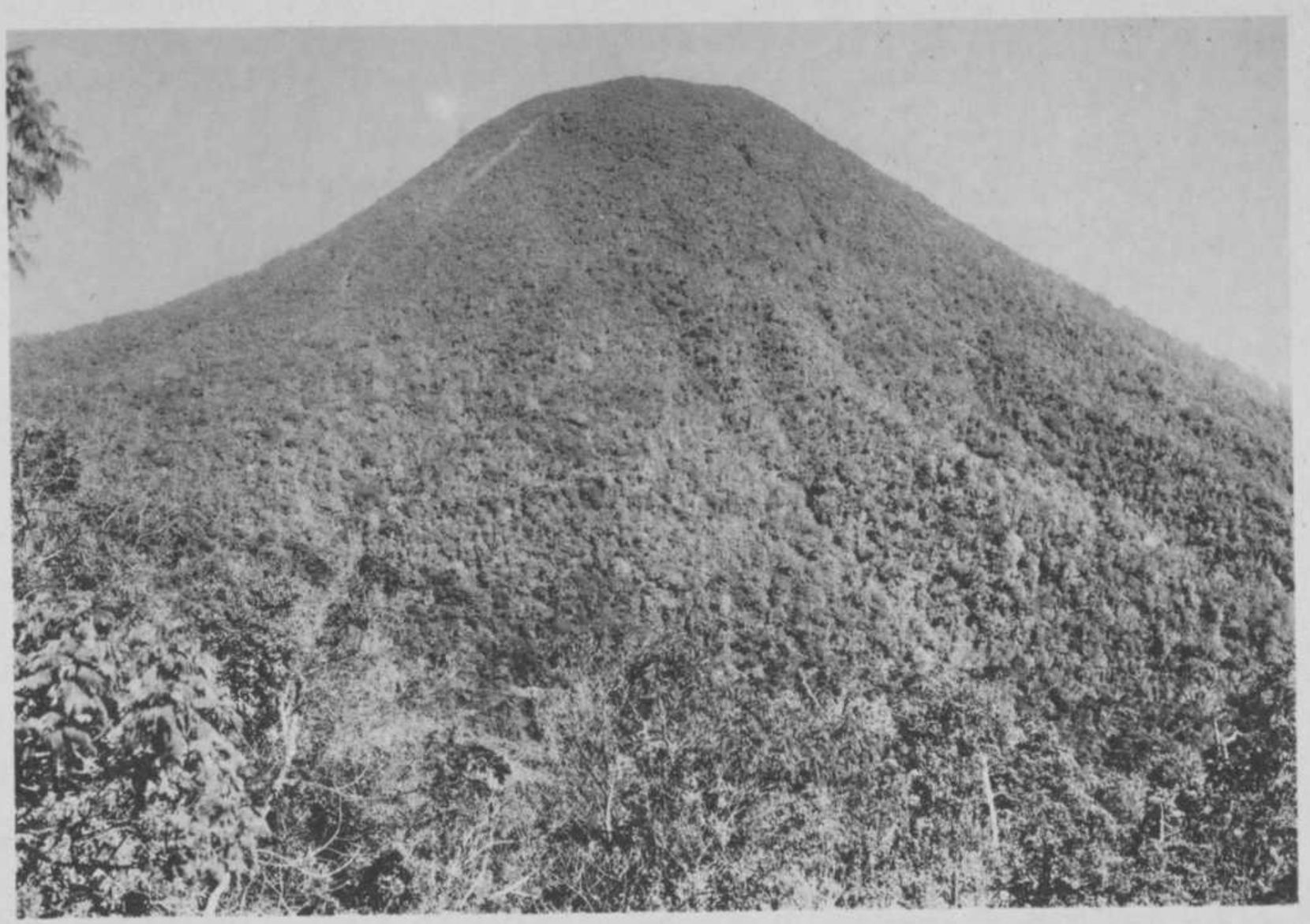
Z

Zemeros flegyas javanus MOORE ... 78
Zingiberaceae .....
ZOLLINGER, H. 85, 187, 222
Zosterops 75, 102, 113, 211
Zosterops chlorata FORB. 113
Zosterops fallax SHARPE 70, 76, 133
Zosterops palpebrosa sindorensis SIEB. 136, 160, 212, 240

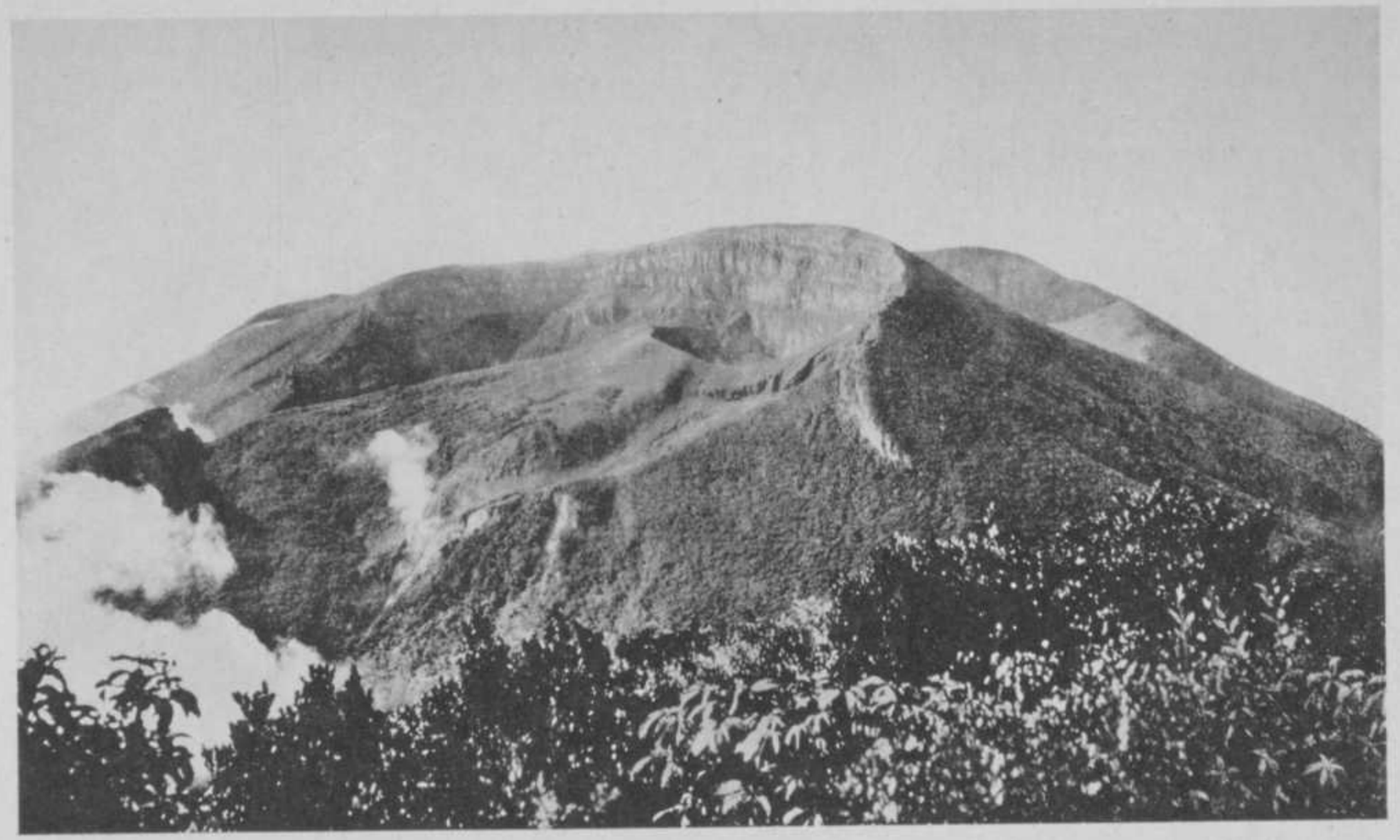
View of the mountains from the East, taken from a point above Sindanglaja. In the foreground ricefields, on the left Mt. Gedeh, on the right Mt. Pangrango.



View of Mt. Pangrango and Mt. Gedeh, seen from the East (tea-plantation Rarahan). Top of Mt. Pangrango covered with a cloud-cap.

