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SARGENTIA

A CONTINUATION OF THE
CONTRIBUTIONS FROM THE ARNOLD ARBORETUM
OF HARVARD UNIVERSITY

V

FRAGMENTA PAPUANA

[OBSERVATIONS OF A NATURALIST IN NETHERLANDS NEW
GUINEA]

BY

H. J. LAM

WITH TWO MAPS AND THIRTY-TWO TEXT-FIGURES

Translated from the Dutch by
LILY M. PERRY



PUBLISHED BY
THE ARNOLD ARBORETUM OF HARVARD UNIVERSITY
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1945

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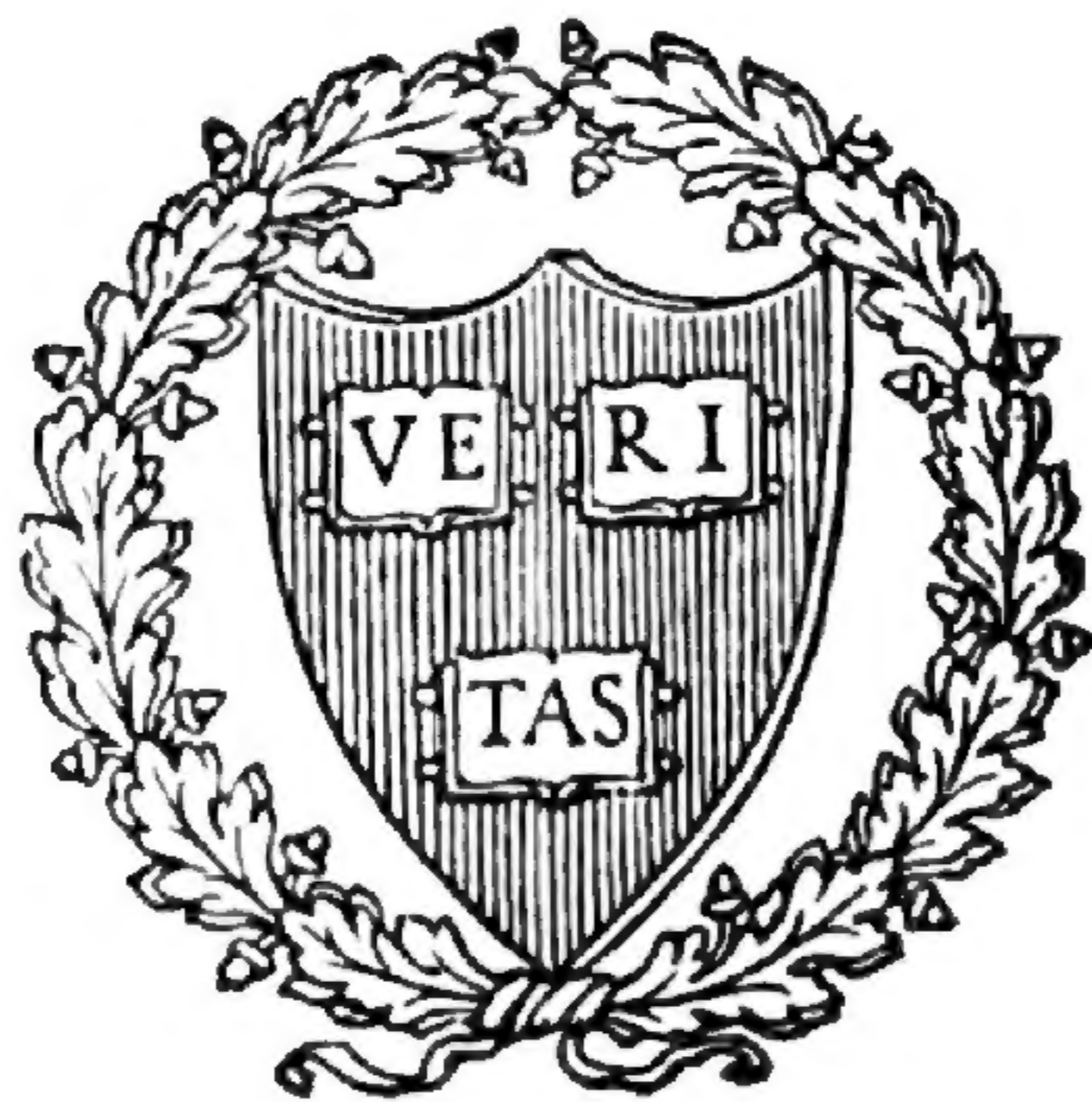
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FOREWORD

UP TO the beginning of the present century New Guinea, from a botanical standpoint, was largely a *terra incognita*. While some field work had been done, little intensive exploration had been attempted. This is manifest in Schumann & Lauterbach, *Die Flora der Deutschen Schutzgebiete in der Südsee*, 1900, covering the formerly German-controlled part (Kaiser Wilhelms-land), the western half of the Solomons, the Marshalls, Carolines, Palau, Mascarene, and Marianas Islands. They were able to record only 1560 species of vascular cryptogams and flowering plants from the vast area indicated. In the early part of the present century German botanists intensified their work on Northeastern New Guinea, while Australian, British, and Netherlands botanists increased their field activities in their territories. Finally, beginning in 1925, the Arnold Arboretum sponsored various expeditions to Papua, the Solomon Islands, and the New Hebrides. These collections have been greatly augmented by the material brought together by Mr. L. J. Brass, botanist on the three Archbold Expeditions to New Guinea, 1933-34, 1936-37, and 1938-39. On the last expedition Mr. Brass was assisted by Mr. C. Versteegh and Dr. E. Meyer-Drees.

Shortly after the close of the Nederlandsch-Indische-Amerikaansche Expedition, 1938-39, in furtherance of our work of identifying New Guinean plants here, Dr. Lily M. Perry began a translation from the original Dutch of Professor H. J. Lam's *Fragmenta Papuana*. The latter appeared as a series of articles in the *Natuurkundig Tijdschrift voor Nederlandsch-Indië*, 1927-29. Meanwhile, the present war spread rapidly and little-known New Guinea fell into enemy hands. As a concomitant of this war, the necessity for emergency foods has created a great demand for information regarding the poorly known floras of the Southwest Pacific region. Because Professor Lam's account of his experiences and observations on the vegetation of Netherlands New Guinea is very instructive, Dr. Frans Verdoorn, also a staff-member of the Arnold Arboretum, suggested that it might be helpful to have the translation published, and he in turn took up the matter with the Board for the Netherlands Indies, Surinam, and Curaçao, in New York. This Board not only endorsed his idea but also, through its office in Washington, made a liberal grant to the Arnold Arboretum to assist in covering the cost of publication. For this generous support we are particularly indebted to Dr. P. J. Honig.

Normally, permission to publish the translation would have been sought from the author. However, the representatives of the Government of the Netherlands East Indies, through the Board for the Netherlands Indies, Surinam, and Curaçao, have not only acted as sponsor by giving us permission to publish the translation, but, as mentioned above, have contributed materially to the actual cost. This authoritative group took the attitude that, through the medium of an English translation, the important data included in Dr. Lam's account would be more widely available, and through such a publication a real contribution would be made of which the general public could take advantage. Apart from the fact that Professor Lam's articles present an excellent picture of the terrain and its difficulties, as well as suggesting the possibility of subsisting in the lowland, if such necessity should arise, it must not be overlooked that at the same time a great deal of purely botanical information will be available which is now to be found only in a few of our libraries.—E. D. MERRILL.

PREFACE

THE FRAGMENTA PAPUANA by Professor H. J. Lam is, without doubt, one of the most important botanical publications on Netherlands New Guinea. The series consists of seven articles published as follows: I. Chronological survey of the Mamberamo Exploration in general and of the Expedition to Central New Guinea 1920–1922 in particular, *Natuurk. Tijdschr. Nederl.-Ind.* **87**: 110–130. 1927. II. Some meteorological data collected during the Central New Guinea Expedition 1920–1921, *op. cit.* **87**: 130–138. 1927. III. Impressions of the Lower Mamberamo Territory, *op. cit.* **87**: 139–180. 1927. IV. The Meervlakte and the foothills, *op. cit.* **88**: 187–227. 1928. V. The north slope of the Central Mountain Range, *op. cit.* **88**: 252–324. 1928. VI. Above the forest limits: Doormantop and its vegetation, *op. cit.* **89**: 67–130. 1929. VII. Land and people of the Dika and Toli Valleys, *op. cit.* **89**: 291–380. 1929. Appendix, *op. cit.* **89**: 381–385. 1929. The corrections following the appendix have been inserted in the places indicated. The original is abundantly illustrated with 93 figures. It was decided not to reproduce the halftones, but the majority of the drawings are included in this English version. The tables appended to Fragment VI have not been reproduced, since all the plants listed are discussed in the text.

Although the botanical information embodied in these articles was the primary objective of the author, and also ours, I cannot but express something of the pleasure I have derived from Professor Lam's delightful pen-pictures of the country and its inhabitants. The botanical enumerations and descriptions are interspersed with a vivid and living journal covering the year which he spent in New Guinea. The summaries of his impressions, the faithful recording of details, the intuitive appreciation of beauty so well expressed in scenes of nature, and the variety of his observations: all these lend color and interest to this work.

On account of the proximity of the regions explored by the van Overeem Expedition, of which Professor Lam was the botanist, and by the *Nederlandsch-Indische-Amerikaansche Expedition* (Richard Archbold Expedition, 1938–39), it seemed to be desirable, in handling the botanical collections of the latter, to obtain some idea of the content of the *Fragmenta Papuana*. Hitherto in our work together, Dr. Merrill has given me the benefit of the gist of short Dutch descriptions whenever the need arose; but he is much too busy to take the time to impart to me the content of such comprehensive articles. For this reason, obviously it was necessary for me to learn some of the fundamental principles of the Dutch language. In this it was my good fortune to receive careful and painstaking instruction from Mrs. J. A. C. Fagginger Auer. She also most graciously supervised about half of the translation. In the remaining parts Dr. Frans Verdoorn has been exceedingly generous and repeatedly helpful in unraveling complex sentences, as well as in explaining various Malayan words and other difficulties. Dr. Merrill has very kindly read the manuscript, and I am indebted to him for many useful criticisms and suggestions. The errors and omissions, of which I hope there are not too many, are mine alone.—
LILY M. PERRY

FRAGMENTA PAPUANA^{1,2}

[OBSERVATIONS OF A NATURALIST IN NETHERLANDS NEW GUINEA]

H. J. LAM³

with two maps and thirty-two text-figures

Translated from the Dutch by

LILY M. PERRY

Introduction

THE ARTICLES which I propose to publish consecutively under the above common title are taken from an extensive and hitherto unpublished manuscript. As botanist, I participated in the first part of the Mamberamo Expedition in New Guinea under the leadership of A. J. A. van Overeem, at that time Captain of the General Staff. Shortly after my return in January 1921, I began to work up my notes, and it was the end of 1924 before I completed the task. Through various and sundry circumstances, however, this work remained unpublished. It was late in 1926 before I set eyes on the manuscript again. Since it was written, much has been published on New Guinea and regarding our Mamberamo Expedition. Nevertheless, I think that there is enough of value in these notes to warrant their publication as *Fragmenta Papuana*. To that end the copy has been revised as necessary, utilizing the published literature to complete it.

The first article of the series is of an introductory nature and relates to the history of the Mamberamo Expedition in general and to that of the expedition of 1920–1922 in particular. The second article contains merely meteorological data which I assembled during the expedition. The remaining Fragments, which I hope will follow, relate to the vegetation, and each will consist of studies of the plant formations of the several regions visited, again with accessory small detailed maps, landscape sketches and photographs. Only one article in its principal content touches upon the field of ethnology; for that reason this will be published elsewhere.

The first two articles which follow are accompanied by two sketch maps which will be useful not only for Fragments I and II but also for the remaining

¹ *Natuurk. Tijdschr. Nederl.-Ind.* 87: 110–130. 1927. Introduction and Fragment I.

² (Footnote taken from the Addenda). In a footnote at the beginning of Fragment V, it was stated that the "Indisch Comité voor Wetenschappelijke Onderzoekingen" rendered possible the publication of the "*Fragmenta Papuana*" in its original illustrated form. Through a regrettable oversight in the introduction to the first part of the *Fragmenta*, the fact was not mentioned that the Scientific Expedition to Central New Guinea 1920–1922 was organized and equipped by that Committee, the chairman of which was Lieut.-Gen. H. N. A. Swart, at that time Vice-President of the Council of the Netherlands Indies.

Other additions and corrections given at the end of *Fragmenta VII* are interpolated in their proper places in this translation.

³ At the time of the publication of the translated articles, Prof. Lam's title was Assistant in the Herbarium of the 's Lands Plantentuin, Buitenzorg, Java; at present he is Director of the Rijksherbarium, Leiden, Netherlands.



MAP A

Legend

1. Tulband-bivak
2. Edi-bivak
3. Wand-bivak
4. Batavia-bivak
5. Kalong-bivak
6. Veen-bivak

N. B. The area limited by a border in the Central Region is considerably enlarged and given in greater detail in Map B.

parts. Map A (river bivouacs 1–6) gives a general view of the entire region; a part of it is enlarged in map B (land bivouacs 1–20).

I. Chronological survey of the Mamberamo Exploration in general ⁴ and of the Expedition to Central New Guinea 1920–1922 in particular

A. History previous to the Expedition 1920–1922.

1884. Voyage of the government steamship "Havik." The ship reached Havik Island, just upstream from the present Pionier-bivak.

⁴ Cf. also: Verslag van de Militaire Exploratie van Nederlandsch-Nieuw-Guinee 1907—1915, uitg. Dept. v. Oorlog, 1920.

1900. Voyage of the steamship "Camphuijs" of the Koninklijke Paketvaart-Maatschappij to Havik Island.

1906. Voyage of the government steamer "Brak" to Havik Island.

1909. Voyage of the small government steamship "Pionier" (after which Pionier-bivak is named) 20 km. beyond Havik Island, and an additional trip of 15 km.⁵ further by proa.

1909-1910. Franssen Herderschee Expedition.⁶ This reached the Meer-vlakte for the first time and proceeded up the van der Willigen River. On account of the illness of many participants, this undertaking had to be discontinued at the beginning of the overland journey. The base was located first at Koetei-bivak on the van Gelder River, but later it was moved to the Old Pionier-bivak on the left bank of the Okten River a few hundred meters from its mouth. The altitude reached was 850 m. A small part of the Idenburg River was reconnoitered.

1910-1911. Moszkowski Expedition.⁷ Two noteworthy journeys of Dr. Moszkowski, accompanied by a European preparator and a few natives. The first journey included an investigation of the mouth of the Mamberamo. Base: Franssen Herderschee's Pionier-bivak. Moszkowski was shipwrecked in the Edi Falls and lost all collections and equipment. On the second voyage he reached the Meervlakte, sailed up the van Daalen River, and finally for some days followed the overland route located by the Franssen Herderschee Expedition. On the return journey he was again shipwrecked. Although some entries in Dr. Moszkowski's publication indicate that he certainly visited most of the points which he describes, other passages leave one in doubt as to whether or not all statements are to be trusted. There seems to be some question as to whether or not both shipwrecks actually occurred. On the last part of his land journey he was accompanied by one Papuan. Moszkowski believed that he was within 40-45 km. of Carstensztop.

1911. De Wal Expedition. The old Pionier-bivak used as a base. Reconnaissance of the Idenburg River up to the great gap, including some tributaries.⁸

1913-1915. Oppermann Expedition. Reconnaissance of the van Rees Mountains and the coastal islands. The expedition explored the Idenburg and the Rouffaer Rivers and their source-streams.⁹ The commander of the detachment, now sub-Lieutenant L. A. C. M. Doorman, prosecuted a bold and swift journey into the mountain-region, whereby he, starting from what we now call the Doorman River, ". . . November 21, 1914 . . . reached a mountain-summit 3800 m. high . . . (the present Doormantop), which . . . afforded a view of the drainage of the central chain." As a result of his observations he indicated the probability that the southern valleys were inhabited. This journey was the immediate forerunner¹⁰ of the

1920-1921 van Overeem Expedition, which was followed by the 1921-1922 Kremer Expedition:

⁵ Rouffaer, Drie opvaarten van de Mamberamo, Tijdschr. Kon. Ned. Aardr. Gen. XXVI (1909) p. 86—Rambonnet, De jongste opvaart der Mamberamo, *ibid.*, p. 946.

⁶ Dr. J. K. van Gelder, Verslag omtrent eene geologische verkenning van de Mamberamoring op Nieuw-Guinee.—Jaarb. Mijnwezen in Ned. Indië voor 1910, XXXIX (1912), 87.

⁷ Dr. Moszkowski, Expedition zur Erforschung des Mamberamo in Holländisch Neu-Guinea—Zeitschr. der Ges. f. Erdkunde, 1912, p. 271 and 365, 3 maps.

⁸ De Wal, Verkenning der Idenburgrivier, *ibid.* XXIX (1912), p. 293.

⁹ J. W. Langeler and L. A. C. M. Doorman, Nieuw-Guinee en de exploratie der "Meervlakte," 1913-1915—De Aarde en haar Volken (1918), pp. 141-208.

¹⁰ Another journey of Doorman, undertaken on the same expedition, was similarly the precursor of the Ned.-Amerikaansche Expedition 1926; cf. footnote 9.

MAP B

Legend

	altitude	
1. Prauwen-bivak	110 m.	
a. Casuarisnest	"	233 m.
b. A small summit east of it	"	162 m.
2. Moeras-bivak (Woud-bivak)	"	110 m.
3. Kremer-bivak	"	120 m.
4. Aalscholver-bivak	"	130 m.
5. Brug-bivak	"	240 m.
6. Steen-bivak (Bivak-Batoe)	"	425 m.
7. Cruciferen-bivak	"	840 m.
8. Bivak G. Boetak	"	1425 m.
9. First Parkieten-bivak	"	1750 m.
10. Beek-bivak	"	2430 m.
11. Uitzicht-bivak	"	3120 m.
12. Radio-bivak	"	3330 m.
13. Mos-bivak	"	±3000 m.
14. Bamboe-bivak	"	±2450 m.
15. Jachthut-bivak	"	±1900 m.
16. Second Parkieten-bivak	"	±1750 m.
17. Dika-bivak	"	±1250 m.
18. First Toli-bivak	"	±1300 m.
19. Second Toli-bivak	"	±1400 m.
20. Panara-bivak	"	±1400 m.

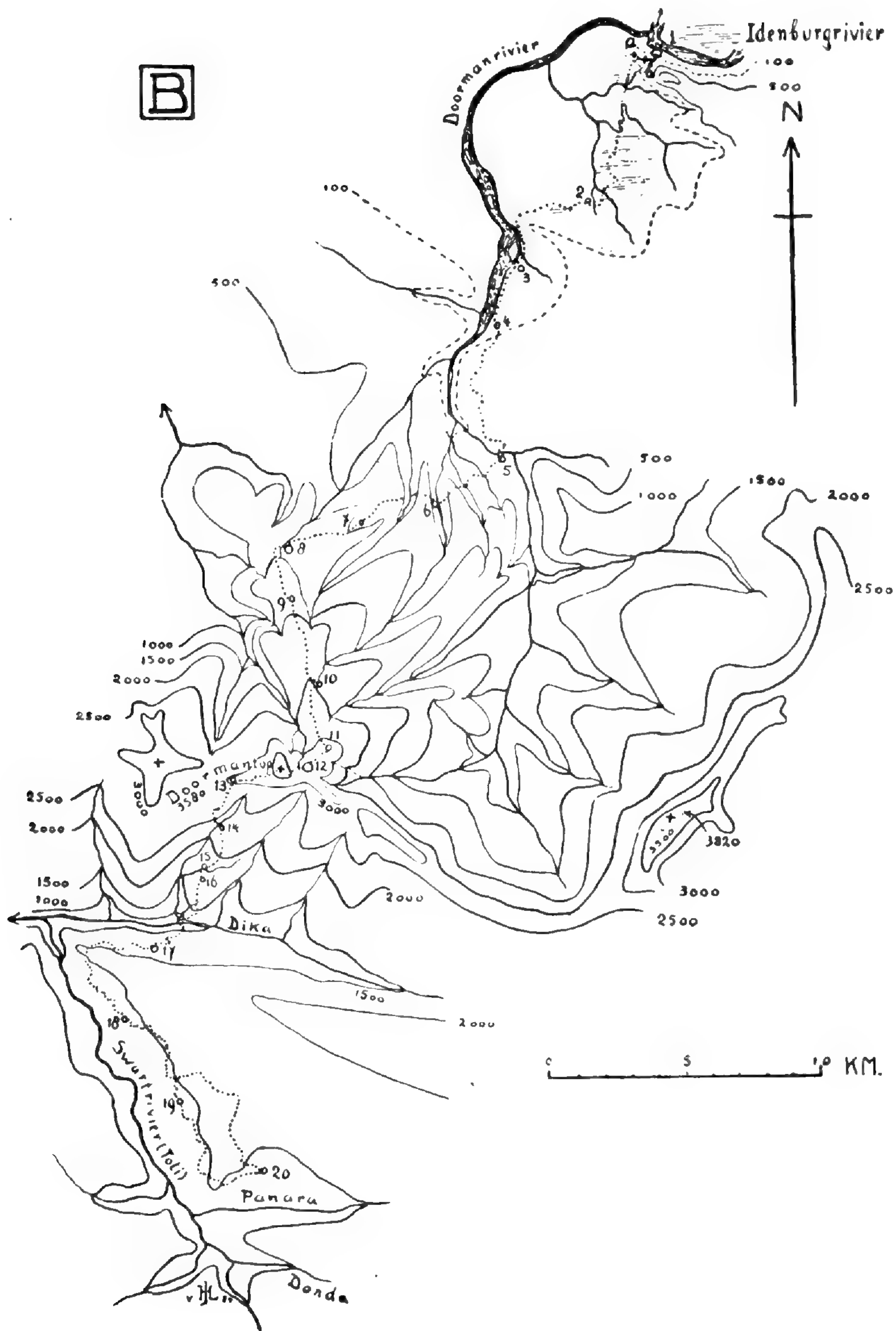
N. B. The bivouac-names in bold type are those at which supply depots were established. Regular communications were maintained between the camps. Bivouacs 3, 13, and 15 were visited only on the return trip.

* *

*

B. Van Overeem Expedition.

Personnel: A. J. A. VAN OVEREEM, Captain of the General Staff, Leader.
 J. H. G. KREMER, "Captain-Lieutenant," in charge of the astronomical and meteorological observations and the river-survey.
 J. VAN ARKEL, Captain of the Infantry, commander of the supporting military detachment, responsible for reconnoitering the advance terrain, assisted by
 K. DROST, First Lieutenant of the Infantry.
 J. KOUIJ, First Lieutenant of Military Administration.
 H. J. T. BIJLMER, Medical Officer, charged with organizing the medical service and with making anthropological observations.
 A. TEN HAAF, Medical Officer, after a few months of illness, replaced by
 H. DE ROOK, Medical Officer.
 J. JONGEJANS, Controller of Inland Administration, the latter located at Boeloengan, responsible for the recruiting and the general supervision of the Dyak oarsmen, and for the ethnographic work.
 Dr. P. F. HUBRECHT, Geologist.
 Jhr. W. C. VAN HEURN, Zoologist to the Institute of Plant Pathology at Buitenzorg, Zoologist.
 Dr. H. J. LAM, Assistant at the Herbarium and Museum for Systematic Botany of the 's Lands Plantentuin at Buitenzorg, Botanist.
 P. DROOG, First Lieutenant of the Royal Engineers, Director of the Radio Division.
 One mantri (Ajoeb) from the 's Lands Plantentuin at Buitenzorg



and one assistant-mantri (Siman) from the Herbarium at Buitenzorg as botanical helpers; two mantris (Eri and Djenung) from the Zoological Museum at Buitenzorg as helpers for the zoologist.

The last four joined the expedition later. In addition there were: one student-reconnoiterer, one sergeant-major administrator, five European sergeants, four native sergeants, five native corporals, 89 native privates, one European military correspondent, one European sergeant hospital-attendant, one European corporal hospital-attendant, one European private hospital-attendant, two Ambonese hospital-attendants, two native engineers (later placed under supervision of PAKCHWER, a European engineer), 163 convicts (of whom 10 were foremen), and 116 Dyak oarsmen. The radio section had its own personnel, which arrived later. Among them were one Adjutant non-commis-

sioned officer of the Royal Engineers, and two European corporal-signallers of the Royal Netherlands Marines.

Itinerary.

January 1920.

15. Departure from Soerabaja, at 4 o'clock in the afternoon, of the government steamers "Deneb," "Albatros," and "Koetei," the last commanded by Capt. Kremer.

21. Arrival at Amboina.

24. Departure from Amboina.

26. Arrival at Manoekwari. Capt. Kremer here transfers to the "Deneb." The "Koetei" has returned to Java.

31. Departure of the "Deneb" with the small government steamer "Pionier" in tow.

February.

1. Departure of the "Albatros" from Manoekwari.

2. At half-past eight in the morning the "Albatros" steams into the mouth of the Mamberamo; at half-past ten it is followed by the two others. At van Pee Island a new break of the river-course is found. Here at one o'clock the "Albatros" runs aground and just 24 hours later floats again.

5. The "Deneb" arrives at Pionier-bivak.

6. The "Albatros" and the "Pionier" arrive in front of the main bivouac.

7-8. Bivouac-building; observations near Scholten Island by Capt. Kremer.

12. First visit of Papuans.

13. Arrival of the "Edi," on which are Controller Jongejans with Dr. ten Haaf and the Dyaks. One of the last is seriously ill and dies the following morning. The remainder of the month is utilized with bivouac-building and proa-making. Many visits from the Papuans.

March.

8. Arrival of the "Albatros" with the remainder of the supplies for four months, a new group of convicts, and 10 Balinese oxen.

12. First reconnaissance of the rapids at Havik Island by Capt. Kremer, the Controller, and the Dyak chiefs Taman Lendah and Anji Nau. Water-level very high. The Dyaks advise against attempting to pass the rapids at this time. Moreover, an influenza-epidemic breaks out.

20. At 12 o'clock the first transport departs, consisting of two motor-boats and 12 proas, manned by 113 Dyaks, one infantry brigade, 40 convicts, and five engineers, under the leadership of Capt. van Overeem, Capt. Kremer, Contr. Jongejans and Dr. ten Haaf.

21. Their arrival below Marine Rapids. A proa with officer's baggage capsizes, and a European non-commissioned officer is saved by the Dyaks.

22. Both motor-boats pass the rapids, in the course of which a native helmsman falls overboard and is saved with difficulty by the Dyaks. Edi Rapids reached. During the high water-level the motor-boats cannot pass these. Additional cases of influenza.

26. The Dyaks bring additional supplies to the base. More influenza cases.

April.

4. Capt. van Arkel arrives with six proas. It has taken him five days, because of high water, to cover a distance later requiring only two. On March 20 a Dyak died of pneumonia. An attempt is made to open a trail overland to Edi-bivak, but this effort is abandoned after a few days.

7. A second Dyak transport, 13 proas, departs downstream.
15. This transport returns with 10 proas; seven sick Dyaks are left behind. Two convicts have died of influenza at Pionier-bivak.
21. The water has fallen so much that the motor-boats can be pulled over the falls.
23. Departure from Edi-bivak with two motor-boats and 19 proas, in which are the leader, Capt. Kremer, Capt. van Arkel, and in addition one European sergeant, 9 convicts, one Ambonese private (hospital-attendant), and 105 Dyaks.
25. One of the motor-boats loses its propeller.
26. Repair of the motor-boat. Day of rest. The Dyaks secure 100 kg. of fish from the river.
27. Passing of Batavia Rapids and arrival at the Meervlakte. Establishing of the new Batavia-bivak on the right bank of the river.
28. A transport of 75 Dyaks returns to Edi-bivak; others search for trees from which to make proas (length 17-18 m.; the ordinary proas are 10-12 m. long and about 80 cm. broad; under favorable circumstances they carry, in addition to five Dyak oarsmen and three passengers, a load of 200 to 250 kg.).

May.

1. The transport arrives from Edi-bivak.
5. The other occupants of the Edi-bivak arrive at Batavia-bivak. Among them are Controller Jongejans and Dr. ten Haaf. Two proas are ready for loading.
8. All but seven Dyaks return with 15 proas to Pionier-bivak.
9. Departure for the south; each motor-boat tows a loaded proa. The crew consists of five staff-members, 12 native fusileers, 17 convicts, seven Dyaks, and five engineers, together with provisions for a month. Both river-banks are inundated. Some nights Kalong-bivak is under water.
11. Establishment of Prauwen-bivak on the high bank nearest to where the Idenburg River leaves the mountainous area 1.5 km. upstream from the mouth of the Doorman River. The following days are spent in bivouac-building and in establishing friendly contacts with a small Papuan tribe from a distant region.
14. The leader and Capt. Kremer go with the motor-boats to Batavia-bivak. It appears that the 105 km. can be covered in eight hours.
18. Arrival of the transport. The "Edi" appeared May 9th, with a light load, 62 days after the arrival of the previous boat. On the night of May 10-11 Pionier-bivak lay partly under water. A few dysentery cases; much malaria.
28. The water has dropped very quickly in the past few days.
29. First reconnaissance into the interior. The party, consisting of Capt. van Arkel and Capt. Kremer with four fusileers and six convicts, departed on the 24th and returned today. They proceeded 10 km. from Prauwen-bivak along the very broad (400 m. wide) freshet-bed of the Doorman River, the stream not being navigable by regular transport. They did not locate Doorman's trail, since he commenced his overland journey from the left bank of the river.
30. A space is cleared for an outlook on the top of Casuarisnest.

June.

5. The transport, under the direction of Controller Jongejans, starts down river, carrying Dr. ten Haaf, who is seriously indisposed. Both the leader and Capt. Kremer suffer attacks of fever.

13. Arrival of the zoologist and botanist at Pionier-bivak with the "Albatros."
14. Second reconnaissance by Capt. van Arkel.
15. Third reconnaissance by Capt. van Arkel.
17. In the night of 17-18 a slight earthquake is felt.
19. Departure of the fourth reconnaissance party under Capt. van Arkel, with four privates and four convicts. Purpose: to find a suitable place for crossing the Doorman River.
23. Return of the patrol. No place in the river narrower than 80 m. is found.

July.

2. Fifth reconnaissance under Capt. van Arkel and the leader. Capt. Kremer departs for downstream to bring up the third motor-boat. The patrol finally has found a place 16 km. distant from Prauwen-bivak where the Doorman River is 35-40 m. wide. Capt. van Arkel has remained behind to build a rattan bridge and to examine the lay of the land.
22. Arrival of the geologist at Pionier-bivak with the "Albatros."
23. Capt. van Overeem arrives from upstream at Pionier-bivak.
28. Capt. Kremer, with Lieut. Kooij and Dr. Hubrecht, makes a two-day reconnaissance of the Marine Rapids, with the objective of bringing up the third motor-boat.

August.

1. Departure of Dr. Bijlmer and Contr. Jongejans for Prauwen-bivak. Capt. Kremer, the zoologist, and the botanist suffer from various maladies.
8. Departure of the geologist and botanist for Prauwen-bivak. In Batavia-bivak they meet Contr. Jongejans and Dr. Bijlmer, who have been waiting there for the next transport, on account of Contr. Jongejans having had an attack of malaria.
14. Arrival at Prauwen-bivak of the four previously mentioned members of the expedition.
16. Communication from Capt. van Arkel that he has not yet located Doorman's old trail, and that he has established a supply-depot (just in front of what is later Cruciferen-bivak) at about 20 km. from Prauwen-bivak and at about 800 m. altitude, after a trip over very difficult mountain-terrain. Two Chinese convicts of the last mountain-transport have been missing since Aug. 15.
20. Return on a small raft of the missing convicts.
28. A sad day in the annals of the expedition. The leader, Capt. Kremer, and the zoologist arrive at Prauwen-bivak with the report that the "Edi" is in peril, having been grounded on an uncharted rock close to Scholten Island since the 16th. It is feared that she will break up. The cargo and the crew have been landed on the beach. With this ship the radio equipment, under Lieut. Droog, has arrived, in addition two European corporal-signallers of the Royal Netherlands Marines, an adjutant non-commissioned officer, and Pakchwer, the European (Russian) supervisor of engineers. Further, on account of the low water-level, the third motor-boat is stranded below the Batavia Rapids. The saddest event of the day, however, is the death of a European sergeant, commander of Brug-bivak, who has committed suicide. The following day the leader and Dr. Bijlmer assist in the burial.

September.

2. The setting up of the radio equipment at Pionier-bivak. The reception appears to be successful; the dispatch offers many difficulties. Return of the

leader and the doctor from Brug-bivak. They bring the news that Capt. van Arkel has found Doorman's trail (just in front of what is later Goenoeng Boetak-bivak) and along that route they have reached a higher altitude. Four escaped convicts are recaptured at Batavia-bivak.

5. The radio equipment is tested at Prauwen-bivak. A special radiogram is received from a ship in Torres Strait near Australia, and Amboina, Bandung, Hongkong, and Cavite (Manila) stations are heard.

6. The advance-guard arrives, whereupon the leader, Capt. Kremer, and the geologist proceed with a transport of 90 convicts into the mountainous region. In the afternoon we are visited by 21 bird-hunters, 2 Chinese and 19 Papuans, from the coast. They have left Hollandia and reached the Idenburg River overland, living by hunting and fishing. Then they have constructed proas, and, in hope of our assistance, have come down the river.

10. Arrival of Lieut. Droog at Prauwen-bivak. He brings the report that the "Edi," with a damaged boiler, floated on August 31st and got away under its own power. The radio equipment does not appear to be powerful enough to receive dispatches from Amboina.

12. Contr. Jongejans proceeds downstream to recruit Dyaks as carriers for the overland journey.

18. Departure of the botanist for Brug-bivak, also of Lieut. Drost, who in the meantime has arrived at Prauwen-bivak. A week later the zoologist follows. After Lieut. Drost returns, on the 28th, the zoologist and the botanist proceed to Goenoeng Boetak.

October.

1. News is received from the vanguard that it arrived on Sept. 16 at Radio-bivak, where it met Capt. van Arkel. In this part of his report the leader proposes to introduce the names *Doormantop*, *Doorman River*, and *Swart River*.

9. A later communication mentions that the leader, before he descends into the valley, will leave a supply of provisions at Radio-bivak. Capt. van Arkel has done some scouting to get an idea of the best route to follow.

10. Arrival of the first Dyak transport at Goenoeng Boetak. It has a crew of 54, with Contr. Jongejans, Dr. Bijlmer, and Lieut. Droog. The purpose: to proceed inland and then to continue collecting at higher altitudes. The botanist joins this transport; the zoologist remains at Goenoeng Boetak.

16. Arrival of the transport at Radio-bivak. The crew consists of the four mentioned staff-members, two Dyak chiefs, 52 Dyak carriers, one European sergeant, one European corporal-signaller of the Marines, and 10 convicts.

17. The botanist finds a handkerchief which belonged to Lieut. Doorman.

18. Departure of the vanguard for the valley. This consists of the leader, Capt. Kremer, the geologist, Capt. van Arkel, Dr. Bijlmer, and Contr. Jongejans, one European sergeant, one Ambonese student-reconnoiterer, one Menadese private (hospital-orderly), 5 native fusileers, 26 Dyaks, and 20 convicts. The botanist and the Radio-Lieutenant remain at Radio-bivak. The latter, with little material, reconstructs the radio equipment, with the result that all important news is quickly received.

22. Arrival of the vanguard in the Dika valley and first friendly contact with the Timorinese people. A food-shortage develops at Radio-bivak.

26. Messages arrive from the valley; among other things is the first news-item that is to be sent out, announcing the discovery of the Timorini.

27. In the evening at half-past ten there is a total eclipse of the moon.

29. In consequence of the dire food-shortage, all who are not strictly necessary for bringing up food or for leadership must leave the Radio-bivak. Among them is the botanist, who proceeds to Goenoeng Boetak, where the food-supply is sufficient for the time being. A speedy runner is sent to the valley to carry word to the vanguard of the situation at Radio-bivak. Also unnecessary men at Goenoeng Boetak are sent farther downstream; the rations of the active carriers are restored to the old standard and those of the people in camp are curtailed more than half.

November.

1. A transport of Dyaks, 16 strong, proceeds from Goenoeng Boetak; three convicts, one private, and four native helpers (three of the zoologist's and one of the botanist's) go downstream. Communications from the vanguard indicate that a fairly serious incident has occurred in connection with the Dyaks' stealing of a Timorinese pig. This event, however, turns out all right, at the cost of several chopping knives.

3. Two Dyaks, speedy runners, arrive, coming in a day from Radio-bivak to Goenoeng Boetak with telegrams to be sent regarding the continuation of the expedition, since the goal, Wilhelminatop, has not been reached.

4. These communications are sent through to Prauwen-bivak by relays of runners, so that in three days from Radio-bivak telegrams can be in Prauwen-bivak.

5. Arrival of Capt. van Arkel and Lieut. Droog at Goenoeng Boetak. A strong extra transport (among whom are 14 Dyaks) departs downstream; the zoologist, who, except for a few days at Beek-bivak, has collected continuously at Goenoeng Boetak, joins it.