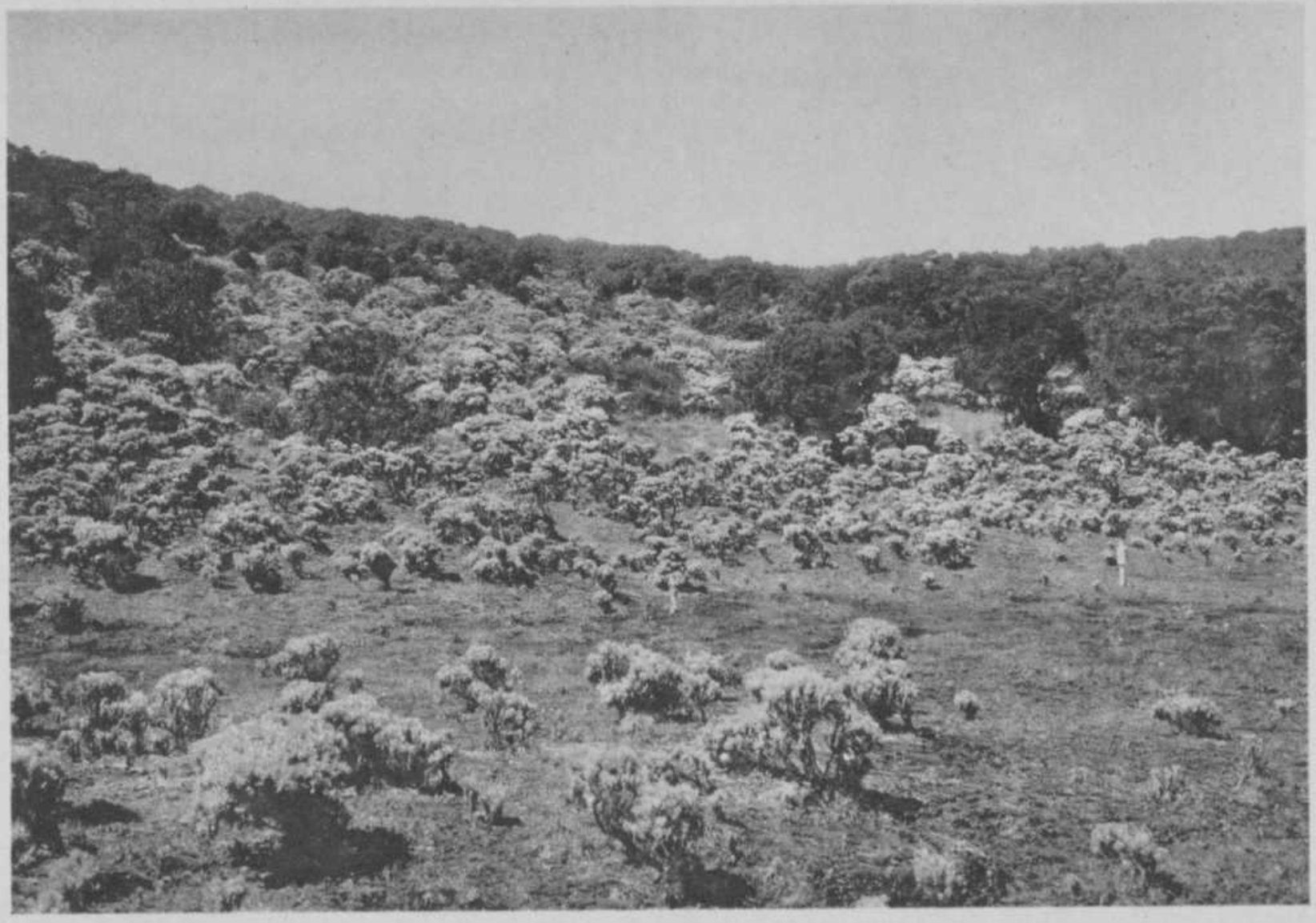


Top of Mt. Pangrango, seen from the ravine of the Tji-saät.



Top of Mt. Gedeh, seen from the summit of Mt. Pangrango; on the right the western end of the aloon-aloon with a triangular part where the forest has been destroyed by a bush-fire in 1914, and is replaced by *Anaphalis javanica*. In the foreground the vegetation of the Pangrango; to the left of the centre a small cloud of steam rising from the crater Wadon.

South-western part of the crater-valley of Mt. Pangrango; in the foreground *Anaphalis javanica*; in the background *Vaccinium*-forest; in the distance Mt. Salak.



Centre of the crater-valley of Mt. Pangrango, with plenty of *Anaphalis javanica*, and in the background the *Vaccinium*-forest.

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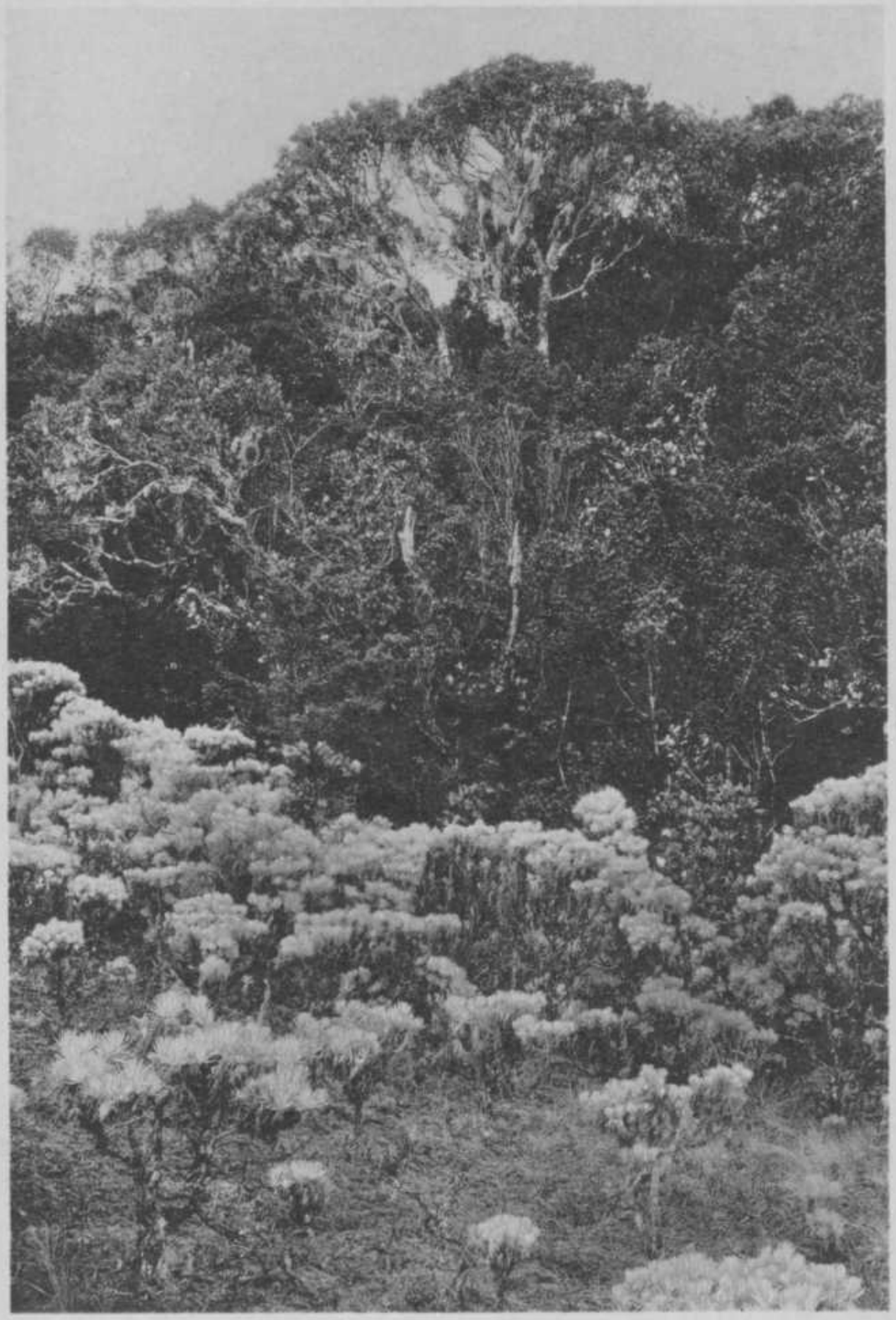
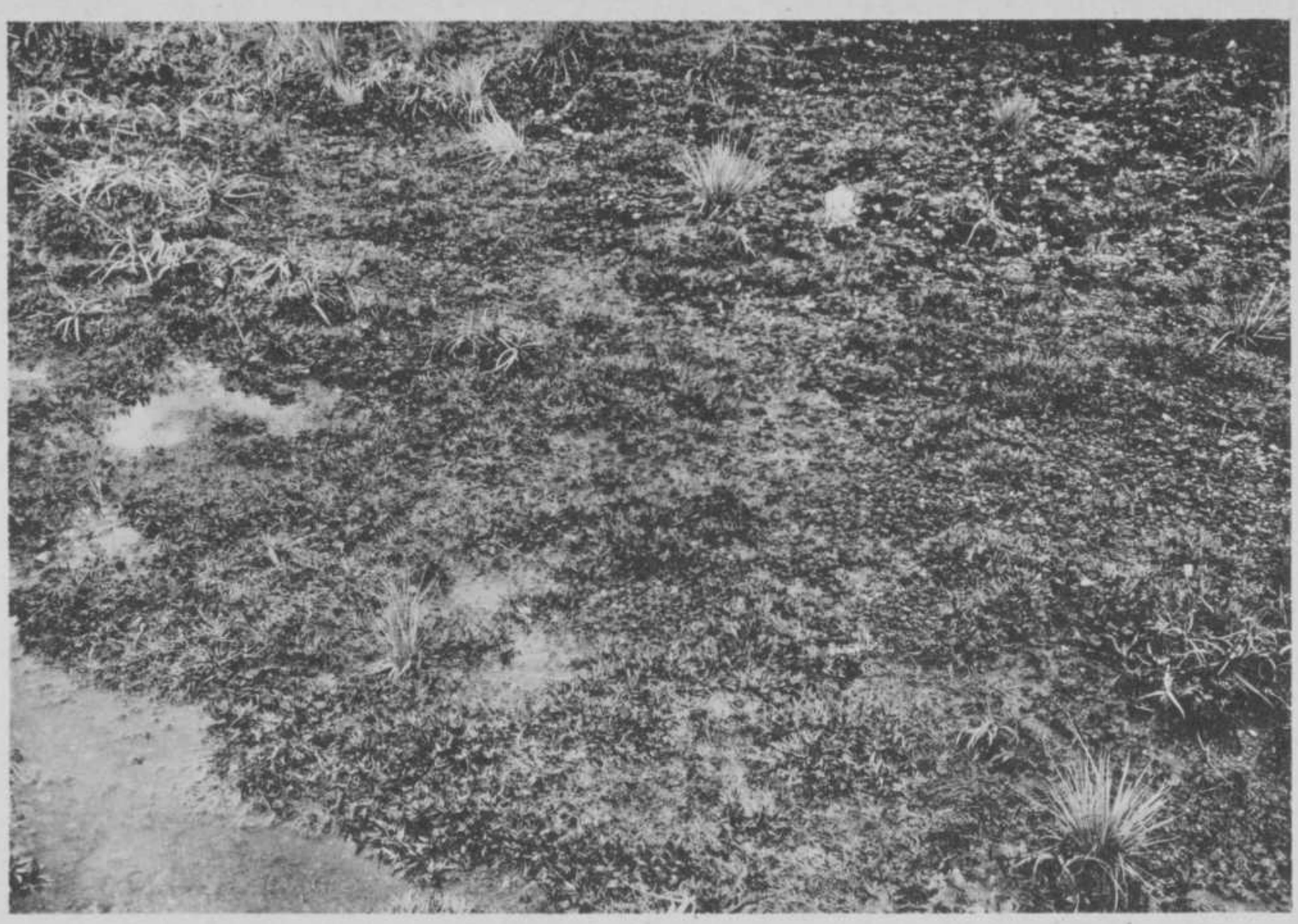
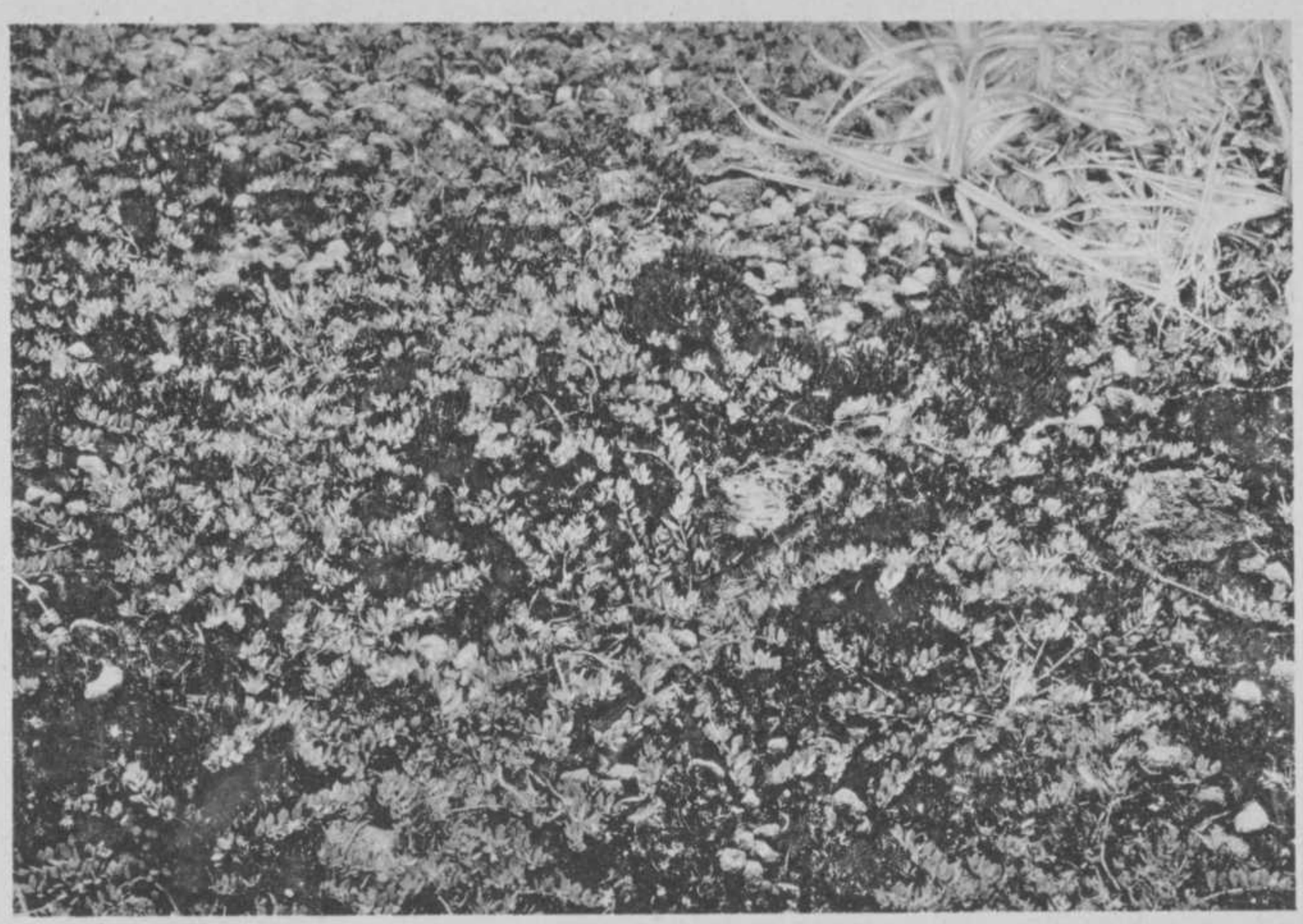


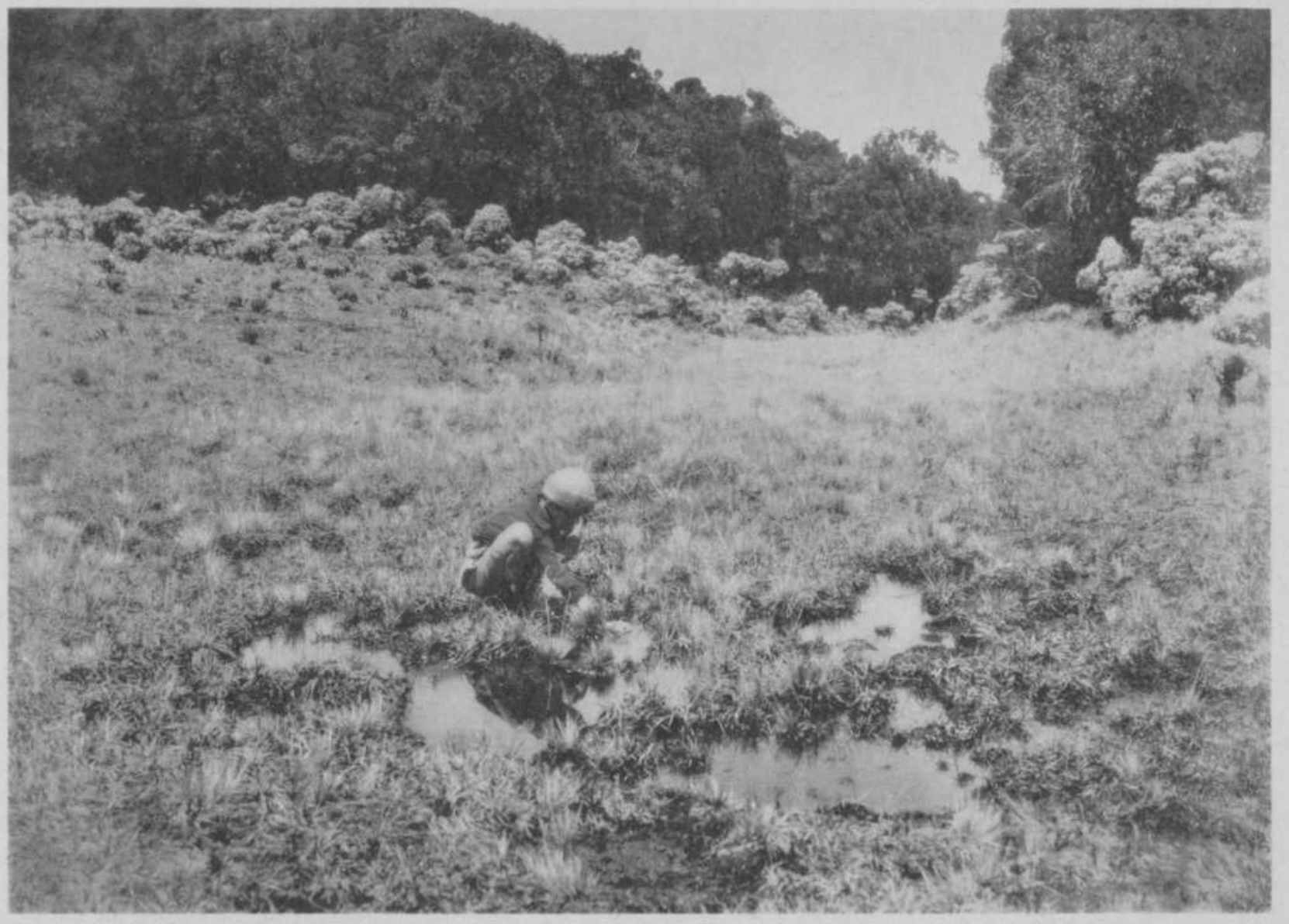
North-eastern part of the crater-valley of Mt. Pangrango. Forest-edge with *Anaphalis javanica* in the foreground. The large "umbrella" shaped tree is *Leptospermum javanicum*, with *Usnea* on the branches.