6. Arrival of Capt. Kremer at Goenoeng Boetak.

7. Departure of Capt. Kremer, Capt. van Arkel, and Lieut. Droog for Prauwen-bivak. Through the measures taken, the botanist secures an opportunity to proceed further inland. Up to now the supply-line has stood as follows:

1	{ Amboina	} Once a month, sometimes less, by government steamer.
	{ Pionier-bivak	
2	{ Batavia-bivak	} 50 Dyaks with 10 proas, 3½ days up, 1½ days down, 1 day rest.
	{ Prauwen-bivak	
3	{ Brug-bivak	} 3 motor boats towing 2 loaded proas, 3 days up, 1 day down.
	{ Goenoeng Boetak	
4	{ Radio-bivak	} 70 (later 85) convicts, 3 days up, 2 days down, 1 day rest.
	{ Dika-bivak	
5	{	} 45 (later 60) convicts, 2½ days up, 2½ days down, 1 day rest.
	{	
6	{	} 23 Dyaks (among these 1 chief), 3½ days up, 2½ days down, 1 day rest.
	{	
7	{	} 11 Dyaks (among these 1 chief), 3 days down, 1 day rest, 3 days up.
	{	

8. Departure of the botanist, with a mantri, a convict, and 3 Dyaks, to Radio-bivak, with an interim of four days at Beek-bivak. Here he obtains word that the last Dyak transport from Radio-bivak will depart the 17th for the valley; he wishes to join this group.

14. Arrival of the botanist at Radio-bivak. On account of the breaking of a tree supporting it, the rattan bridge of Brug-bivak falls into the stream. A new one is made.

17. Departure of the botanist with the Dyak transport for Dika-bivak.

18. Arrival of the botanist at Dika-bivak.

21. Departure of the vanguard to make a 5-day journey through the main valley.

24. The most southerly point (Panara) is reached.

27. Departure of the vanguard from Dika-bivak.

December.

5. The vanguard again at Prauwen-bivak. A convict, obviously insane (with a persecution complex), after stabbing a Timorinese soldier in the back as he is standing on guard, fled with a proa some days ago and has apparently perished.

6. Departure of the leader, Contr. Jongejans, and the zoologist for Pionier-bivak. There telegrams are exchanged with Java as to whether or not to continue the expedition.

25. Departure of the botanist from Prauwen-bivak.

28. His arrival at Pionier-bivak.

January 1921.

7. The radio equipment is successful in reaching Amboina for the first time with a dispatch. Packing of the collections.

10. Arrival of the "Gemma," escorted by the "Pionier," but only the latter comes up to Pionier-bivak; the "Gemma" remains below the dangerous rock near Scholten Island. This boat has brought the ethnographer, Dr. P. Wirz, and also the report that, in eventually continuing the expedition, Capt. Kremer will be made the leader. The contract with the Dyaks has expired; they have to be recruited anew.

The water-level, which has remained very low, now begins to rise quickly as a result of the rains in the mountains. Arrival of the geologist, who has lost some equipment in the Edi Valley.

12. Departure of the "Gemma," with Capt. Kremer, who is going to Amboina to consult with the Indian Committee by wire. The zoologist, the botanist, and the Radio-Lieutenant also depart. The "Pionier" remains provisionally on the river.

C. Kremer Expedition.

European Staff: J. H. G. KREMER, "Captain-Lieutenant," leader.

J. VAN ARKEL, Captain of the Infantry, Commander of the covering detachment.

K. DROST, First Lieutenant of the Infantry.

A. ZIJLMANS, First Lieutenant of Military Administration.

H. DE ROOK, Medical Officer.

Dr. P. F. HUBRECHT, Geologist.

Dr. P. WIRZ, Anthropologist-Ethnologist.

*Itinerary.*¹¹*January–September.*

Preparation and transportation of supplies to the depots in the mountains, particularly to that in Dika-bivak. Reconnaissance from there to the south.

October.

10. Earthquake, felt at Dika-bivak at 11:45 A.M., direction north-south, lasting 30–45 seconds. In the neighborhood great landslips occur, from the results of which the Dika is hidden for some hours.

12. Arrival of the leader and the geologist, Dr. Hubrecht, with 34 Dyaks.

16. Departure of the staff with 41 Dyaks and 32 Timorinese carriers toward the south. As a medium of exchange *tigalèhs* (cowrie shells, *Cypraea moneta*) are used; with these, goods and services are purchased.

17. Remain in Panara-bivak, where we have many visitors; a number of carriers are recruited and a shooting match is organized.

18. Departure for Donda, the next lateral valley after the Panara. The Timorinese carriers receive a day's wage of one *tigalèh*. This camp is used on September 14–15 by a reconnaissance patrol.

20. March to the Koeboe, a tributary on the left side of the Swart River. No Timorinese carriers are used. In the Kampong Doendoe renewed friendships are established, and we hear the first report about a dense population in the Baliem valley. From here on the advanced division will work in entire independence, this guaranteeing a large freedom of movement, but also, as a consequence of the food-situation, only limited time is available. Much food, however, can be had from the people. Lieut. Drost remains behind for the time being.

24. Departure for Kampong Noega in the Koeboe Valley. The Timorini carry the loads without pay.

25. Departure for Kampong Tamak, altitude 1750 m.

November.

1. The departure for Kampong Noreagobak, in the extreme south of the Koeboe Valley.

4. Reconnaissance by the leader of Mount van Arkel (3100 m.), which was visited by Capt. van Arkel on September 18. Also a few shorter trips are taken in the neighborhood. The natives make many visits.

8. The watershed between the Swart River and the Baliem Valley is crossed: Bivouac on the Djoe, a tributary of the Baliem. New friendships established. Also here an attempt is made to retard the expedition by claiming that the Baliem people will be hostile.

10. The Baliem reached. On its banks in a Kampong at 2400 m. altitude a bivouac is made the 11th, close to the Tora, an isolated rock which rises about 400 m., almost perpendicularly above the river. Friendly relations are quickly established.

14. The entire vanguard is now combined at this bivouac. Lieut. Drost remains behind in Tora-bivak to guard the supplies.

17. The Baliem is crossed by a very strong suspension bridge, and on the opposite side native carriers are recruited; they proceed to Tora-bivak to bring

¹¹ Adopted from the synopsis in the "Indische Gids," 1922, p. 550 et seq., and from verbal information.

supplies. Thus Lieut. Drost can follow the same day. Bivouac on a ridge at 2800 m.

18. Pieremeh, a small tributary on the right of the Baliem, is reached. The territory from here to Wilhelminatop is uninhabited, but a good path leads over the Central Chain towards the south, where the Pesechems live. The distance still to be covered is 30 km. Lieut. Drost again remains behind to guard the supplies.

19. Departure of the leader, the geologist, and Capt. van Arkel to the south. A marshy area at 3800 m. altitude is crossed. Wamgimeh, the faithful native guide, and 10 clansmen accompany them as carriers.

20. After crossing a ridge at 4100 m. altitude, the upper Baliem is reached, on the left bank of which at 3200 m. a bivouac is made. In the afternoon 10 natives arrive with 3 pigs and many sweet potatoes and much sugar cane; they were sent by Lieut. Drost.

21. The Baliem is followed upstream. Bivouac is made on the south margin of the upper Baliem plain. This is the high plain which Franssen Herderschee saw from Wilhelminatop in 1913.¹²

22. With the help of the native carriers the Wamena is reached. From Wilhelminatop the stream flows towards the east and perhaps does not belong to the Baliem system.

23. A large number of natives return, promising to bring foodstuffs. Rest a day here.

24. Wamgimeh returns with a number of Dyaks. The vanguard leaves for the south. Bivouac on one of the tributary sources of the Wamena.

25. A very good trail is followed. It appears later to be the path that traverses the Central Range from north to south. Bivouac at a forest margin.

26. Reconnaissance of the north side of the Central Chain.

28. Arrival of Dyak carriers with supplies.

29. Departure for a pass which is observed to cross the ridge in an easterly direction. Here are met a number of old friends, who were supplied with sweet potatoes by a group whom they have unknowingly followed.

30. Scouting the terrain, in which everywhere one is surrounded by patches of snow.

December.

2. Arrival of Lieut. Drost, who brings sweet potatoes and five pigs. Here the altitude is 4150 m. (Last bivouac except one).

3. A small group, including the entire staff, advances and bivouacks at 4450 m. (Koude-bivak). Heavy snow some nights. Wilhelminatop lies to the east of this bivouac.

4. Through a narrow crevice, and after a difficult ascent of 300 m., the last easy climbing is reached. A large snow field is crossed. The small glacier appears to be vanishing. Later an ice block of about 100 cu. m. is observed. It perhaps was dislodged by the earthquake of October 10th. At 10:30 the highest point (4750 m.) of Wilhelminatop is reached. Here is found the heap of stones erected by the Franssen Herderschee Expedition on February 21, 1913. The record placed therein is partly legible. Here a statement of the

¹² Cf. A. Pulle, *Naar het Sneeuwgebergte van Nieuw-Guinea* (Uitg. Mij. Goede en Goedkoope Lect., A'dam, z. j.), p. 169, and P. F. Hubrecht, *Maatsch. t. Bevorder, v. h. Nat. Onderz. d. Ned. Kol. Bull. no. 68* (1913), p. 46.

personnel of this party is added: Capt. Kremer, Capt. van Arkel, Lieut. Drost, Dr. Hubrecht, one native student-reconnoiterer, 22 Dyaks, and four convicts. Bivouac today at 4300 m.

8. Lake Habbema, already observed from Wilhelminatop, is reached. It is 700 m. wide and 6 km. long (east to west) and lies at an altitude of 3000 m. The depth is 2-3 m.; the lake apparently has no drainage. Many Papuans come to visit us here.

10. The Baliem is again reached.

17. The ridge of Mount van Arkel is passed (2700 m.) and the summit again crossed. Everywhere the natives celebrate with feasts.

20. Hundreds of visitors come to Doendoe to take leave, during which visits 13 pigs are killed.

29. Arrival at Prauwen-bivak.

January 1922.

1. Arrival at Pionier-bivak.

II. Some meteorological data collected during the Central New Guinea Expedition 1920-1921 ¹

A. Hygrometer observations.

The Royal Magnetic and Meteorological Observatory at Weltevreden lent me a set of two thermometers, one of which was arranged for use with wet bulb. In this the bulb was wrapped with a small piece of cotton, the free end hanging down into a can of water. The readings were corrected according to the tables appertaining to each instrument, and the relative humidity was determined by consulting Neumayer's table (*Anleitung zu wissenschaftliche Beobachtungen auf Reisen*). The numbers of the observation-stations agree with those on maps A and B. Pionier-bivak is not numbered; Prauwen-bivak appears only on map B. In the tables, t means temperature of the dry bulb thermometer, t^1 that of the wet bulb thermometer, all in degrees Centigrade. [Only a summary of the observations is given here; included under each caption are the highest and lowest readings.]

Table I

Observations at Pionier-bivak (position: in the shade in the cleared bivouac-area): 22 observations; altitude 60 m.; date, August 2-6, 1920; time, various hours from 6 A. M. to 9 P. M.; t 24-30.8°; t^1 23.4-26.2°; relative humidity 64-94; weather, rain twice, other records blank.

Mean t 26.3°. Mean relative humidity 86.

Observations at Goenoeng Boetak-bivak, Map B, 8 (position: in the forest under a small shed, about 1.5 m. above the ground): 29 observations; altitude 1424 m.; date, October 1-11, 1920; time, various hours from 6 A. M. to 8 P. M.; t 15.8-20.5°; t^1 15.8-20.2°; relative humidity 89-100; weather variable, one observation dry, one sunny, two bright, the others cloudy, misty (foggy), and rainy.

Mean t 18.3°. Mean relative humidity 98.4.

Observations at Radio-bivak, Map B, 12 (position: open terrain above the forest-limit; under small shed about 0.5 m. above the ground): 21 observations; altitude 3332 m.; date, October 19-27, 1920; time, various hours from 7 A. M. to 6 P. M.; t 8.4-20.8°; t^1 7.4-15.1°; relative humidity 51-100; weather, six observations clear or sunny, the others foggy or rainy.

Mean t 12.2°. Mean relative humidity 86.5.

Maxima and minima.

Observed maximum: 34° (April 28, 1920) (33.5° on June 7 and 8).

Observed minimum: 20.5° (May 10 and 11, 1920).

Lowest day-maximum: 28° (February 26, 1920).

Highest day-minimum: 24.5° (five times between February 20 and June 26, 1920).

B. Barometer observations.

The Meteorological Observatory at Weltevreden supplied me with an aneroid barometer (no. 9582), chiefly for use in making altitude-observations. A few

¹ *Natuurk. Tijdschr. Nederl.-Ind.* 87: 130-138. 1927.

times I verified these observations with a hypsometer, of which a few records are noted below. All values found have been corrected by standard methods. In the calculations the barometer-readings are in mm., the thermometer-values in 5's. [For convenience in summarizing the tables which follow, Roman numerals are used to designate the captions thus: I, observed at; II, date; III, hour; IV, aneroid reading in mm.; V, temperature in degrees Centigrade; VI, altitude in m.; VII, remarks.]

Table II

I, Pionier-bivak, 23 records; II, August 2-6, 1920; III, various hours between 6 A. M. and 10 P. M.; IV, 754-757.8; V, 24.4-29.8°; VI, 46-94; VII, average, 71 m.

The above data were obtained with the aneroid barometer which had been checked by the Observatory. Later I readjusted the instrument with reference to the hypsometer (see under Prauwen-bivak); the subjoined numbers are since recorded at Pionier-bivak.

Table III

I, Pionier-bivak, 4 records; II, January 4 and 5, 1921; III, 10 A. M. to 4 P. M.; IV, 751.8-755; V, 25°; VI, 81-116; VII, average, 99 m.

For a control, the aneroid barometer was checked on the return journey at Makassar harbor. The following record was made:

Table IV

I, Makassar harbor, 2 records; II, February 1 and 4, 1921; III, 9 A. M. and 4 P. M.; IV, 758.8 and 757.9; V, 25°; VI, 35 and 46; VII, average, 41 m.

The last two values give an average of 41 m. altitude, the data of the table above (Table III) 99 m., the difference indicating an error in the instrument; subtracting this error from the values found for Pionier-bivak (Table III), we obtain 58 m. This number agrees fairly well with the average value obtained in Table II, i. e. 71 m. On the basis of these observations, I think that the altitude of Pionier-bivak must be placed at about 60 m.

The observations in the van Rees Mountains, the Meervlakte, and the Central Mountain Region follow:

Table V

I, Tulband-bivak, Map A, 1; II, August 8, 1920; III, 3 P. M.; IV, 755; V, 25°; VI, 81.

I, Edi-bivak, about 8 m. above the river, Map A, 2, three records; II, August 9 and 10, 1920; III, 6 A. M.-6 P. M.; IV, 754.6-757; V, 25°; VI, 58-81; VII, average, 71 m.

I, Wand-biyak, Map A, 3, two records; II, August 8, 1920; III, 4 P. M. and 9 P. M.; IV, 752.1-756.1; V, 25°; VI, 69-116; VII, cloudburst beginning, cloudburst over.

I, Batavia-bivak, Map A, 4, four records; II, August 11, 1920; III, noon-8 P. M.; IV, 752.2-754.2; V, 25°; VI, 92-116; VII, average, 101 m.

I, Kalong-bivak, Map A, 5, two records; II, August 12, 1920; III, 2 P. M. and 5 P. M.; IV, 752.2 and 752.9; V, 25°; VI, 104 and 116.

I, Veen-bivak, Map A, 6, one record; II, August 13, 1920; III, 4 P. M.; IV, 750.9; V, 25°; VI, 127.

I, Prauwen-bivak, Map B, 1, ten observations; II, August 15-17, 1920; III, 7 A. M.-10 P. M.; IV, 751.5-754.0; V, 24.2-29.3°; VI, 92-118. After these records were made the aneroid barometer was set at 754.0 (reading of the hypsometer), so that this instrument in the future was read without correction; 17 more records were made at this station, of which two check or control readings on the hypsometer. II, August 17-25, 1920; III, 7:30 A. M.-10 P. M.; IV, 750.1-754; V, 26-30°; VI, 92-153; VII, average, 112 m.

I, Casuarisnest-top, Map B, 1a, one record; II, —; III, 10 A. M.; IV, 741.7; V, 25°; VI, 233.

I, Summit east of Casuarisnest, Map B, 1b, one record; II, —; III, 10:30 A. M.; IV, 747.6; V, 25°; VI, 162.

I, Brug-bivak, Map B, 5, 23 records; II, September 20-26, 1920; III, 6 A. M.-8 P. M.; IV, 740-744; V, 23-27.5°; VI, 209-268; VII, heavy rains in the evening of the 25th and the night and morning of the 26th; average, 239 m.

I, Batoe-bivak, Map B, 6, four records; II, September 28, 1920; III, 10 A. M.-7 P. M.; IV, 724.8-727.2; V, 24.1-26.4°; VI, 412-436; VII, average, 424 m.

I, Cruciferen-bivak, Map B, 7, four records; II, September 29, 1920; III, 12:30-6 P. M.; IV, 691.4-693.8; V, 23.5-25.3°; VI, 818-856; VII, average, 840 m.

I, Goenoeng Boetak-bivak, Map B, 8, 22 records; II, September 30-October 11, 1920; III, 7 A. M.-8 P. M.; IV, 644-648.6; V, 20-23°; VI, 1382-1448; VII, average, 1424 m.

I, First Parkieten-bivak, Map B, 9, three records; II, October 13, 1920; III, 11:30 A. M.-8 P. M.; IV, 620.8-622; V, 18.4-20.4°; VI, 1647-1747; VII, average, 1752 m.

I, Beek-bivak, Map B, 10, five records; II, October 14, 1920; III, noon-9 P. M.; IV, 570.9-572.8; V, 15.4-18.4°; VI, 2412-2453; VII, temperature of stream-water, 13°; average, 2432 m.

I, Uitzicht-bivak, Map B, 11, four records; II, October 15, 1920; III, 2-8:30 P. M.; IV, 528.4-529.2; V, 12.8-19.6°; VI, 3087-3157; VII, average, 3118 m.

I, Radio-bivak, Map B, 12, 18 records; II, October 16-26, 1920; III, 6 A. M.-11 P. M.; IV, 512.3-516.4; V, 8-21°; VI, 3314-3406; VII, average, 3332 m.

I, Doormantop, three records, one hypsometer reading, the other two aneroid; II, October 22, 1920; III, 9:30 and 9:45 A. M.; IV, 496.6-499.0; V, 15-16.5°; VI, 3581-3615.

I believe that the altitude of Doormantop must be accepted as about 3580 m.

III. Impressions of the Lower Mamberamo Territory ¹

IN THIS and the following articles of *Fragmenta Papuana* which are concerned with the flora and the vegetation of the regions I visited in New Guinea, I have made use of the published botanical literature in which parts of my collection are elaborated (*Nova Guinea* vol. 14, Botany, book 1, 1924, and book 2, 1926). A list of the articles now published concerning the van Overeem and Kremer Expeditions will be added at the end of the *Fragmenta* series.

Where possible, therefore, plant names published in these articles are recorded. However, to obtain later a more complete picture of the vegetation, the numbers of my collection with preliminary determinations as well as undetermined numbers in sequence, wherever feasible, are also given. By this means, workers interested in this region will be enabled to add the scientific names when these numbers appear in the literature.

* *

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When Dumont d'Urville, exactly a hundred years ago (Aug. 1827), sailed with his ship the "Astrolabe" along the northern coast of New Guinea, he surmised from the strong discoloration of the sea-water that he was then in the neighborhood of the mouth of a large river. Later he wrote about it as follows:²

"A huit heures [August 16] l'eau de la mer prenant sur notre route une teinte verdâtre, j'envoyai le petit canot pour sonder sur cet espace. Il ne trouva point de fond a cinquante brasses, et je dirigeai la corvette au milieu de cette bande décolorée. A dix heures et demie un nouveau changement de couleur bien plus marqué se montra partout devant nous à une demi-encâblure de distance. Cette fois l'eau était tout-à-fait jaunâtre et bourbeuse ; à onze heures nous donnâmes tout au travers de ces eaux décolorées, et nous traversâmes plusieurs lits de courans très-rapides et très-bruyans. Une quantité de branches d'arbres, de fruits détachés et de débris de plantes flottai(en)t à la surface des eaux. A onze heures et demie, dans l'endroit où leur teinte était la plus fangeuse, l'eau que nous puisâmes n'était plus que très légèrement saumâtre. Toutefois, en ce lieu même, nous n'eûmes pas fonds par cinquante brasses"

"Je regardai donc comme un fait positif que ces eaux provenaient de quelque rivière considérable qui se décharge dans la mer sur cette partie de la côte. Bougainville observait le même fait au même endroit, et en tira la même induction. Précisément dans cette partie, la terre de la Nouvelle Guinée forme une pointe basse et fort avancée en mer (pointe d'Urville). Tout porte à croire que cette pointe a été formée par les attérissemens d'un torrent considérable."

In conclusion, just a little further, " la bande des eaux fangeuses n'a pas moins de dix ou douze milles de largeur, ce qui annonce une dimension considérable pour le fleuve qui les produit."

"A cinq heures cinquante minutes du soir, nous traversâmes un fort remoux, et rentrâmes enfin dans la Mer bleue."

¹ *Natuurk. Tijdschr. Nederl.-Ind.* 87: 139-180. 1927.

² Dumont d'Urville, *Voyage de la Corvette l'Astrolabe*, IV (1832, Paris).

Meanwhile, as we have seen in the first Fragment, it was 1884 before the country was penetrated along this waterway for the first time, and February 1910 before the real interior, the Meervlakte, was reached. In June 1920 my traveling companions and I had the privilege of appropriating the words of Dumont d'Urville for our own, and of approaching the mouth of the Mamberamo. I shall insert here a little information about the mighty river, which, in spite of its swiftness, is still the only good trade-route between the coast and the interior of northern New Guinea.

With the Sepik (Kaiserin-Augusta River), the Mamberamo is one of the largest streams of the territory. The data available concerning this river are still very meager and do not amount to more than mere guesses, but, notwithstanding, they give us some idea of its size. The Mamberamo provides the drainage of a tropical high mountain-range almost 500 km. long and about 100 km. broad. This territory, where the rainfall is very important and on the average amounts to surely a few meters per year, is extended by the district to the north of it, which also drains mostly by way of the river, giving a drainage-area of 100,000 sq. km., roughly estimated. In looking over the short list given below, wherein the Mamberamo is compared with the Amazon and the Rhine, it is helpful to recall that the first-mentioned river possesses two about equally worthy tributaries, the van der Willigen River and the Idenburg River. The length is measured on the last named tributary.

	Rhine	Mamberamo ³	Amazon ⁴
Length in km.	1320	900	5500
Drainage-area in sq. km.	224,000	100,000	7,000,000
Solid materials carried toward the sea in kg. per year	2-5 thousand	15.1 thousand	1000-2300 thousand
The same per year per sq. km.	15,000	150,000	200,000
Average reduction of land per year in cm.	0.006	0.06	0.08
Capacity (water conveyance) in cu. m. per second	240	10,000	120,000
The same in cu. km. per year	7.6	315	3780

From these figures the great difference is evident, on the one hand, between the two tropical rivers themselves, and on the other, between these and a temperate zone river. This shows the enormous quantity of solid materials transported by tropical rivers. Here also is affirmation that, through vigorous erosion resulting from heavy rainfall, this territory diminishes in height ten times as rapidly as western Europe, namely 6-8 cm. in a century. Furthermore, we see that the Rhine, although longer than the Mamberamo and with more than twice as large a drainage-area, conveys 1/40 as much water, and that the Amazon, with 70 times as large a drainage-area, conveys only 12 times as much. The large capacity of the Mamberamo is in concordance with its comparatively great depth. In the lower course of the river, the channel is 15-18 m. deep, and near the Edi Rapids depths of 40 m. have been sounded, but in the relatively narrow passage in front of Prauwen-bivak 1920-1922 only 20 m. was sounded. Passing from the upper into the middle course of the river, one finds a long narrow gap, 9 km. long and 50-75 m. broad, through which the water flows with great force, and above the cleft, freshets make a difference

³ The figures given in the table for the Mamberamo are adopted from van Gelder (l. c. 91).

⁴ K. Braak, Waar blijft het Amazone-slib? Een geografisch probleem—De Natuur Jaarg. 43, No. 1, p. 21.

of 40 m. in the height of the water-level. Likewise the great velocity of the stream causes difficulty in navigating the river. At the mouth the current is still 3.5–5.5 km. per hour. As a result the tide can never enter within the estuary, and this in turn has a great influence on the flora of the river-banks.⁵ At Pionier-bivak, situated 180 km. from the coast at an elevation of 60–70 m., the stream-velocity is 7.5–9 km. per hour. In contrast to this, in the lake-region it is merely 1.8–3.7 km. per hour. The rapids naturally have a much greater velocity. Also it is obvious that, below the rapids, rather large differences may appear in the water-level, and that the regulating influence of the Meervlakte on the water-level in the lower course is not so great as was once supposed.⁶ On my arrival at Pionier-bivak, the lowest water-mark registered was 29 dm. below that observed at the arrival of the advance party. On April 8–10, and after that on May 20, 1920, the gauging apparatus showed the greatest height observed, namely + 42. Therefore, according to our observations, the difference in water-level amounted to 7.1 m.

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At sunrise the coast lay as an indefinite narrow strip on the horizon. Already we were in water of a dirty gray-green color, which presently changed to brown. Gradually, as we approached the coast, the water became more discolored, the counter-current stronger. Toward ten o'clock we approached the mouth of the river, which slowly emerged from the low level strip of land. Toward the east the coast ended in the nearby Cape d'Urville, toward the west it stretched out endlessly: a broad beach beaten by heavy waves and bounded by a long row of *tjemaras* (*Casuarina equisetifolia* Forst.), many of which had already been felled by the force of the waves. The estuary is 500 or 600 m. broad and drains its water into the sea without noticeably broadening. Possibly this coast⁷ is rising with respect to the sea-level.

With our entrance into the estuary, we are suddenly engulfed by the country, and henceforth begins the endless succession of meanders which follow one after another. There is no distant view over the land. The morning mist still hangs upon the coast-line, one of the many daily recurrent phenomena, which frequently characterize the lowland in the tropics. The great Kampong Teba, located close to the shore on the right bank, is now abandoned.

In so far as is perceptible from the ship, the outer aspect of the shore-vegetation confirms the supposition that the tide never or very seldom forces itself into the mouth of the river. The extended mangrove-forests, which on the south coast intrude many kilometers into the country, are entirely lacking here. I see on the shores here and there small light green trees which might possibly be considered as mangrove plants, but immediately thereafter the old lowland-forest appears. Moreover, one notices at once the sago-palm (not *Nipa*),

⁵ Moszkowski (l. c. 277) claims that during the east monsoon the north wind forces the brackish water up to 24 km. from the mouth of the Aiberam. He should have found here a strip of mangrove-forest 18 to 20 km. long. The influence of ebb and flow should be noticeable to van Pee Island. The distance from Pionier-bivak to the sea, according to van Gelder (l. c. 92), is about 240 km., from Pionier-bivak to Batavia-bivak about 65 km. By his aneroid readings, Koetei-bivak (Fragment I) is located at 26 m. altitude, Batavia-bivak at 51 m. Concerning the regulating influence of the Meervlakte on the water-level of the river, see van Gelder, l. c. 90.

⁶ Verslag. Milit. Explor. Ned. Nieuw-Guinee 1907–1915 (Weltevreden 1920), 122.

⁷ Concerning the probability of a rising north coast, see van Gelder, l. c. 93–94.

a typical fresh water plant, growing here. With field-glasses one can observe the spininess of the petioles and the leaf-sheaths. Close to the coast this region is clearly still marshy; the forest is relatively low. Very soon the shores and the forests alike become higher. At odd intervals on the bank a *Pandanus* stands, elsewhere a small bamboo-clump, here and there also a small strip of *gelagah* (*Saccharum spontaneum* L.). As for the rest, it is the usual aspect of a tropical forest-margin, with many lianas and clinging Araceae, a robust trunk being visible only now and again through openings. Sometimes a small hut of sago leaves lies hidden on the bank, one of the hunters' huts which the roving Papuans build as shelter for a night or two. For hours at a time we travel through this sparsely inhabited territory of almost perfect virginity, without seeing a trace of settlement. Hour after hour the same scenery: the broad river with ever new curves, the brown water with its eddies and driftwood, and the high forest-walls whence the sultry fragrance of the tropical primeval forest comes to us. And moreover, there are elements which characterize this country so strongly for the traveler that they become perfectly inherent in the New Guinean scenery for him: the flocks of screaming white parrots with their characteristic profile which fly over repeatedly, and the hornbills, the *ankangs*, the great plump black bird with its much too large beak and the creaking sound of its wings. These two permeate the landscape as if they were the spirit of it, but some other birds as well appear at first acquaintance to complete the picture: the stately soaring light reddish brown heron, which again and again flies across in front of the ship to settle a little farther away on a branch of a tree; sometimes also the flocks of *kalongs* (fruit-bats), which, especially at the sound of the steam-whistle, swarm out of a solitary tree standing in a *gelagah* [*Saccharum*] field, and circle around in great numbers, with their membrane-like wings shining in the sunlight, until silence has returned.

Gradually the river becomes broader, the mouth being narrower than many places higher up. *Gelagah* [*Saccharum*] fields appear in greater numbers and greater dimensions on the inside curves. We find so few points of comparison for judging the dimensions in this strange land that we at first thought the *gelagah* plants were four or five meters high. Later I measured a flowering specimen that was 9 m. high. The background of the high forest-walls measures 40 to 50 m., but, compared with the width of the river, its height is difficult to estimate, for it seemed much lower. Everywhere we see evidence of the continual changes in the course of the river. These take the form of steep eroded shore-banks, in lower spots frequently with areas of dead or dying trees, often also with piles of dead tree-trunks. Sometimes glimpses of low hills are to be seen, but the banks are still entirely flat. About 4 o'clock in the afternoon we pass Kerkhoven Island, after having been almost stranded at one o'clock by a new break in the river at van Pee Island. Almost immediately beyond Kerkhoven Island we see the first trace of hilly land in the form of a 5 m. high clay wall on the river-bank. Nearby is a kampong, but here also no trace of the population is seen. Toward dark we anchor in 9 fathoms 4 feet (17.4 m.) of water.

The following morning at sunrise, when we again get up steam, the light morning mist is still hanging over the tree tops. Three-quarters of an hour after our departure we pass the first hills on the bank. The forest is unmistakably thicker than farther downstream. Here and there specimens of the breadfruit-tree (*Artocarpus* sp.) are recognizable; once in a while we see a tree-fern, and

often the monotonous green forest-margin is colored by the orange-red inflorescences of a *Mucuna*. At last, not far from Pionier-bivak, we meet natives for the first time: a small proa with three men, two dogs, and a small fire, a combination which gives us a glimpse of the primitive life of these people of the primeval forest. We pass the mouth of van Gelder River, the only tributary of any importance in this region, where Franssen Herderschee camped in 1910. A little later we sail along the right bank, passing Duiven Island. Already in the distance the location of Pionier-bivak is visible. At quarter of ten we anchor in front of the inside curve opposite the bivouac, which, in the midst of a cleared place, looks small compared with the majestic surroundings of the mighty primeval forest against a background of blue hills.

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The knowledge of the flora of this region was based in 1920 on the following collections:

- a. A collection of about 500 numbers of herbarium and preserved material and 115 living plants, of W. K. H. Feuilletau de Bruyn, at that time First Lieutenant of the Infantry.
- b. Two hundred and seventy numbers brought together by the Medical Officer, A. C. Thomsen; this collection, like the previous one, was assembled on the banks of the Mamberamo and the Idenburg Rivers.
- c. A collection of 625 numbers of herbarium and preserved material and 200 living plants gathered on the north coast of the mouth of the Mamberamo by Medical Officer R. F. Janowsky.

At the very time when this Fragment was being written, the writer's collection at Pionier-bivak and its vicinity, 388 numbers of herbarium and preserved material, was added, as well as that of Dr. W. M. Docters van Leeuwen, who in 1926 collected about 1000 numbers of herbarium and preserved material in this region.

I should here emphasize that the following sketch of the vegetation rests exclusively on my own collection and therefore is very incomplete. In particular, as far as tree-species are concerned, very little can be said on the basis of the collection. In reality, it is only a number of more or less coherent observations on the flora of this territory, which will perhaps serve as a groundwork upon which later writers may build further and to which they may add their own observations. However, before I give my own impressions, I shall give a brief ecological sketch of the vegetation. Similarly, I intend to do the same for each of the regions which will be discussed in these Fragments. At the same time this sketch will serve as a pattern to which we shall repeatedly return when describing other regions, and which therefore will serve as a basis of comparison. We take *Figure 1* as a starting point, a schematic representation wherein I have tried to bring together ⁸ the principal morphological and ecological characteristics of this plant-association, the tropical lowland primeval forest.

⁸ Cf. also the strikingly precise description of a tropical rain-forest in: K. Sapper, *Geologischer Bau und Landschaftsbild*, 2. Auflage, Bd. 61 van "Die Wissenschaft" (Vieweg, Braunschweig 1922), p. 107 and following, and in: Id., *Die Tropen-Natur und Mensch zwischen den Wendekreisen* (Stuttgart 1923), p. 60 et seq.; these articles I can warmly recommend for reading.

In its ideal form the tropical primeval forest is an organism, the lower limit of which is the ground, the upper the forest-roof. The latter is supported by what may be designated as the forest-skeleton: the trunks of giant trees, frequently without branches, which rise several score meters, their crowns forming the forest-roof. But there is still a third limit—the margins, such as we find along the river-banks. Both the roof and the margins are closed to such an extent that entirely different conditions prevail within the forest than outside, where the sun, the wind, and the rain have free play. Within the forest the light is dim, frequently suggesting twilight, the wind as well as the light is broken, and the rain loses its force. This is why all outward conditions within the forest remain within very strict limits. And whereas outside all sorts of extremes of light and dark, of wind and calm, of extreme heat and sudden cooling, of great humidity and dryness, are possible, yet within the forest these conditions are extremely constant, as if the inner parts of the forest were a

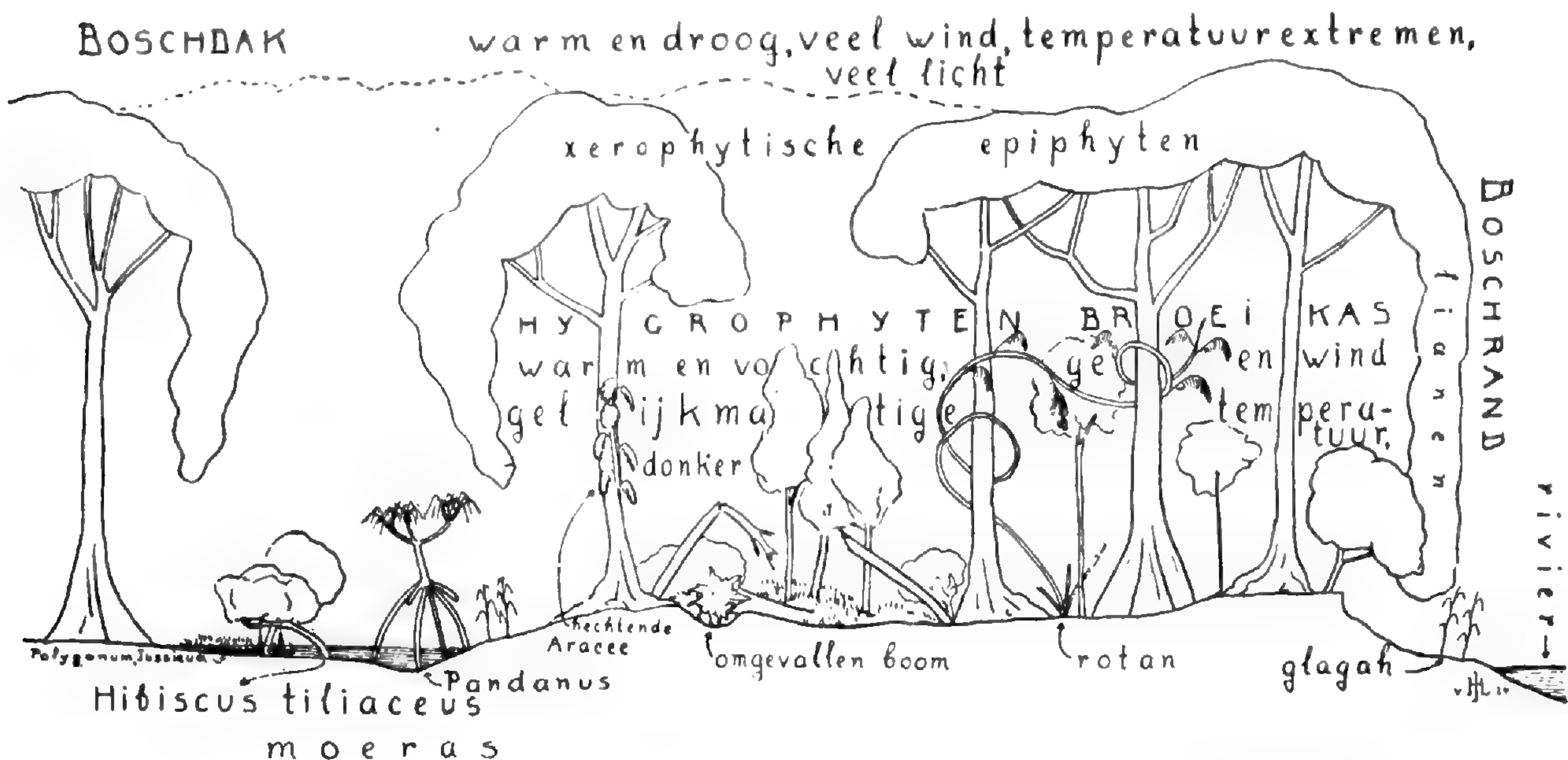


FIG. 1. Schematic representation of the rain-forest. Boschdak = forest-roof; boschrand = forest-margin; broeikas = conservatory or hot-house; vochtig = damp; g[e]lagah = *Saccharum*; gelijkmatige = even; moeras = marsh.

natural conservatory wherein the light alone changes with day and night. For not only is the forest-roof thick, but also, even in still stronger measure, the forest-margin is closed by the overwhelming mass of lianas which frequently extend to the ground, and which can form so thick an undergrowth that—unfairly, as we shall see—the forest itself has been called impenetrable. In very broad outline these are the ecological principles of the tropical rain-forest, a plant association of which we, with Schimper, accept as a fact that it originated through an equable rather high temperature and a rainfall of at least two meters evenly distributed over the year.