Centre of the crater-valley of Mt. Pangrango. In the left corner below is the brook; the bank is covered with *Isachne pangerangensis, Agrostis infirma, Carex hypsophila,* and young plants of *Anaphalis javanica.*



Crater-valley of Mt. Pangrango; wet patches with *Laurembergia coccinea*, and dark moss cushions of *Enthostodon Buseanus*. In the right corner above young plants of *Carex hypsophila*.



South-western part of the crater-valley of Mt. Pangrango; marshy ground near the brook, covered with *Isachne pangerangensis* and *Agrostis infirma*.

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Crater-valley of Mt. Pangrango; edge of the forest with moss cushion of *Rhacomitrium lanuginosum*, about 90 cm thick. On the moss are developed *Gleichenia vulcanica*, *Rhododendron retusum*, and *Anaphalis javanica*.

Crater-valley of Mt. Pangrango, western part. In the background old individuals of *Anaphalis javanica*, in the foreground *Carex hypsophila*, and young plants of *Anaphalis*. Near the left corner below an *Agrostis infirma*.

Flowering branch of *Vaccinium laurifolium*, seen from below.

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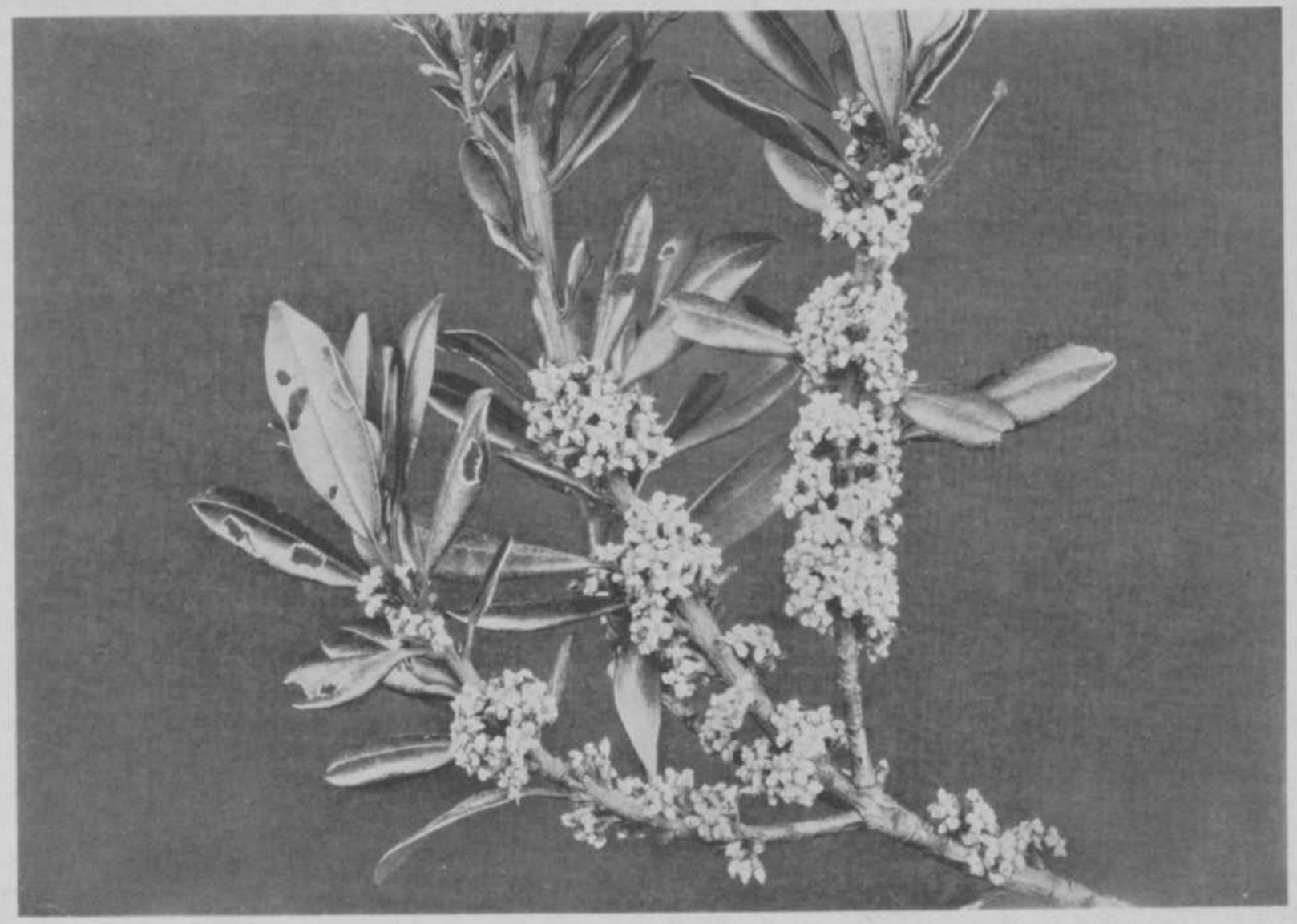
A branch of *Schefflera rugosa*, with fruits.



A branch of *Rapanea avenis*, with male flowers.