In such a rain-forest, with its conditions optimum in many respects, the struggle for existence among individuals and species is so sharp that, with an equal degree of justification, one can defend the proposition that these species and individuals, which carry on a life and death struggle, are units, while the primeval forest in its entirety may be looked upon as a mighty organism, wherein, as in all organisms, the maintenance of equilibrium is constantly sought. For if the balance becomes disturbed somewhere, for example by the

crash of an old forest giant, which in its fall has torn open a gap in the forest, has broken the forest-roof, and therefore has greatly changed the conditions in that spot, then we see immediately how the flora reacts at the infliction of the wound. Thus in the human organism the thrombocytes and the leucocytes: there develops at the site (of infection) an accelerated growth, a crowding of life's forces, and an increased energy, with the result that the wound becomes temporarily closed and the skin is very quickly healed again. In the injured forest there immediately arises in such a place a dense mass of tall herbs, shrubs, and young trees which now for the first time have an opportunity to develop. At the same time the loose flexible branches of lianas descend from the forest-roof slowly to join with the lower flora and thus close anew the forest-roof. So it is, seen from the standpoint of the primeval forest as a unit; but from that of the individual or species it is a reaction to suddenly changed conditions. The obligate hygrophytes disappear, now that the full sunlight, the rain, and a little wind can reach the ground. But all sorts of other plants, which mostly otherwise would not even commence to develop, now shoot up and begin striving with each other for light. Again in this struggle a few slowly triumph, in the long run not more than one or two trees, and thereby the wound is healed. Meanwhile fungi and bacteria have done their work, completely destroying the fallen trunk.

The conservatory under the forest-roof is the dwelling-place of hygrophytes, plants which can live only in an atmosphere of continuously very high humidity. Here the humidity almost always ranges between 90 and 100%;⁹ in such a tropical rain-forest there are plants with leaves not more than a single cell-layer in thickness (Hymenophyllaceae). Others possess arrangements by which they may shed water as quickly as possible; for instance, the drip-tips of the leaves of some species do that mechanically, aided by the sloping position of the leaf. Many leaves possess water-glands or hydathodes by which water is secreted during those hours when the maximum relative grade of humidity is such that evaporation cannot take place. In this way, under the conditions outlined, these plants maintain the necessary water-stream from the roots to the leaves. In general, the dimensions, the thinness of the leaves, and the possession of a great number of stomata work to the same end.

On the soil rich with humus, in this hot-house of the thick forest, usually little grows, a result of the lack of light which seems to be a limiting factor. Autotrophic plants which grow here frequently have a poor appearance; on the other hand, plants which require no light, such as fungi, bacteria, and higher saprophytes, ordinarily are common and thrive luxuriantly. In lighter places, however, distinct herbs often appear, frequently in small communities, as for example a few Araceae, ferns, and species of *Elatostema* and *Selaginella*. Shrubs are thin and scattered and frequently possess not a single complete leaf, all being much injured by insects and in addition covered with epiphyllous mosses and algae. Their flowers are usually inconspicuous in size and color, often greenish or white. Above these shrubs rise smaller trees, likewise thin and slender, frequently with bolt upright trunks, while leafless stems of large lianas twine themselves into all sorts of contortions through the forest. Then follow some stories of ever larger trees which, however, all remain under the forest-roof, their crowns forming a natural forest-cover according to some

⁹ Cf. Fragment II, table I, observations on cleared land; in the forest the relative condition of humidity is considerably higher.

authors, but I have seldom seen this cover to such an extent. Some research workers, such as Wallace,¹⁰ Beccari,¹¹ and Brown,¹² think they are able to distinguish fairly sharply separated stories. Between these trees, whose trunks are hidden under many clinging plants (especially Araceae and ferns) and hygrophytic epiphytes (ferns and mosses), there are the particularly bad groups of *Pandanus* species and rattans which, with the fallen giants of the woods, make the forest locally almost impassable. Moreover, I naturally conclude that the character of the soil itself does not influence this.

Therefore, only the highest trees, with their vast crowns forming the forest-roof, are exposed to conditions other than those of the previously discussed group. Their crowns are exposed to the full influence of sun, wind, rain, and changing temperatures, and consequently they cannot be considered particularly as hygrophytes; nevertheless, the conditions are not so extreme that they may be called xerophytes. Here also the external factors of the equatorial climate are still confined within very narrow limits. Furthermore, the roots of the very same trees live in the more favorable circumstances of the hygrophytic forest. So, one considers the woody giants in such a forest and also in part the secondary trees as belonging to an ecological group between the extremes of hygrophytes and xerophytes, namely, the mesophytes.

But true xerophytes naturally are the epiphytes which live above in the forest-roof. Exposed to the same outward circumstances as the crowns of the forest-giants, they lack entirely the conditions of the last to take up water conveniently, and they must manage to get along with the small amount of water which they can absorb as vapor out of the atmosphere and the little which they can obtain during periods of rainfall. It is obvious then that such plants usually are small and possess more or less well-developed water-tissue which allows them to use this water, once taken up, as economically as possible. In brief I wish to remind my readers that, until recently, the earlier opinion of Schimper¹³ was held, that xerophytism (the word xerophily is wrong, since these plants are not drought-loving but drought-enduring) is expressed only in morphological-anatomical characters. If one saw a plant with hard thick leaves, with a thick hairy covering, with a waxy or thick cuticle, then that plant would be without doubt a xerophyte. The latest researches, for example those of Maximov¹⁴ on plants of the steppe, and of Senn¹⁵ on alpine vegetation, have proved that a xerophyte is characterized, in the first place, not by a morphological-anatomical adaptation, but by a physiological one. Earlier, it was thought, on the basis of outward observations, that xerophytes possessed means of preventing evaporation. Exactly the contrary is true; evaporation in xerophytes is very much greater than in mesophytes, and the outer or epidermal covering is not important except when the stomata are closed (and that happens in sudden drying). The adaptation of the xerophytes lies therefore, in a greater resistance against and an easier endurance of prolonged drying up.

¹⁰ A. R. Wallace, *Natural Selection and Tropical Nature* (1895), p. 240, cited by Brown, l. c. 33.

¹¹ O. Beccari, *Nelle Foreste di Borneo*, 2nd edition (1921), p. 412.

¹² W. H. Brown, *Vegetation of Philippine Mountains* (Manila 1919), p. 31.

¹³ A. F. W. Schimper, *Die epiphytische Vegetation Amerikas*, *Bot. Mitt. aus den Tropen* II (1888); see also W. H. Brown, *Veget. Philipp. Mountains*, p. 296.

¹⁴ N. A. Maximov, *Physiologisch-ökologische Untersuchungen über die Dürresistenz der Xerophyten*, *Jhrb. f. Wiss. Bot.* LXII (1923), I, 128.

¹⁵ G. Senn, *Untersuchungen über die Physiologie der Alpenpflanzen*, *Verh. d. Schweiz. Nat. f. Ges.* 1922, II, 154.

For this, in addition to the previously mentioned morphological-anatomical characteristics, the following are also compensating factors: a high osmotic pressure in the root-cells of terrestrial plants, a strong evaporation (hence, in general, a powerful water-transportation), and the possession of much mechanical tissue. Some morphological observations are not primary but merely a consequence of the physiological quality, as, for example, the smallness of the plants, which is a result of the delayed carbonic acid assimilation by the repeated closing of the stomata. As means of diminishing the evaporation surface, the smallness of the leaves can well be a morphological adaptation, just as is the possession of water-tissue or water-reservoirs in tubers, stems, or leaves. Extreme xerophytism appears frequently to coincide with the presence of such a water-tissue; one recalls, for instance, Cactaceae, *Mesembryanthemum*, *Sedum*, *Sempervivum*, *Agave*, and many others. A large number of epiphytes (Orchidaceae, *Hydnophytum*, and *Myrmecodia*) have similar organs, thick leaves, tubers, etc. Moreover, some epiphytes can catch or absorb the little available water quickly, the orchids, for example, taking up capillary water through the long gray aerial roots.

Finally there is the forest-margin, where nearly the same conditions prevail as on the forest-roof, only in less extreme measure. In this habitat lianas and rattans especially are quite numerous, but most of these develop fully particularly in the forest-margin, which they often entirely cover with their long pendent and thickly foliated branches. They also are mesophytes and they too can absorb water from the ground *ad libitum*. That they continue to do so in large measure is noticeable by the structure of their stems, the wood of which is perforated with very large vessels which often, and especially after rainy weather and in the full sun, contain so much water that they are a welcome source of drinking water—welcome also for the trustworthiness of this source. In these forest-margins the most colorful flowers are to be seen. Many lianas have large flowers with striking colors. Within the forest they rarely occur. I need not here refute the fairy tale of the “luxuriant tropical forest with its beautifully colored flowers and butterflies;” it probably originated in the minds of those who know tropical forests not through their own observations but through fancy, since enthusiastic and superficial observers are charmed by the colored pictures in the encyclopedias and by imagination. Furthermore, one observes practically nothing of animal life except insects, and of these frequently too many. Larger animals are rarely observed, but their tracks are often seen. Many of these forest-dwellers are nocturnal; moreover they are shy and flee quickly and quietly at strange noises. Frequently then during the day there prevails in the sultry calm of the forest an almost perfect silence which, moreover, is accentuated by the melancholy deep cooing of large doves and is broken only by the screams of parrots or the rough bickering of hornbills, and sometimes far in the distance by the hoarse cry of a cassowary. The cicada chorus naturally is heard at night, but chiefly in open places, as in the vicinity of camps. In the forest itself this chorus is hardly sufficient to disturb the impression of a deep smouldering stillness.

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The region about Pionier-bivak (*Fig. 2*), which, according to estimates, has an altitude of 60–70 m., is controlled especially by the river, inasmuch as the hills do not approach the bank. The flat parts consist of a heavy clay rich

with humus and are intersected by a number of creeks with nearly impassable beds of soft deep mud. In *Figure 2* one of the creeks is designated as *a*, viewed towards the southeast. Here and there are small marshes (*b*, *c*) between the elevations of land, and not far from the river sharp little ridges begin as foothills of the mountains farther inland. I shall presently consider the names of a few plants and plant-associations which we find here. It does not seem unsuitable to me to begin with Pionier-bivak itself, because here we find a number of weeds well worth brief consideration. In connection with this idea I should like to arrange under this concept the species belonging to the native flora which persist as well as the adventive ones which have come from outside, plants which more or less tolerate or even prefer the presence of men who clear openings in the forest. So far this place is more remarkable for weeds than most others

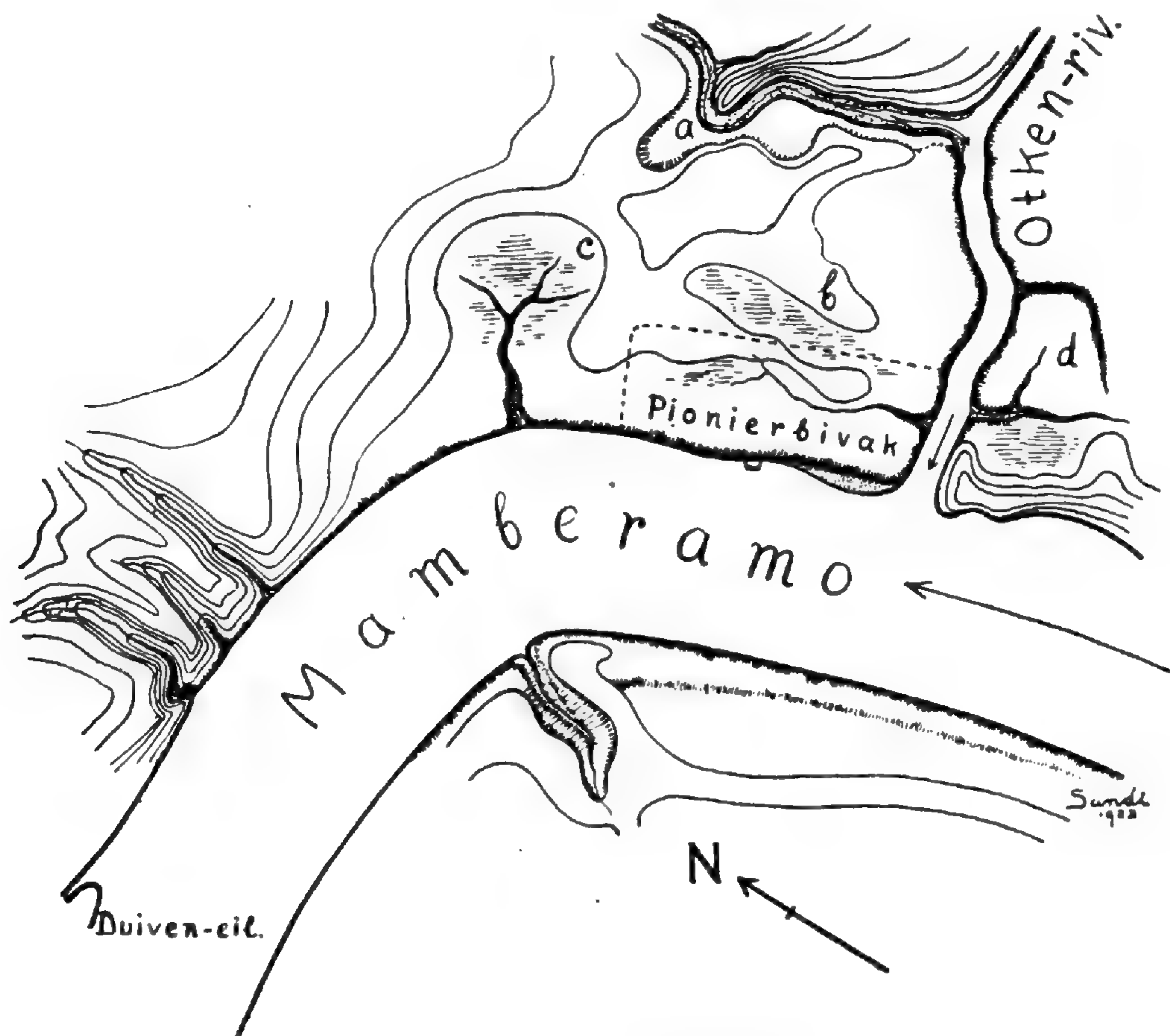


FIG. 2. Small sketch-map of the vicinity of Pionier-bivak; explanation of the letters in the text; the contours are at 5 m. intervals.

because the camp is surrounded on all sides by hundreds of kilometers of primary forest, where the adventive plants do not occur. We have therefore an area before us from which, for the larger part, the original flora has disappeared. Hence the conditions which prevail in the forest have become drastically changed. In the first place nearly all hygrophytes find it impossible to live here. Most mesophytes have been and still are being violently removed. Thus conditions are created which make it possible for other plants ("anthropochoren" or "anthropophilen"—plants of dwelling places or plants following man) to penetrate (if only they were present) and to live beside the native plants which can persist under these conditions (*apophytes*). I found in the open region of Pionier-bivak a number of truly adventive plants, which, therefore, either indirectly or directly must have been introduced by man. Pionier-

bivak was established at this location in December 1913, but about a year later it was abandoned. The growth became so dense that the advance-guard of our expedition encountered here in February 1920 a luxuriant stand of shrubs and young trees. I must, however, point out that in the neighborhood there were present some small foci of infection, that is to say, the old Pionier-bivak (May 1911) on the left bank of the Okten River (*Fig. 2, d*) near our Pionier-bivak, and furthermore, at a greater distance away was Koetei-bivak (January 1910) on the van Gelder River; possibly also the settlements of the Papuans have exercised some influence on this. For the sake of completeness I recall the ascents of 1880, 1900, 1906, and 1909, but for the importation of adventive plants those can scarcely have been of any importance.

The list of weeds (ruderal plants)¹⁶ which I found follows:

I. THROUGHOUT THE TROPICS OR OF WIDER DISTRIBUTION:

1. *Ageratum conyzoides* L., originally native in South America, now pantropic.
2. *Eleusine indica* Gaertn., also in the subtropics.
3. *Euphorbia hirta* L. (*E. pilulifera* L.)
4. *Euphorbia thymifolia* L.
5. *Lindernia crustacea* F. v. Muell., originally native in the Old World, now pantropic.
6. *Mitreola petiolata* Torr. & Gray (*M. paniculata* Wall.).
7. *Oldenlandia corymbosa* L.
8. *Paspalum conjugatum* Berg., originally native in South America, now pantropic.
9. *Portulaca oleracea* L., in all warmer regions.

II. TROPICS OF THE OLD WORLD:

10. *Amaranthus caudatus* L. (*A. gracilis* Desf.).
11. *Lindernia pyxidaria* All., also in the subtropics.
12. *Oldenlandia diffusa* Roxb.

III. SOUTHEASTERN ASIA:

13. *Lindernia mollis* Wettst. (*Vandellia mollis* Benth.), Himalaya, China, Malaya, Sumatra.
14. *Ilysanthes antipoda* Merr. (*Bonnaya veronicifolia* Spreng.), British India, China, Malayan Archipelago.
15. *Stachytarpheta indica* Vahl, British India, Malayan Archipelago [Native of tropical America].
16. *Pouzolzia zeylanica* Benn. (*P. indica* Gaud.), tropics and subtropics of British India South China, Malayan Archipelago, and Australia.

Moreover, here grew apparently as ruderal plants a couple of Cucurbitaceae (nos. 629, 630). [These are *Momordica cochinchinensis* Spreng. (trop. As.-Arch.) according to the Addenda.]

The most striking fact in the above list is that almost all of these plants have a very wide distribution. Not less than 9 of the 16 or 56% are tropical cosmopolitans, and 12 or 75% are widespread over the tropics of the Old World (Australia sometimes excluded). Probably their slight fastidiousness in respect to outward conditions and their easy mode of dispersal predetermine these plants to cosmopolitanism. Regarding the manner of distribution of the plants mentioned above, not less than 13 of the 16 possess very small, more or less round, smooth or wrinkled seeds or fruits which, where great distances are concerned, are spread chiefly through the influence of people; of the remaining three, the method of dissemination is more uncertain. *Ageratum conyzoides* L., with fruits crowned by five tolerably stiff acute calyx-lobes, is perhaps spread

¹⁶ The determinations I owe to Mr. C. A. Backer, formerly of Buitenzorg, now of Pasoeroean. Here, as in later instances, I have used Merrill's Enumeration of Philippine Flowering Plants, I-IV (1922-1926), for the nomenclature and distribution.

by birds; both grasses, *Paspalum conjugatum* Berg. and *Eleusine indica* Gaertn., are perhaps spread by the wind, possibly by people.

As for the apophytes which have persisted at the bivouac, we can perhaps include some Cyperaceae, such as *Fimbristylis* (no. 635) and *Cyperus*, and also a species of *Jussiaea* (no. 506), all of which occurred in a small marsh (Fig. 2, b).

We now come to the discussion of a real forest-flora. We have already seen above that, as a rule, it is not the forest which makes this land so particularly hard to penetrate in many places. It is true that here and there appear somewhat hindering rattan or *Pandanus* complexes, but, generally speaking, the forest itself is not especially thick apart from the forest-margin. Here chiefly it is the nature of the soil which makes the terrain so arduous. Whoever does not know a country such as New Guinea cannot easily imagine those difficulties, which likewise cannot be made clear by means of pictures. One must himself have roamed around over this soft, miry, and slippery terrain with its unexpected deep muddy creeks, frequently very difficult to pass, with their steep banks. This condition prevails in the "dry" season. In the rainy season, when the river fills and more than fills with its water all the muddy creeks far back into the land—also in the neighborhood of Pionier-bivak—then this region offers difficulties which even for experienced woodsmen have remained unsurmountable. It happened once, during our expedition, that provisions had to be brought to Edi-bivak, where the advance-guard was imprisoned by a sudden rise of water and the supply of food was exhausted. One of the non-commissioned officers, an experienced jungle runner, was given an order to open a path with a group of convicts in the direction of that camp which was 22 km. distant in a straight line. The group worked five long days with might and main, contending with the numerous muddy creeks which sometimes had to be circumvented by detours 700 to 800 m. inland. After the fifth day it had not advanced farther than Havik Island, 2 km. distant from Pionier-bivak.

As mentioned above, owing to a number of circumstances, I collected little tree material in this territory. Therefore, from the hundreds of tree species, there is little to be gained by naming the few which I caused to be felled and from which I secured material. Later explorers, and first among them Docters van Leeuwen, who examined this terrain more intensively, doubtless will be able to contribute thereto more valuable data. It is sufficient to mention *Intsia amboinensis* Thouars (no. 612) (Arch.),¹⁷ a tree regularly sought for by the Dyaks from which to make their proas. A woody giant I came across in the middle of the forest was *Pittosporum ramiflorum* Zoll. (E. Arch.), which, although 45 m. tall, did not protrude above the forest-roof. Also I have seen enormous *Ficus* species on the other side of the river somewhat inland from the site where in 1926 the Albatros-bivak was built. I once saw a giant specimen some 60 m. in height, with a large number of aerial roots, which together surely covered an area 20 m. in diameter. It is hardly necessary to mention that *Ficus* species are also abundant in this forest (nos. 653, 729, 731, 757, 758, and 765). Likewise *Jambosa Thomseni* Diels,* with pretty purple-red flowers, was a rather tall tree (35 m.).

¹⁷ The distribution will be given shortly and comprehensively by: Arch. (entire Malayan Archipelago), W. Arch. (western part of it), E. Arch. (eastern part of it), Phil. (Philippines), Trop. As., Trop. S. E. As., N. Austr., Polyn. (Polynesia), Trop. O. W. (tropics of Old World), pantrop. (tropics of whole world), and others. New species are indicated by an asterisk. The addition "end." (endemic) stands in some places also for endemism in its wider sense, thus, for example, including the Bismarck Archipelago.

On the north side of the camp is one of the many small marshes which lie along the river (*Figs. 1 and 2, c*). Here the forest roof is more or less interrupted and the sunlight falls on the crowns of the low Pandanaceae which form the higher overgrowth. On the drier margins typical small trees such as *Kleinhovia hospita* L. (no. 743, trop. As.) and *Vitex Hollrungii* Warb. (Arch.) occur, while *Hibiscus tiliaceus* L. (pantrop.) var. *abutiloides* Hochr. and *Cordyline terminalis* Kunth (trop. As.-Polyn.) frequently are close to the margin of or even partly in the water. Towering over all plants in many spots breadfruit trees (*Artocarpus ?communis* Forst.; Arch., Polyn.) raise their crowns. The shallower parts of such little swamps frequently have a compact growth of Cyperaceae (nos. 533 and 535), *Jussiaea* (no. 506), and *Polygonum dichotomum* Bl. (trop. S.E.As.-N. Austr.). *Combretum tetralophum* Clarke (trop. As.-N. Guin.) creeps along on marshy ground.

In the forest the smaller trees are naturally more easily reached. Among them are some which are conspicuous because of their colorful flowers, such as *Ixora Kerstingii* K. Schum. & Lauterb. (end.; nos. 557, 768) and *Phaleria* (no. 461), the last cauliflorous. A species of *Tabernaemontana* is especially obvious because of the very light large orange-colored fruits, which one sees floating everywhere on the river and which one may observe even at sea. Other smaller trees, 10–15 m. high, belong to the Rubiaceae, such as *Timonius stipulosus* Boerl. (Celebes, N. Guin.; no. 478) and *Tarennia Guelcheriana* Val. (E. Arch.), and to the genera *Sterculia* (no. 471), *Dillenia* (e. g. *D. pedunculata* K. Schum., end., and *D. castaneifolia* Miq., end.), *Pycnarrhena* (*P. grandis* Lauterb., end.), and *Semecarpus* (*S. Lamii* Slis* and *S. fulvo-villosus* Lauterb., end.), the last genus with the black resin, characteristic for so many of the Anacardiaceae, which causes an itching inflammation of the skin. Also species of *Laportea*, tropical stinging nettles, are not uncommon, as *L. decumana* Wedd. (Arch.). In addition some small palms are widespread in all stories of the primary forest (nos. 651, 672, 728). I name further *Stemonurus ramuensis* Lauterb., the myrmecophilous monimiaceous *Anthobembix dentata* Val. (no. 769, end.), a *Horsfieldia* (no. 770), *Conocephalus Gjellerupii* Hub. Winkl. (end.), *Santiria acuminata* K. Schum. (end.), and a few noteworthy Leguminosae, namely *Maniltoa gemmipara* Scheff. (no. 670, end.), which is cauliflorous (as is *Phaleria*), and *Hansemannia* (no. 692, end.) with regular flowers in which the thick clusters of white stamens make one think of a species of the Myrtaceae or the Lecythidaceae. Also I found here *Desmodium umbellatum* DC. (trop. As.).

Along the banks of the Okten River are *Kleinhovia hospita* L., *Premna integrifolia* L., and a number of species of *Ficus* which all are abundant. Here and there one finds *Erythrospermum Wichmanni* Val. (end.), the white-flowered *Lepidopetalum hebecladum* Radlk. (N. Guin., Key and Aru Is.), and the beautiful *Schuurmansia* (no. 481), a small and slender tree, frequently bent over the water, its long narrow leaves very thickly crowded at the apices of the branches, while from the middle of this foliar cluster protrudes the very large clear purple inflorescence with a profusion of small flowers.

Amongst the shrubs there are almost none that have showy flowers and fruits. I found there representatives of the following genera: *Ardisia* (no. 432), *Saurauia* (*S. mamberamana* Diels * with white or rose flowers), *Solanum* (nos. 636, 706), *Diospyros* (no. 698), *Antidesma* (nos. 660, 707), *Breynia* (no. 746), *Garcinia* (no. 750), *Cyrtandra* (nos. 441, 759), *Gomphandra* (nos. 427, 657),

Amaracarpus (*A. mesophyllus* Val.*), *Pipturus* (*P. argenteus* Wedd.; Arch., Polyn.), *Semecarpus* (*S. magnificus* K. Schum., end.), *Chisocheton* (nos. 502, 573), *Orophea* (*O. Dielsiana* Diels, end., nos. 433, 492), *Pittosporum* (*P. galai* K. Schum., end., no. 723), *Melodorum* (*M. micranthum* Warb., end., no. 751), *Tylecarpus* (*T. papuanus* Engl.), and *Aphania cuspidata* Radlk. (N. Guin., Waigeo; nos. 416, 418). All the plants mentioned have inconspicuous small flowers, often greenish white in color. Yet there are shrubs which are more showy. For instance, I found here an *Abroma* (*A. fastuosa* R. Br., trop. As., Austr.; no. 465) with flowers which attract attention by their elegant and unusual structure and the combination of darker modest colors, purple-brown and yellow. A couple of *Clerodendron* species also give color to the undergrowth. Most species of the latter genus occur in somewhat more open situations and frequently are decorative with their colorful inflorescences. Those met with here have their flowers whitish mingled with rose and lilac; they are *C. buruanum* Miq. (E. Arch., Phil.) and *C. porphyrocalyx* Schum. & Lauterb. (end.); the latter is beautiful after blossoming on account of its enlarged fiery red calyx, against which the black fruit shows in sharp contrast. Some color is given to the forest by a few Rubiaceae, not on account of their corollas, but because of the enlarged calyx-lobes. Not only *Morinda umbellata* L. (S. E. As.) var. *papua* Val. and *M. bracteata* Roxb. (Arch.) var. *celebica* Miq., but also *Mussaenda cylindrocarpa* Burck (end.), show this phenomenon; besides, in the first-named species the tuber-like inflorescence and infructescence attract attention. Just as on many other islands in the Archipelago, the family here also is richly developed in the undergrowth. In addition to its representatives already indicated, I found a *Pavetta* (no. 498) and a few species of *Psychotria* in damp places, *P. obscura* Val. (end.), *P. subherbacea* Val. (end.), *P. leptothyrsa* Miq. (E. Java, Moluccas, N. Guin., Palau; nos. 494, 699), and no. 678. Also represented here are *Oldenlandia corymbosa* L. (N. Guin., Carol.), *O. diffusa* Roxb., *O. pubescens* Val. (end.), and the half-shrubs *Ophiorrhiza seriata* Val.* and *O. cuneata* Val.*

As we have already seen, there are not many herbs on the forest-floor. In a few places there are small areas of *Selaginella* (*S. gracilis* Moore, end.) typical of the primary forest, and of *Elatostema*, here represented by *E. Weinlandii* K. Schum. (end.), *E. Pellionianum* Gaudich. (E. Arch.), and *E. novoguineense* Warb. var. *angustifolium*, over which the first predominates. Scattered in not too dry places are some Begonias (nos. 459, 467, 563, 752, 760), in more moist spots Cyperaceae, such as *Scleria* (no. 479) and *Cyperus* (nos. 632, 715). In darker parts of the forest robust Zingiberaceae (nos. 480, 484, 499, 501, 572, 638, 650, 656) are common; we also find here species of the genus *Phrynium* (nos. 444, 449, 562, 648), some Commelinaceae (nos. 496, 716, 724), among them the beautiful *Forrestia mollissima* Koord. (Arch.; nos. 450, 659) with its bright purple flowers and fruits and orange seeds; *Donax canniformis* Rolfe (Arch., Polyn.) is fairly plentiful, and in addition a few Acanthaceae, as *Peristrophe tinctoria* Nees (no. 421, trop. As.), *Lepidagathis hyalina* Nees (no. 528, trop. As.), *Hemigraphis reptans* T. Anders. (no. 403, E. Arch.), and a species of *Hygrophila* (no. 412). The rest of the low flora consists almost entirely of ferns and Araceae, scattered and in small communities. In the Araceae I found here *Schismatoglottis pomatophila* v.A.v.R.* and *S. angustifolia* v.A.v.R.*, both with white and greenish spadix and white spathe, also *Homalomena pygmaea* Engl., *H. lilacina* v.A.v.R.*, and *Holochlamys elliptica* v.A.v.R.* In

a marshy creek-bed near Pionier-bivak (Fig. 2, c) was a community consisting exclusively of *Helminthostachys zeylanica* Hook. f. (trop. As., Austr.), *Pleopeltis aquatica* v.A.v.R., and *Holochlamys guineensis* Engl. A very large part of the terrestrial ferns belong to the typical hygrophytes, the Hymenophyllaceae. Here, for instance, *Trichomanes infundibulare* v.A.v.R.* occurs in large numbers; other extreme hygrophytes are the delicate *Lindsaya tenuifolia* Bl. (Arch., Polyn.) and *Asplenium cuneatum* Lamk. (pantrop.). In the terrestrial group also are the small *Schizaea dichotoma* Sm. (trop. O. W.), *Campylogramma pteridiformis* v.A.v.R.*, *Pteris Warburgii* Chr. (E. Arch.), and *Dryopteris schizophylla* v.A.v.R.* Near the location of the later Albatros-bivak on a gravelly bank skirting the inner bend of the river and overgrown with a young but already tall forest, I observed a sparse development of *Asplenium pseudovulcanicum* v.A.v.R.*, *Dryopteris urophylla* Chr. (trop. S. E. As.—Polyn.), and *Dictyopteris irregularis* Pr. (Arch.), with *Dipteris dissecta* O. Ktze. behind the natural bank in damper places as practically the only ground cover.

Here and there also are some small terrestrial Orchidaceae,¹⁸ such as the demure *Microstylis Lamii* J. J. Sm.*, which seems to prefer a habitat of stones overgrown with moss. In addition are *Goodyera confundens* J. J. Sm. and above all the beautiful *Zeuxine amboinensis* J. J. Sm. var. *argentea* J. J. Sm., with a rosette of fairy-like leaves prettily marked and reflecting a metallic lustre. On more open places, for example on shaded river-banks, a handsome *Spathoglottis* (*S. grandiflora* Schlecht., no. 564), about 1.5 m. high and with lilac flowers, is also frequent.

Both the terrestrial Orchidaceae and the higher saprophytes are widespread. For instance, *Cotylanthera tenuis* Bl. (Arch.), one of the Gentianaceae, with pale stems, scale-like leaves, and a small pale lilac, yellow, and white flower, is common here. Locally such saprophytes may very well be common, a number sometimes being found together. This is especially the case with the fine species of *Sciaphila*, which are rather inconspicuous, first because they frequently are hidden almost entirely under fallen leaves, and second, because they do not stand out against the forest background on account of their dark red color and slender habit. I found here *S. longipes* Schlecht. (end.) and *S. andajensis* Becc. (end.) growing together, the first being taller, about 25 cm. as opposed to the second, which is 10 cm. high. The same color, perhaps more purple, is seen also in the vegetative parts of *Epirrhizanthes papuana* J. J. Sm. (end.), the inflorescence of which is dirty white.

The fungi, richly represented here, are by far the most important saprophytes. They and the bacteria form a large group which, with the assistance of high temperature and great humidity, effect disintegration in nature, thus playing an important part in the cycle of matter. A number of the fungi decompose dead wood; others prefer decayed organic material in the form of humus. The beautiful shining black (like sealing wax) fungi¹⁹ of the genus *Ganoderma* (*G. Cochlear* Murr.) belong to the first group. Amongst others growing on wood I came across *Lentinus maculatus* Berk., *Polyporus arcularius* Fr., *Trametes Persoonii* Fr., and two species of salmon-colored *Pilocratera*, an ascomycete in the form of a short-stalked little cup (*P. Hindsii* Henn. and *P. tricholoma* Henn.). *Polyporus rugosus* Nees is one of the most peculiar of the

¹⁸ The determinations of the Orchidaceae by Dr. J. J. Smith are available only in manuscript, so that in most cases no mention of distribution or of new species can be made.

¹⁹ I owe the determinations of the fungi to the late Dr. C. van Overeem.

polypores growing on humus. The lower side of the pileus is almost entirely black; the immature round thick cap, gray-white beneath, rises on a stalk 1–40 cm. high. This species is solid and hard, like many fungi living on dead wood. Most fungi growing on humus are fleshy and soft, as, for example, the profusely branched *Clavaria* species (no. 549). A pretty sight in the forest is the beautiful *Dictyophora* (probably *D. phalloidea* Desv., pantrop.; nos. 443, 2089) which I found at various times, always growing singly. I fortunately had an opportunity to follow its development, being located nearby. On the first day of observation, I found the "devil's egg" at 6 P. M. between the plank-buttresses of a woody giant. The top of the white-gray oval object, the upper half of which protruded from the ground, then showed a small tear through which a yellow jelly-like mass was visible. Just 24 hours later the split had opened only a little farther, but on the third day at 8 A. M. a small yet unveiled head protruded on a short stalk about 7 cm. above the ground. In this phase, development is very rapid: not an hour later the plant was full-grown, and it shone with a stalk about 15 cm. high and a small conical gray head thickly beset with tiny carrion-flies and little butterflies. From the constriction beneath it, the beautiful net-like pure white veil flared widely below. Toward midday the veil began to lose its turgor and at one o'clock it hung down withered. At six in the evening the head nodded low and the following morning the entire fruiting body lay already half-decayed on the earth.

The most remarkable discovery in this territory was *Echinophallus Lauterbachii* Henn., known from the Moluccas and New Guinea. The full-grown fruiting body of this fungus, allied to *Dictyophora*, appears still to be unknown. I found only the "egg" phase. The generic name is derived from the fact that the "egg" is not smooth but so thickly studded with numerous prickles that one might compare it with a colorless *rambutan* fruit (*Nephelium*). Later (middle of 1926) I found the plant, again immature, on Morotai, northeast of Halmahera.

Other fungi of this territory in my collection are under the following numbers: 411, 415, 426, 434, 488, 504, 512–524, 541, 546, 550–552, 559, 561, 569, 574, 576–579, 587, 588, 620, 665, 673, 713, and 774.

Now that we have seen what there is to be found in the forest-terrain, I shall devote a little further attention to the plants growing in the forest-framework and the forest-roof, the climbers, the clinging plants, and lastly the epiphytes. Among the clinging plants here, the ferns and the Araceae again take the leading place. Pressed against the tree-trunks, they work themselves upward toward the light that most of them never reach. In the Araceae one finds plants varying in size from the small species of *Pothos* to the giant *Rhaphidophora*. A large number of these seemingly form a transition between the climbing plant and the epiphyte; for, although they can live on without difficulty, when for some reason their connection is broken with the ground, they never appear to attain this situation of their own accord. In addition to the frequently numerous anchoring roots which grasp the host-trunk horizontally, these plants also possess other roots, which must surely be interpreted as absorbing roots. These grow down perpendicularly along the trunk, becoming continually thinner toward the lower part of the plant, so that in full-grown specimens only very thin rootlets reach the ground. It is clear that these rootlets are altogether insufficient to meet the daily water need of these large, leafy, and doubtless strongly transpiring plants. It has also been ob-

served that the plants, without experiencing loss, keep on living and growing when the rootlets are removed. Hence, just as in epiphytes, the necessary water-supply must be furnished in other ways, for instance with the help of clinging or aerial roots. Thus a mutilated plant has in reality become an epiphyte. We are inclined to look upon such cases as a transition between an epiphyte and a clinging plant, that is to say a form which perhaps is working its way up from a clinging plant to an epiphyte, in a certain sense therefore a semi-epiphyte. This term was introduced for another group of plants, which normally begin their life as epiphytes (many species of *Ficus*, for example) and later, by sending out aerial roots, obtain contact with the ground, a contact which thereafter they cannot afford to lose. Thus in a way, our form of semi-epiphyte is a more advanced stage. We should be able to distinguish them as *deutero-hemi-epiphytes* in contrast with the *protero-hemi-epiphytes*, among which, for example, we would understand the afore-mentioned *Ficus* species. Karsten asserted somewhere²⁰ that "die Araceenpflanze des weiteren auf epiphytisches Leben angewiesen (ist)," but here in the Indies I have never observed a case of spontaneous breaking of the connection with the ground.