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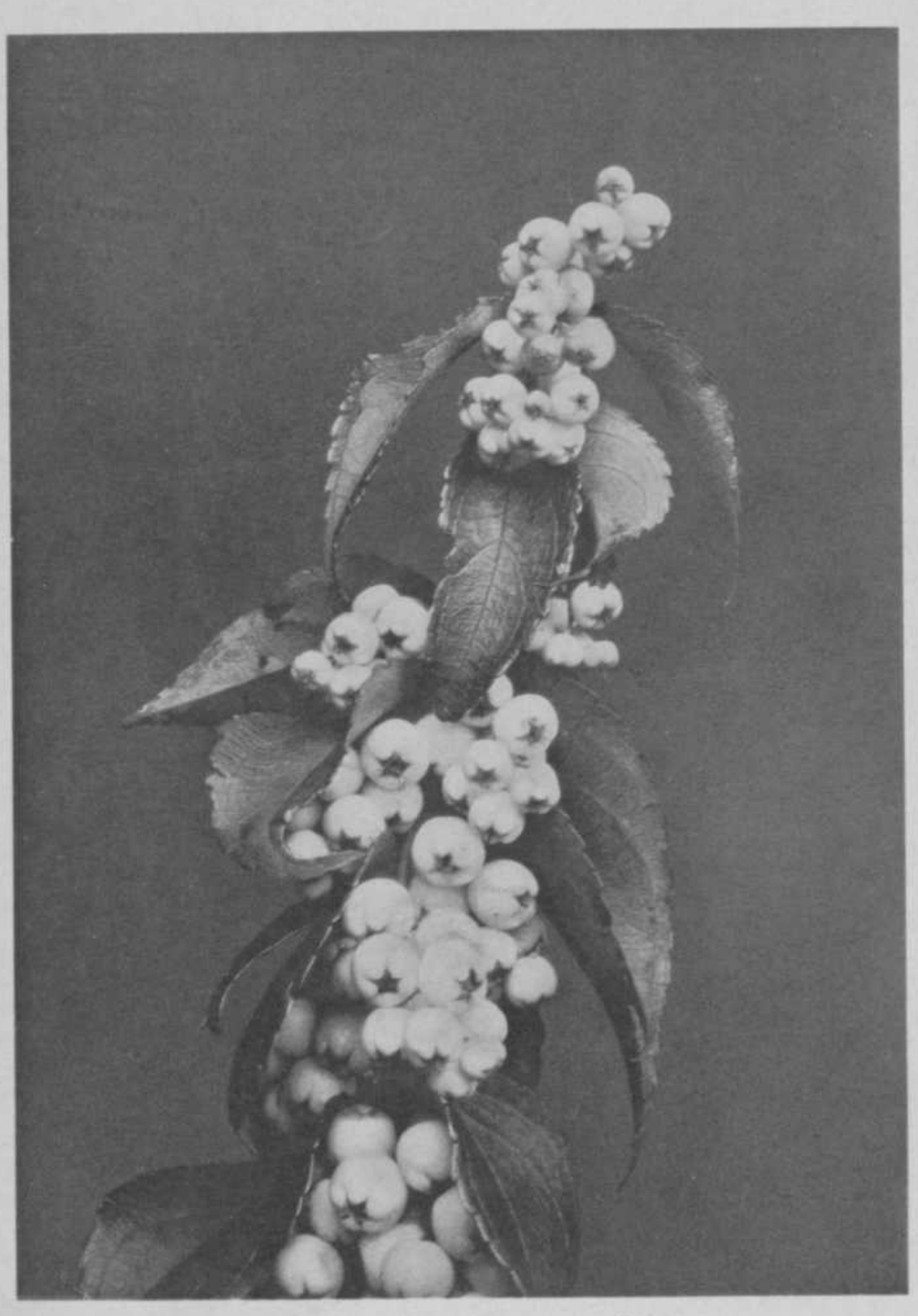
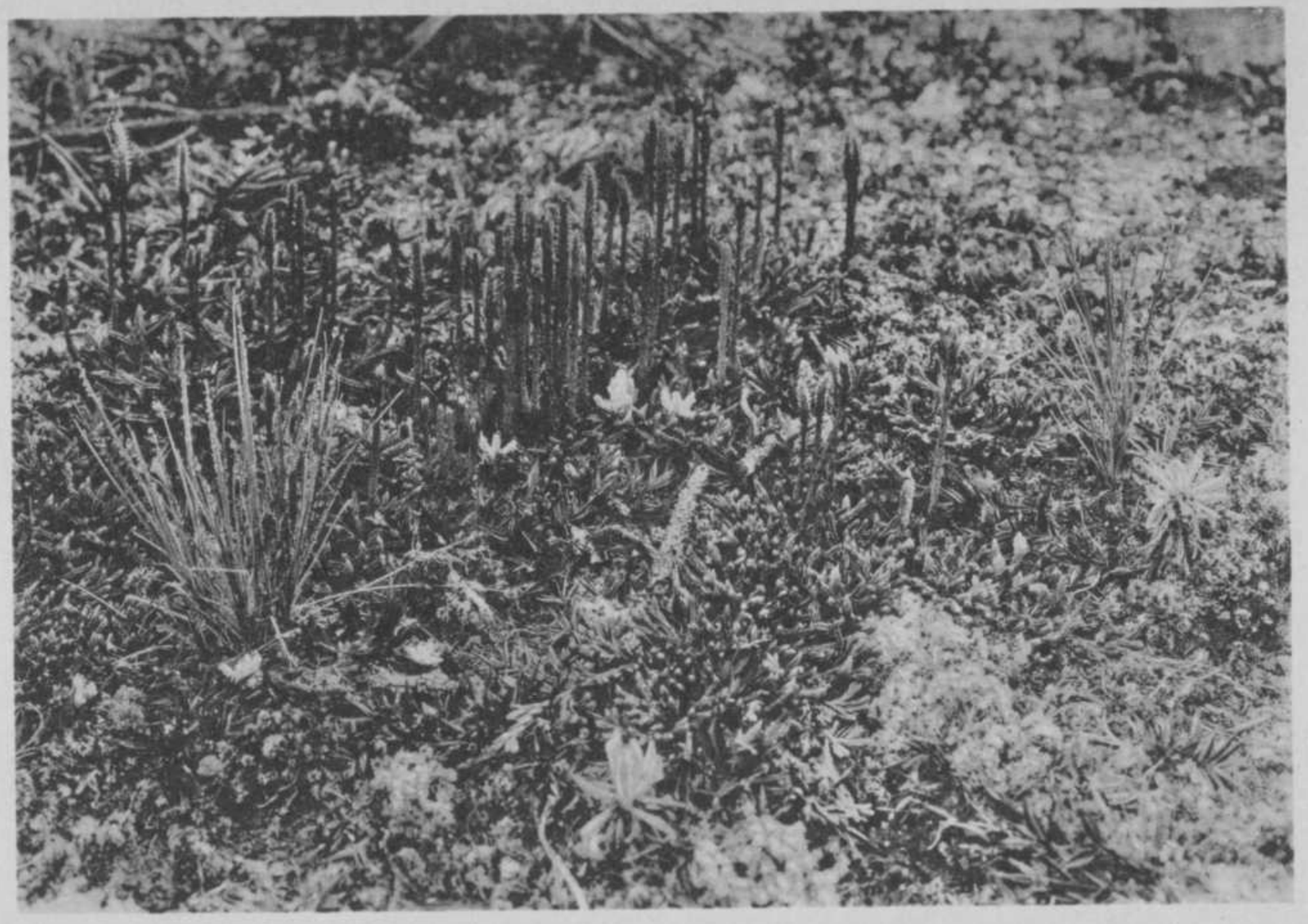


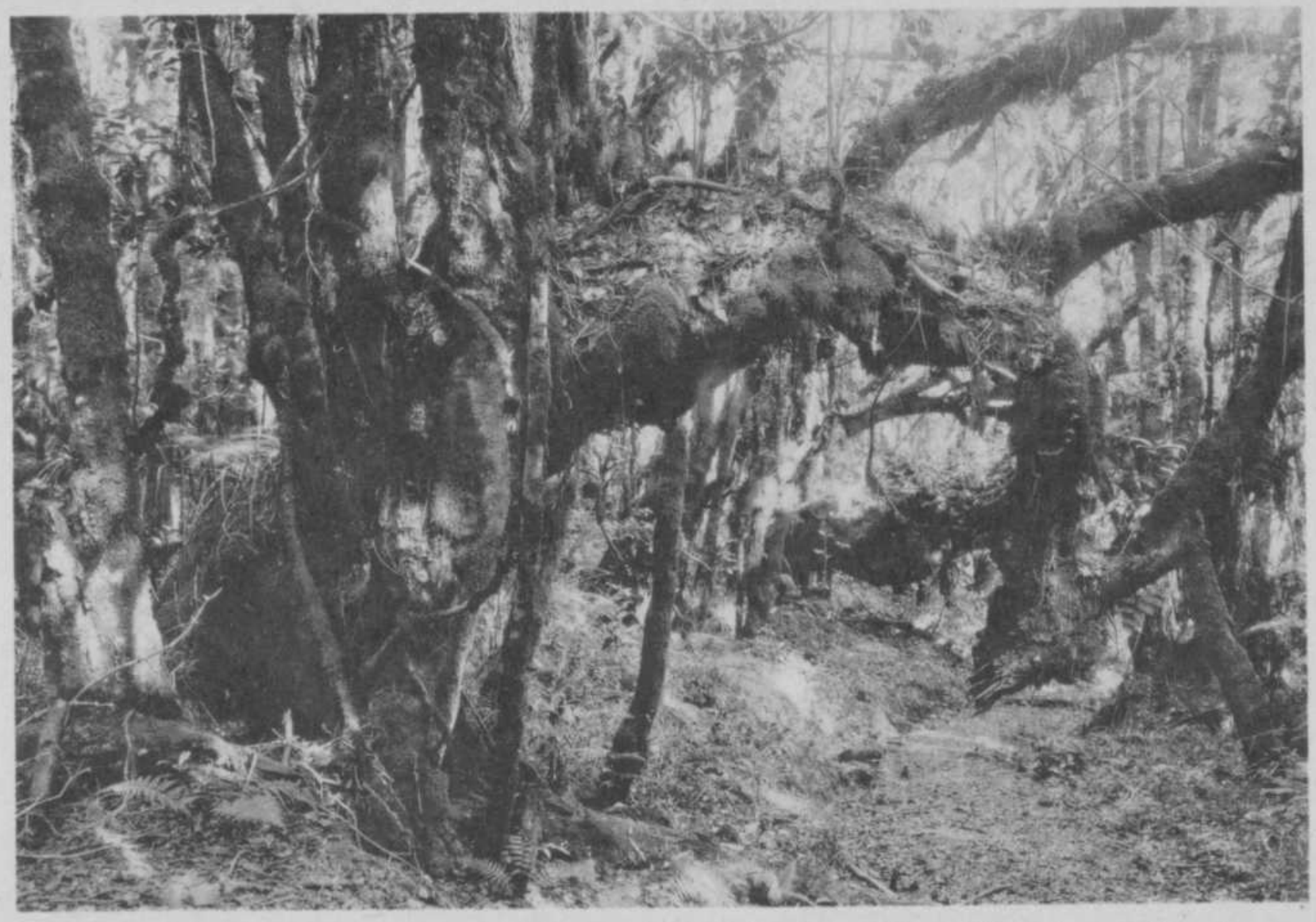
A branch of *Gaultheria leucocarpa*, with fruits.



Crater-valley of Mt. Pangrango with *Lycopodium Wightianum*. In the foreground to the left *Agrostis infirma*, covered with dew-drops; to the right, white patches of *Rhacomitrium lanuginosum*.