Many of the Araceae may become very tall and drape the central parts and sometimes even the higher branches of the trees with their large frequently lobed dark green leaves. The genus *Rhaphidophora* is well-represented among them. I found here *R. obliquata* v.A.v.R.* (with fiery red fruits), *R. novoguineensis* Engl. (end.), and *R. latifolia* v.A.v.R.*; *Pothos Albertisii* Engl. (end.) and *Epipremnopsis magnifica* v.A.v.R.* also have red fruits. *Pothos Versteegii* Engl. (end.) is common.

Amongst the ferns the number of different species is overwhelming. In the vicinity of Pionier-bivak a *Stenochlaena* sp. (*S. ?aculeata* Ktze., no. 424) is especially common. Young plants are frequently found on the small trunks of young trees; the pinnate fronds bear pinnae only in one plane, closely appressed to the slender trunks and almost covering them. At the apex of older specimens, fronds of entirely different form develop; they are much larger and are no longer appressed against the host-trunk, but hang free. Above these the fertile fronds develop.

In addition to species of rattan, here are a great many specimens of *Flagellaria indica* L. (trop. O. W.), an often robust liana, which climbs upward with the aid of tendriferous leaf-tips. The white-flowered *Faradaya splendida* F. v. Muell. (E. Arch.) is common too, but almost exclusively along river-banks. A very sturdy species of *Piper* (no. 685), related to the Australian *P. Mestonii* Bailey, occurs generally both in the forest and on the river-banks. Owing to its fiery red stout infructescence, it presents a striking appearance in the forest. Other climbers include *Dioscorea oppositifolia* L. (no. 761; S. E. As.), *Medinilla Lorentziana* Mansf.* var. *suffruticosa* Mansf.* (no. 495), *M. quintuplinervis* Cogn. (end.; no. 662), and other Melastomataceae (nos. 639, 663), a *Cryptocarya* (no. 744), further species of *Conocephalus* (nos. 404, 467), *Ichnocarpus volubilis* Merr. (trop. S. E. As.—Austr.), f. *sogerensis* Markgr., a very prickly *Caesalpinia* (no. 474), a *Salacia* (no. 652), besides the menispermaceous *Stephania Zippeliana* Miq. (E. Arch.) and *Macrocculus pomiferus* Becc. (end.). We found here the climbing pandanaceous *Freycinetia* (no. 766), its sharply 3-angled stems pressed closely against the tree, while, just as in *Stenochlaena*, the branches of older specimens hang free.

²⁰ O. Karsten, Handbuch d. Naturwissenschaften, III (1913), 685, art. Epiphyten.

A plant which, with *Faradaya* and the red-fruited *Piper*, often stands out, because of its colorful flowers, is a magnificent *Mucuna* with large orange-red inflorescences. More rare is *Tecomanthe ?dendrophila* K. Schum., with clusters of large pale lilac and red bell-shaped flowers. Other lianas here are the apocynaceous *Parsonsia curvisepala* K. Schum. (end.) and *Lamechites* Schlechteri* Markgr.*

Climbers may also occur among the herbaceous plants. In addition to a couple of cucurbitaceous plants, no. 468 and *Luffa cylindrica* Roem. (trop. O. W.; no. 472), encountered in the reeds along the river-banks and perhaps introduced, I found the convolvulaceous *Lepistemon urceolatus* F. v. Muell. (Austr.; no. 565) with still another representative of this family (no. 413).

The semi-parasites are represented by *Loranthus plicatulus* Krause*, a species with red-violet flowers.

I have already stated above that, in the epiphytic flora, the Orchidaceae especially and the ferns are very strongly represented. Elsewhere earlier, as an example of these riches, I have mentioned an instance in which I collected not less than 28 different species of flowering orchids in a half hour's time on a single branch of a river-bank tree. A number of non-flowering orchids occurred there too. That the two groups mentioned particularly occupy such an important place amongst the epiphytes is, according to Schimper,²¹ owing to the smallness and lightness of their spores and seeds.²² Thus they may easily be spread by the wind or just as easily fasten themselves in moss-cushions or in crevices in the bark of the host, where they happen upon enough water to enable them to germinate. Other families—provided that the plant is organized for an epiphytic way of life or at least can tolerate it—are selected on account of juicy fleshy fruits, which are eaten by birds and animals. The fruits of *Myrmecodia*, *Hydnophytum*, and the Loranthaceae are brought to the branches by being rubbed from the beak. Those of *Medinilla*, Zingiberaceae, Ericaceae, and many others are dropped in the excreta. A number of hemi-epiphytes also may be placed in this category (*Ficus*, Araliaceae, Piperaceae). Thus firstly, the nature of fruits and seeds—organs often of very constant nature in a family, a fact explaining why some families furnish many epiphytes, others practically none—determines which groups of plants make the origin of epiphytes possible. Schimper theorizes that the plants of the forest-floor, which, no matter how, possessed an aptitude to continue in life as epiphytes, formed the first representatives of this group, and that adaptations did not originate until later.²³

One of the most noteworthy plants of this group, although neither an orchid nor a fern, is *Trichosporum* (aff. *T. radicans* Nees, no. 419), with its clusters of fiery red flowers. Other members of the group are the peculiar myrmecophilous plants, such as *Myrmecodia* and *Hydnophytum commune* Val.* (no. 446), which harbor ants in the cavities of their thick tuberous stems, and their allies which occur in great numbers in the mountains. *Randia Gynopachys* Boerl. (Java, Celebes, N. Guin.) is another epiphyte here. The genus *Hoya* is also well-represented (nos. 592, 593, 653, 738).

As for the Orchidaceae, of all the families which occur here, it is surely the richest in epiphytes. Included here are a species of *Grammatophyllum* and

²¹ A. F. W. Schimper, Die epiphytische Vegetation Amerikas—Bot. Mitt. aus den Tropen II (1888), 157.

²² Schimper l. c. p. 21.

²³ Schimper, l. c. p. 29.

the stately *Dendrobium violaceoflavens* J. J. Sm., of which I observed a few specimens on the highest branches of an almost leafless tree. This remarkable orchid, with coarse attenuate leaves and fleshy lilac-speckled flowers in thinly arranged axillary inflorescences, stands upright on a branch of the host. One specimen measured 2.5 m. in length, but a much larger specimen, lost in felling the tree, must have been 4 m. long. By far the greater part of the epiphytic Orchidaceae, however, are small or even very small plants. Amongst these, particularly the genera *Dendrobium* and *Bulbophyllum* are strongly represented, as, for example, by *Dendrobium ostrinum* J. J. Sm. var. *ochroleucum* J. J. Sm., *D. angraecifolium* J. J. Sm., *D. rugulosum* J. J. Sm., *D. Baeuerleni* Krzl., *D. transversilobum* J. J. Sm., *D. Macfarlanii* F. v. Muell., *D. prestocaulis* Schlecht., *D. anosmum* Lindl., *D. comatum* Lindl. var. *papuanum* J. J. Sm., and by *Bulbophyllum tectipetalum* J. J. Sm. var. *longisepalum* J. J. Sm. and *B. ensiculiferum* J. J. Sm. Of other genera I mention *Eria Lorentziana* J. J. Sm. & Krzl., *Robiquetia Mooreana* J. J. Sm., *Sarcochilus Moorei* Schlecht., *Podochilus scalpelliformis* Bl., *Sarcanthus bicornis* J. J. Sm., and *Schoenorchis plebeja* J. J. Sm. One of the very small epiphytic orchids is a curious leafless species of *Taeniophyllum* in which the roots, having taken over the function of leaves, lie pressed flat against the host-branches and radiate in all directions, whereas the small flower-stalk rises from the junction of the roots. *Taeniophyllum tamianum* J. J. Sm. and *T. tripulvinatum* J. J. Sm. were found here also.

The number of epiphytic ferns, as noted above, is very large. Again the small forms are in the majority. Many of them have a wide distribution, the result perhaps of the lightness of the spores, which are easily spread by the wind. They possess this phenomenon in common with many higher fungi, but it is not easy to understand how toadstools living on the floor of the primeval forest can be spread through the medium of the wind. The seeds of the Orchidaceae also are unusually light. That widespread plants within this group are much less numerous is perhaps a consequence of the circumstance that these seeds on germination must meet particular conditions not found everywhere (mycorrhiza).

Examples of such a widespread distribution are: *Humata Gaimardiana* Sm. (trop. S. E. As.—Polyn.), *Pleopeltis phymatodes* Moore (trop. and subtrop. O. W.), *Polypodium verrucosum* Wall. (Arch.—Austr.), *Asplenium tenerum* Forst. (trop. As.), *Loxogramma involuta* Fr. (Arch.—Polyn.), *Merinthosorus drynarioides* Copel. (Arch.—Polyn.), and *Hymenolepis spicata* Pr. (Madag., Mascar., trop. As.—Polyn.).

No matter how common, an always attractive plant is the elegant *Ophioglossum pendulum* L. (trop. As., Austr., Polyn.), which occurs as a pendent epiphyte along river-banks and above damp places. The single leaf hangs down slack and long like a broad dark green ribbon, while out of the middle the thick knobby cylindrical sporophyll appears. A superficial likeness with this species of *Ophioglossum* is shown by certain members of the genus *Vittaria*. The numerous leaves (as expressed in the generic name) are ribbon-shaped, but the sporangia are found in the longitudinal split of the leaf-margin. I here found *V. ensiformis* Sw. (Java, Sumatra, Mascaren.), with a peculiar interrupted distribution reminding us of our incomplete knowledge regarding this area.

Another group of epiphytes, the beautiful Lycopodiaceae, are frequent on lower parts of tree-trunks. Some species native in the coastal lands and lower

mountain-regions hang down as a dense light green mass, such as *L. subfalci-forme* v.A.v.R., which is indigenous here. In the higher mountain-regions we shall come across a larger number of terrestrial representatives of the genus.

In places where the banks are steep, mostly through erosion on account of the stream and therefore on the outside curves, the high trees at the water's edge form the margin of the forest assailed by the river. On the more level inner curves narrow strips of reeds occur here and there. In the vicinity of Pionierbivak, where one can notice already the influence of the foothills of the van Rees Mountains, the strips are narrow. But nearer the coast, and similarly in the Meervlakte, as we shall see, the reed-fields cover large areas. In so far as I could determine, these communities consist mainly of two species. The one chiefly dominant is the large *gelagah* (*Saccharum spontaneum* L.²⁴), a robust plant often 9–10 m. high. Among these plants I found frequently the smaller *Phragmites Karka* Trin. (no. 773), not taller than 3–5 m. Both species possess beautiful fine panicles. Sterile specimens of the two species can be distinguished from each other by their stems, those of *Saccharum* are constantly solid and have bamboo-like thickened nodes, whereas those of *Phragmites* are hollow. Furthermore, the leaf-margins of the second are much less roughly hairy than those of the first.

Before we step into the proa and permit ourselves to be brought over the rapids to the Meervlakte by our never sufficiently praised wilderness companions, the Dyaks, and before going from there into the unknown mountains, a few words on the impression of primeval forest life must be inserted. For some impressions are worthy of remembrance and, in spite of some disagreeable ones, make us always desirous of returning again to this immense and grand country. Magnificent with respect to its dimensions of forest and river, even when one looks upon them at close range, grand in its virginity and its proud silence at the intrusion of people who will at some time conquer the country, it will persist until man also shall have vanished and his influence shall have been lost forever.

Many memories bind us to each small place that we have visited: this is stronger still in the mountains, where so many more influences coöperate to that end. The Mamberamo navigators will ever see before them the broad muddy river with its numerous curves, the still, high forest-walls, the translucent morning mists which hang without motion in the treetops until 8 or 9 A. M. They will feel the heat vibrate above the river-banks at midday and again sniff the heavy damp odor of the forest, evidence of the incessant progressive decay of organic material. Again the melancholy cooing of doves will be heard at regular intervals high up in the tree-tops, frequently also the noisy cry of the hornbills, which are hardly seen amongst the mass of leaves and branches until, with the harsh flapping of their wings, they fly away. Then we see again their dark silhouettes before us as they depart, frequently in pairs, over the river, and the screaming cockatoos with their blunt heads and swift wing-beat, which in the evening at the fall of twilight come in large flocks to sleep in the trees. Some will bear in memory the distant hoarse cry of the cassowary. Sometimes too it is the distant howl of a Papuan dog that comes hovering over the water by the river.

²⁴ Unfortunately I neglected to collect material of this species, so that the identity is not scientifically certain. This mistake has been made by many collectors before me. The grass is usually considered too common to justify the difficulty in collecting it, and hence the exact distribution of *S. spontaneum* L. is not definitely known, although this may be a strange remark to make about such a widely distributed and common species.

The bivouac life itself has also left behind many memories; the numerous interests of the expedition, the water-level, the daily results of the work, the members, the happenings in camp, the life and work of the convicts, the soldiers, and the Dyaks, the making of proas, the regular departure of transports toward the interior and then, frequently too late, the boat, which one morning entirely unexpected came steaming around the distant bend of the river and brought all camp-dwellers to attention.

* *
*

The ascent with the proas has been described too often for me to weary the reader with a new detailed description. I shall therefore limit myself to a few comments and the insertion of a few maps which I made of this part of the Mamberamo (cf. Map A, Fragm. I).

The ascent via proa by our expedition lasted three and a half days, but in normal circumstances it should be possible to make it in three days. On August 8, 1920, I started with the geologist from Pionier-bivak. We traveled along the right bank. Sometimes there is paddling, but mostly the Dyaks make use of all kinds of projections on the bank or even trees overhanging the bank to tow the proa forward with their hooks. At Havik Island the inner bend of the river is taken; after that we come again into the main river, which temporarily maintains the same aspect. Sometimes we stop and rest for a little while on a small boulder-strewn bank, and sometimes a few Dyaks go into the forest to get rattan or to try to shoot some animal or bird for a meal. A little later we choose to do some cooking and bathing, but at 2 o'clock we still are at Tulband-bivak, named thus after a conglomerate formation that, as a forerunner of the Marine Falls, lies in a little narrower stretch of the river and somewhat resembles the form of a turban. On the left bank is a spit of land, formed by a small tributary which empties here into the main river. Somewhat farther upstream lie naked marl rocks washed bare by the water, so that there is room and a good place for a camp. Apparently this is one of the places where the andesite formation,²⁵ of the younger sedimentary rocks, broke through, and on account of their hardness these rocks have offered more resistance to erosion by the river. They are the cause of the rapids. At this point the river is much constricted and small rapids rush to the other side. Here already the hills come much closer to the river; there are no flat areas of importance and in many places this bare sedimentary rock-formation reaches the river.

The forest has kept the same appearance along the way. I recognized repeatedly the same trees and lianas, on the bank, which I have already mentioned above. The large number of landslides of all ages which one sees in the vicinity of Tulband-bivak is striking. Some come as far as the bank, and the younger still show the chaos of loosened blocks of stone, while in all directions tree-trunks stand obliquely and between them the light green color of tall herbs and young trees shows.

On the sandy point by the bivouac I found a very dense growth of a fern, *Nephrolepis hirsutula* Pr., mixed with sparse stands of *Phragmites* and shorter grasses. Scattered here and there were specimens of *Euphorbia serrulata* Rw. (trop. S. E. As., Austr., Polyn.) and *Spigelia anthelmia* L. (introd. from trop. Amer.).

²⁵ According to van Gelder, l. c. 92-93, pl. XI, XII, the rock-formation at the entrance to the rapids at Tulband-bivak is andesite; at the Marine Rapids sandy marl; at the Edi Rapids andesite; and at the Batavia Rapids sandstone.

The following day we pass the rapids. Shortly after we have left the bivouac we see the Marine Falls lying before us at the bend of the river (*Fig. 3*). The river is here narrowed by a large number of rock-masses, the largest of which are overgrown with small trees; above is a wide basin of calm water and in the distance the characteristic small sharp point appears. This rises steeply close to the bank and forms the forerunner of the formidable Edi Falls and itself causes a narrowing of the river-bed. Close in front of the rapids we cross the river, so as to make our way up along a large loose mass of boulders—the first of significance—situated near the left bank. With the swift current to the right of us everything goes smoothly and a half hour later we slip in below the great calm where all the driftwood and other vegetable-refuse gyrates slowly in a large circle. After that it is calm along the boulder-bench, where a number



FIG. 3. Marine Rapids; view looking upstream.

of beautiful specimens of purple-flowering *Desmodium heterocarpum* DC. (trop. As., Austr.) stand. After we have passed the small sharp point, a straight stretch of river lies before us, but the banks are full of indentations, each of which forms a pool of counter-current, and these stony spits each cause a small rapid which must be overcome. Steep hills with bare rock walls rise high here and there on the left bank. They are the andesite hills, which, according to van Gelder, have brought about the origin of the Edi Falls (*Fig. 4*). Along the right bank the sedimentary rock-formations still border on the water, but now they sometimes lie flat, although a little farther on they appear to incline and project in a zig-zag manner (*Fig. 5*). The Edi Rapids are violent but short. Here there is only a narrow gateway between steep walls, on the right bank partly obstructed by a large number of rounded boulders. Just below the falls the passengers and the cargo are taken from the proas, whereupon the Dyaks, some with their proas on one bank, some on the other, pull up the empty

boats. At 2 o'clock we reach the small bivouac lying on the upstream border high against the steep slope. Since noon the earlier fine weather has become rainy and windy, and shortly after a tributary, which empties into a wide basin above the rapids a short distance from the bivouac, begins to swell and empty its muddy water with much driftwood into the Mamberamo. This camp is pleasantly located with the view of the river (*Fig. 6*), but the pleasure is somewhat spoiled for us by a stormy night. The wind coming through the narrow entrance of our shelter made us afraid of two old dead trunks which stood close behind the camp.

The third day we followed a long and calm part of the river. After some hours of rowing we rested, and after we had again departed we met a proa with Papuans, the second on this trip. Without any striking events, the last camp was reached at quarter-past three. This was named Wand-bivak because of a



FIG. 4. Mamberamo between the Marine and Edi Falls, view looking upstream; on the left bank are andesite hills, on the right sedimentary formation.

high horizontally deposited rock-wall, which rose perpendicularly behind the little bivouac. Not an hour later one of the heaviest cloudbursts which I have ever seen in the tropics broke. A thick curtain of pouring rain surrounded us and came through the thatched roof, permitting nothing to remain dry. So we sat hours on end, altogether motionless. The darkness fell early. On the other side is a terrace about 10 m. high, formed by a horizontal layer of stone, and from that thundered downward some wild waterfalls. From near at hand we heard the landslips rattle, and at times in the neighboring forest an enormous tree crashed to the earth with a dull roar and an ominous cracking of the wood, which sounded above the noise of the rain and the waterfalls. With great difficulty we light a candle-lantern and by the flickering light see outside the naked shining bodies of the Dyaks busy pulling the boats higher and bringing the cargo to safety, fearful lest everything would drift away with the sudden rise of water. But toward 8 o'clock the rain lessens a little, and we try to make a fire. The thick smoke has no effect on the swarms of mosquitoes, which

appear as a forerunner of the large swarms of gnats in the Meervlakte. It becomes necessary to stretch our wet mosquito netting, which we had not needed in other camps. Thus the really small discomforts of wilderness life alternate with many moments of happiness derived therefrom, and when the following morning in a decreasingly drizzling rain we sat in the boat and watched the sun slowly come out, all the distress of the previous night was forgotten. Sometimes we follow along the high terrace on the left bank, from which even now small waterfalls tumble down. Along the other bank extends a similar terrace. The vicinity of Wand-bivak is obviously characterized by an almost horizontal position of the strata. Along the bank here one frequently sees a curious stone-formation. It seems as if the rocks consist of a number of joined boulders, each surrounded by one or two thin layers



FIG. 5. Exposed layers of sedimentary formation along the bank of the Mamberamo.

which cover them like a rind. Sometimes the upper surface is bulged so that one obtains the impression of a weathered convex shell. In other places we see the same formation worn smooth and therefore cut through, the upper surface then rather suggesting fossilized "suncracks." In many places a piece of rock-wall stands perpendicular to the water, and sometimes we pass a stream that has cut through the rock-formation and formed a narrow, winding, and dark canyon with exactly perpendicular walls.

As we near the Batavia Rapids, the incline becomes greater everywhere and the stream swifter. At nine o'clock we rest a short time on a large boulder-strewn bank at the inside of the bend which still cuts off Batavia Falls from our view. The Batavia Rapids consist of a long series of ledges (sandstone according to van Gelder) which spread out over a long and broad bend of the river. At quarter past five we cross one uplifted reef after another at the inside curve, while on the other side the swift main stream flows rapidly with

large waves. Already the hills on the banks are lower. They continue to withdraw, and finally the river is calm and broad again. Another bend, and the wide Meervlakte lies before us, the marshy area 300 km. long and 60 km. broad. In recent geological time, it must once have been a large lake, which drained gradually as the Mamberamo cut itself deeper into the threshold of the van Rees Mountains. Even yet one finds there large pools, and the river flows

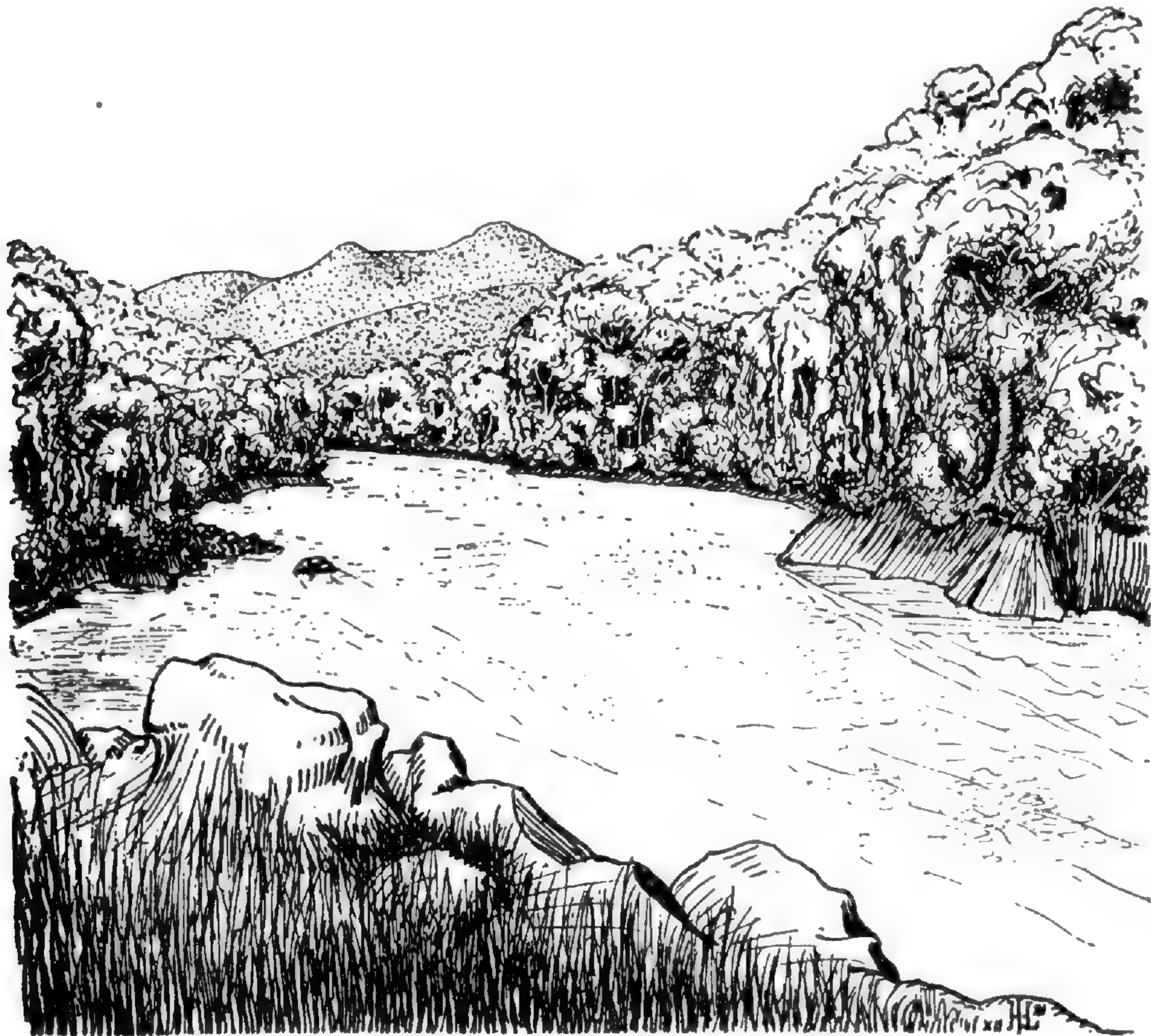


FIG. 6. View from Edi-bivak, looking upstream.

slowly in wide curves over the thick clay-formation. When this terrain began to drain, vast reed-fields appeared on the gently sloping banks as pioneers of vegetation. On the driest places these gradually are replaced by a thin and low forest, and the Meervlakte itself is covered with a characteristic marsh-vegetation which diverges considerably from that of dry land. An ensuing Fragment must be devoted to the impressions which I obtained of this remarkable terrain.

IV. The Meervlakte and the foothills ¹

THE PREVIOUS Fragment ² has brought us through the falls of the Mamberamo to Batavia-bivak, situated on the north side of the Meervlakte ³ against the southern spurs of the van Rees Mountains. In passing, as is mentioned at the close of the last Fragment, the Meervlakte—the largest of a few similar low-lying basins which lie north of the Central Range—was probably a lake in geologically very recent time, the level of which fell gradually, as its drainage system, the Mamberamo, cut deeper into the outlying extensions of the van Rees Mountains. This process is at present undoubtedly still in full swing. Now we find here a vast marsh, neither land nor water, in which the river flows slowly with slight fall, wide meanders, and continually changing bed. As the water-level lowered, the reed-border must have gradually encroached towards the center of the lake. Little by little the river then began to form a gully or rather gullies in the alluvial land. As the water fell still more, the stream, beginning at the highest point, built up its own levees and has continued that process up to the present. The banks thus formed became the first habitat of the higher flora. Still, however, a large part of the Meervlakte is deep marsh and even in the dry season there are large bodies of open water. But in the rainy season, while the barriers in the river-bed hold back the water for a little time, undoubtedly vast portions of this plain are inundated, and one may suppose that the height of the natural levees agrees with the average highest water-level. I had opportunity again and again to observe proof of this. The development of similar natural levees occurs in all rivers whose level is subject to periodic change, and which flow through territory suitable for their formation. The stagnation during the period of high water causes a deposit of alluvium at that time. We might then also expect to find such levees along periodically flooding rivers, and in such streams as the Mamberamo, whose course is interrupted by natural basins in which the highest water-level is maintained longer than would otherwise be the case. Naturally the first-mentioned is the most common. We find this true of all rivers in flat alluvial land.

Some fleeting impressions gathered while traversing the flat land by boat—three days of travel with the little motor-boat from Batavia-bivak to Prauwenbivak—may here follow. After that we shall dwell more fully on the vegetation in the vicinity of the latter bivouac. In the first place we shall discuss the peculiar marsh-growth of that part of the Meervlakte, in order that, thereafter, as a means of transition to a following Fragment, we may still mention something concerning the flora of the foothills.

At 7 o'clock on the morning of August 12, 1920, we left in the motor-boat from Batavia-bivak. The stream here flows slowly, not more than two miles an hour. The river is several hundred meters wide and in most places bordered by a narrow *gelagah* [*Saccharum*] strip. On our left the foothills of the van

¹ Natuurk. Tijdschr. Nederl.-Ind. 88: 187-227. 1928.

² This Tijdschrift LXXXVII (1927), 139.

³ J. K. van Gelder, Verslag omtrent eene geologische verkenning van de Mamberamo-rivier op Nieuw-Guinea—Jaarboek van het Mijnwezen in Ned. Oost-Indië, XXXIX (1910, published 1912), 99 et seq.

M. Moszkowski, Expedition zur Erforschung des Mamberamo in Holländisch Neu-Guinea—Zeitschr. d. Ges. f. Erdkunde, 1912, 366 et seq.

Rees Mountains still rise, but when we have rounded a bend, the Meervlakte in all its majesty lies before us. We leave behind the dark quiet of the van Rees Mountains under the now rising mists; more to the east we see the higher peaks of the Gauttier Mountains (*Fig. 7*), but before us on the southern horizon high cloud-banks point the direction in which we have to look for the mighty Central Mountain Range. The stream here becomes wider and wider and on the lowest part of the plain is a kilometer wide. The forest of the bank is low and ragged and over large areas is pressed back by wide *gelagah* [*Saccharum*] fields. Wherever the forest comes to the bank we notice that woody giants are very rare; many spots on the outside curves have been laid waste by a recent freshet; already the stream is actively changing its bed, eroding its banks, and depositing mud in other places. We pass a woody giant of which half the root-system already protrudes outside the denuded bank. With another flood the tree will fall into the river, and its trunk will speedily form a part of the high wood-piles



FIG. 7. Van Rees Mountains (left) and Gauttier Mountains (right), seen from the Mamberamo.

which one sees here and there along the bank. The muddy banks lie stretched out on the inside bends, so gently sloping that one scarcely can see the boundary between the gray slime and the dirty brown river. Gray as the mud, several large crocodiles lie parallel with the water-line in the sun. Some remain in place, others glide noiselessly into the water as we pass. Once we saw a couple of very young ones above the water on a branch jutting out over the river. On the outside curves, the low forest, frequently without a *gelagah* [*Saccharum*] strip, comes to the water's edge. With the deeper water, the steep muddy wall rises about a meter above the river. On straighter stretches the forest frequently alternates with sago-thickets, a marshy transition to the *gelagah* [*Saccharum*] covered banks only on the inner bends, behind which the forest begins.

Little by little the day became brighter, and toward 11 o'clock the high peaks of the Central Range lay cloudless before us (*Fig. 8*); only the base was still surrounded by a thick fleecy low mist. Almost directly south we saw the mighty summit which Doorman climbed in Nov.–Dec. 1914, and which height

at that time he placed at 3810 m. (a later measure gave an average of 3580 m.). To the left of Doormantop, which is recognized by a small indentation at the highest point, lies the "4050" summit, correctly about 3820 m. altitude. The low saddle between the two, with the flanks of both mountains toward each other, forms the source of the Doorman river. East and west of these two towering peaks the mighty mountain range stretches out as far as we can see.

At quarter-past one we reach the junction at Kalong Island, where the Idenburg River out of the south and east and the van der Willigen River out of the west unite and, under the name Mamberamo, flow to the sea. Both branches are of about the same width, but the westerly one makes a stronger impression. For another half-hour we go on, then land on the left bank at Kalong-bivak.

This noon I had the opportunity of glancing at the surroundings of this little bivouac. The land here is entirely flat, first sloping inland very gradually, then somewhat more abruptly, finally changing into a marsh. The forest, in



FIG. 8. Doormantop (middle) and 3820 m. peak (left), seen from the Mamberamo.

comparison with that of Pionier-bivak, is strikingly rich in bird's nest ferns (*Asplenium nidus* L.), which are on almost every tree. In this terrain also we make our first acquaintance with a locally very common but poisonous snake (*Acanthophis antarcticus*), a short broad reptile with a much thinner tail and broad head. According to Ouwens,⁴ the poison is very dangerous but the reptile does not seem to be aggressive. It is said that this snake tempts small animals within range by lying coiled up and making its slender tail quiver. In the forest we are tormented by swarms of mosquitoes and a great number of buzzing flies which, however, disappear toward evening. Quietly the river flows along past us, many small white terns (probably *Sterna minuta*) dart quickly over the smooth water or allow themselves to be carried along sitting in a row on a drifting tree-trunk. Toward dark it is evident that the name of this bivouac is well chosen: enormous numbers of *kalongs* (fruit bats) fly over from the northeast to the southwest.

⁴ P. A. Ouwens, *De voornaamste giftslangen van Nederlandsch Oost-Indië* (Leiden, 1916) p. 15, pl. IV.

The second day of the journey, we are again on the way at half-past six. On higher places along the bank we see many breadfruit trees (*Artocarpus* sp.) and a palm (*Kentia?* sp.), called *niboeng* in the eastern part of the Archipelago, and in lower lying places much sago and *Pandanus*. The levee along the banks now and again is lower, and there the marsh comes almost to the river. At some places it is even interrupted and we pass along vast reed-fields. Probably these are the spots where old cut-off stream-loops have become filled with sand and thick mud. Later we saw from the mountain that all the land in the vicinity of the river was traversed by a number of similar lagoons, frequently many kilometers long, cut off from the main stream. Of these, both previous connections with the river were silted up. On the younger of these filled-in spots, a *gelagah* [*Saccharum*] community has already developed. The older ones are overgrown with forest and therefore are never visible from the river. Flocks of *kalongs* repeatedly fly out of a few isolated trees in such *gelagah* fields.

We come across few signs of inhabitants. At 9 o'clock we pass an abandoned hut, and, after traveling through a long stream-meander which almost doubled back on itself (one of those which in the near future will be cut off), at ten-thirty we come to a kampong of ten houses. There also stand two small huts belonging to bird-hunters, and many queer-shaped proas, these, like the inhabitants, gray as the mud of this territory.

Shortly after leaving this kampong we meet one of the peculiar proas such as we saw only in the Meervlakte. They are hewn out of a heavy trunk, the bottoms broad, the body rather deep, the sides sloping inward and supplied with narrow openings, the upper part narrow. The bow and stern are cut off transversely, therefore, seen from the front, they appear to be blunt; seen from above, however, they seem to be narrow. Perhaps this form was developed because of the unfriendly attitude of different tribes along the river. The crew can conceal itself entirely behind the sides and keep an eye on the opponents through the holes. As we saw them, there was always one of the rowers sitting on the prow, one leg hanging over the water, the other bent up under him, the boat being propelled by a long oar with a small round blade. Most of the boats showed signs of long use. Frequently there was almost nothing left of the thin sides. A few times we happened upon such boats lying idle or proceeding very slowly with a crew of two or three Papuans. Sometimes they caught fish and roasted them over a little fire in the middle of the boat; sometimes we saw a thin column of smoke hanging above the water of the reed-field. Some had a few scrawny yellowish dogs, with which they had been hunting. At 11:30 A. M. we pass a small hut with three Papuans. At one o'clock we see a small abandoned house; beyond all is loneliness and wilderness. At three o'clock Veen-bivak is reached; it derives its name from a small side creek with clear brown fen water. Later Lieut. Droog, who had a free proa at his disposal, discovered a large fen lake, 2-3 km. in diameter, a few hundred meters from the river. Reeds bordered the lake and many water-birds inhabited it. Among others he saw cormorants, which we also saw later on the Doorman River. The lake was very shallow at the margin, but in the middle the bottom could not be seen. Several creeks empty into this lake.

The forest in the vicinity of the bivouac shows a similarity with that of Kalong-bivak. A large number of breadfruit trees occur here. Near the edge of the marsh we see many tracks of pigs. A pure stand of *Cordyline terminalis* Kunth grows about 4 m. high. It has branched ribbed stems, from which

here and there conical aerial roots a few decimeters in length hang down. Beyond this zone the marsh becomes flat. It supports a community of *Scleria elata* Thw., with sharply 3-angled stems and 3-winged leaf-sheaths, about as tall as a man.

Just as on the first two days, so on the third day we start early. The daily morning mists rise speedily and allow the sun considerable play over the almost Dutch landscape. At seven-thirty we pass some tiny abandoned huts and a half-hour later a proa with three Papuans and a dog. At half past eight four small huts and a small banana-plantation, over which an old man keeps watch, are observed. Sometimes we pass by the mouths of large side-creeks or rivers, all on the left bank, and therefore on the side toward the mountains. Along the broad muddy banks walk beautiful black and white herons, and also smaller white birds on high stilt-like legs. We see many places which lead us to presume that they were earlier entrances to old loops of the stream. At 12:30 we

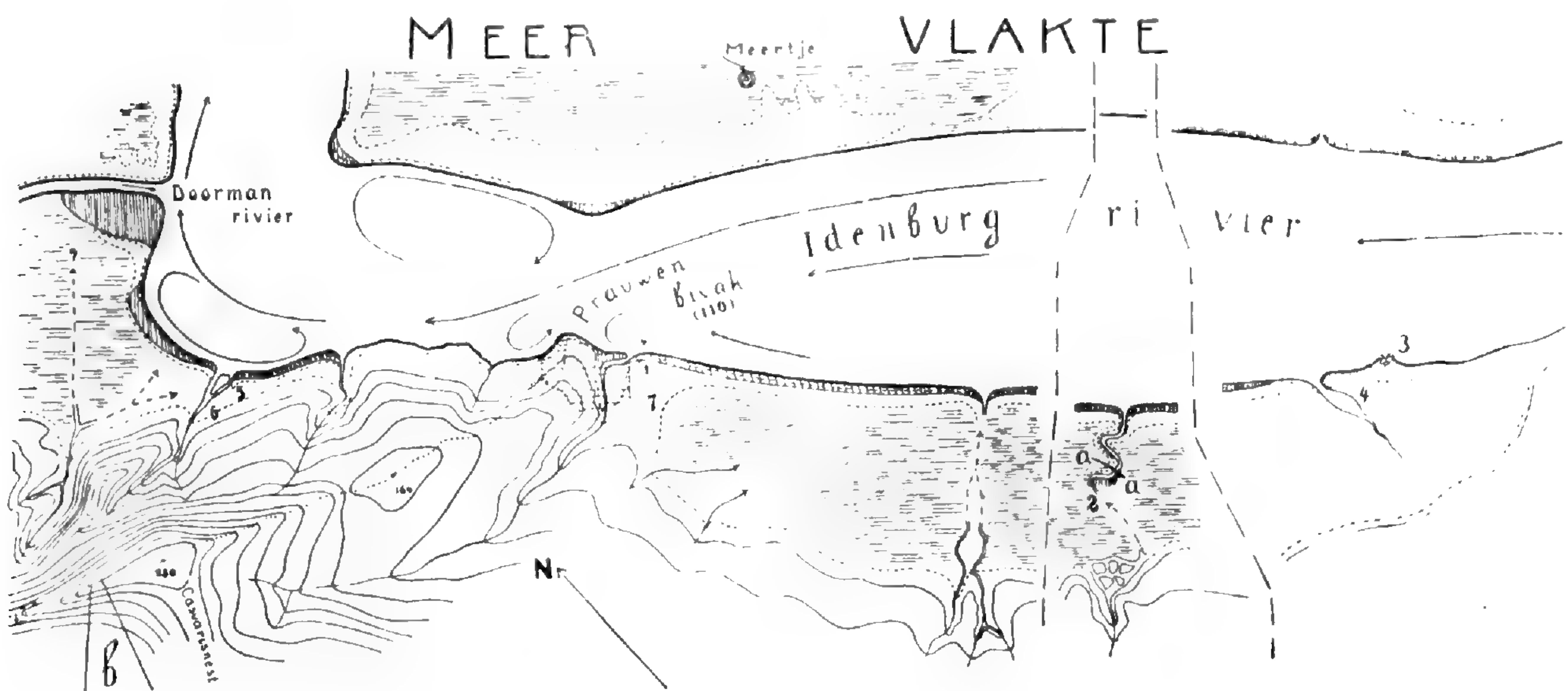


FIG. 9. Sketch map of the vicinity of Prauwen-bivak; the long uniform river-section southeast of the bivouac is twice broken on the map, for simplification; the stippled line indicates about the average highest water-level; the other lines are at 10 m. intervals; horizontal hatching = bivouac; vertical hatching = *Saccharum* fields; altitude in meters; explanation of letters and figures in the text; . . . = trail; meertje = small lake.

go by the mouth of a small tributary with clear fen water, and an hour later, also on the right bank, we approach a large inhabited kampong of not less than 12 houses. On the bank we count 13 proas.

The foot of the mountain, visible under the clouds, comes steadily nearer; several details in the outline grow more distinct. The clouds are lifting somewhat and the beautiful 1050 m. summit south of Prauwen-bivak is visible. Along the left bank on the upstream point of a small island, we see a high pile of accumulated driftwood bleached in the sun, and shortly after that the mouth of the Doorman River. The clearer and cooler water of the latter immediately disappears under the dirty and warmer water of the main stream. Prauwen-bivak lies directly ahead, near a steep hill. At two o'clock in the afternoon of the third day we have reached the far side of the Meervlakte.

With the aid of a sketch map (Fig. 9) we shall therefore subject to a closer consideration the different terrain- and vegetation-forms in the vicinity of the bivouac.

In the first place, on the other side of the bivouac I can study much of the vegetation of this part of the Meervlakte, and elsewhere certainly again other forms of vegetation will occur. Similarly there is a forest-margin (cf. *Fig. 10*) in the neighborhood of the small temporary bivouacs, and lying behind it a more or less open marsh. The ground of the forest-margin is highest immediately bordering the river and is extremely regular and flat. For the tropics, the forest has a very unusual aspect. The undergrowth is almost entirely lacking there. Occasionally the thick winding stems of a few lianas swing in great loops between the trunks, but the trees are widely spaced and one is not hindered by the great mass of young trees, shrubs, rattans, and screw-pines which one meets on higher terrain. This all gives one the impression of an almost European vegetation and it is even more so if the ground be covered with a community of grasses and small herbs.

The boundary of the higher forest coincides with the average highest water-level; consequently the high forest is lacking wherever the terrain is lower near the bank. Thus the appearance of the vegetation is clearly influenced by this limiting factor, the water. The soil consists of a compact clay which, nevertheless, does not extend high enough to dry out sufficiently and thus allow the requisite amount of oxygen for plant-growth. In the dry season—though in the equatorial region not strongly pronounced—the forest-margin only is dry. Beyond that lie, at least in this region, vast pools and marshes with clear brown fen water. But as the rains occur in the mountains, the river-water rises higher and higher, the clear fen waters apparently are expelled by the muddy water of the river, and at the highest water-level the forest-margin also is under water. Then over the entire terrain a new muddy layer is deposited, and repeatedly I saw the traces of it upon tree-trunks and branches at a height above the ground which astonished me again and again.

This continual saturation of the ground results first of all in retarding the respiration of plant-roots. Some species cannot withstand such obstacles and are restricted to drier stretches. Consequently a strong limitation in the number of species is an important result. The plants which can endure the abundance of water show, although of course in lesser degree, adaptations such as are known to us in the case of the mangrove. Many possess a spreading superficial root system, a factor which likewise is the cause of the thinness of the forest. Another adaptation is the possession of true respiratory roots, such as are met with in other fresh water marshes (e.g. in Central Sumatra). The most noticeable example of this I found in a rattan species (apparently a *Calamus*). The small forked gray-brown respiratory rootlets of this plant project in thick and broad radial rows on the naked and muddy base of the trunk at a distance of about 7.5 m. above the ground. So far as I know, respiratory roots have never before been observed in any species of rattan. True, they are already known in a number of other palms and in many dicotyledons of fresh water marshes. For further particulars concerning these rattan pneumatophores I refer to my article published⁵ elsewhere. There are also in this terrain a few other plants which in a similar manner provide for the deficit of oxygen, from which their root-systems suffer. Many woody plants in such a terrain possess very large lenticels on the exposed parts of roots and on the lower parts of the trunk. Sometimes these are grouped particularly on

⁵ H. J. Lam, Ademwortels bij Palmen—Handelingen Derde Ned. Ind. Natuurwetensch. Congres (Buitenzorg 1924), p. 318 and 477.

stilt roots (another resemblance to mangrove plants) or on aerial roots (analogous to the mangrove plant *Avicennia*). For instance, I observed the first here in a few *Barringtonia* species. The previously mentioned *Cordyline terminalis* Kunth, with its conical aerial roots, and the *waroe* (*Hibiscus tiliaceus* L.) especially present beautiful examples of the second. *Hibiscus tiliaceus* L. is unusually common in this locality. In dry habitats there is no trace of aerial roots to be seen, but on marshy ground thick bundles of these slender roots protrude from the obliquely standing trunks or overhanging branches. One can thereby observe that these aerial roots, all at the same height above the ground, are abruptly and strongly branched; without doubt this is the direct influence of the water and also a new indication of the height to which the river-water can rise and at which level it apparently remains for some time. One could occasionally observe a new level of weaker branching at the lowest water-level in this particular place. It is noticeable by the recently formed roots that any cork-formation fails to appear under water, whereas the root-parts between the two levels of branching show a weak development of cork.

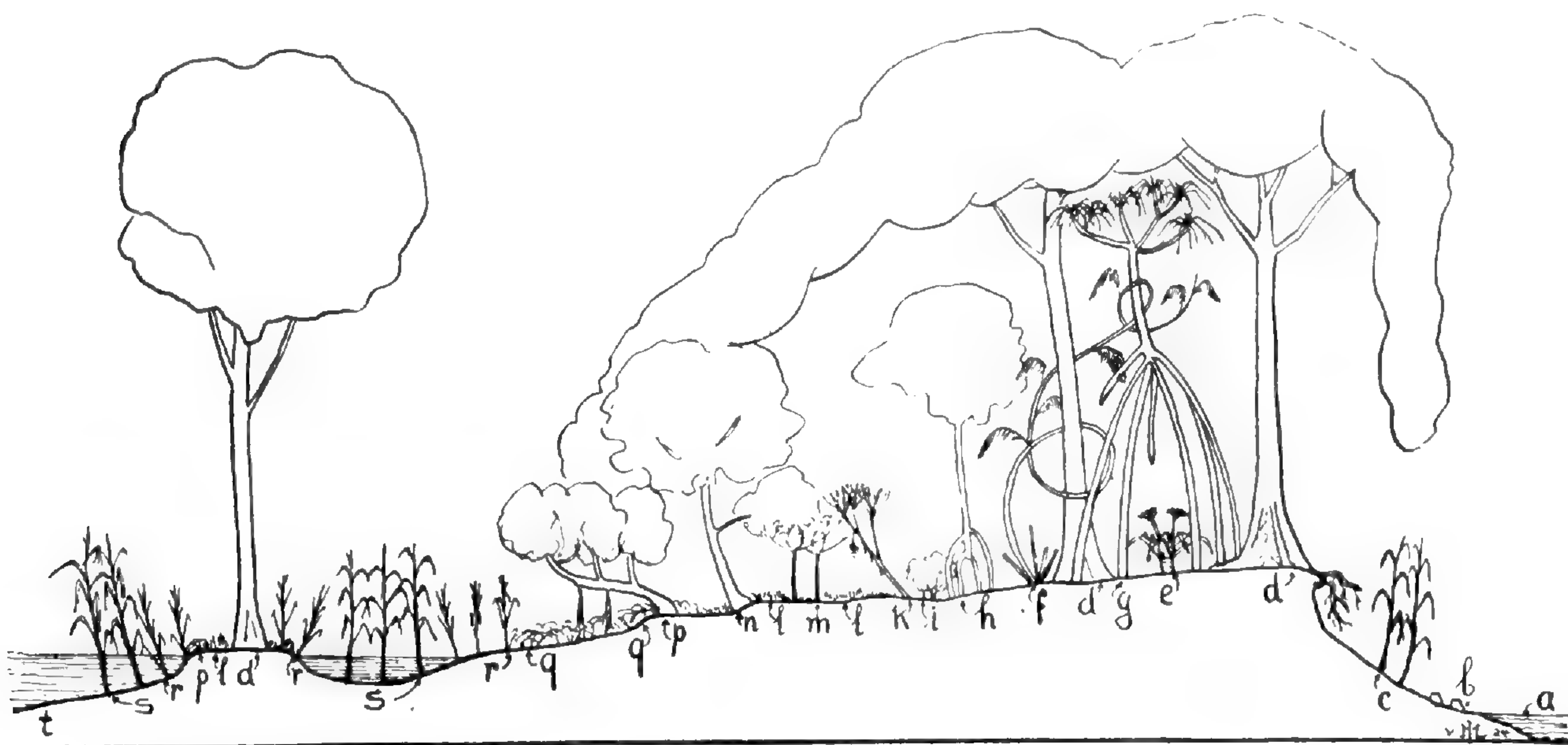


FIG. 10. Schematic cross-section through the forest-margin of the Meervlakte from the river (a) to the marsh (t); explanation of the other letters in the text.

Here the terrain slopes gradually inland, sometimes with small terraces. The trees become lower and in this strip we meet with the above-described adaptations. Reeds and grasses mingle little by little with the undergrowth.

The inner forest-margin is unusually rich in forms, a fact especially noticeable in comparison with the poor outer margin, where only trees and lianas form the over-growth. In the sunny marginal zone between forest and marsh the ground is covered with a thick stand of *Phegopteris prolifera* Kuhn. The margin is very irregular: here the reed-formation juts into the forest, there a dry spit of forest land projects into the marsh, and everywhere small runways, apparently made by pigs or crocodiles, extend through the more or less broad stretches of reeds.

Let us look at the flora of this area a little closer (cf. *Fig. 10*), proceeding up the muddy shore of the river until we have reached the marsh. Beyond the strip of smaller level-changes of the bank, we find here again and again mud-pyramids (*Fig. 10, b*) of beautiful form on flat parts of the muddy beach. They

arise because the perpendicular downpour of tropical rain washes away the mud around one object or another, frequently a fallen leaf, sometimes branches, small fruits or stones. Then small weak conical columns form, of which a transverse section is very similar to the covering and of which it presents each irregularity of the margin. Older ones may be 10–15 cm. high, but even they are dependent on the water for their existence since, after an extended drought, they may be washed away by rains which destroy them. Above the stretch of these peculiar forms along parts of the bank not subject to direct eroding-action by the stream, we find the previously described reed-community of *Saccharum spontaneum* L. and *Phragmites Karst* Trin. On the steep bank of outer bends, the ground is frequently hidden under a cover of liverworts (nos. 847, 1091), among others, *Anthoceros*. As soon as we have overcome this last obstacle, we find ourselves in the margin of the woods. A number of small trees stand near the bank and lean more or less over the water. A single forest-giant (*Fig. 10, d*), with pillar-shaped trunk and enormous broad crown, stands far above the other trees. Among the smaller trees are a few species of *Ficus* (nos. 844, 1101) and *Vitex glabrata* R. Br. (S. E. As.—Austr.). Two species of the taller trees in the forest are particularly abundant: *Dillenia calothyrsa* Diels* with cinnamon-colored trunk, large leaves, and large yellow flowers, and the previously mentioned breadfruit tree (*Artocarpus* sp.). *Dillenia* prefers the drier parts of the forest margin, whereas *Artocarpus* seems to be more common on damp ground. This tree also occupies the marsh in the drier parts.

Here and there stems of rattan-palms occur between the trunks of these trees, also other lianas, such as *Flagellaria* and *Entada scandens* Benth. (no. 1154, pantrop.), the latter having pods more than a meter long hanging high in the trees. Occasionally there are some tall specimens of *Pandanus* (*Fig. 10, g*). The forest-floor beneath the taller plants is very poorly covered. On most spots other than the many dry leaves of *Dillenia* and *Artocarpus* one can see nothing except the dark gray compact clay. On similar terrain a small terrestrial orchid is common: *Vrydagzynea elongata* Bl. (end.), a low-growing plant with white inflorescences. More toward the sunny side of the marsh there are small communities of *Leptaspis* (no. 788), *Panicum* (no. 899; *Fig. 10, l*), and other grasses (nos. 835, 1133). *Helminthostachys zeylanica* Hook. f. is plentiful but always occurs on damp terrain. In the drier parts of the forest-margin, shrubs and other representatives of the low flora are almost entirely absent. In addition to the small orchid already mentioned, here also occur the araceous *Schizocasia acuta* Engl. and scattered specimens of the pretty amaryllidaceous *Crinum asiaticum* L. (no. 1002; trop. As.—W. Polyn.) (*Fig. 10, e*), the latter reminding one of the beach, if it be a sandy beach, on which the plant ordinarily occurs. It is a coarse but stately herb with a thick rosette of leaves pointing obliquely upward and crowning the bulky black caudex; from the center of this the robust inflorescence with its umbel of narrowly lobed white flowers projects. The only shrub which I found here was *Morinda bracteata* Roxb. var. *celebica* Miq. (*Fig. 10, i*).

As the terrain slopes to the marsh, we find much lower trees 10–15 m. high, a few with prop-roots (*Fig. 10, h*). These trees obscure the inner margin of the real forest, but farther inland we note the richer flora of the marsh-border. Among these smaller trees a couple of species of *Barringtonia* are fairly abundant, *B. acutangula* Gaertn., with fragrant rose flowers, and another species related to the common *B. racemosa* Bl. of the sandy shores and *B. acuminata*

Bl. of Borneo; this species too has rose flowers in a somewhat pendent slender raceme. Another small tree, *Syzygium megalanthelium* Diels*, likewise with rose flowers and striking on account of its light-colored trunk, is generally distributed here.

Fungi, as is to be expected, flourish in rich variety (nos. 845, 903-5, 1089, 1093-4, 1142-3, 1152). I found *Polyporus grammacephalus* Berk. among others on dead wood. A couple of species of moss were also collected (nos. 848, 1092).

Without doubt, however, the most interesting part of this terrain is the strip forming the transition from the forest-margin to the marsh. Particularly in places where the transition is gradual on account of a slow and regular decline of the ground, the different zones are well-developed and sharply separated, and I noticed the same sequence at the transient small camps between Batavia-bivak and Prauwen-bivak. Still in the shade of the last low trees, *Cordyline terminalis* Kunth begins to appear. The thin stem stands more or less obliquely, and the narrow leaves are crowded and directed upwards at the apices of the branchlets, the large thin inflorescences and infructescences being pendulous. It has globose dark purple fruits. Somewhat farther in but still in the shade, there follows an even more sharply defined area dominated by a plant with equally striking habit, the zingiberaceous *Tapeinochilus* (aff. *pungens* Miq., no. 926; Fig. 10, m). The stem is smooth, articulate, and upright. Its aspect suggests that of a bamboo stem but it is herbaceous, massive, and fleshy. It rises unbranched to 2.5 or even 3 m. At the apex it bears an enormous ovate inflorescence, about 3 dm. long and 1.5 dm. in diameter, consisting of a thick axis beset with hard shining prickly bracts, which are dark green at flowering time and dark brown in fruit. These bracts entirely enclose the strongly flattened flowers, except for a small portion of the corolla. The calyx is greenish white, changing to red at the apex, the corolla is a pretty golden brown; the whole inflorescence gives somewhat the impression of a large pineapple. Under these inflorescences, lateral branches about 2 m. long radiate at a wide angle from the vertical which, like the main stalk, are bare, but at their apices they are again branched in the same way. The twigs bear relatively few small leaves at their tips and likewise show the spiral common to species of *Costus*.

Having passed through this peculiar part of the forest, where only the naked stems of *Tapeinochilus* form the undergrowth and their broad projecting branches and heavy inflorescences rise above our heads, we arrive beyond the shade of the forest-margin. In front of us lies the marsh with small groups of trees on the somewhat drier places, but for the largest part covered with tall-growing plants. The forest-margin there is principally composed of low trees inclining toward the marsh (Fig. 10, n), such as *Premna integrifolia* L., *Kleinhovia hospita* L., and a couple of species of *Ficus* (nos. 916, 951). The *waroe* (*Hibiscus tiliaceus* L. var. *abutiloides* Hochr.; Fig. 10, p) is found here in large numbers, and the same is true for *Artocarpus*, as far as the drier places in the marsh are concerned.

The transition from the bare forest-bottom to the marsh-flora is introduced by grasses and terrestrial ferns, such as *Helminthostachys zeylanica* Hook. f. (Fig. 10, l). Usually there follows a strip of the previously mentioned entangled fern-species, *Phegopteris prolifera* Kuhn (trop. O. W.; Fig. 10, q). It forms a mass a meter high, which appears more or less to follow the water-line in dry periods. This plant possesses very long wiry stems but a very compact habit. It is propagated almost exclusively by gemmae; everywhere one may find a

number of young plantlets on the fronds, but only after a long search did I find a specimen with spores.

The chief border-plant of the adjacent marsh is *Scleria elata* Thw. (Fig. 10, r; no. 836; trop. As.), growing about 2.5 m. high and recognized by the sharply 3-angled stem and similarly shaped leaf-sheaths. However, the deeper places are overgrown with higher reeds. Unfortunately, in the absence of specimens, their identity is uncertain, but it is perhaps not too daring to suggest that we have here a mixture of *Phragmites* and *Saccharum* (Fig. 10, s). Where the water is still deeper, all higher growth is lacking.

The climbers and epiphytes here occur chiefly in the thinner forest-margin and in this terrain mostly on the side toward the marsh. Epiphytes having particularly, at least as far as we know, only very distant connection with the earth, occur in undiminished numbers. Similarly I have already noted above that the bird's nest fern, *Asplenium nidus* L. (trop. O. W.), is unusually common in the forest itself, but toward the margin of the marsh we found also *Antrophyum parvulum* Bl. (Java, Penang, Phil.), *A. semicostatum* Bl. (S. E. As.—Polyn.), *Nephrolepis radicans* Kuhn (trop. As.), a pretty fern with limp drooping pinnately incised fronds, and a number of species of *Pleopeltis*, such as *P. nigrescens* Carr. (S. E. As.—Polyn.) and the more or less nest-like *P. punctulata* Bedd. (trop. O. W.). Here also the myrmecophilous *P. sinuosa* Bedd. (Arch.) climbs upward along the trunk and branches of the host with the aid of anchoring roots. The thick rhizomes are hollow and thickly beset with bright brown scales. The wall is thin, the interior being hollow even to the conical outgrowths which bear the fronds. A species of small brown ant lives in these passages. Again we meet *Ophioglossum pendulum* L., particularly over the damp places, and in drier places *Vittaria* species, as *V. zosterifolia* Willd. (Madag.—Polyn.) and *V. squamosipes* v.A.v.R.* *Hymenolepis spicata* Pr. (Madag.—Polyn.) is very common. I found only one species of *Lycopodium*, *L. falciforme* v.A.v.R. (N. Guin., N. Pomm.).

Species of *Hoya* also are very common on the branches of trees on the sunny margin of the marsh, and in the higher branches one may see *Myrmecodia* (no. 1095) and *Hydnophytum* (*H. radicans* Becc., end., and *H. commune* Val.). It is hardly necessary to mention that orchids are likewise richly represented. Among others, I found here *Liparis confusa* J. J. Sm. var. *papuana* J. J. Sm., *Thrixspermum validum* J. J. Sm., *Bulbophyllum tollenoniferum* J. J. Sm., *Appendicula reflexa* Bl. var. *neo-pommeranica* Schlecht., *Pomatocalyx incurvum* J. J. Sm., *Acriopsis javanica* Rw., *Robiquetia gracilistipes* J. J. Sm., *Dendrobium toadjanum* J. J. Sm., and *D. subfalcatum* J. J. Sm. Here *Elatostema pedunculatum* Forst. (Madag.—Polyn.) is also epiphytic.

Just as the epiphytes are found in the margin of the marsh, climbers also occur in this habitat. In the gnarled branches of a *waroe* (*Hibiscus*), *Faradaya splendida* F. v. Muell. climbs high; elsewhere we find *Abrus pulchellus* Wall. (no. 832; E. Afr.—N. Guin.) and *Ichnocarpus volubilis* Merr. (trop. As.—Austr.). The number of Araceae is not nearly so large as on drier terrain, *Pothos Albertisii* Engl. (end.) being almost the only representative here. The red-fruited *Piper* (nos. 834, 1098) too prefers the darker part of the forest. Another liana fairly common here is *Combretum trifoliatum* Vent. Finally, one of the very common plants covering trunks is a species of *Dischidia*, apparently *D. imbricata* Schum. (*D. Collyris* Wall.) (nos. 969, 1080; Arch.) of which the orbicular small leaves on both sides of the stem lie pressed flat against

the host-trunk. The young parts of this plant, also those which are protected against direct light, are rose-colored. The leaves are somewhat convex and cover, as in other species of the genus, a number of fine rootlets which grow from the nodes and extend their branches out into the humus collected beneath the leaf.

On the bivouac side of the river, marshy stretches lie between the stream and the foothills, the vegetation of which is very similar to that of the Meervlakte (cf. *Fig. 9*). It is best developed in the shore-area lying southeast of the camp. Nevertheless, the flora here is already unmistakably under the influence of the hills and, particularly on the margin, typical hill-plants extend into this area. Also on the side of the river a natural levee is formed, mostly but a few meters broad. Between this levee and the hills, the terrain is almost impassable and in many places occupied by a deep marsh. The undergrowth consists of a large number of *Pandanus* plants of all sizes, large grassy reed-complexes mingled with Cyperaceae, Zingiberaceae, and robust terrestrial ferns. About halfway between the camp and the river-bend to the southeast of it, a small tributary empties (*Fig. 9, 2*), so that I could continue my observations both on the land side and on the Idenburg River side. South of this terrain lies the pretty saddle mountain (1050 m.) of which we had a view from the bivouac. We saw this mountain later from Doormantop as a small hill in the distance.

On the bank of a small creek (*Fig. 9, l*) at the mouth of a brook I found a beautiful and richly flowering specimen of *Dillenia calothyrsa* Diels*, the branches loaded with large yellow flowers. Also here, in the shade of a white-flowering *Syzygium megalanthelium* Diels*, a number of specimens of *Jussiaea* (no. 885) stood on the muddy shore, with a small community of *Fimbristylis* (aff. *F. Merrillii* Pulle, no. 891). Everywhere inland the ground-cover consists of species of *Mapania* (nos. 1015, 1016, 1042, 1199), the shrubs *Desmodium umbellatum* DC. (no. 1020) and *Kibara* (aff. *moluccana* Perk.) (no. 1230), and an undergrowth of small herbs, particularly the acanthaceous *Rungia* (no. 782) and *Hygrophila* (no. 1021), and also the commelinaceous *Floscopa scandens* Lindl. (no. 1038; trop. As.—Austr.). Here I found also a couple of staminate plants of *Baccaurea dasystachya* F. v. Muell. (no. 1007), of which elsewhere (*Fig. 9, 6*) I observed a number of pistillate trees. I also saw here the large pods of *Entada scandens* Benth. (no. 1154) hanging from the highest branches of the trees. In a small marsh in the neighborhood were many *Pandanus* plants, and along the drier edges a number of tree-ferns (*Alsophila scaberulipes* v.A.v.R.*). The marsh itself was covered with a growth of Zingiberaceae (nos. 1062, 1106), mixed with the beautiful yellow-flowered *Curculigo scapigera* Hall. f. (end., no. 1047).

From the land side I examined this stretch of the bank at two places on the river. Once with a proa I went up the small tributary which forms the drainage of a large fen between the river and the hills (*Fig. 9, 2*). The mouth is 15 to 20 m. broad, and the banks consist of stiff and slippery clay; it seemed to me that here also natural levees are formed, only proportionately smaller than near the large river. Also the vegetation is more or less the same but less sharply divided into zones. After having gone around some curves, one comes unexpectedly to a low reed-field on the right bank. After that, first in clusters, later as a unit, the primary forest rises high, while the background is closed by the saddle-mountain. An obstruction of dead trees (*Fig. 9, a-a*), which have made some of the smaller rivers of New Guinea so notorious, prevented me

from going further with the proa, and the terrain appeared to be almost impossible for walking. On the left is a low *waroe* (*Hibiscus*) forest full of aerial roots and low overhanging branches and trunks above the muddy ground, the latter covered only with fallen leaves. The small levee here is not broader than one or two meters and indeed in many spots is entirely lacking. On the bank is a small community of *Fimbristylis* (no. 891) and near by one of *Pouzolzia hirta* Hassk. (S. E. As.—Austr.). The tree-flora of the levee is poor and consists almost exclusively of *Hibiscus tiliaceus* L. var. *abutiloides* Hochr., *Kleinhovia hospita* L., *Vitex glabrata* R. Br., and *Barringtonia* (no. 1006). As far as undergrowth occurs, this is composed of species of *Cyperus* (nos. 805, 808), *Helminthostachys zeylanica* Hook. f., *Diplazium esculentum* Sw., and, just as in the Meervlakte, also on the margin of the marsh, *Phegopteris prolifera* Kuhn, with which is the usual growth of *Scleria elata* Thw. in wetter places.

The other place where I examined this terrain from the river lay by the first bend southeast of Prauwen-bivak (Fig. 9, 3). Here, on the first gravel-bank along the shore, I saw a rugged specimen of *waroe* (*Hibiscus*), but, in this much drier location, without aerial roots and with more upright trunk and branches. Beyond, the terrain is drier and the forest contains more woody giants. Enormous specimens of *Flagellaria* climb to the highest crowns, rattans hinder progress everywhere, and a rather thick undergrowth of shrubs proves that this terrain is no longer subject to periodic flooding. Among the shrubs I found *Anomopanax* (no. 1012), *Garcinia* (no. 964), and especially a number of Rubiaceae, which constantly dominate the undergrowth. There are, for instance, species of *Ixora* (no. 787), *Lasianthus chlorocarpus* K. Schum. and *Lasianthus* no. 797, *Tarenna Guelcheriana* (K. Schum.) Val. and another species of this genus (nos. 968, 1052, 1053), *Psychotria leptothyrsa* Miq. (Ceram), *Mycetia javanica* Korth. (S. E. As.), and a *Plectronia* (no. 970). A single tall *Pandanus* occurs here among the trees; I saw one with aerial roots originating at about 10 m. above the base. In addition to the above-mentioned shrubs, the undergrowth contains *Crinum asiaticum* L., an intruder from the Meervlakte. Also *Donax* (no. 900) is common here, just as at Pionier-bivak. Clinging Araceae are relatively rare; *Rhaphidophora drepanophylla* v.A.v.R* was collected here.

On the edge of this terrain a small brook flows into the marsh (Fig. 9, 4). Under the light shade is a small community of three species: *Polygonum celebicum* Dans. (Borneo, Phil., Celebes, Moluccas), a *Panicum* (no. 899), and *Alternanthera sessilis* R. Br. (pantrop.; no. 901).

Another locality I examined was the land near the mouth of the Doorman River. On the right bank lies a large *gelagah* [*Saccharum*] field. Behind this the forest appears to be about the same as the Meervlakte type or rather one of the many aspects which the plain offers. Here a close growth of screw-pines [*Pandanus*] screens a marsh which is furnished with small compact groups of trees festooned with lianas. Among the screw-pines the low flora consists almost entirely of grasses and Cyperaceae. *Donax* and *Leea sambucina* Willd. (trop. O. W.) grow on the drier parts of the levee, also a few tall ferns, *Tapeinochilus*, rattans with pneumatophores, etc. *Phaseolus truxillensis* H. B. K. (S. E. As.; no. 988) is a beautiful purple-flowered liana on the river-bank.

The vegetation on the left bank offers a similar picture. I found here too a yellow-flowered *Pisonia* (nos. 980, 982) as a shrubby tree in the undergrowth. Here again *Artocarpus* is very plentiful. I commented in my diary regarding

this: one of every five trees is an *Artocarpus*. Perhaps this is a little bit overdrawn, but in any case it illustrates the frequency of this tree. I also collected here a myrmecophilous *Conocephalus* (no. 983). The number of myrmecophilous plants in New Guinea is strikingly large, and they belong to the most diverse families. Beccari, on his journey through the Archipelago, observed these interesting plants and devoted to them a beautiful work⁶ wherein he described and illustrated a large number of them. Most belong to the Rubiaceae and particularly to the genera *Myrmecodia* and *Hydnophytum* (here nos. 924, 986, 1107), each of which has a large number of species. But the Verbenaceae, the palms (some rattans), the Euphorbiaceae, the Myristicaceae, the Asclepiadaceae, the Monimiaceae, and even the ferns contain myrmecophilous representatives. We add to this list the above-mentioned *Conocephalus* (Moraceae), the gesneriaceous *Cyrtandra* (nos. 804, 810), *Semecarpus myrmecophilus* described by Lauterbach,⁷ and lastly a *Canarium* species native in the Moluccas and New Guinea (*C. acutifolium* Merr.⁸). A very high liana here was *Phylacium bracteosum* Benn. (no. 993; Malacca to Phil. and New Guinea).

Close to Prauwen-bivak on the northwest side, the hilly land slopes gently toward the river. Toward the marsh the vegetation does not differ essentially from that on the other side of the river, but these terrains offer so much variation that one repeatedly encounters new combinations and plant societies. So I encountered a river bank vegetation at 5 (Fig. 9) which was divided into some very sharp zones and which will be described briefly.

Beyond the muddy shore, here also covered with many mud-pyramids, is again the usual reed-area, in this instance about 4 m. broad. The land rises a few decimeters and immediately, mingled with the *gelagah* [*Saccharum*], are some breadfruit and *waroe* trees festooned with herbaceous climbing plants such as *Luffa cylindrica* Roem. (trop. O. W., cultiv. pantrop.). Farther in, a flat strip about 10 m. broad supports a few trees under the light shade of which is a very thin undergrowth of *Cordyline terminalis* Kunth, *Tapeinochilus*, and a few tall ferns such as *Diplazium esculentum* Sw. (trop. As.—Polyn.). The young fronds of the last are used as a very well-flavored green vegetable. With these ferns are a number of Cyperaceae (nos. 802, 830, 902, 919, 959, 1017, 1023, 1104, 1174), like the *Diplazium* 2–3 m. high. Apart from this the land is bare and, even in the dry period, still very wet; at high water-level this terrain is surely flooded. Still farther in *Cordyline* and *Tapeinochilus* are no longer found; both apparently need a combination of much dampness and considerable sunshine. In the Meervlakte also they appear to be limited to these conditions. Wherever the ground is drier and therefore the shade of the trees thicker, Cyperaceae dominate the undergrowth. Intermingled with them are a few small herbs, for instance species of *Hygrophila* (no. 1021) and *Rungia* (no. 922). In this last zone, about 5 m. broad, is the real hill forest covering the now slowly rising land. In its margin, however, various species typical of the transitional region grow. One of these is the earlier referred to *Baccaurea dasystachya* F. v. Muell., of which I found at 6 (Fig. 9) a number of pistillate specimens (no. 875) growing together. It is a small tree with very

⁶ O. Beccari, *Piante Ospitatrici, Malesia II* (1884–6), pp. 7–284, t. 1–65.

⁷ C. Lauterbach, *Engl. Bot. Jahrb.* LVI (1921), p. 366, and W. Slis, *Nova Guinea XIV* (1924), I, p. 99.

⁸ Mentioned in my monograph of the Burseraceae of the Netherlands Indies, which will shortly appear in the "Bulletin du Jardin Botanique de Buitenzorg."

fragrant flowers hanging down from the trunk in rather long racemes. It is noteworthy that Schumann & Lauterbach in their "Flora der Deutschen Schutzgebiete in der Südsee" mentioned (p. 392) a similar habitat for this species: "auf dem zeitweise überschwemmten Vorlande am Fusse der Berge." This plant in the Buitenzorg Herbarium is represented only from Sumatra, Billiton, and New Guinea. Schumann & Lauterbach credit it also to Java. In September 1920 I found it in flower; the blossoms are tolerably large and light yellow. At the time of my return from the mountains in December it bore greenish purple spherical fruits.

In addition to the tree indicated above, the Euphorbiaceae are represented by another species of *Baccaurea* (no. 1039) and by the curious *Endospermum formicarum* Becc. (no. 1028; New Guinea, Morotai), which, as the specific name reveals, is myrmecophilous. It is a moderately tall tree with fragrant flowers. All branches have thin walls and are hollow. These cavities originated through the intervention of a species of large black ant, which, as Beccari has already observed, bored through the wall. I found this to be the case when, in the middle of 1926, I discovered (*Fig. 11*) the tree along river-banks in Morotai Island (northeast of Halmahera). The nodes of the branches are slightly constricted and are entirely or almost entirely solid. The internodes contain a very compact and light pith. The ants⁹ themselves enter the branches by eating through the wall. Often they seem to select for that purpose scars of fallen leaves, since these perhaps offer somewhat less resistance, but openings may be found anywhere. Once an opening is made, the pith quickly disappears and living room¹⁰ is available. Frequently scale-insects¹¹ are kept therein.

Other Euphorbiaceae in this region are a species of *Mallotus* with light yellow flowers (nos. 954, 1030) and the large-leaved *Macaranga riparia* Engl. (Key Is., N. Guin.—Polyn.; no. 1037), of which both the bast and the periphery of the pith contain a thick-flowing, dark red, sour gum. *Phaleria papuana* Warb. (end.; no. 909), with wine-red cauliflorous fruits, belongs in the category of smaller trees. A small palm, *Licuala* (no. 876) also is common here. The general picture of this forest is very attractive. As a transitional region between two very different types of vegetation the flora is interesting; and the forest is easily passable on account of the relatively sparse undergrowth. This was the place that I, after having seen fresh cassowary tracks many consecutive days, saw one of these large birds flee in front of me. Apparently they came here to drink from a small brook where naked muddy spots alternated with small patches of *Helminthostachys zeylanica* Hook. f. and *Pleopeltis aquatica* v.A.v.R.

Lianas, clinging plants, and epiphytes are well-represented here. *Flagellaria* and *Gnetum* are fairly plentiful. Sometimes *Ichnocarpus volubilis* Merr. occurs. In still other spots we find *Conocephalus* (nos. 950, 1029), *Dioscorea* (no. 1035), and *Cissus discolor* Bl. (S. E. As.; no. 1034). A *Trichosporum* (nos. 858, 884, 1051), with its beautiful fiery red flowers, gives color to the trunks to which it is attached. *Pothos quinquevenosus* v.A.v.R.* adds its yellow spadix or its fiery red fruits.

⁹ On Morotai, according to the determination of Dr. W. M. Wheeler (Cambridge, U. S. A.): *Camponotus (Colobopsis) quadriceps* F. Smith.

¹⁰ Beccari, Malesia II, p. 44, t. II.

¹¹ According to Dr. Wheeler, belonging to a genus related to *Coccus*.