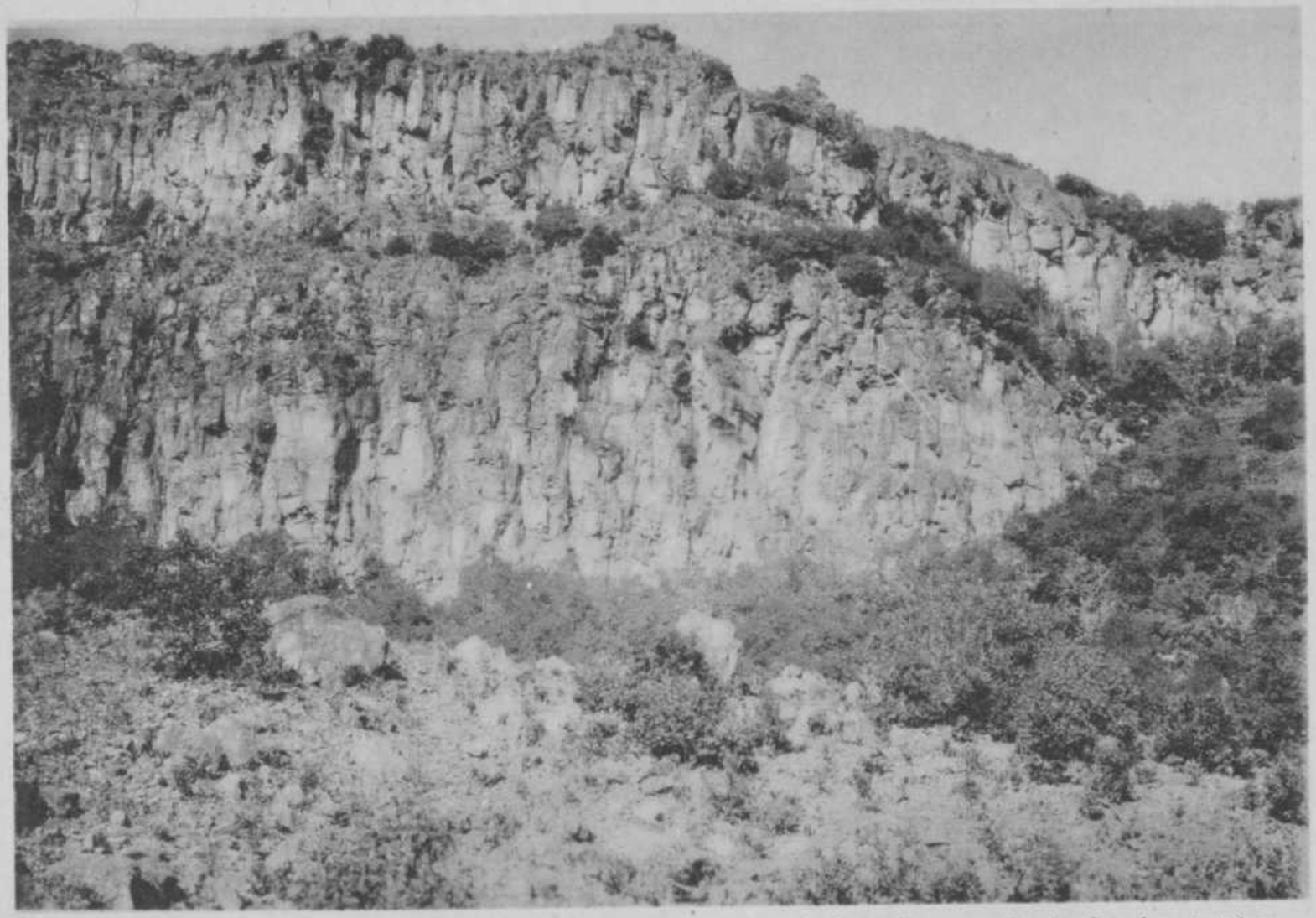
Along the road from Kandang Badak to the summit of Mt. Pangrango, about 2700 m above sea level; *Primula imperialis*, *Ranunculus javanicus*, and *Sanicula europaea*.

Near Kandang Badak, 2400 m; edge of the forest; stems covered with thick moss cushions. In the left corner, below, a young plant of *Polyosma ilicifolia*; to the right in the foreground *Plagiogyria glauca*; *Pleopeltis triquetra* as an epiphyt on the stems.



Along the path from Kandang-Badak to the crater of Mt. Gedeh, about 2500 m. Old specimen of *Vaccinium varingifolium*.

Vaccinium-forest near the border of the crater rim of Mt. Gedeh, 2700 m. Undergrowth is scarce, and there are no moss cushions on the trunks; lichens are growing on the lower parts of the trunks.



Crater-wall of Mt. Gedeh, seen from the crater, about 300 m high, with a poorly developed vegetation.

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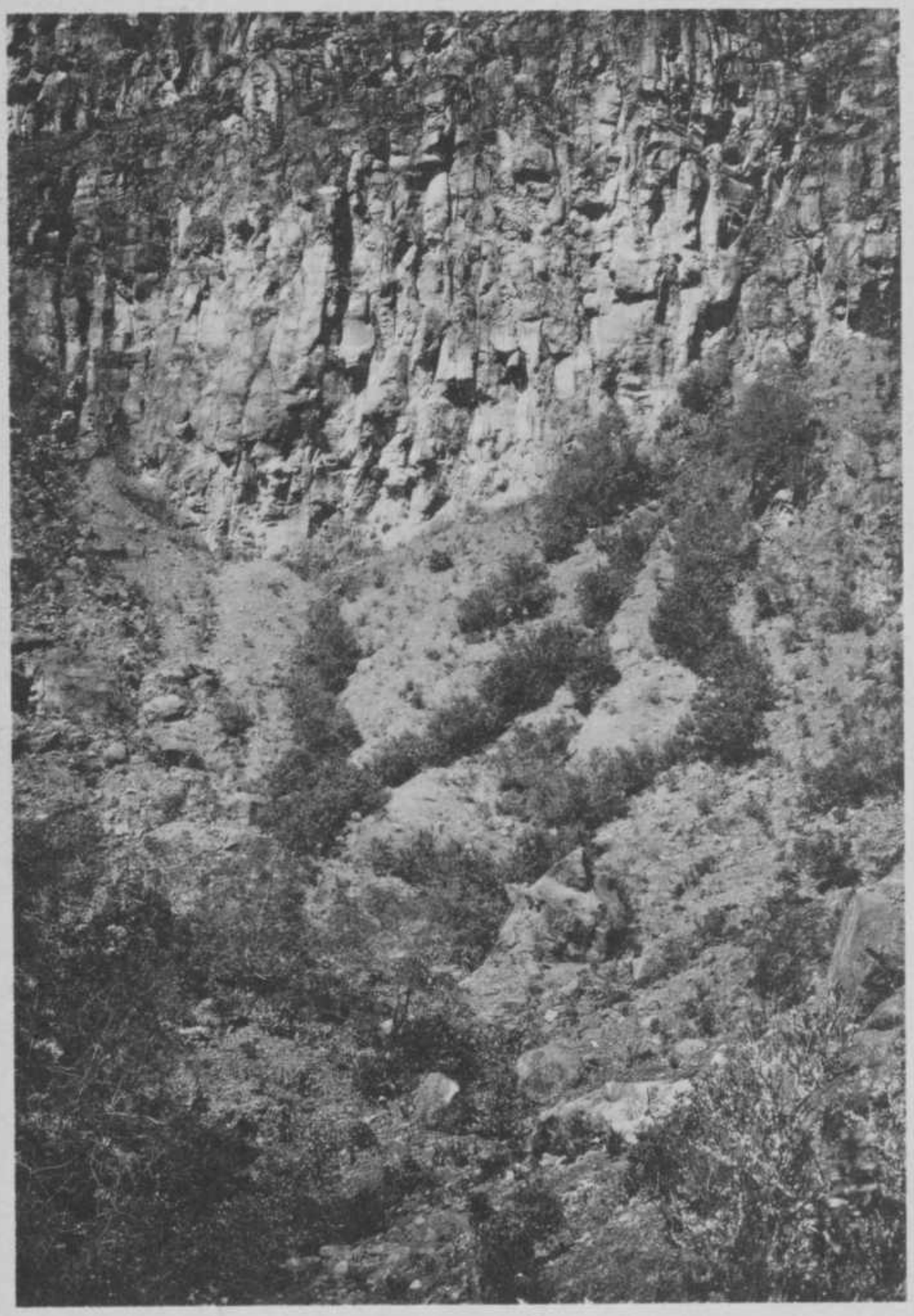

Base of the crater-wall of Mt. Gedeh with debris-cone; in the drains young specimens of *Myrica javanica*.

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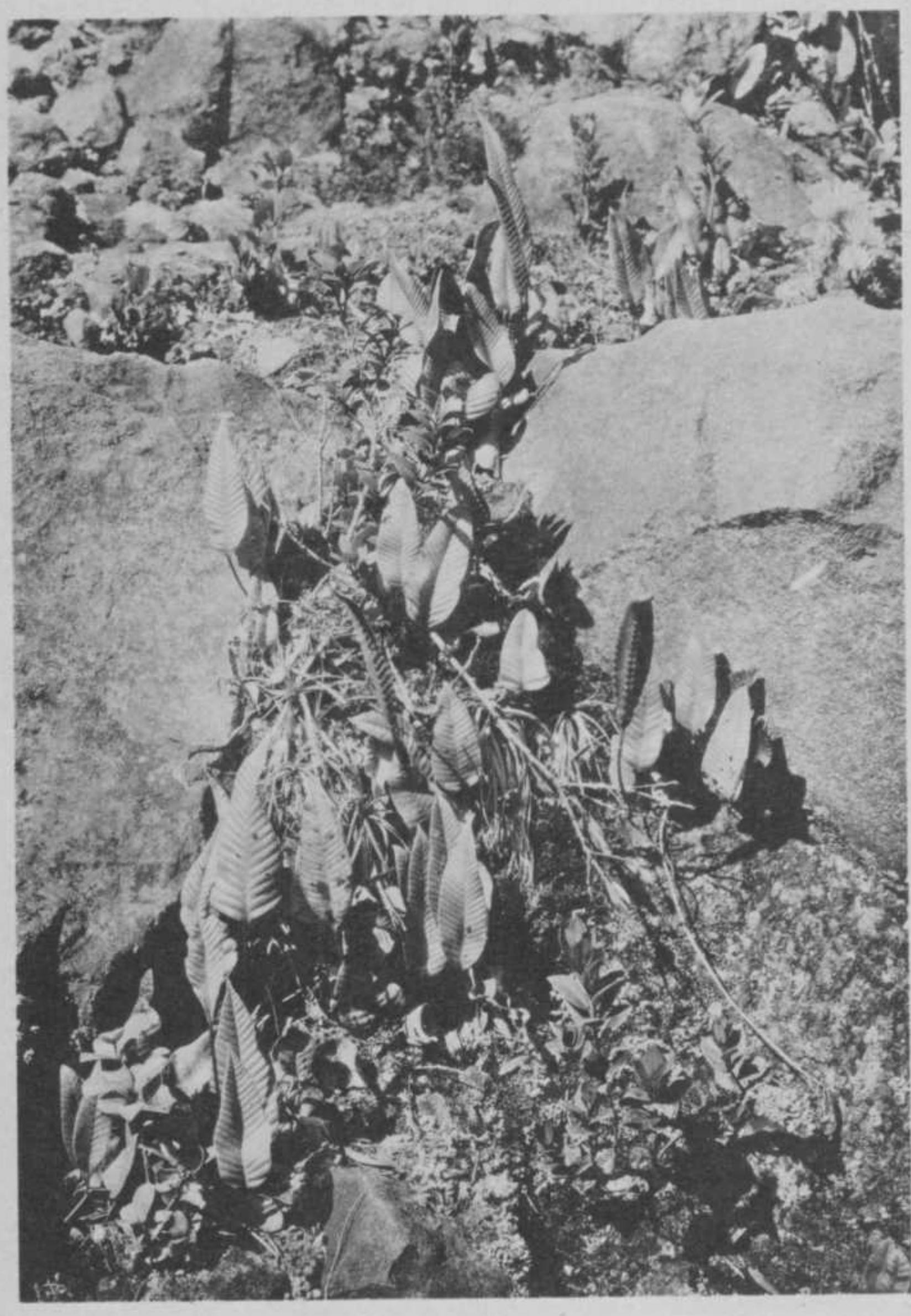

Lava-boulders in the crater of Mt. Gedeh with *Pleopeltis feei*. The small shrub in the foreground is *Gaultheria fragrantissima*.

View of the aloon-aloon of Mt. Gedeh taken from the top of Mt.Gemuruh. To the right slope of Mt. Gedeh, covered with alpinoid forest; in the background Mt. Mandalawangi.

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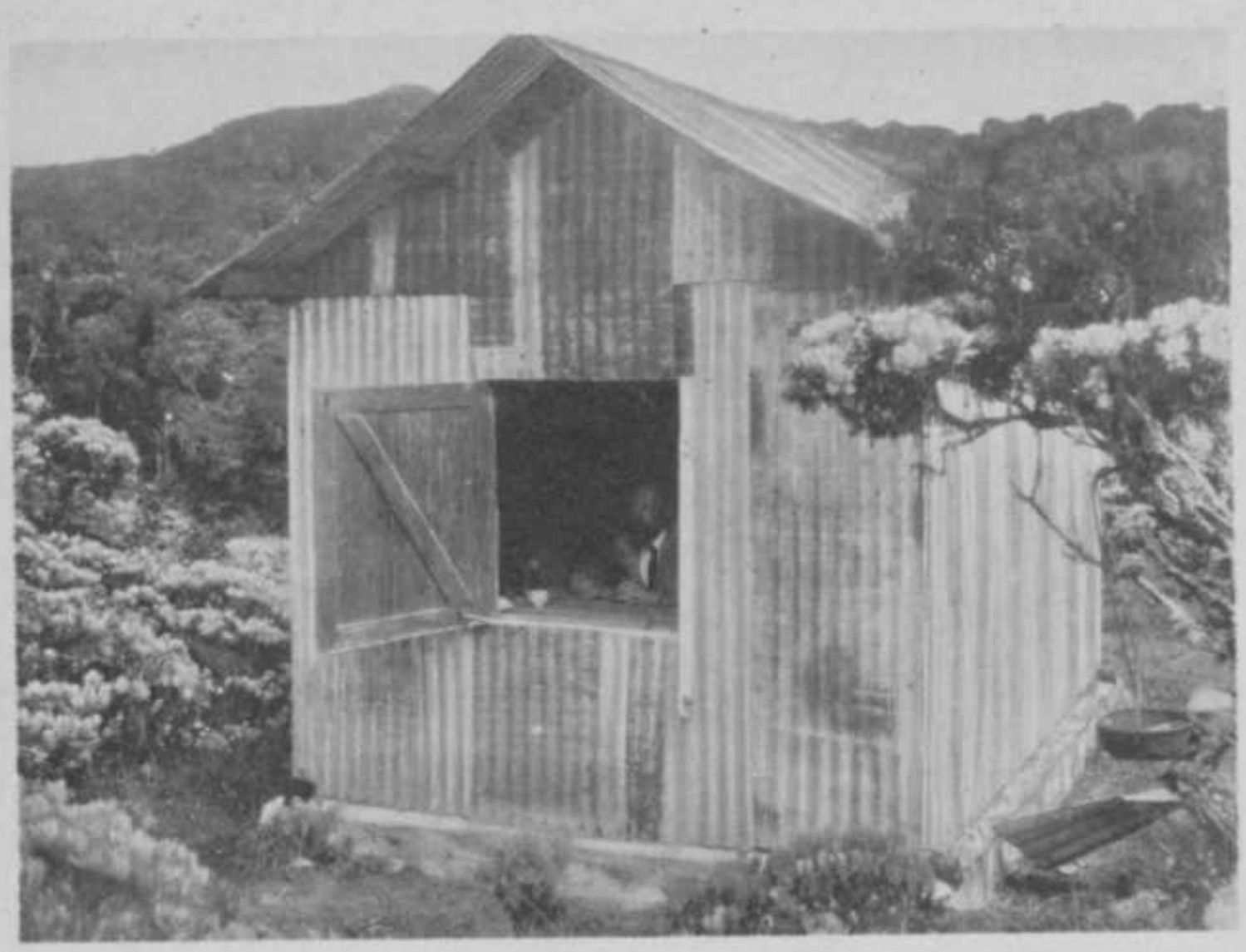

A. Cabin in the crater-valley of Mt. Pangrango, about 3000 m.

B. Rest-house and laboratory at Lebak Saät, about 2400 m.

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A. *Gentiana quadrifaria*; top of Mt. Pangrango, old plant.

B. *Polygonum chinense*; in the foreground *Hypericum Leschenaultii*, *Carex hypsophila*, and *Plantago major*.

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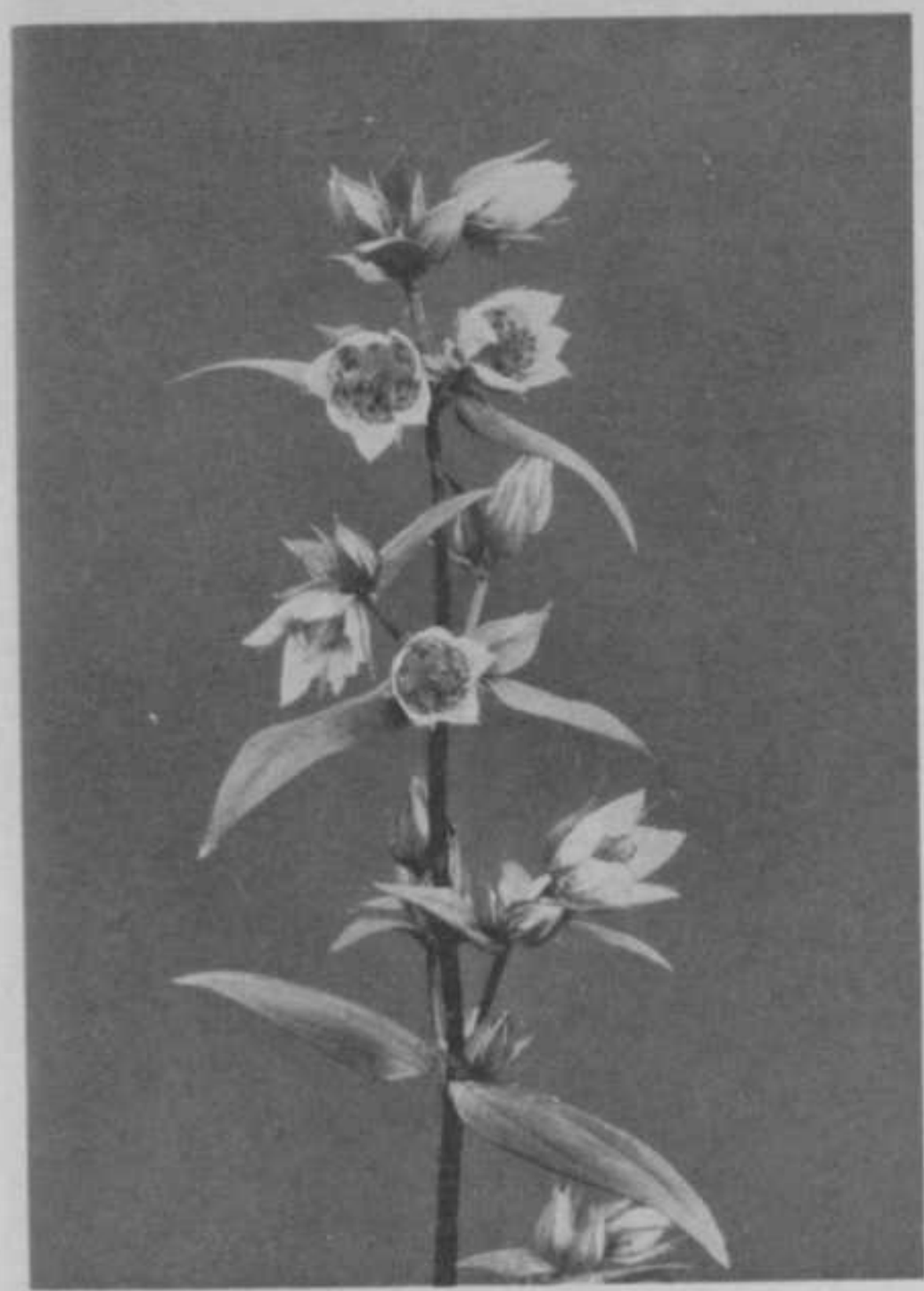