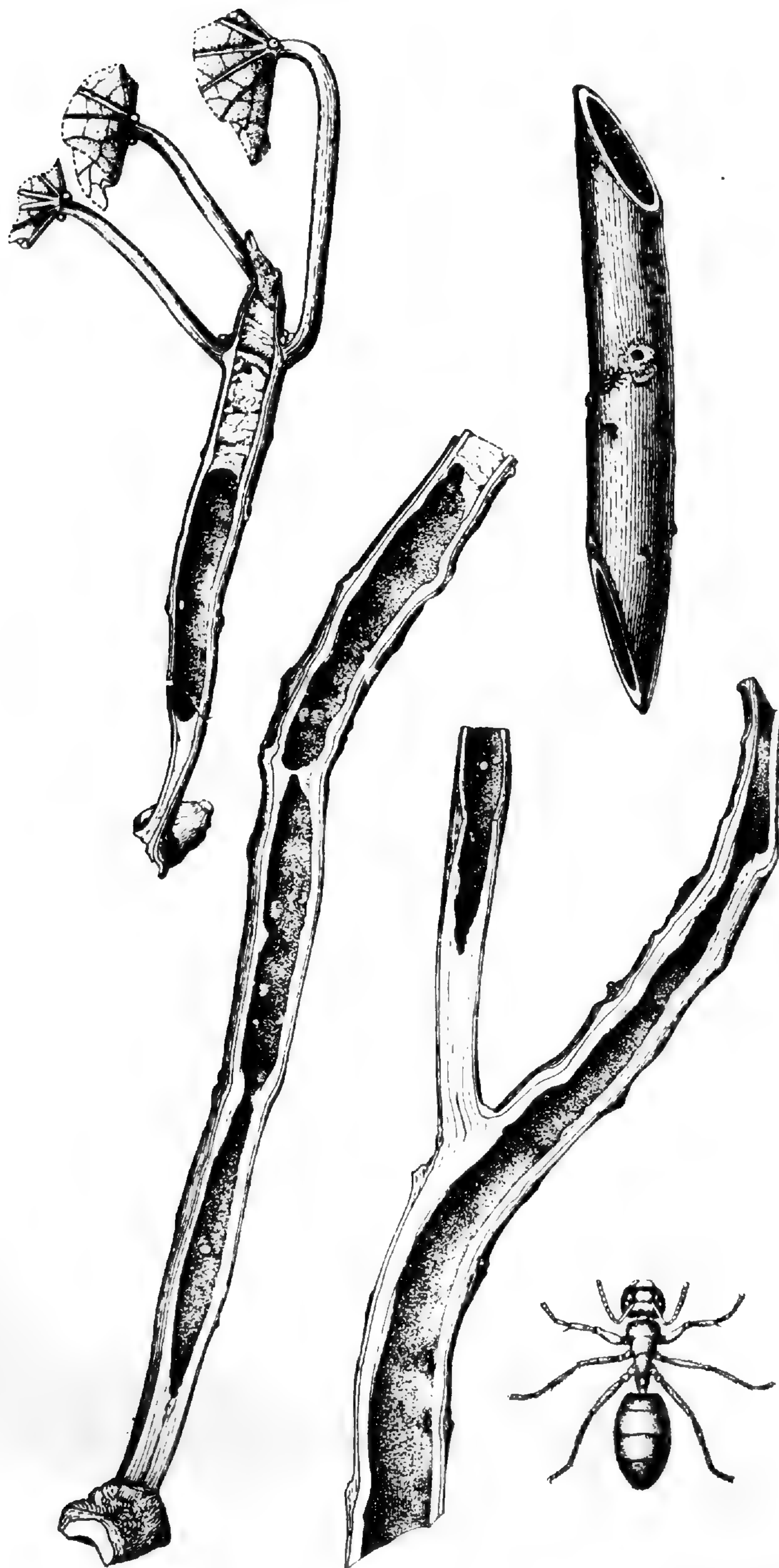


FIG. 11. Branches of *Endospermum formicarum* Becc., with ants (*Camponotus [Colobopsis] quadriceps* F. Smith) and scale-insects (*Coccus?* sp.).

Few herbs grow here. There is a single small area with *Elatostema*, or ferns such as *Diplazium cordifolium* Bl.; on higher terrain the most important herbs are *Donax* (no. 990) and scattered specimens of *Pentaphragma macrophyllum* Oliv. (end.; nos. 784, 785, 908, 971), especially characteristic of the lower foothill regions. The latter, through its robust somewhat coarse growth and its large yellow flowers, is a striking herb (Campanulaceae). *Elatostema novoguineense* Warb. frequently occurs as a component of a small community with ferns and *Selaginella*. *Elatostema pedunculatum* Forst. is epiphytic here, but always on the lower branches or parts of the trunk; *E. frutescens* Hassk. (Java, Sumatra, N. Guin.), likewise an epiphyte, also grows here.

With the description of this terrain we now have come to that of the lower hills. The foothills to the west of Prauwen-bivak are separated from the river by the gently sloping region described and offer a great variety of aspects. Deeply carved creek-ravines and steep boulder-beds of short torrents alternate with hills strewn with large pieces of deeply fissured rock. To the northwest of the bivouac a spur of the saddle-mountain rises rather steeply. Through a singular error of the officer of the supporting military detachment, the highest summit of the spur received the name "Casuarisnest." It is thus a worthy counterpart of the "Dromedarisberg" on the south side of the mountain, of which Pulle¹² relates that he was obliged to rename it "Kameelberg," since it has not one, but two summits. With the first advance of the vanguard into the interior, the officer took a pile of leaves on the top of the hill for a cassowary's nest, in which the bird known as the mound-builder lays its eggs. At the summit, about 230 m. altitude, towards the southwest (*Fig. 9, b*) an outlook was later opened, giving a view of the Central Mountain Range which was sketched from there (see Fragment V) and surveyed. A blanket was placed here in a vertical position, which later was observed from Doorman-top and rendered Kremer good service in checking his position. At a distance of 30 km. it was distinctly visible to the naked eye, especially when the sun was low in the west.

In describing the flora of this hilly country we shall again start from the bivouac. It is not surprising that here no ruderal flora has developed. When I arrived, the bivouac was only three months old, the first landing having been May 11, 1920. Possibly a few Scrophulariaceae (nos. 864, 889) might be considered to be adventive plants. This is not necessarily true of the *Jussiaea* which was growing on the bank. For that matter conditions here are not nearly so favorable for the establishing of aliens as at Pionier-bivak. The supplies brought were less in quantity and many of these were repacked. But in addition the bivouac, with its small area and its steep slope subject to erosion, is much less favorably situated for the persistence of adventive plants. The dead wood in the bivouac was apparently an excellent habitat for fungi (nos. 817-9, 870, 879, 928-32, 998-9, 1066-8, 1087-8, 1090, 1160, 1193-5, 1219, 1234, 2091-2). I found not only *Ganoderma Cochlear* Murr. and *Polyporus rugosus* Nees, previously reported from Pionier-bivak, but also *Polystictus Lamii* Lloyd, *P. affinis* Nees & Bl., *Phaeoclavulina Zippelii* van Overeem, *Auricularia auricula Judae* Schroeter, *Fomes lamaoensis* Murr., and a bird's nest fungus (no. 2088). I also observed here *Dictyophora phalloidea* Desv. (no. 2089) in a sterile condition, and collected, on the body of a butterfly, the insect-fungus *Cordiceps Moelleri* Henn. (no. 2111) earlier described from New Guinea. For the sake

¹² A. Pulle, Naar het Sneeuwgebergte van Nieuw-Guinea, p. 125.

of completeness I note the collection of a few green algae (nos. 1082, 1235) from a neighboring brook, and some mosses (nos. 1070, 1204, 2095-6) from fallen tree-trunks.

The factors which control the forest in this region are naturally identical with those which prevail on the hills near Pionier-bivak. The only difference to which we shall here call attention is that of soil. At Pionier-bivak the hills consist of sedimentary rocks and their erosion products, but here the soil is derived from eruptive rocks. It is generally accepted that the mountains of New Guinea originated¹³ geologically in relatively recent time. For the Central Chain this is the Tertiary (Miocene), for the mountains lying to the north, some think an even later age must be accepted.¹⁴ All the mountains are still entirely covered with sediments which are found up to Wilhelmina-top (4750 m.). The northern chain of the Central Mountain Range appears to form an exception to this. In three places far removed from each other, the chain seems to consist of eruptive rock-formations, namely, at the source of the Rouffaer River (van Gelder),¹⁵ in the region of Doorman-top (van Overeem Expedition), and again on a point east from there (de Wal Expedition). Because of the little knowledge which we possess regarding the flora of this gigantic island, it would be useless now to attempt to correlate the differences in the flora with differences in soil. Consequently, at present, we need not dwell longer on the ecology of this forest, which still remains a typical rain-forest many hundred meters higher up. I am, however, not claiming that local differences cannot be found. A strongly broken terrain, such as the young mountains with their deep ravines and steep inclines, naturally provides all kinds of different conditions. Slopes composed of blocks of rock, relatively flat parts with many steep walls practically without humus, damp ravines, small summits, and narrow ridges indicate some minor divisions of such a region, each of which exerts a series of distinct influences on the flora. Through these, the forest offers sufficient variation.

The previously mentioned *Vitex Hollrungii* Warb. is plentiful on the slopes of Casuarisnest. A stately palm (*Kentia*, no. 1065), rare here but very common higher up on the mountain, will be discussed in the next Fragment. Of the other moderately tall trees I indicate the white-flowered *Galearia* (no. 1190) and a few species of *Baccaurea* (nos. 1039, 1192, 1229), all cauliflorous. Somewhat smaller are *Ardisia lanceolata* Roxb. (no. 814; Malacca, Sumatra, Java, Borneo, Celebes, Phil.), with lilac flowers and dark purple fruits, *Dracaena angustifolia* Roxb. (trop. As.—N. Austr.), a couple of species of *Ixora*, *I. bivak-kensis* Val.* and no. 938, with a thick red and creamy yellow inflorescence, *Goniothalamus caloneurus* Miq. (no. 957; end.), a few representatives of the genus *Garcinia* (nos. 1013, 1187, 1202), all with white or yellow flowers, *Gnetum Gnemon* L. (no. 1228; trop. Afr.—N. Guin.), *Tabernaemontana aurantiaca* Gaudich., and a species of *Gonocaryum*, the last two with rather large orange-colored fruits.

In most places the undergrowth is rich in shrubs (chiefly endemic): *Aglaia* (nos. 809, 958, 1083), *Chisocheton Lamii* Diels*, *Saurauia Lamii* Diels*, *Styrax*

¹³ Miss Gibbs (Journ. Ecol. VIII, 1920, 105, note) records, on the authority of Smith Woodward, that typical marine fossils from the Miocene have been found at 4200 m.; she suspects that the uplifting took place during the Pleiocene.

¹⁴ Moszkowski (l. c. 283) mentions fossils from the van Rees Mountains as of the late Tertiary period.

¹⁵ Jaarboek Mijnwezen XXXIX (1910), 101.

(no. 811), *Macaranga* (no. 1189), *Symplocos Lamii* Brand*, *Tylecarpus papuanus* Engl. (end.), *Amaracarpus lanceolatus* Val.*, *Cyrtandra* (nos. 804, 810, myrmecophilous), *Morinda bracteata* Roxb., *Lasianthus chlorocarpus* K. Schum. (no. 1217), *L. chrysotrichoides* Val.* (no. 975), *Lasianthus* no. 936, *Clerodendron buruanum* Miq., *Orophea Dielsiana* (Lauterb.) Diels, *Semecarpus laxiflorus* K. Schum., *Urophyllum glomeratum* Val.* and *U. calycinum* Val.*, *Parasponia* (no. 953), *Pipturus repandus* Wedd. (Arch.), *Kibara* (no. 1230), *Antiaropsis decipiens* K. Schum. (nos. 799, 1081; end., from a systematic point of view a noteworthy moraceous plant, which is conspicuous because its inflorescences have fiery red bracts), and finally a few Leguminosae (nos. 852, 854-5, 920), also Melastomataceae such as *Otanthera Lamii* Mansf.*, with white flowers and raspberry-like fruit, and *Ochthocharis megalophylla* Mansf.*, with rose flowers. A number of other species, in motley variety, occur in the undergrowth. Separately I shall mention *Drimys oligocarpa* Schlecht. (end.), since it may be considered as a forerunner of the true mountain-flora in which we shall encounter other species of that remarkable genus of the Magnoliaceae.

Toward the river, where the earth is more level and therefore damper, there are occasional patches of *Cotylanthera tenuis* Bl. (Java, Borneo, Phil., Soemba), a pale-colored saprophytic plant of the Gentianaceae, which one frequently notes on similar terrain. On the slope the enormous number of juvenile rattan plants is striking, also those of a conifer which I cannot determine with certainty, but which is apparently *Agathis alba* Foxw. Young plants of this are scarcely distinguishable from those of *Podocarpus Blumei* Engl., which likewise occurs in New Guinea. Bird-hunters informed us, however, that extensive stands of dammar trees (which furnish the copal of commerce) are found along the banks of a tributary of the van der Willigen River, and so I think that my supposition is justified. In addition to the shrubby undergrowth many herbs occur. Amongst the most beautiful of these are *Pentaphragma macrophyllum* Oliv. and *Forrestia mollissima* Koord. (no. 952). Also striking is the small *Geophila reniformis* D. Don (pantrop.), which formed almost the only ground-cover on a small area at the foot of a hill; the plant attracted as much attention by its snow-white flowers as by its cherry-red fruits. A number of Zingiberaceae (nos. 806-7, 925, 1001, 1210) belong naturally to the robust herbs. On the summit of Casuarinest two species (nos. 823, 1079) grew promiscuously. In damp places a couple of handsome species of *Dianella*, *D. coerulea* Sims (Phil., N. Guin., N. Austr., New Caled., Fiji) and *D. carinata* Hall. f. (end.) are common, as is also *Ophiorrhiza crispa* Lauterb. (end.). *Dianella carinata* Hall. f. is very plentiful up to near the forest-border. *Oldenlandia pubescens* Val. (end.) prefers a drier terrain. In similar places the ground is frequently covered by more or less extensive patches of *Elatostema*, *Begonia* (nos. 851, 890), *Selaginella gracilis* Moore, and *S. puberulipes* v.A.v.R.* In the last species, which does not grow very large, I several times observed that almost all the sporophylls were connate, so that leaves and sporangia alternate with each other. Terrestrial ferns in this forest are likewise unusually abundant. In damper places toward the river are small communities of *Blechnum orientale* L. (trop. As.—Polyn.). Apart from that one finds in the undergrowth *Tapeinidium pinnatum* Chr. (Arch.—Polyn.), *Diplazium cordifolium* Bl. (Afr.—Polyn.) and *D. opacifolium* v.A.v.R.*, *Lindsaya trichophylla* Copel. (end.), *Syngamma pinnata* J. Sm. (E. Arch., Austr., Polyn.) and *S. lanceolata* Diels (N. Guin., Fiji), *Blechnum Finlaysonianum* Wall. (Arch.), *Aspidium teratocarpum*

v.A.v.R.*, *Asplenium cuneatum* Lamk. (pantrop.), *Dryopteris repandula* v.A.v.R.*, and *D. cyclosora* v.A.v.R.* Among the ferns one of the most common ground-covers is the dark green *Trichomanes cupressoides* Desv. On blocks of rock on the slopes I found a couple of species of the last genus intermingled, *T. millefolium* Pr. (Sumatra, Java, Phil., N. Guin.) and *T. suffrutex* v.A.v.R.* Similar blocks, which are scattered on the north slope of Casuarisnest, are frequently entirely covered with mosses and ferns and a number of small Orchidaceae growing with them. Examples of the ferns are *Campylogramma pteridiformis* v.A.v.R. (end.) and *Lindsaya trichophylla* Copel.; the orchids belong particularly to the genus *Microstylis*, which occurs in similar habitats on many islands of the Archipelago; the species here is *M. Floscularia* J. J. Sm. Often others are noted, such as *Eurycentrum atroviride* J. J. Sm., with the leaves dark green above, and *Hetaeria oblongifolia* Bl. var. *papua* J. J. Sm. In the humus among these blocks of stone are a few terrestrial Araceae, such as *Homalomena Peekelii* Engl. (end.) and *H. Versteegii* Engl. (end.), and in somewhat damper places *Holochlamys elliptica* v.A.v.R.* and *Schismatoglottis pomatophila* v.A.v.R.* Among the herbaceous flowering plants, the acanthaceous *Rungia* (no. 1022) and *Hemigraphis angustifolia* Hall. f. (no. 888; Arch.) appear. In addition to the already mentioned *Hetaeria*, another terrestrial orchid here is *Plocoglottis tropidiifolia* J. J. Sm. Occasionally the saprophytic burmanniaceous *Gymnosiphon affine* J. J. Sm. is noticed.

Among the clinging Araceae, which occur here in very large numbers, *Rhaphidophora drepanophylla* v.A.v.R.* and *Pothos papuanus* Becc. (end.) are plentiful. Representatives of the last genus and *Dischidia imbricata* Schum. are the most common plants covering the tree-trunks, and, particularly in specimens of small size, the leaves are frequently less than 1 cm. in diameter. Possibly these are young forms, since I observed neither flowers nor fruits on such plants. On the other hand, *Scindapsus altissimus* v.A.v.R.* is a very large plant which I found on the summit of Casuarisnest. It has a large cigar-shaped bright yellow spathe almost 50 cm. long and 6.5 cm. thick (still closed) growing aloft in the crown of a tall tree. The leaves of this plant are somewhat the shape of those of the banana, the older ones being frayed transversely in the same way.

Large lianas are always rare in the center of the forest. Of the smaller ones which do not reach the forest-roof, I collected the purple-flowered *Dissochaeta Schumannii* Cogn. (end.) and *Uvaria littoralis* Bl. (no. 1182; trop. As.), the latter with beautiful chocolate-colored flowers widely scattered along the almost leafless, thin, and flexible stem.

The epiphytic flora of the lower parts of the trunks offers little new. I again found *Nephrolepis radicans* Kuhn. Another epiphytic or somewhat clinging fern is *Trichomanes aplebioides* Chr. (Moluccas, N. Guin.), a species with dimorphic fronds; the fertile ones are smaller and are placed close together on the rhizome, the larger sterile ones extending upward separately. Also I found here *Polypodium sclerophyllum* v.A.v.R.*

Among the epiphytes in the crowns of trees, the Orchidaceae again occupy the most important place. There are *Pomatocalyx incurvum* J. J. Sm., *Appendicula reflexa* Bl. var. *neo-pommeranica* Schl. and *A. (aff.) furfuracea* J. J. Sm. (no. 1178), *Dendrobium squamiferum* J. J. Sm. and *D. poneroides* Schl., *Eria oligotricha* Schl., *Ceratostylis mamberamensis* J. J. Sm., *Podochilus scalpelliformis* Bl., *P. mamberamensis* J. J. Sm., and *P. imitans* Schl., *Dendrobium Phalangillum* J. J. Sm., *Malleola palustris* J. J. Sm. & Schl., *Glomera uniflora* J. J. Sm.,

Bulbophyllum mamberamense J. J. Sm., and finally *Taeniophyllum* (no. 1085). The melastomataceous *Pogonanthera reflexa* Bl. (S. E. As., W. Arch., Phil.), with yellow flowers, is also an epiphyte. Another very plentiful epiphyte in this region is *Dimorphanthera tridens* J. J. Sm.* (no. 976), a richly flowering plant with large, broad, bell-shaped flowers of a warm red color. Like the *Glomera* and *Dianella* previously mentioned, this ericaceous species, in a certain sense, may be considered as a forerunner of the mountain-flora, since, in the main, related species are mountain-plants.

Prauwen-bivak was one of the most pleasant camps, in spite of the clouds of day and night mosquitoes. Our never sufficiently praised mosquito-room reduced the pest to a bearable minimum. Lying close to the river and a few meters above it, this bivouac provided a spacious and sunny view. Toward the southeast spread the broad river and the foothills of the Central Mountain Range (Fig. 12). Immediately before us lies the forest-margin of the Meer-

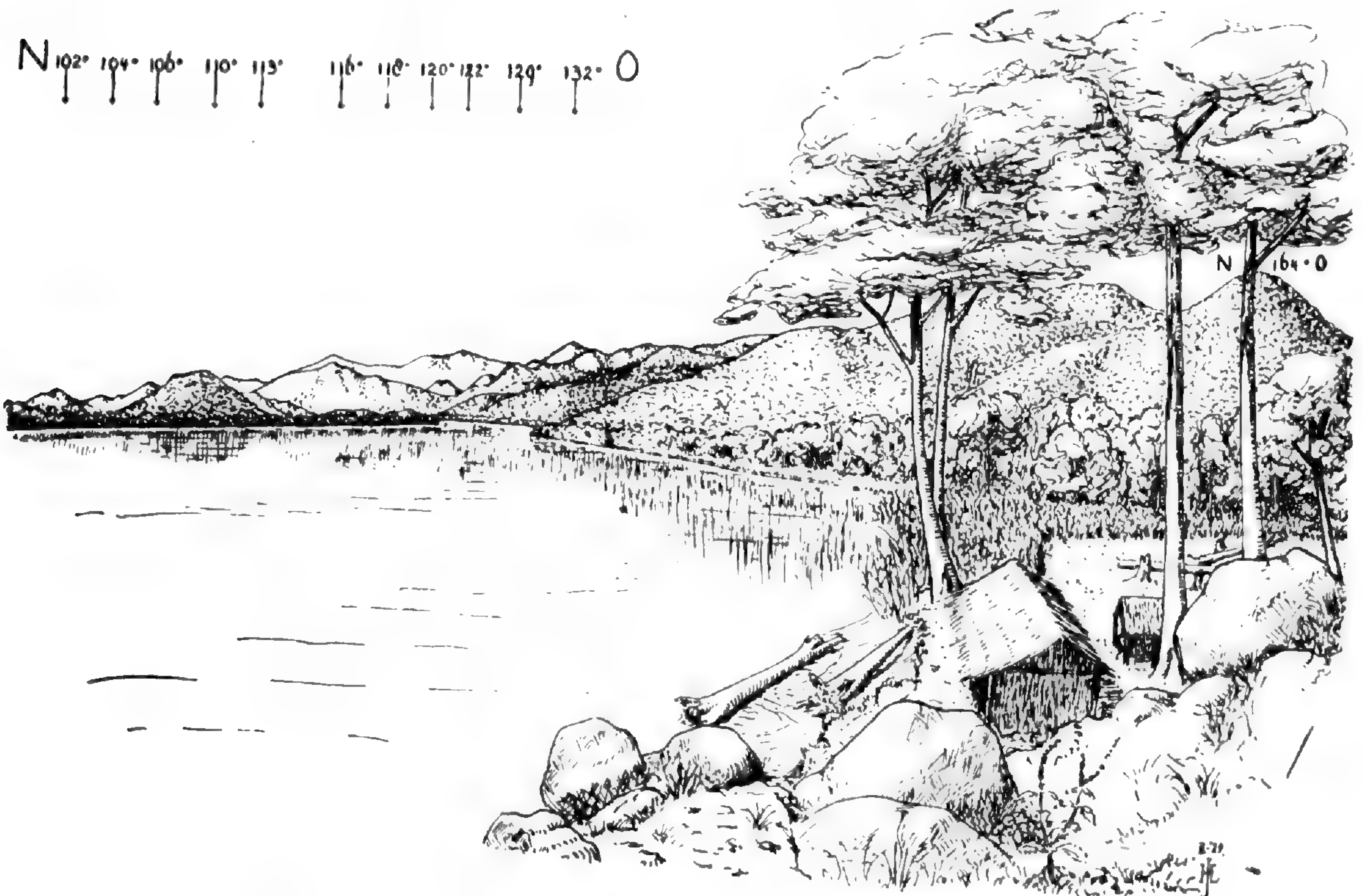


FIG. 12. Outlook from Prauwen-bivak to the southeast.

vlakte. Toward the north we again see the wide stream, with its slowly circling eddy full of driftwood and other vegetable-debris, and the mouth of the Doorman River in the background. Here we enjoyed our morning coffee at sunrise; here we sat together in the late afternoon to gaze at a beautiful sunset. Then silence and repose descended on the sultry plain before us, and with the fading of the daylight the strange bird *Cracticus quoyi* also ceased its calling. This call so strikingly resembles that of a far distant Papuan dog that at first we were repeatedly mistaken regarding it. At that hour also, the parakeet flocks (*Chalcopsittacus duivenbodii*) flew over toward the mountains, where later we could see them fly home after a long day on the plain. But this scene was not always peaceful. Sometimes a rain-storm from the southeast, rushing across our mosquito-proof shelter, drove us all out with our books and notes.

On such evenings, however, we could enjoy the lightning-discharges over the wide plain, which illuminated the whole neighborhood.

The commissary department also was attractive in this bivouac. Sometimes on the table appeared a large bowl filled with fish fresh from the river; then again we had real turtle soup, the thigh of a cassowary, or a fat crown-pigeon. Once while there we tried *koeskoes* (*Phalanger maculatus*), and one day the doctor and I even ventured to eat crocodile, which is not as distasteful as tradition says, and strikes a happy medium between fish and veal.

It appeared indeed as if the animal kingdom in this vicinity likewise found greater expression than elsewhere. Apart from the usual nuisances of the forest, such as mosquitoes, leeches, wasps, and ants, which one finds everywhere, we observed much more wild life than at Pionier-bivak. I have already mentioned that once I saw a full grown cassowary flee with great strides and much noise. Tracks which I measured were up to 26 cm. long and 20 cm. broad. I have mentioned too the crown-pigeons. Of the animals here, after the pigs, the *koeskoes* (*Phalanger maculatus*) are the most common. These are sluggish animals which sleep through the day and go out marauding at night. Occasionally we shot one out of a tall tree, and for a long time we kept a young one in the camp. It was practically motionless during the day and, moreover, was very vicious. Another marsupial, once caught by the zoologist in a snare, was *Parameles*, a small creature which lives on the ground and somewhat suggests a small piglet.

Of the reptiles, I have previously called attention to turtles and crocodiles, and also to the poisonous snake *Acanthophis antarcticus*. Occasionally larger snakes were brought in or observed; I myself saw one about 2.5 m. long. Frogs, numerous in this country on account of the relatively few snakes, are seen everywhere, and are particularly audible. Sometimes at night we heard a loud almost roaring or bellowing call in the forest which we attributed to one of these amphibians. The doctor once noticed a good specimen swimming in the river, which, spread out, was more than 50 cm. across. Giant forms were also found amongst the earthworms. In all characteristics they reminded one of the common earthworm, but they were up to 1 m. long and 2-3 cm. thick.

I will close these few remarks on the fauna with a brief discussion of one of the most curious phenomena in nature that I ever witnessed: the swarms of day-flies. As is well known, day-flies are the adults of neuropterous insects belonging to the family Ephemeraidae. The larvae live in various stages as predators in the water, but the imago, which eats no food during its ephemeral existence, is concerned exclusively with the propagation of the race. This fact itself is sufficiently remarkable, but still more so is the simultaneous emergence of all imagoes at a definite place.

Ephemera swarm in the lower stretches of the large rivers, and repeatedly we witnessed this phenomenon occurring in little or great profusion once every two or three weeks. The Meervlakte appears to be a peculiarly favorable region for these insects: nowhere did we see such enormous swarms of them as here; and this natural phenomenon makes the greatest impression on one who sees such a swarm originate in his immediate vicinity, and the next moment is encircled by myriads of these insects. One day when I was returning from the mouth of the Doorman River in the direction of the camp, I was engaged with the coolies in gently paddling the proa. Somewhat sleepy from the fatiguing work of the forenoon in the sultry marsh, my eyes were half-closed against the

intense light reflected from the surface of the calm and smoothly gliding stream. Suddenly my attention was drawn to a day-fly fluttering up and down near the proa, a white and light yellow delicate little insect which hastily and with sudden turnings dragged its slender appendages over the water. Still without suspecting what was about to happen, I gazed languidly out over the broad calm river until all at once my interest was awakened: an ephemerid appeared close beside me, struggling to free itself from the water. Although now I tried to observe with greatest interest and every effort, I failed to follow in full detail what occurred there. At close quarters I tried to see how the insects emerged from the water, but yet at the same time my eyes were drawn to many other points, thousands of them, where the same thing was happening. A few minutes later, I looked out over the river, so quiet a moment ago; its surface was already swarming with thousands of day-flies. After a considerable time spent in close scrutiny, I succeeded in observing a day-fly twist out, free itself from the larval covering, and dart quickly away. The empty skin, as an almost invisible membrane, slowly drifted away with the stream. Within a very short time—not more than five minutes—the whole river was covered with millions of day-flies. Some flitted to and fro over the water, others rose a few meters above the surface and repeatedly fell into the proa. The males have the extremities transformed into claspers, with which they embrace the females. I observed but few pairs. Occasionally I saw two contact for a short period, but I could not determine whether this was really the act of copulation. Just as in the European species, among the thousands of males present, here only a few females appear. Both sexes have two thread-like appendages on the abdomen—in the male much longer than in the female—with which they draw two fine traces across the water. Under the last abdominal segment the female has two pear-shaped egg-sacs which are easily lost by contact. Not long, a few hours at the most, the swarm remains in full strength. At first repeatedly hundreds of individuals join it, but gradually birds come from the forest and reed-fields, as well as fish from the muddy bottom, to reap the harvest. Small bee-eaters and *spitsvoegels* fly to and fro. I observe those already wearied by the hunt and satisfied, resting on branches protruding out over the water, but nevertheless, they could not resist the temptation of throwing themselves once more into this abundance of food. A thin darker cloud of birds whirled through the thick white cloud of day-flies, and the pink jaws of the Siluridae snapped above the water repeatedly. At twelve o'clock I saw the first day-fly appear; at three they had all vanished. What has become of the remaining individuals which have not fallen victims to the birds and fishes, or which the wind has not thrown down unhospitably in the forested river-banks?

Later I went downstream again with the small motor-boat, likewise about noon. I chanced upon another even larger swarm. From afar, the river appeared as if it were buried under a snowfall of day-flies. We traveled for more than an hour through the uninterrupted thick swarm, which thus was at least 15 km. long. A moderate estimate (10 individuals per cu. m.) gives 120 million day-flies.

In Europe a similar phenomenon is known. Brehm¹⁶ gives us a striking description of this, prepared by Réaumur, who observed it on the Marne during an evening in 1738. In all details the description agrees with my observations.

¹⁶ Brehm, Tierleben, Insekten, 3rd edition (1892), p. 548, and 4th ed. (1915), p. 55.

I have already said a few words concerning the Papuans who dwell in the Meervlakte, and I shall not venture further into the anthropological and ethnographical domain. However, I shall not close this Fragment without a comment on a striking journey made by bird-hunters coming overland from Hollandia on Humboldt Bay. They knew how to reach Prauwen-bivak and apparently had learned of our presence in the Meervlakte and counted on our support. Otherwise they probably would not have risked this undertaking. The band was led by two Chinese, the rest being sturdy Papuans from the north coast. In all there were 21. Perhaps I should not have mentioned this incident were it not for the fact that the band, according to their leaders, had lived entirely on the produce of the land. In a ten weeks' march overland they reached the upper course of the Idenburg River. At first they had been able to obtain some provisions from the kampongs through which they passed, but very soon they had to live entirely on the country itself. While each day an organized group searched for food, the others hunted birds of paradise and crown-pigeons. Thus they travelled for more than 70 days, living on food obtained by hunting and fishing. On a point downstream from the great gap of the Idenburg River they made four proas, and with these dropped downstream, reaching Prauwen-bivak after seven days. There, under our protection, they remained some time to hunt.

It is frequently said that the tropical primeval forest, and particularly that of New Guinea, furnishes little food—too small an amount to supply the needs of travellers. This band provided the clearest evidence that this is not the case, at least for the lowland. It will not be easy for pampered Europeans to follow their example, although Moszkowski¹⁷ says that he lived exclusively on the country for nearly two months in the Meervlakte. In low regions there are always plenty of pigs, pigeons, and cassowaries. The river contains an abundance of excellent fish; the Dyaks frequently secured 10–20 kg. in an hour. And the Meervlakte and other areas with fresh-water marshes supply as much sago as one could wish for. Furthermore, as side-dishes for meals, there are to be considered turtle and monitor-lizard eggs, young palm-buds and young fern-leaves (*Diplazium esculentum*). The growing tips of *Pandanus* and rattans can likewise be eaten, breadfruit provides a vegetable, while roasted *Gnetum* seeds, fruits of species of *Syzygium*, and some species of rattan may serve as tidbits. In case of need, other sources of food are: all kinds of marsupials, such as tree-kangaroos and phalangers, the duck-bill, smaller birds and larger ones such as the jungle fowl, the kalongs (fruit-bats), crocodiles, and snakes, not to mention other reptiles and amphibians. Thus at low altitudes one need not fear starvation. But in the mountains conditions change quickly. The most important sago, forming the chief article of food, disappears. The breadfruit tree soon follows. Once high in the mountains, one finds scarcely more than pigs and cassowaries, *Pandanus*, palms, some small birds, and marsupials. Even the natives never go into the mountains without taking food with them, since it is realized that existence on what the country supplies would be precarious. Wollaston relates a touching illustration of this.¹⁸ It concerns a case in which about ten Papuans, mostly women and children, perished from hunger during a journey into the mountains, because they had not carried a sufficient supply of food with them.

¹⁷ Cf. footnote 3 in this Fragment.

¹⁸ Geogr. Journ. XLIII (1914), p. 264.

V. The north slope of the Central Mountain Range ^{1, 2}

DURING the month (August 15–September 18, 1920) that I spent at Prauwen-bivak, the Casuarisnest was developed as a location-point for the future inland expedition, as the Central Mountain Range was our objective both from the standpoint of biological field work and in accordance with our commission. It has already been mentioned in Fragment IV that an outlook on this hill was opened toward the southwest. Here a greater part of the route to be followed is to be seen and sketched (*Fig. 13*).

It was September 18, 1920, that Lieut. Drost and I set out upon our inland journey with the weekly transport. As mentioned earlier, I was accompanied by two native helpers, Ajoeb, mantri of the 's Lands Plantentuin at Buitenzorg, and Siman, assistant mantri in the Herbarium.

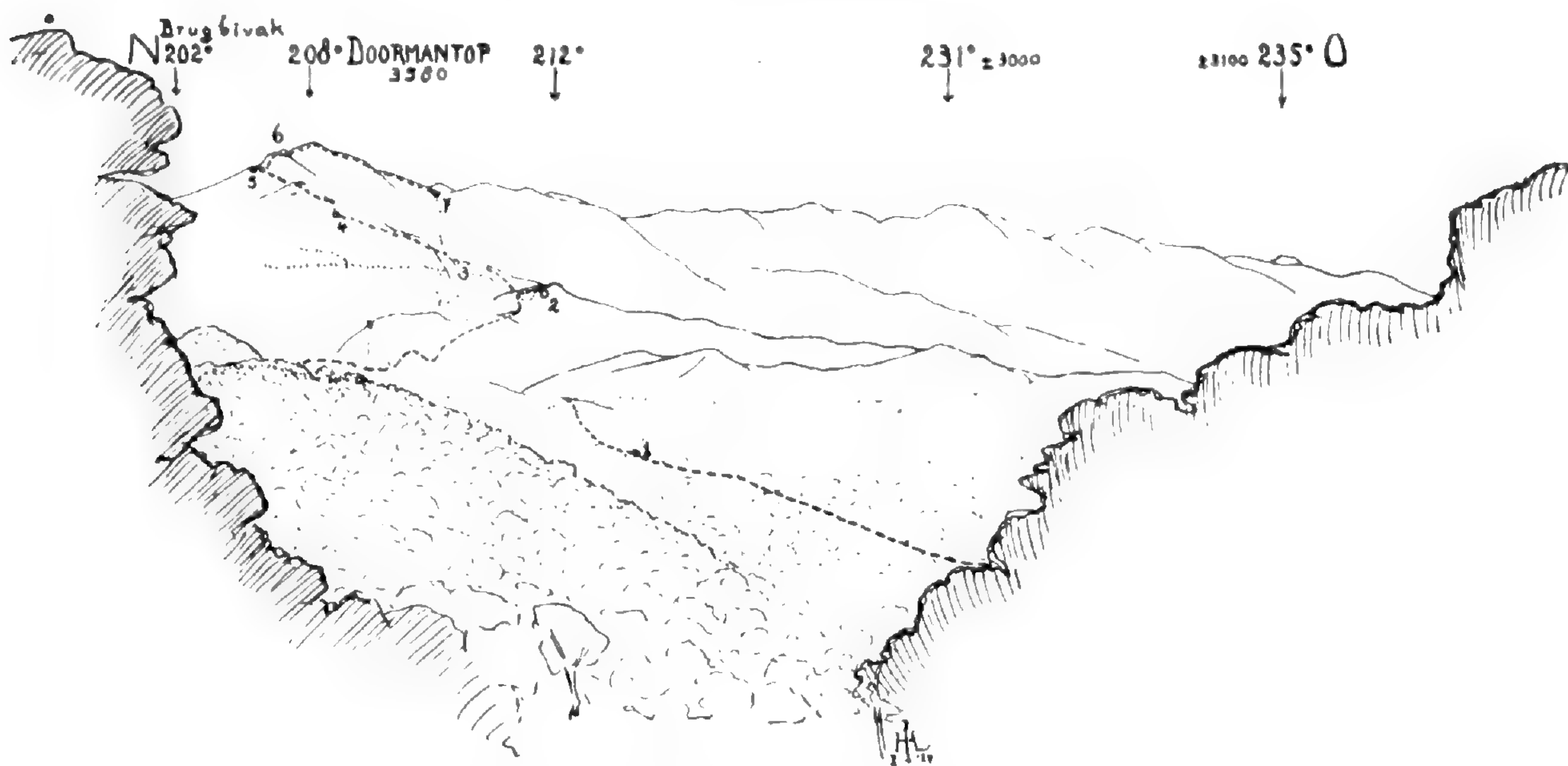


FIG. 13. Sketch of the Central Mountain Range, seen from Casuarisnest. — — — — = visible part of the route followed; = part of the route not visible; 1 = Woud-bivak; 2 = Bivak Goenoeng Boetak; 3 = First Parkieten-bivak; 4 = Beek-bivak; 5 = Uitzicht-bivak; 6 = Radio-bivak; 7 = Mos-bivak.

At the time of our departure, the patrol of Capt. van Arkel was still operating in the advance-terrain. He had reached Doormantop just two days before. On September 6th, the leader, Capt. Kremer, and the geologist followed their trail with a strong transport; the ethnographer, the doctor, and the zoologist remained at Prauwen-bivak.

After having passed the open clearing we descend again to the plain (cf. Fragment I, Map B). The trail, which originally ran across the marshes, was later diverted more toward the foot of the hill, because it appeared that the ground-condition did not permit a regular transport to travel by the old route.

¹ *Natuurk. Tijdschr. Nederl.-Ind.* 88: 252–324. 1928.

² The Indian Committee for Scientific Research, which organized and equipped the Scientific Expedition to Central New Guinea 1920–1922, made the publication of this series of richly illustrated articles possible by a grant from the Royal Natural Philosophical Society. The editors and the writer express their appreciation for this support, to the Committee named.

After one transport had passed over, the superficial layer of roots was so destroyed that, even in the dry period, one sank so far in the marsh that it was impossible to make any progress. But even our new trail nearer the foothills leads us over long stretches which are transformed into deep muddy pools. Soon the trail turns away from the foot of the hill and lies over entirely level terrain. At first the path is easy. The brooks coming from the hills have cut into the terrain, thus forming terraces; the banks are perpendicular, and between the broad loops lie entirely flat areas where the growth is thin and the vegetation reminds one strongly of the forest-margin of the Meervlakte. There are only a few woody giants; the remaining timber is slender and small, only few trees having a diameter of three to four decimeters. In the undergrowth practically all shrubs are lacking, but locally there are solid stands of *Elatostema* or *Selaginella*, and indeed of many different kinds of ferns. In other places where the forest-floor is almost bare, *Vrydagzynea elongata* Bl. occurs. In short, we find here so many points of agreement with the vegetation of the forest-margin of the Meervlakte that we may well suppose that this terrain is inundated in the rainy season, at least occasionally.

At nine-thirty, after having forded a couple of smaller brooks, we reach a larger stream that meanders so much that we have to cross it six or seven times at short intervals. It is a beautiful broad brook, with a bed of hard sand and gravel. The water is clear and occupies about 10 m. of the 25 m. wide flood-bed, the deepest channel being almost a meter deep, so that we wade through up to the hips. Through the narrow opening made by the brook in the forest, we see a small part of the heavily wooded hills to the southeast. Slowly and noiselessly the dark water flows by us, while here and there a heavy tree-trunk lies half under the water; I note in the branches of such a tree the half-destroyed carcass of an old hornbill which has died a natural death.

After a short rest at this place we proceed. Now for a part of the way we follow the bank, high and steep on the outer curves, flat and broad on the inner curves and here sometimes with small *gelagah* [*Saccharum*] fields. In such patches we almost always note the Job's tears grass (*Coix Lacryma Jobi* L.), the hard fruits of which are used by the Papuans as beads. Sometimes we proceed a few hundred meters across the bed of the brook, here divided into streamlets, and continue our journey again over another terrace-bank. A characteristic plant of such stream-beds is a small *Ficus* (no. 1285), a widely branched shrub with a flat top, the narrow-lanceolate leaves all spreading horizontally 0.5–2 m. above the water. Perhaps the top of these shrubs is about equivalent to the highest water-level. Some specimens grow on the bank and the branches of these develop chiefly on the side toward the stream, spreading far over the water; most, however, are erect on gravel-banks or in the shallow water. The branches stretch out at a tolerably sharp angle in all directions, but particularly downstream; thus the plant may reach a diameter of three to four meters. In 1926, in the lowlands of Morotai, I found again a similar growth in river-beds; possibly it was even the same species, for entire gravel-banks were covered with a thick shrubby pure stand of *Ficus*. The habit is particularly characteristic of plants which live in similar habitats. Beccari³ first called attention to this peculiarity and designated the phenomenon as stenophylly (a condition characterized by narrow leaves). He men-

³ O. Beccari, *Nelle Foreste di Borneo*, 2nd edition (1921) p. 324, 424, t. LVII.

tioned its occurrence in *Fagraea*, *Garcinia*, *Psychotria*, *Eugenia*,⁴ *Syzygium*, *Erycibe*, *Saurauia*, *Tetranthera* (l. c. t. LVII), *Milletia*, and *Pinanga*. He thinks that the particular form of the leaves and the development of slender flexible branchlets is an adaptation to constant air-currents over the river-beds and in ravines subject to periodic flooding. He mentions *Salix babylonica* L. as an example of this in Europe. Beccari named air-currents as the cause of the adaptation in the first place; but I think Ridley⁵ is closer to the truth in placing more emphasis on the fact that such plants have to offer resistance to the dragging force of the torrents. Rightly he compared the leaf-form and the flexibility of the twigs with plants living in flowing water (e.g. species of *Potamogeton*), with floating leaves arranged in large measure to resist the effect of the current. In addition to this species of *Ficus*, we add to Beccari's list *Homonoia riparia* Lour. (S. E. As., W. Arch.) which sends⁶ out vertical twigs from its somewhat horizontally radiating branches.

Apart from the *Ficus*, the bank was practically bare except for the fairly common *Hemigraphis reptans* T. Anders. (1243-4), a small acanthaceous plant with relatively large whitish flowers.

Intsia amboinensis Thouars is very plentiful on the forested terraces. *Gonocaryum*, *Gnetum Gnemon* L., and *Tabernaemontana aurantiaca* Gaudich. are undergrowth shrubs. Also abundant is a small palm with a short trunk (nos. 965, 1181), previously encountered in the hilly terrain at Prauwen-bivak. It was immediately noticeable because of the few broadly lanceolate leaves being gray-white beneath, the distal half being longitudinally slit into two lobes.

After we pass this region, the trail becomes considerably worse. Although the ground looks rather dry and passable, the carriers have destroyed the path entirely and made it a broad track of slimy brownish mud which constantly becomes broader, since everywhere the drier outer margin will hold. Nevertheless, there is no way of avoiding a stretch of 10 meters where we sink almost to our knees in the soft mass, and thus we slog along two hours through an uninterrupted series of sloughs until about 11:30 A. M., when we reach Moeras-bivak (Woud-bivak), a dreary collection of frame huts on swampy muddy ground. After a bath of problematical value and moderate satisfaction, it is midday, the first of 80 such midday stops, which are utilized in general with talking, writing, and smoking; tea is served, and after the twilight has fallen the noon meal is repeated. Curiously enough we can sleep here without mosquito nets, this being also true of the intermediate bivouacs in the van Rees Mountains. We have no explanation of this phenomenon of the total absence of mosquitoes at night. Lack of standing water surely is not the cause.

The following day the trail as a whole is better. Slowly we approach drier ground intersected by many clear brooks: we again draw near the foot of the hills. Here are extensive patches covered with a very low-growing *Begonia*, *B. bipinnatifida* J. J. Sm. (end., no. 1257), a plant hardly 1 dm. tall, with very dark green, repeatedly and finely incised leaves and pink-white flowers. Else-

⁴ Endert (Midden-Oost-Borneo Expeditie 1925, Ind. Comité v. Wetensch. Onderzoekingen 1927, p. 254, fig. 100) mentions a stenophyllous species of this genus on boulder-banks. He also names a *Ficus*, *F. glomerata* Roxb. (p. 253, fig. 99), to which species, however, my New Guinean collection does not appear to belong.

⁵ H. Ridley, Trans. Linn. Soc. II. Bot. III (1888-1894), p. 270 (1893).

⁶ Phil. Jour. Sci. I (1906), p. 682, pl. XLII; cf. also J. G. B. Beumeé, Een tropische wilg, De Tropische Natuur XIII (1924), 43, pl. 2.

where another species of this genus grows (no. 1256) and the dull color of the forest is broken occasionally by the flower-clusters of *Clerodendron buruanum* Miq. After two hours of marching we reach the foot of the low hill which we had observed from Casuarisnest, lying as a low projection in the vast sea of level primary forest (cf. *Fig. 13*). Before we ascend we hear the roar of the Doorman River on the far side. There the incline is steep, for the river has eroded the hill. Immediately after passing the slope we have to ford a muddy brook, after which follows a small stretch of level forest, next a steep point of land with scanty vegetation, and finally a deep clear tributary, the water of which is breast-high. We arrive at a great bare boulder-strewn bank covered only in the higher parts with *gelagah* [*Saccharum*] and *Coix Lacryma Jobi* L. It is a beautiful point. The river-bed is some hundred meters broad here; the water runs swiftly in the channel between the broad boulder-strewn banks. The larger islets in the channel are covered with high trees and shrubs and are fringed with reeds. Enormous tree-trunks are stranded on the gravel-banks, having been brought down by stream-freshets. Entirely stripped of bark, they now lie bleaching in the sun and thus offer a favorite sleeping-place for large monitor-lizards. Here I saw one about 7 dm. long, with serrated crests on the back. All these trees lie with the root-system, or what is left of it, pointing upstream.

In the background the mountain-slopes rise steeply; clouds envelop the higher parts. On the left bank of the river lies the long low gently rolling hilly ridge which Doorman crossed in 1914. His inland journey began on the bank opposite us. After crossing the marshes, he continued straight on toward the inland slopes, over the ridge, down again, and finally steeply upward. At about 1300 m. altitude we should find his trail and continue along it to the summit named for him. Our own route from here is obscure. We still have no evident objective toward which to proceed. However, a great landslip is a fixed point among the numerous ravines and ridges.

The Doorman River exhibits the same characters which distinguish so many New Guinean rivers. Glancing at the map, one sees a number of rivers on the south side of the mountains—as many in the plains as in the mountainous country—each indicated by a narrow line. On the other hand, very broad ones are shown at the foot of the hills, sometimes extending over rather great distances. The fact that the rivers form deep valleys in the soft mud of the alluvial plain as well as in the mountain-country, but not in the gravel-formation at the foot of the slopes, seems to me to be due to the relatively recent age of this range. In the older mountains the rivers have already broadened their valleys. In the mountains also the fall of the river is not great, the more or less broad terraces attesting to the deposition of finely divided materials, this being true also in the valleys. Here, however, we find narrow, deep, and very sheer ravines, characteristic of young mountain-ranges. On account of the gradient, the stream flows very rapidly, and in this phase large quantities of coarse material are immediately deposited at the end of a declivity, where the fall suddenly lessens. The speed of the current here is still too great for the deposition of silt, but as soon as the end of the gravel bank is reached the muddy plain begins and, in spite of its lessened current, the river once more carves its bed deep into the soft earth. The Doorman River in its course likewise shows these three phases. According to Doorman's report, its stretch from here to the mouth on the Idenburg River is similar even over a great distance.

The doctor, who came part-way up the river from Prauwen-bivak, verified this. Later we could see from Doormantop that the river, from the place where it leaves the hills and extends far to the north, repeatedly branches and develops a number of channels. From Doorman's report,⁷ it appears that he found deep marshes on the left bank, alternating with terraces almost without undergrowth and traversed by many small brooks. I cannot share the supposition of some members of the expedition. On the strength of the difference in size between the torrent-bed of the river, almost 400 m. broad at this place, and its narrow mouth (about 40 m.) where it joins the Idenburg, they thought that water must have been lost by flowing laterally into the marsh. Those who know the terrain will presently understand that this is not probable, for on the basis of a rough estimate of the flowage capacity, it will be seen that between the point of departure from the hills and the mouth on the Idenburg River no water can be lost. At low water-level the mouth is very deep. In spite of the great clearness of the water, one cannot see the bottom. With a primitive plumb made with the aid of fishing lines, I measured the depth; it appeared to be between 5 and 6 m. I estimated the rapidity of the current at 10–15 cm. per second. These figures give a volume of $0.15 \times 40 \times 5$ cu. m. = 30 cu. m. Later, at a similar water-level, I estimated the volume at Brug-bivak (240 m. alt.), entirely uninfluenced by the previous calculation, at $0.75 \times 35 \times 1$ cu. m. = 26 cu. m. Both values agree reasonably well, the difference coming within the margin of error. One of the causes for the hypothesis of lateral drainage is without doubt the fact that the cooler water of the Doorman River disappears almost immediately under the warmer water of the Idenburg River. As a result, the water of the tributary does not show clearly or can only be seen over a narrow strip.

After we have crossed the broad boulder-strewn bank and waded across one of the arms of the river, we enter a level area. The hills again recede and the river forms a number of terraces separated from each other by steep banks about 1 m. high. On account of their flatness, their hard gravelly earth, and their resulting scanty vegetation, they are easily passed. At this point Kremer-bivak was established by the first reconnaissance party, and was used by the downward transport as an intermediate camp, since it was two days' journey from Brug-bivak to Prauwen-bivak.

Under the light forest covering these terraces, whole fields of tall light green *Selaginella* form a beautiful undergrowth. To the right of us rushes the magnificent river, with its clear water undulating downward in a long frothing sequence. Shortly before we reach the second transient camp, the trail leads us under the crown of a solitary *Ficus* on the banks of a brook. The branches of this tree are festooned with a richly flowering specimen of a beautiful *Mucuna* (no. 1360) with large vermilion-orange flowers. A few hundred meters farther lies Aalscholver-bivak (Cormorant camp) on the last terrace below the point where the river leaves the steep hills. In the late afternoon, after having dined, we sit looking out over the river (*Fig. 14*), where the birds, from which the camp derives its name, are incessantly busy. They are entirely black and make the very same impression as the corresponding Dutch species. Repeatedly we see them sit on the water, float down with the stream, the head directed upstream and constantly looking around. Then suddenly they disappear under the water and after a time come up to fly immediately, skimming

⁷ J. W. Langeler & L. A. C. M. Doorman, *De Aarde en haar Volken* (1918), 186.

close above the water, the head somewhat low. Then the same game begins again. In the calm of twilight the large hornbills fly over in pairs with a creaking noise, and here the cockatoos may be seen at play in the trees where they sleep. At night a short but heavy rain falls; the next morning the river is turbid and somewhat swollen. At six-thirty we are already on our way. It is a short day's march over the hills to Brug-bivak. Here presently a better route is found. Originally the river-course was followed as closely as possible, although great difficulties were experienced on account of the unusually steep slopes. Later, the trail was projected over the practically level upper parts of the hills. At our departure we still follow a transition to the latter stage, for



FIG. 14. Doorman River at Aalscholver-bivak, looking downstream.

the trail many times crosses small ravines of manifestly very short and steep torrents, again evidence of the youthful age of this mountain-range. If one had not everywhere found basic eruptive rock-formations, one would be inclined to believe that these hills are an uplifted coral reef, so flat are their upper surfaces. Later, from the mountain-top, we could observe this particularly well.

The forest is dense here. An unusually large quantity of moss, growing on the ground and on the lower parts of tree-trunks, attracts attention, the altitude being about 350 m. With respect to this moss-flora, a singular phenomenon is that, in the lower mountain-region at about 800 m., it is found exclusively on broad level plateaus between ravines, whereas at higher altitudes the exposed ridges particularly show the heaviest growth. In the latter instance the moss-vegetation has developed much more heavily than in the first. I fail to find a

satisfactory explanation for this phenomenon. In the forest on the south side of the Central Mountain Range at 1000 m. altitude, Pulle⁸ mentions two types of vegetation: (1) tall trees with many ferns but few mosses and scanty undergrowth; (2) typical mossy forest with a very dense growth of moss covering the ground and the trunks and branches of the trees, as well as the undergrowth of many shrubs. The first type, according to Pulle, is on limestone, the second on sandstone; he says nothing about the topography of the terrain. While this explanation does not apply here because of the lack of sedimentary rock-formations, it seems to me that the topography is of decisive influence, both in the lower and in the higher mountain-forest.

After a steep descent we reach the graceful suspension bridge, over which we cross the river, where, on a small terrace, Brug-bivak is built some meters above the water-level. Immediately behind the camp the hills rise steeply. In the vicinity we see the high walls of a deeply cut ravine, where a beautiful mountain-stream, 30 to 35 m. wide, either flows smoothly against the slippery rocks, or hastens in waves along the banks strewn with large boulders, or finally, swiftly and silently flows along the small narrow terraces. We are here 16 km. distant in a straight line from Prauwen-bivak, and at an altitude of 240 m. (cf. Map B, Fragment I). I spent a full week in this locality on the banks of the roaring mountain-stream, which previously perhaps no human being other than the primitive Papuan had ever seen. It was the last opportunity, for a long time, to take advantage of the warm sunny lowland, before we commenced the cold and wretched period in the next camp, Goenoeng Boetak.

The slope of this ravine is heavily forested. From the camp one can see the white trunks of Leguminosae, with the branches frequently densely beset with Loranthaceae. *Artocarpus* is still found here. On the plateau of the left bank, as in so many places in this territory, the undergrowth is unusually rich in ferns: *Diplazium cordifolium* Bl., *D. Huttonii* Chr. (Arch.), *Dennstaedtia erythrorhachis* Diels (Phil., Celebes, N. Guin.), *Dictyopteris heterosora* Bedd. (Malacca), *Tapeinidium pinnatum* Chr. (Arch.—Polyn.), *Syngamma quinata* Carr. (Arch.—Polyn.), *Trichomanes millefolium* Pr. (S. As.—Polyn.), and *T. suffrutex* v.A.v.R.*, the last two with very dark green foliage. *Elatostema*, which elsewhere colors such large patches of ground light green, is here, as regards the number of individuals, only slightly represented. In addition to some terrestrial members, such as *E. Weinlandii* K. Schum. (end.), *E. Lamii* Hub. Winkl.*, and *E. frutescens* Hassk. (Java, Sumatra), I found a couple of climbing species and also the epiphytic tuber-bearing *E. Pellionianum* Gaudich. (E. Arch.). On the bank of a brook again I found *Microstylis Floscularia* J. J. Sm., growing by preference on mossy stones. Here too are a few species of *Ophiorrhiza*: *O. rivularis* Val.*, *O. doormanniensis* Val.*, and *O. torricellensis* Laut. (end.). Here grow the first specimens of the genus *Argostemma*, which is particularly well-represented in mountain-regions. These are small herbs with relatively large snow-white flowers. The undergrowth of shrubs is not exceptionally dense, but among the smaller forms the number of species is fairly large. *Cyrtandra* (no. 1345) and *Saurauia submodesta* Diels (no. 1346) are very plentiful. Among the smaller trees is the purple-flowered melastomataceous *Allomorpha parviflora* Mansf.* Among the hygrophilous epiphytes in the forest are the common *Asplenium cuneatum* Lamk. and *Medinilla Teysmanni* Miq. (Celebes, Phil., N. Guin.), with pale cream-colored flowers.

⁸ Maatsch. ter Bevoud. v. h. Natuurk. Onderz. d. Ned. Kol. Bull. no. 68 (1913), p. 34.

A long relatively broad stretch on the right bank of the river, a little upstream from the camp, gave me a good picture of the flora of beach-terraces. The stenophyllous *Ficus* is scattered everywhere, growing in the water amongst naked boulders inundated at high-water. Somewhat rare, but nowhere entirely absent, is a graceful tree-fern, *Alsophila glauca* J. Sm. (trop. As.), a robust plant attaining a height of 10 m., with a full crown and a trunk 25 cm. in diameter (measured with the old leaf-bases). Just as along the river-banks near Pionier-bivak, the forest-margins here also in a few places are adorned with the flaming red-purple inflorescences of *Schuurmansia*. For that matter, *Leea gracilis* Lauterb.* and some species of *Ficus* (nos. 1264, 1338) are common plants of the forest-margin. Here too the dark green frond of *Ophioglossum pendulum* L. hangs down from the tree-trunks over the water.

On the terraces themselves—which are arranged one above the other with an average difference in height of 1 m.—is the very large tree *Pometia pinnata* Forst. (Phil., Molucc.—Polyn.), which, as is frequently the case in this species, bears characteristic witches' brooms, these falling on the ground with the mature leaves, making positive identification possible. This species is discussed by Magnus⁹ as an example of "unbegrenztem Wachstum in einer Knospensvariation." A large number of the trees here are beset with Loranthaceae, the brittle stems of which, running along those of the host, everywhere send their haustoria into the nourishing wood. One of these is *Loranthus Lamii* Krause* with dark red flowers.

The undergrowth of the forest is rather dense but never troublesome. In addition to a species of *Breynia* (no. 1250), there is an abundance of common robust terrestrial ferns, such as *Diplazium polypodioides* Bk. (1.5 m. tall; S. E. As.—Austr.), *Nephrolepis hirsutula* Pr. (2 m. tall; pantrop.), and *Odontosoria decipiens* Chr. (3 m. tall; end.), which form dense thickets under which the ground is usually almost bare. Elsewhere are smaller species, such as *Trichomanes aphlebioides* Chr. (Molucc.—N. Guin.), which attracts attention on account of the dimorphism of its sterile and fertile fronds. Where the undergrowth is thinner, one finds the usual covering of *Elatostema* and *Selaginella*, the former represented here by *E. Weinlandii* K. Schum., *E. novoguineense* Warb., *E. minutiflorum* Hub. Winkl.*, the latter by *S. gracilis* Moore and *S. subtrisulcata* v.A.v.R. *Begonia* also is locally common; in one spot I found *B. bipinnatifida* J. J. Sm. (no. 1362) again, at another locality were other species (nos. 1369, 1390). In the forest on the banks I found, now partly suspended in the crown of *Phaleria papuana* Warb. (no. 1359), the same *Mucuna* (no. 1360) already observed at Aalscholver-bivak, forming, in the branches of the supporting tree, a small bower from the roof of which clusters of large bright brick-red-orange flowers hung down. Also I found here the first *Nepenthes*, apparently *N. maxima* Nees, as a forerunner of a genus which extends to the highest mountain-summits. One sees representatives of the mountain-flora, e. g. *Argostemma* and the epiphytic *Vaccinium tiariforme* J. J. Sm.*, more in evidence here than in the hilly terrain at Prauwen-bivak. In addition to the plants just named, one notes in the forest certain climbers, *Tetrastigma Lauterbachianum* Gilg (end., sensu ampl.), *Acalypha Hellwigii* Warb. (nos. 1381—2; end.), and the graceful *Lygodium Versteegii* Chr. (Phil., N. Guin.). Of the hygrophytic epiphytes, *Asplenium scandens* J. Sm. (E. Arch.—Polyn.), *Elatostema Pellionia-*

⁹ W. Magnus, Blätter mit unbegrenztem Wachstum in einer Knospensvariation von *Pometia pinnata* Forst.—Ann. Jard. Bot. Buitenz., Suppl. III, 2 (1910), p. 807.

num Gaudich. and *Medinilla Teysmanni* Miq. may be named, in addition to a number of species of *Pleopeltis*. Among the fungi growing on decaying wood, I mention *Polystictus incisus* Lloyd (Phil.), *P. Blumei* Lév., *P. xanthopus* Fr., and *Hexagonia tenuis* Hook. Here I found a *Cordiceps* (no. 1375) on a spider. Leaf-mosses (nos. 1268, 1270), liverworts (nos. 1300, 1304—5, 1400, 1404), and algae (nos. 1297, 1306, 1348) were collected for the sake of completeness.

In this forest I observed a peculiar pile of leaves at the base of a tree, it being about 1 meter square and 3 dm. high. On one side was an opening, the entrance to a passage about 75 cm. long. It looked very fresh, and the natives thought it was the work of wild pigs, prepared as a shelter for the night for their young.

The finest spots in this splendid ravine are the sunny boulder-strewn banks with their beautiful vegetation. In the vicinity of the bivouac, three of these are easily reached, and, notwithstanding their similarities, each has its own character. The most southerly one lies between the swift river and a steep hill. In the background a beautiful small tree, *Ficus* (no. 1380) shades a number of small pools. A patch of richly flowering *Begonia* (no. 1335) grows against the steep slope, down which the water continually trickles. In a small more level spot are a couple of species of *Impatiens* (nos. 1239, 1287). Both are robust plants more than 1 m. tall, with very large flowers about 6 cm. diameter, in one species brick-red, in the other a beautiful warm orange color. The terraces described above begin on the north side of this bank. The transition to forest is formed by a strip of tall-growing *gelagah* [*Saccharum*] and entangling ferns.

A second boulder-strewn bank lies immediately north of the bivouac. Here the river seethes against a smooth rock wall. The stenophyllous *Ficus* forms a cover close to the water; two species (nos. 1285, 1380) grow promiscuously. *Nephrolepis hirsutula* Pr. is plentiful higher up among the boulders. Wherever the ground rises, the vegetation is richer in species and denser. Grasses (nos. 1275, 1282, 1372—4, 1377, 1379, 1398) grow high amongst the rocks. There are a few Labiatae (nos. 1255, 1387), a couple of Acanthaceae, the usual *Hemigraphis reptans* T. Anders. (nos. 1243—4) and a *Lepidagathis* (no. 1262), and also one of the Scrophulariaceae (no. 1290). Taller shrubs and small trees are mingled with the vegetation, for example, *Oldenlandia Auricularia* F. v. Muell. (trop. As.—Austr.), *Breynia* (no. 1367), and *Leea gracilis* Lauterb.* Here occurs *Glochidion philippicum* Rob. (no. 1251; Arch.), striking on account of the singular fruits, with bright orange seeds, scattered along the outstretched branches. *Semecarpus laxiflorus* K. Schum., the more or less climbing rubiaceous *Mussaenda cylindrocarpa* Burck var. *leptosepala* Val.*, and *Morinda umbellata* L. (trop. As.—Austr.) var. *papuana* Val. occur closer to the slope. Against the damp slope *Begonia* (no. 1245) and *Impatiens* (no. 1389) attract attention because of their color. In the middle of the boulder-strewn bank, among low shrubs and tall grasses, a beautiful *Ixora* (no. 1249) blooms with an enormous profusion of flowers. This locality is unusually rich and colorful. The branches of a vigorous *Ficus* are literally covered with epiphytic ferns and Orchidaceae. Of the ferns I mention *Nephrolepis radicans* Kuhn, *Pleopeltis heraclea* v.A.v.R. (Arch.), *P. commutata* v.A.v.R. (Arch.), *P. accedens* Moore (Arch.—Polyn.), *Hymenolepis spicata* Pr. (Madag.—Polyn.), *Trichomanes humile* Forst. (Arch.—Polyn.), *Humata vestita* Moore (Arch.), *Arthropteris dolichopoda* v.A.v.R.*, *Antrophyum parvulum* Bl. (Arch.); and among the Orchidaceae (nos. 1260—1, 1265—6, 1298, 1307, 1315, 1347) *Podochilus imitans* Schlecht.,

Phreatia pisifera J. J. Sm., *Oberonia diura* Schlecht., *Bulbophyllum concolor* J. J. Sm., *B. nigrilabium* Schlecht., *B. aristilabre* J. J. Sm., *B. cochleoides* J. J. Sm., *B. serratulifolium* J. J. Sm., *Appendicula oxysepala* J. J. Sm., *A. Chalmersiana* F. v. Muell., *Dendrobium erectifolium* J. J. Sm., and *Coelogyne Beccarii* Rehb. f. In the grassland, among the trees giving only local shade, is the robust *Blumea sylvatica* DC. (no. 1294; Java, Phil.) and a *Rubus* (no. 1293) scrambling over the ferns. Two beautiful terrestrial orchids grow more in the shade: a white-flowered *Spathoglottis* (nos. 1277, 1395) and *Macodes Sanderiana* Rolfe, the latter having velvety leaves dark green above and dirty violet beneath, with salmon-colored nerves. This *Macodes*, like a few other terrestrial orchids (nos. 1303, 1385) such as *Cystorchis* (no. 1314), grows nearly in the closed forest. A strip of *Cordyline terminalis* Kunth forms the transition between the boulder-strewn bank and the hill-forest. Between the slope and the river, one finds a ground-cover community of terrestrial ferns and species of *Elatostema*. Among the latter, *E. Weinlandii* K. Schum. is dominant. This species, with *Selaginella subtrisulcata* v.A.v.R., forms an extensive vegetation on the shore-terrace along the boulder-strewn banks.

The third boulder-strewn bank lies on the other side of the river. Here the pattern is entirely different. Between the bank and the steep rocky slope lies a series of rather deep hemmed-in pools which were formed by the action of torrents. They are connected and show little decline in level, being fed by water filtering through under the boulders; they end in a deep bay draining into the river between huge boulders. The vegetation on the outside of the bank, along which the river rushes in a lengthy acceleration, consists of a thin stand of *gelagah* [*Saccharum*], in which are lodged scattering pieces of white-bleached driftwood. Areas never or only exceptionally flooded are covered with an assemblage of low grasses and herbs; higher up are the shrubs already mentioned above. In addition to the always present *Ficus*, there is a noteworthy *Boerlagiodendron* (no. 1319), which I found later on the return journey along brooks in the hills below Brug-bivak. It is a small shrub-like araliaceous plant with deeply incised palmate leaves. The most remarkable part of the plant is the inflorescence. Each of the rays of the umbel bears three secondary axes, the middle and shortest one with sterile flowers, the longer lateral ones with fertile flowers. The sterile flowers develop rapidly maturing false fruits. These false fruits are fleshy and translucent and resemble the fertile fruits, which later develop from the perfect flowers. Beccari¹⁰ reports that, in one species of this genus, fertilization and distribution of the plant is fostered by birds, which by the beating of their wings when eating the sterile fruits scatter the pollen of the higher-placed fertile flowers and thereby accomplish their fertilization. I have not been able to verify these observations. However, I noted other phases and jotted down the following:

First phase: young inflorescence entirely green and surrounded by green bracts.

Second phase: the lateral inflorescences with perfect flowers still surrounded by bracts extend above the sterile cluster, the flower-buds being bright rose-orange in color.

Third phase: the buds of the fertile flowers are evident. They are every-

¹⁰ O. Beccari, Malesia I (1877), p. 194.—See also J. G. Boerlage, Ann. du Jard. Bot. Buitenz. VI (1887), p. 101, 112, pl. XIII–XV, and H. Harms in Engler & Prantl, Nat. Pfl. Fam. III (1898), p. 8, 31, 32.

where darker rose-orange than the sterile ones and also show darker longitudinal stripes; the sterile flowers begin to form the globose, smooth, and dark red "fruits."

Fourth phase: the "sterile fruits" approach maturity in pairs with the development of wrinkles and minute warts on the surface; they are now dark purple-red; the fertile flowers are open.

Fifth phase: all pseudo-fruits are wrinkled and ripe, outside very dark purple, the flesh yellow; the fertilization of the perfect flowers has taken place in this phase, and already the small dark red fruits are beginning to form.

Sixth phase: the pseudo-fruits have fallen or have been eaten; the fruits of the perfect flowers are ripe; they remain, however, smooth and unwrinkled; their color is red, sometimes somewhat greenish.

Material was collected of all these phases.

A small community of *Equisetum debile* Roxb. (trop. As.—Polyn.) mixed with *Kyllinga brevifolia* Rottb. (pantrop.; no. 1406) occurs close to the small pools back of the boulder-bank. The steep slope rising behind the pools is flecked with white because of the enlarged calyx-lobes of *Mussaenda*, the white undersurface of leaves of *Maoutia ambigua* Wedd. (Celebes, Molucc., N. Guin.), the white and purple flowers of *Clerodendron buruanum* Miq. var. *Versteegii* Bakh., and the white inflorescence of *Conocephalus amboinensis* Warb. (Molucc., N. Guin.). The undergrowth consists of an entangled community of the beautiful *Gleichenia Warburgii* Chr. (E. Arch.), which separates the forest and the pools by a broad association; meanwhile the shore on the side of the boulder-strewn bank is beset with the ubiquitous stenophyllous *Ficus*, which stretches its long horizontal branches some meters out over the water.

The memories which I treasure of this camp are the most agreeable of the entire expedition. Here, in these virgin surroundings with the fresh clear mountain-stream, was a veritable breathing space, as much from the point of view of bathing as from that of drinking, in contrast with our experiences in the lowland camps. Sometimes I felt myself as one who, after a lapse of many thousands of years, once again glimpses the world and its inhabitants after the deluge. Then to his amazement he becomes conscious that he is apparently recalling his own primitive condition and can sympathize with roving prehistoric man. "*The sleeper awakes*"; the modern man finds himself again in the primary forest, but notwithstanding his present-day conveniences and the influences of his culture, he finds it again as he left it: as something that has remained lovely and almost indispensable to him.

The mornings are spent rambling in the vicinity. At noon I label the collection. The only inconvenience which I experience is caused by a large stinging fly, which easily bores through my puttees. A bath, frequently the second of the day, follows the work. Afterwards, toward twilight, I sit with the camp-commander, a European sergeant, on the bench of rough timber on the shore, the sergeant telling me numerous Atjeh stories, sounding a bit like good old Amsterdam tales, as we witness the fall of evening, the swift rise of darker shadows over the high walls of the ravine. After darkness is complete we return to reality. During the evening entries are made in the diary, records are filled in, and sometimes negatives are developed. On such evenings it is late before I seek my mattress next to the mantri's sleeping place.

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With the first transport arriving after I have come, the zoologist appears, in a downpour of rain, and covered with leeches which have to be removed even from the eyes and mouth with tweezers. After a day of rest, our journey together begins on September 28. The first day is easy. After we leave the ravine, we are again on one of the plains or gently sloping plateaus. A couple of times the ravines of smaller streams have to be crossed; after that we follow a broad generally rising ridge, from which we can occasionally see something of the Meervlakte through the trees. In this section is an area where the ground is covered with many large boulders; perhaps this is the foot of the great landslide which we saw from the Doorman River. For the time being the character of the forest remains the same. There is little undergrowth; large areas are almost without shrubs, the undergrowth consisting of scattered or more or less associated communities of *Elatostema*, *Selaginella*, and *Begonia*. The forest is high and, to judge from the flowers lying on the ground, it consists of practically the same species as are found in the hilly terrain near Prauwen-bivak. *Dimorphanthera tridens* J. J. Sm. (no. 976),¹¹ with dark red flowers, found in the neighborhood of Prauwen-bivak, appears to be very plentiful here. On a brook-bank I note *Tecomanthe dendrophila* K. Schum. (end.), already collected at Pionier-bivak; it is a bignoniaceous plant with large clusters of lilac and red bell-shaped flowers. At about 500 m. I find acorns (the only time I have found them) lying on the ground. Next is a rather deep and very wet ravine; finally we reach the brook on which Steen-bivak (425 m.) or Bivak Batoe is located somewhat lower down. Its name is derived from a couple of gigantic conglomerate blocks of several hundred cu. m. each, which apparently crashed down from above. There is a narrow and deep passage between them, which ends in a very small cave inhabited by swallows and bats. Plant-growth occurs only on the less steep upper and farther sides; the side towards the brook is perpendicular or even overhanging, thus forming a good protection and making bivouac-building for the convicts superfluous. Like practically all mountain-brooks at this altitude, this one is exceptionally pretty; the clear water flows over broad smoothly worn rocks from pool to pool. Here is a small waterfall, there the boulder-bed is broad and divided into various channels now separating, then again uniting, and meanwhile forming beautiful islets covered with vegetation. Here again is the stenophyllous *Ficus*. On a branch overhanging the water is the beautiful *Rhododendron Vonroemeri* Koord. (apparently identical with *R. Macgregoriae* F. v. Muell.), with large pale orange flowers. On the surface of a small plateau above the camp, the moss-growth is very heavy. The mossy ground is strewn with the small *Medinilla auriculata* Lauterb. (end.), with lilac flowers, and another species of the genus with white flowers (no. 1409). Both grow as epiphytes in the moss on the lower parts of tree-trunks. Here for the first time we become acquainted with a phenomenon that is very common in higher mountain-regions, in that terrestrial plants climb high in the moss along the trees: a beginning of the intermingling of ecological groups in the mountain-forest (Fig. 15). *Lindsaya trichophylla* Copel. (end.) is plentiful on this plateau.

The journey on the following day soon brings us out of the ravine, and via a narrow little ridge to one of the plateaus. Here it is almost level; the ground is soggy and densely covered with moss, the cover otherwise consisting of different plants usually found in damp places. Among these is a very common *Cyperus*

¹¹ Cf. Fragment IV.

(related to *C. alternifolius* L.), taller than a man. In addition, there are various terrestrial ferns and some terrestrial orchids. The tall white-flowered *Calanthe leucoseptrum* Schlecht. var. *bisubulifera* J. J. Sm. is a very common orchid here. A species of *Nepenthes* is exceptionally abundant; a very large number of young plants lie with their small spherical pitchers flat on the ground; the older ones climb.

On the other side of this plateau lies a steep ravine with deep canyons, of which there are so many in this part of the world. From an altitude of about 550 m. we have to descend 150 m. From afar we hear the roar of the river and, by repeated reverberation against the walls of the ravine, the sound produces the illusion of a much mightier stream than really is found. Partly by way of a precipitous brook we reach the bottom of the valley and find there a beautiful broad and deep mountain-stream, too deep and too swift for fording. Across the stream, above a waterfall about a meter high, lies a giant tree-trunk lodged between two projecting rocks, high above the present water-level. Although this slippery bridge is not particularly easy, nevertheless it offers a welcome means for crossing and we make use of it, some erect, most, however, sitting astride the log; the latter method is more practical than dignified. On the other side, located on a small level terrace, is the camp which Captain van Arkel used for some time as a supply-depot, but which is now forsaken. The chasm is again scaled on the other side; once up, the slope is less steep, and gradually we go higher. Here the forest has regained its customary appearance: tall tree-trunks, scanty undergrowth, a few lianas and climbers. The moss covering is heavier and there is a rich low flora on the more level plateaus which is not found on the slopes. At about 700 m., among other trees, I see a giant *Pandanus*, the crown alone 10 m. high, the aerial roots developed from the trunk at 25 to 30 m. above the ground.

Once in a while there is an indistinct view, now to the north, then again toward the south, as we ascend a ridge running about east and west, which will bring us toward the ridge properly named Doormantop (cf. *Fig. 13*, left of 2). Following the gradual slope part of the way, we continue along steep slopes over all kinds of dead wood and fallen trees. Here are various specimens of *Angiopteris crinita* Chr. var. *intramarginalis* v.A.v.R.*, with the frond-segments dull white beneath. Shortly after, we cross a clear brook, on the banks of which are specimens of the large-flowered *Impatiens* common at Brug-bivak. The same species also occurs on the banks of a larger stream which we crossed earlier. We are here at about 800 m. altitude. After passing this brook we work our way along a muddy and deep trail, suddenly finding ourselves again amongst thick moss-cushions as we continue upward toward a narrow ridge. Clearly, here we are beyond the critical altitude which forms the boundary between the region of mossy plateaus and exposed mossy ridges. Here we find a superabundance of thick moss-cushions on the trunks and branches. Quickly passing along this ridge, we come to Cruciferen-bivak (840 m.). It is located on a broader part, where the forest immediately resumes its usual appearance. While waiting for the carriers, there is an opportunity to examine the surroundings. In the immediate neighborhood of the huts is a group of *Balanophora* (no. 1425), apparently *B. Oosterzeeana* Val., described from the Arfak Mountains, and nearly related to the Javanese *B. elongata* Bl. The frequently branched brown rhizomes, attached at random to the smaller roots of trees, are covered with star-shaped minute excrescences. The inflorescence

develops on these rootstocks as small spherical outgrowths which, in continued growth, burst open. The inflorescence, surrounded by light yellow bracts, projects through the gradually enlarging slit; when full-grown, the flowering heads are supported on thick yellow stalks surrounded at the base by the weakening bracts. The two sexes occur here in about equal number. It is useful to mention this, since in some known species staminate individuals are either strongly in the minority or even at times entirely lacking. Just as in many other obligate parasites (and saprophytes also), the vegetative parts are strongly reduced. The bracts, rootstock, and stem are here limited to rudiments.