A. Flowering shoot of *Swertia javanica*.

B. *Thelymitra javanica* with closed flowers, crater-valley of Mt. Pangrango.

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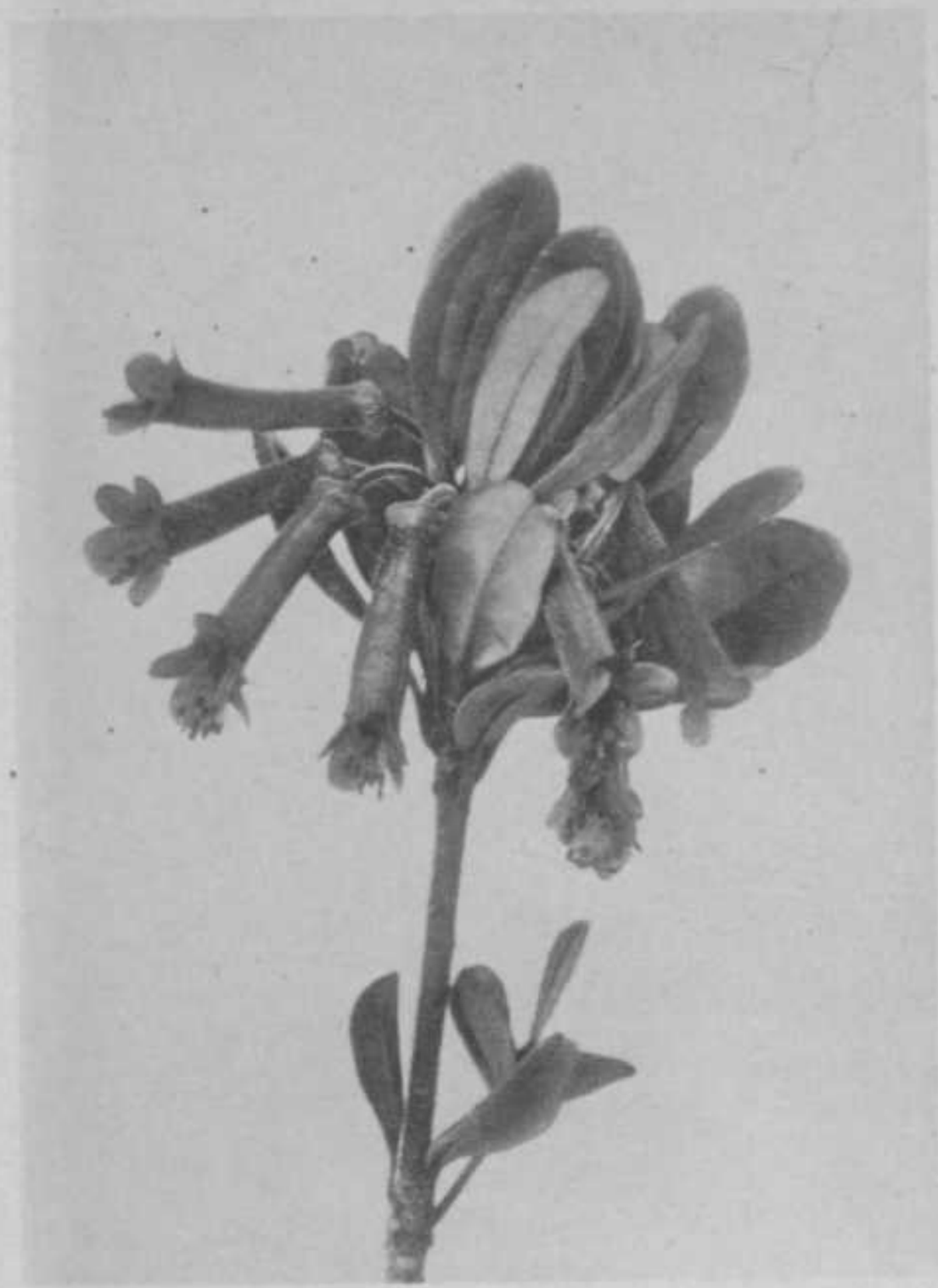

A. Flowering branch of *Rhododendron retusum.*

B. Flowering branch of *Leptospermum javanicum.*

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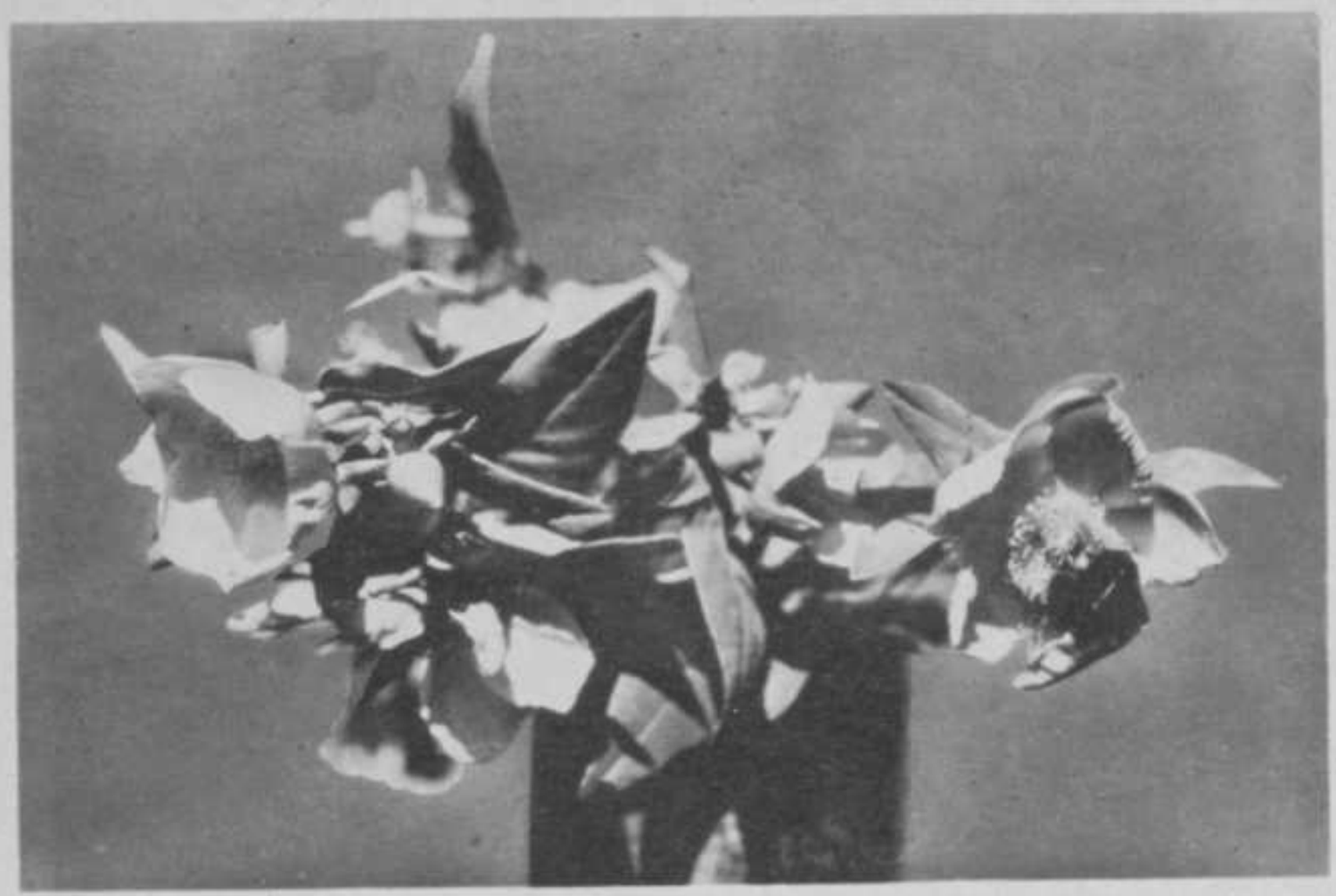

A. Flowers of *Hypericum Leschenaultii*, visited by *Bombus rufipes var. obscuripes*.

B. Aloon-aloon of Mt. Gedeh with moss cushions of *Rhacomitrium lanuginosum*, among dwarf shrubs of *Anaphalis javanica*.