In addition to *Elatostema* and many species of *Trichomanes*, specimens of *Argostemma* are collected; the last is apparently the same species, *A. nanum* Val. (no. 1415),¹² as was found at Brug-bivak. Higher up this species is replaced by another. *Cardamine africana* L. (1417, trop. Afr., As.—Japan) is the plant from which the bivouac derives its name. This species reminds one of the true mountain-flora, and during the expedition I found it as a representative of the original flora. This small white-flowered plant stands on the bank of a small watercourse under the broad arching fronds of *Angiopteris crinita* Chr. and the large stems of Zingiberaceae (nos. 1418, 1420). The brook-water has a temperature of 20° C. Representing the flora of the lower regions, the orange-flowered *Mucuna* grows here, and also the epiphytic *Rhododendron Vonroemeri* Koord. of Steen-bivak. A less agreeable reminder of these stretches are the stinging flies, which flit buzzing about, but which, like the numerous small mosquitoes, disappear at twilight. With a number of beautiful diurnal butterflies, these form the most striking part of the animal-life at this place. At night a dull roar, which apparently must be attributed to frogs, sounds through the forest.

The following morning it rains steadily, making our departure more disagreeable than it otherwise would have been. An hour after leaving, however, it begins to clear. During this time the aspect of the forest has not changed. On the inland journey we find it bleak and shivery; but even now I clearly recall what a warm and tropically luxuriant impression this forest made on us when, two months after our sojourn in the mountains, we swiftly descended from the misty woods into this typical forest of the lower hilly areas. On this day I wrote in my diary: "The path is steep. After we leave the lateral ridge, suddenly the mossy forest ends and immediately we find ourselves in an area where the vegetation, the odors, the bird-songs, and the temperature are strongly suggestive of those of the lowland. The route looks as though it were unusually easy; I had entirely forgotten such possibilities, having become so accustomed to the acrobatic turns of the trail and to the rock-formations. What appeared to us as difficult of ascent was now even more difficult, but the end was like a path through a park." Presently the trail changes again for the worse. Suddenly, perhaps at an elevation of 1000 to 1100 m., we note a short steep incline. Yet, before we have scaled it, we are surprised to observe unusually strong light in the forest, giving us the impression of approaching an established clearing or camp, or the site of a recent landslide. We have, however, ascended a narrow and steep ridge (cf. *Fig. 13*, near 2); on the other side it is still more precipitous, and suddenly again we are in a typical mossy forest. The crooked

¹² In "Nova Guinea" XIV, 2 (1927), 249, the altitude of this specimen is not given; 3810 m. is the earlier assumed altitude of Doormantop.

gnarled trees are only 15 to 20 m. in height; dense mossy cushions cover the ground, trunks, and branches. A representative of the genus *Kentia* rises everywhere above the forest, the beautiful crowns of this palm being borne on slender trunks. The path follows the narrow ridge and is deeply covered with the soft moss. After a short time we pass a landslip extending down the south slope and permitting a tolerable outlook on the high ridges running from Doormantop towards the northeast. The summit itself is not visible from here, but the slopes of the 3820 m. peak and the vast heavily forested ravines between lie before us in all their details. The highest point is obscured by haze. Far below us we hear the sound of an invisible stream, one of the sources of the Doorman River (cf. Map B, Fragment I). Everywhere is the undulating forest which extends to the highest ridges as far as we can see.

On this ridge I find the first conifer (*Fig. 19*) other than *Agathis* and *Podocarpus*, which occur at lower altitudes. It is a *Dacrydium* (no. 2159), which seems to be rather common. Immediately a large number of species appear for the first time; a true mountain-flora in which there is place for only a few representatives of the lowland vegetation. One of these is *Dictyophora phalloidea* Desv., which I have not observed higher than this altitude (1350 m.). Everywhere the forest is lower and not so dense, on the ridge the trees being only 8 to 10 m. tall. On the north side we hear the murmur of the river far below. We pass the point where the old Doorman trail rises steeply from the ravine as a faint but unmistakable path, and also a couple of small peaks on the ridge. Again we descend. At the margin of the large long ridge sloping from Doormantop 10 km. toward the plain, we reach the bivouac located on a broader plateau. In the terminology of the expedition, the camp is known as Bivak Goenoeng Boetak, although the name (bare mountain) properly applies to Doormantop. The summit regained its rightful name, I think, from the second expedition (Kremer Expedition), and also from the natives. At this place, on the very sheer northern slope, a beautiful outlook over the Meervlakte had been opened without much difficulty. I spent about three weeks at this locality in two intervals (September 30–October 10; October 30–November 7, 1920).

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It would be difficult to imagine a more melancholy and wretched locality than that of Goenoeng Boetak-bivak. Nowhere on the rough northern slope of the Central Mountain Range is the climate so unfavorable as at this elevation. In spite of the prevailing dry season, a day here without rain is an exception; in addition it is always misty in the morning, and sometimes at noon and at night. One can see, from the meteorological data in Fragment II, that the relative humidity in the forest is almost uninterruptedly 100%, and that the air-temperature ranges between 16° and 20° C. These two factors in particular—and frequently a strong wind on the forest roof—dominate the vegetation-picture on this part of the slope. Suddenly the picture changes entirely to that which we discussed above for the lowland rain-forest. The damp atmosphere still hampers evaporation; but this factor is of varying strength and influence in different parts of the forest. The principal element, however, is the temperature, which here is 8° lower than in the plain, and clearly acts as a limiting factor. In nature, one recognizes a number of such limiting factors. One is the acid reaction of the water in high fens, another is the small quantity

of water in sandy soil, or a surplus of water in the fens (Meervlakte), or the salt content of the terrain. It may be said that all, not present in optimum proportions, and, to a certain degree, depending on their absence, act as limiting factors. Moreover, when one speaks of optimum relations, one must bear in mind that each species with respect to each factor may have a specific optimum. These ecological problems, of course, are far from simple, and we cannot do more than indicate roughly some lines embodying our ideas about the living conditions of this mountain-flora. In general, therefore, we can accept the fact that the lower temperature, as compared with that of the lowland, here acts as such a limiting factor for a large number of species. The species that can no longer compete with forms better adapted to this factor are no longer found. In this connection I wish to recall Shibata's investigations,¹³ where he demonstrated for a definite species that a low temperature can hinder the development of fruit. Besides, there are a number of accompanying factors which influence the vegetation and the flora, such as:

(a) The exposure of the vegetation to the frequently strong wind, such exposure depending on the contour, the steepness of the slopes, and the width and direction of the ridges. This factor is associated in a vicious circle with that of temperature. The last favors a less dense and lower forest, and in this the vegetation is at the same time more exposed to the desiccating action of the wind, which intensifies the influence of the temperature.

(b) The steepness of the slopes and the nature of the soil as factors which determine the speed of water-drainage.

(c) The diminished air-pressure, through which both day and night stronger radiation results. The temperature extremes therefore are wider. This factor is still of little significance here, and then only for strongly exposed positions.

That these factors strongly dominate the appearance of the vegetation seems to be clear in the vicinity of this bivouac (*Fig. 16, A*), which is located on a broad less exposed swampy plateau, whereas the narrow ridge, with its precipitous slopes, is very much exposed. Where inclines ascend gradually, the transition from rain-forest to mossy forest corresponds. There is, however, a relatively low critical height, above which a strong change in the topography can bring about a sudden difference in the form of the vegetation. Just as it is improbable that the typical lowland-forest can ascend beyond a certain altitude even though the terrain be favorable, so also it is unlikely that the mountain-forest can extend to lower altitudes under these same conditions. We shall note below that the same is true in regard to the forest-limits generally, and that this proposition applies to all vegetative zones between the coast and the mountain-summits. Nevertheless, independent of the contour of the country, above an altitude of 1200 or 1300 m. one finds another unmistakable different vegetative and floral picture. Furthermore, the principal cause of this change in the appearance and the composition of the forest is the temperature. At this altitude one no longer encounters the majesty characteristic of the lowland individual trees. Other favoring factors are good soil and abundant water-supply. Yet, low temperature can be a real limiting factor impeding, in part or entirely, the favorable influence of other factors and making the ground physiologically both dry and sterile, because the low temperature prevents the plant from carrying out its vital functions as vigorously as in the lowland.

¹³ K. Shibata, *Biol. Centr. Bl.* XXII (1902), 705.

And on the other hand, it appears that nature has supplied mountain-plants with a power of resistance in like circumstances; nevertheless, the first actual result is the disappearance of a large number of species; the second, the appearance of a number of typical mountain-plants adapted to the factors above mentioned. Something of the general appearance of the lowland-vegetation persists only in xerophytes (epiphytes) now becoming a characteristic part of the entire flora—at first scarcely noticeable, later, constantly more clear and more evident.

Before we pass on to a closer discussion of the vegetation and flora of the region of Goenoeng Boetak, to conclude these observations and for the sake of curiosity I recall the opinion of the founder of modern plant-geography, Alexander von Humboldt. In one of his excellent works¹⁴ this traveller has compared an ideal conical mountain in the tropics, not only as to vegetation but also as regards the flora,¹⁵ with a hemisphere of the earth. He imagined that on such a mountain one finds substantially the same plant-zones—and he portrayed it with a sharpness which could only be derived from the vegetation-zones in high European mountains—as when one journeys from the equator towards the poles. He carried this comparison so far that he even wrote:¹⁶ “500 hexapoda” (i. e., almost 1000 m. altitude) “respondent 9° 30' latitudinis vel 50 hexapoda fere 1° latitudinis.” According to this concept the poles, in the field of plant-geography, should correspond to a mountain peak about 8800 m. high at the equator, a mountain therefore about as high as Mount Everest. Von Humboldt's opinion possessed the charm of simplicity and is easily grasped. As an original idea, it loses nothing in value, although we now know that plant-geography is much more complicated than he assumed to be the case. Besides, there is a basis of truth in the thought. In both cases we find the tropical rain-forest at the base, and also in the tropics somewhat higher up a forest poor in species, still higher the conifer forest and the “krüppel” vegetation, and finally the subalpine and the alpine (resp. arctic) flora, often with genera represented in the tropics which have their chief development in temperate regions. Finally both are crowned by a cap of perpetual snow and glaciers. However, von Humboldt saw a most important difference between the hemisphere and the tropical mountain because of the influence of seasons in the first. Because of the seasons, at greater altitudes constantly greater differences arise in the extremes of both the length and the temperature of day and night. One important point that von Humboldt did not consider is genetic plant-geography, which can better be discussed when more is known about the geological history of the earth. It needs no further demonstration that, when reviewed in detail, comparisons of a mountain-flora in the tropics and the flora of the temperate regions scarcely hold in some points. Even of the areas above the limits of the tropical forest, which are frequently spoken of as heaths, this comparison does not hold.

I have inserted these considerations here, since, in the vicinity of Goenoeng Boetak-bivak, for the first time we encounter a vegetation and flora entirely different from that which we have described for the tropical lowland. From

¹⁴ A. von Humboldt, *De Distributione geographica Plantarum secundum Coeli Temperiem et Alitudinem Montium, Prolegomena* (Lutetiae Parisiorum, 1817), 86 et seq., 142 et seq.

¹⁵ “In universum easdem tribus abundare reperies in summis montibus zonae aequinoctialis quas polum versus in zona frigida” (l. c. 143).

¹⁶ l. c. 87.

now on we shall see the differences in a constantly increasing degree, and I have tried roughly to indicate some of these changes in a schematic representation (*Fig. 15*). I have tried to show how the xerophytic epiphytes and hygrophytes, at first separate in the mesophytic forest, gradually approach each other; further, how the hygrophytes at higher altitudes withdraw into the moss and at the same time ascend into the trees, the forest continually becoming more open, while the xerophytic epiphytes descend therein, until both groups slowly mingle, and then the hygrophytes occur in crowns of the trees and the xerophytes on the ground; finally how the last, in the absence of trees, adopt the ground as a

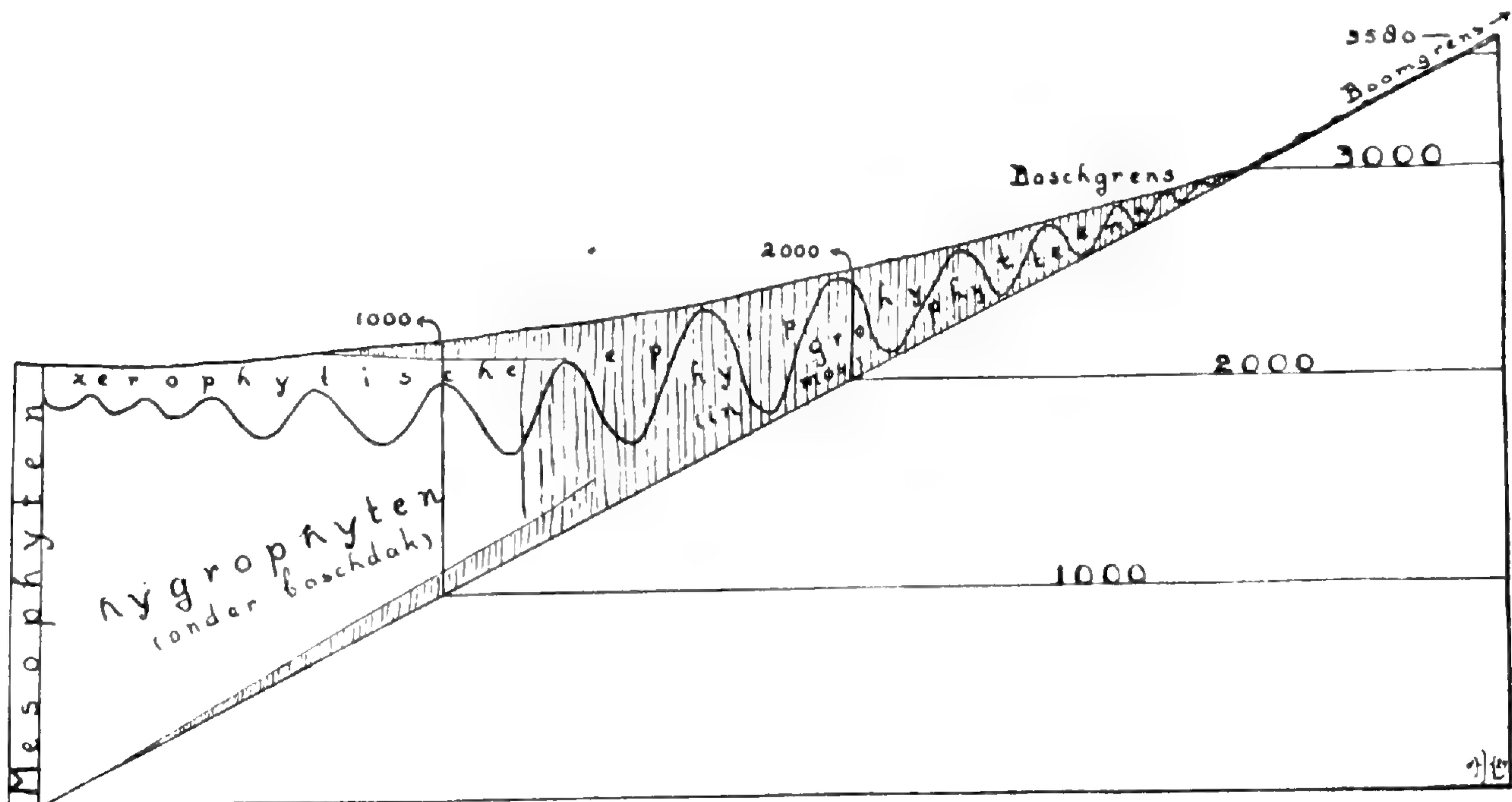


FIG. 15. Schematic representation of the vegetation at various altitudes on slowly and gradually rising terrain; on open ridges the vegetation extends lower, and in sheltered ravines higher than is indicated; the hatching is the moss-covering. Boschgrens = forest-limit; boomgrens = tree-limit; onder boschdak = under forest-roof.

habitat and mingle with typical terrestrial plants. To conclude, the associated plants tend to form separate "islands" in places where external conditions change; still higher the "islands" consist of only a few plants or even of one individual, until snow and ice make existence impossible.

We now return to the flora of this midmountain slope. One of the most striking phenomena is, as already noted, the enormous moss-covering (*Fig. 16, A, a and d, B*). Not only is the ground, particularly on the narrow ridges, covered with a thick layer, but also the lower parts of tree-trunks are concealed, while the branches bear isolated cushions frequently of large size. The thickness of the moss-layer is dependent on various factors, the principal ones being the quantity of light and the possibility of rapid water-drainage. On steep slopes where relatively much light penetrates and the rainfall is not retarded from sinking into the earth; the moss on the ground is several decimeters thick. On tree-trunks an important factor, next to the diameter of the trunk, is the adhesion of the moss-layer to it and the mutual cohesion of the moss-plants. Only the outermost layer of such coverings is living moss (*Fig. 16, B, 1*); the remainder (*id.*, 2) consisting of a more or less decayed mass which serves exclusively to absorb water. During sustained drought—often a full 24 hours—the outer layer dries out a little so that the perpetual drip stops temporarily.

but the total capacity scarcely lessens thereby. As soon as the mists again appear, the water uptake increases and the drip begins again. On dry days after travelling through the forest one is wet to the skin, since each time one grasps a slender tree trunk for support, one is showered by the drip. Furthermore, on ridges without running water, when one is forced to bivouac this water can be utilized and in a number of instances such water was gratefully used.

This growth of mosses (nos. 1452-3, 1455-7, 1462-6, 1468, 1491, 1553-4, 1579, 1897) brings out some points worth mentioning. In the first place plants, essentially terrestrial, ascend along the trunks, so that they may be compared with pseudo-epiphytes such as are found in the humus-covered crowns of the Dutch pollard-willows. Moreover, such a moss-layer is a world in itself. In addition to the living moss-layer and the plants subsisting here on a convenient substratum (*Fig. 16, B, a, b*), a number of lower forms of animal life are also found, such as protozoans and crustaceans, the presence of the latter surely being related to the large quantity of *Utricularia* (*Fig. 16, B, c*) growing in the outer layer. As regards living conditions in such a habitat, as expected, the temperature appeared wholly to agree with that of the atmosphere. While the temperature of the air in the shade on a sunny morning was 20.5° C., I found that of the moss on the ground at 5 cm. deep 18.7°, at 20 cm. 18.4°, and at 30 cm. also 18.4°. The moss-layer on the trees showed a like temperature. One may well accept the idea that the temperature of the inside layer of this great water reservoir is very constant and about the same as the average local annual temperature. The minimum temperature, on the basis of our observations (see Fragment II, Table I), was 15.8° (6 A. M.), the maximum 20.5° (twice observed, at 11 A. M. and 11:30 A. M.), the temperature of the brook was 17.4°, and the average of 29 recordings taken between 6 A. M. and 6 P. M. was 18.3°, which agrees very well with the values found for the innermost moss-layers.

We have seen that the terrestrial flora extends partly up the tree-trunks, whereas the epiphytes increase their downward distribution. Both circumstances result from the fact that the forest is more open, and the factors of the plant-climate on the ground and in the tree-tops are much less divergent than is the case in the rain-forest. The forest-roof is not continuous, at least on steep slopes and exposed ridges, so that hygrophytes find no protection except within the moss-covering. All (Hymenophyllaceae, *Fig. 16, B, a*; *Utricularia*, *Fig. 16, B, c*) grow entirely within the limits of the moss-layer; only the spore-bearing fronds or the flowers protrude.

Now that we have given a general idea of the ecological relationships of this region, we shall observe the composition of the flora (*Fig. 16, A*) more closely. Under the higher trees is the myrtaceous *Mearnsia ramiflora* Diels (end.), which immediately attracts attention with its dark red inflorescences. *Symplocos atrata* Brand* belongs in this same category (*Fig. 16, A, b*), as does *Castanea* (or a related genus), and lastly the palm above mentioned as a *Kentia* (no. 1065; *Fig. 16, A, c*), which everywhere projects above the forest, dominating entire slopes with its profile. It is a beautiful slender tree—I measured one trunk as 22 m. tall without the crown—which strongly suggests the royal palm (*Oreodoxa regia* H. B. K.) but is less vigorous. It is doubtless a representative of the Arecineae, but I was unable with the makeshifts at my disposal to determine even the genus of this palm. Without hesitation the natives with the expedition called it *niboeng*. In the western part of the Archipelago this is the

common name for *Oncosperma filamentosa* Bl., a thorny stooling species of palm which occurs particularly back of the mangroves. In the Moluccas, however, this name is applied, usually with some modification, to a number of palms belonging to different but related genera, yet none to forms representing the same genus as this species; one can find these names (*niboeng, merah, n. ketijl*, and such) in Heyne.¹⁷ Recently, however, Beccari, in one of Lauterbach's "Beitrage zur Flora Papuasiens," described a new *Kentia*, *K. Ledermanniana* Becc.,¹⁸ of which the collector, Ledermann, says that this "Nipunpalme" is a "Charakterpalme des Bergwaldes." The description of the habitat (Hunstein Spitze, 1300 m.) agrees so well with that of my plant that I unhesitatingly sup-

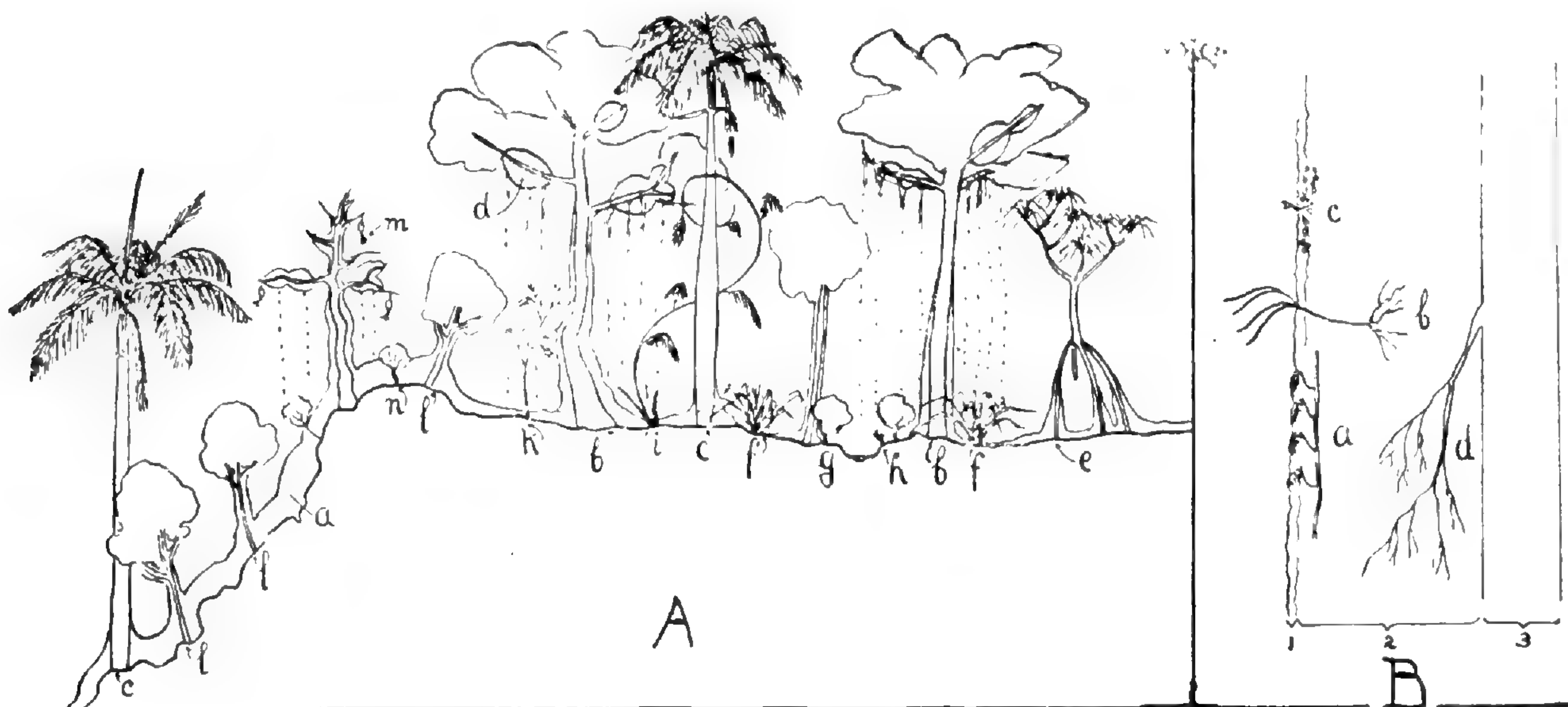


FIG. 16. A. Schematic section through the region at Goenoeng Boetak-bivak, 1420 m.; explanation of the letters in the text. B. Schematic longitudinal section through a trunk covered with moss; 1 = living moss-layer; 2 = dead moss-layer; 3 = tree-trunk; a = Hymenophyllaceae; b = *Psilotum complanatum* Sw.; c = *Utricularia* (nos. 1489, 1557); d = root of the host-trunk in the moss.

pose that my palm will be found to belong to the genus *Kentia*. I observed this species from 100 m. (Prauven-bivak, hilly terrain) to about 1800 m. altitude, with the most pronounced frequency, however, between 1100 and 1500 m.

Under the smaller trees (Fig. 16, A, I), particularly in the undergrowth of the forest on the broader plateau, everywhere low species of *Pandanus* (Fig. 16, A, e, f) occupy considerable place. They are very common in marshy places and there most of them are stemless, and on account of their numbers they often form disagreeable hindrances in the woods. Other plants here are *Elaeocarpus Lamii* O. C. Schm.*, *Symplocos atrata* Brand,* *Xanthomyrtus bryophila* Diels,* *Phaleria Wichmanni* Val. (nos. 1507, 1889; end.), *Schizomeria Pulleana* O. C. Schm.*, *Linociera rupicola* v. Lingelsh.*, *Timonius glaberrimus* Val.*, *T. avenis* Val. (end.), and representatives of the genera *Ardisia* (no. 1563), *Actinodaphne* (no. 1504), *Macaranga* (no. 1502), *Weinmannia* (no. 1574), and further a couple of Rosaceae (no. 1506) and Theaceae (no. 1512), all trees or tree-like shrubs 4–15 m. high. On the marshy plateau back of the bivouac are *Pandanus*, a couple of species of rattan (Fig. 16, A, i), and, particularly characteristic, a very fine half-climbing bamboo (no. 2150) (Fig. 16, A, k). The last two

¹⁷ K. Heyne, De Nuttige Planten v. Ned.-Indië, 2nd ed. (1927), 391, 396.

¹⁸ Engler's Bot. Jahrb. 58 (1923), 442.

have stems only a few millimeters thick. The delicate green stems and leaves of the bamboo fill all the interstices in the undergrowth. Locally a couple of Zingiberaceae (nos. 1444, 1548) are common. Naturally all kinds of ferns are numerous and are present in all sizes: small dark green species of *Trichomanes* and *Hymenophyllum*, such as *T. pseudo-arbuscula* v.A.v.R.*, *T. meifolium* Bory (Masc.—Polyn.), *H. subfirmum* v.A.v.R.*, *H. ellipticosorum* v.A.v.R.*, *H. nutantifolium* v.A.v.R.*, all except *T. meifolium* being mostly concealed in the moss-cushions; furthermore, small forms such as *Pleopeltis obolophylla* v.A.v.R.* and many other species of this richly variable genus are found. Other terrestrial ferns are *Taenitis blechnoides* Sw. (trop. As.—Polyn.), *Tapeinidium stenocarpum* v.A.v.R.*, *Dryopteris rigidifolia* v.A.v.R.*, and *Cyathea perpeltigera* v.A.v.R.*, the last a small dense and compact tree-fern with a trunk about 0.5 m. high. A tree-fern of unusually large size is *Alsophila melanocaulos* v.A.v.R.*. Among the shrubs are many striking Rubiaceae, and of these *Psychotria* is especially well represented: *P. longirostra* Val.*, *P. multicostata* Val.*, and *P. multinervia* Val. (end.). Other Rubiaceae are *Amaracarpus biformis* Val.*, *Oldenlandia Schlechteri* Val. var. *acuminata* Val. (end.), and *Ophiorrhiza doormanniensis* Val.* Here also occur *Maoutia gracilis* Hub. Winkl.*, *Rapanea affinis* Mez (no. 1525; Arch., Phil.), the rutaceous *Lamiofrutex papuanus* Lauterb.*, *Ilex* (no. 1522), and *Libocedrus* (no. 2162); this place is about the lowest limit for this coniferous genus.

Among the clinging plants the Araceae, which are so strongly dominant as coverings of tree-trunks below, are practically wanting here. They are superseded by species of the genus *Freycinetia* (no. 1847), which occur in large numbers. To these may be added a few small species of *Elatostema*, such as *E. Doormannianum* Hub. Winkl.*, which ascend slender mossless trunks; also the climbing rubiaceous *Lucinaea acutifolia* Val.* In this forest there are a large number of hemi-parasites belonging to the Loranthaceae. I found three new species, *Elytranthe leucophloea* Krause*, *Loranthus gigantifolius* Krause*, and *L. cercidioides* Krause*. The last is the most striking of these, with large more or less fleshy orbicular sessile leaves, and with the small bluish waxy flowers arranged in short 3-flowered heads. Herbs, as well as climbers, are few, a result of the dense moss-covering on the ground and trunks. Here and there the white star-flowers of *Argostemma Lamii* Val.* are conspicuous; occasionally amongst the yellow-green and golden-brown moss the pink flowers of *Begonia* (nos. 1500, 1842) are on display. On the banks of small streams and watercourses the blue *Dianella carinata* Hall. f. (end.) is common.

The epiphytes in the more closed forest, at least on the lower parts of trunks, likewise are few. Here and there *Psilotum complanatum* Sw. (pantrop. and subtrop.) grows in the moss (Fig. 16, B, b). The *Utricularia* (nos. 1489, 1557), living in enormous numbers in the outer moss-layer, is nearly related to *U. orbiculata* Wall. (S. E. As.—N. Guin.). It is an extremely small plant, which in spite of its frequency escaped my attention for a long time. It has white sparsely branching stems, fine as cobwebs, creeping through the outer layer of moss; the orbicular small green leaves, averaging hardly 0.5 mm. in diameter, are perceptible to the naked eye, as are also the very small transparent bladders scattered along the stems. Of the millions of little plants which grow here together, I found only a few in flower. The slender inflorescence-stalk protrudes a few centimeters out of the moss and bears one or two relatively large white or pale purple flowers. The micro-fauna and -flora enticed into the

tiny bladders would be a most worthy study, and perhaps whoever investigates this material, which is preserved in alcohol, with the help of specialists, may communicate further details. In addition to protozoans and spermatozooids of mosses and ferns, probably a few Crustaceae,¹⁹ living in the moss, may serve as food for the *Utricularia*.

Among the fungi which occur in this forest, the first to be mentioned is a horse-hair mold (no. 1490; *Marasmius*, perhaps *M. equicrinus* F. v. Muell.).²⁰ As on many other islands of the Archipelago, here also this fungus grows in great quantity in the undergrowth. It consists of long firm flexible threads, which are shining black and very similar to horsehairs. They extend over large interstices from branch to branch or from leaf to leaf, to which they are fastened with small flat suction-disks. Now they are entangled and branched, and again one notes long unbranched sections. It is only seldom that one observes small fruiting bodies on the threads. They are saprophytes living on dead material. Naturally there are other fungi here (nos. 1459, 1490, 1886-7, 1894-6), and also a few lichens (nos. 1580, 1898).

The open ridges, with their extensive sunny areas, show again an entirely different picture. Indeed the ligneous flora—I found among the trees the rutaceous *Terminthodia orbiculata* Markgr.*—here is about like that of the plateau. Already the forest is lower and less dense, but the terrestrial flora and the epiphytes are much more strongly developed in the more intense light. On the ground a singular small melastomataceous plant (nos. 1533, 1907; *Fig. 16, A, n*) is exceptionally common. I found only a single flowering specimen with few flowers, from which the family was easily recognizable. The small leaves of this plant are not more than a few millimeters long, narrowly spatulate, with an abrupt acuminate apex. In this terrain the Ericaceae first appear—small shrubs—among others species of *Vaccinium* (*V. igneum* J. J. Sm.*, *V. brevipedunculatum* J. J. Sm.*, *V. convallariiflorum* J. J. Sm.*, and no. 1899), *Rhododendron Pulleanum* Koord. (no. 1445), and *R. subulosum* J. J. Sm.* (no. 1906), the latter, like the rosaceous *Pygeum* (no. 1446), growing both in the moss on the ground and in that on the trunks and branches, and frequently showy because of the bright red flowers. Here are many kinds of shrubs such as *Elaeocarpus Lamii* O. C. Schm.*, *Drimys hatamensis* Becc. (end.), *Symplocos atrata* Brand*, and *S. trifurceps* Brand*; likewise species of *Levieria* (no. 1535) and *Psychotria* (*P. brevirostra* Val., end.), and the first young specimens of *Libocedrus* (no. 2162), which higher up becomes very common. The most striking thing about this vegetation, however, is the thick tangled masses of *Gleichenia*, of *Lycopodium cernuum* L. (trop. except Afr.), and of the semi-scandent bamboo. *Nepenthes* is abundant here, represented by two species, the common *N. maxima* Nees (Borneo—N. Guin.) and the new *N. paniculata* Dans.* Not only mature climbing plants are everywhere but also the rosettes of young plants, with their large pitchers resting on the moss. Here and there an asclepiadaceous plant climbs; and in the shade, on a mossless spot, a small cluster of *Balanophora* plants (probably *B. Oosterzeeana* Val., no. 1537) stand together. In many places we find climbing Melastomataceae (nos. 1443, 1558) and a *Rubus* (no. 1585). *Medinilla monantha* Merr. (Phil.) var. *papuana* Mansf.* is fairly common. One representative of the Araceae, the clinging

¹⁹ Cf. R. Menzel, Over mos bewonende Cyclopiden en Harpacticiden, enz.—Handel. Derde Ned. Ind. Natuurwetensch. Congres (Buitenzorg 1924), p. 298.

²⁰ Cf. Petch, Horse Hair Blights, Ann. Royal Bot. Gard. Peradenya, VI, 1 (1915), p. 43, pls.

Pothos cuspidatus v.A.v.R.*, with light green spadix and dark purple-brown spathe, occurs here. There are beautiful colors on the trunks due to the fiery red inflorescences of *Trichosporum Horsfieldii* O. Ktze. (no. 1540) and the softer red flowers of a species of *Riedelia* amongst the moss-cushions. Here are a large number of ferns, particularly among the epiphytes. However, terrestrial ferns are not lacking. The practically exclusive *Gleichenia* occupies the sunny spots, but under the trees are *Marattia rigida* v.A.v.R.*, with fronds 2 m. long and having four pairs of pinnae, and the common *Dipteris conjugata* Reinw. (trop. As.—Polyn.), the latter particularly characteristic of somewhat sunny margins. In many places *Trichomanes Roemerianum* Rst. (end.) occurs, and also the easily recognizable *Oleandra cuspidata* Bak. (end.), which immediately attracts attention, the narrow fronds festooning the stiff upright stalks which spring from the rootstock advancing under the moss on the ground and tree-trunks. The number of epiphytic ferns and Orchidaceae is almost countless, and not all the species occurring here can be mentioned. There are numerous species of *Polypodium* and *Pleopeltis*, among which are small forms such as *Polypodium pyxidiforme* v.A.v.R., *P. mesocarpum* v.A.v.R.*, *P. inconstans* v.A.v.R.*, *P. reductum* v.A.v.R.*, and *Pleopeltis remigera* Ridl. Moreover, *Scleroglossum pusillum* (Bl.) v.A.v.R. (trop. As.—Austr.) and *Lomaria acutiuscula* v.A.v.R.* grow here. Among the Orchidaceae there are a number of species with delicate flowers; the genus *Dendrobium*, so rich in forms, is important here, and in the higher mountain regions it continues to be prominent. I find here *D. monogrammoides* J. J. Sm., *D. remotisepalum* J. J. Sm., *D. convexipes* J. J. Sm., *D. sacculiferum* J. J. Sm. with beautiful dark red flowers, *D. centrale* J. J. Sm., *D. polyschistum* Schlecht., and *D. furcillatum* J. J. Sm. Of the other orchidaceous genera, I mention *Agrostophyllum fibrosum* J. J. Sm., *A. lamellatum* J. J. Sm., and *A. [glossorhyncha] galanthiflora* J. J. Sm., the last showing a strong resemblance to the snowdrop (*Galanthus nivalis* L.); *Bulbophyllum navigioliferum* J. J. Sm., *B. flavicolor* J. J. Sm., *B. quadrifalculatum* J. J. Sm., *B. muricatum* J. J. Sm. var. *sublaeve* J. J. Sm., *B. lonchophyllum* Schlecht., and *B. calceolabium* J. J. Sm.; *Glomera rhombea* J. J. Sm., *Ceratostylis muscicola* J. J. Sm., *Microtatorchis podochiloides* J. J. Sm. and *M. triloba* J. J. Sm. with orange-colored flowers; and lastly *Taeniophyllum stipulaceum* J. J. Sm. Usually a growth of liverworts (nos. 1460–1, 1883) covers bare spots on damp rock-walls.

Lastly among the epiphytes are a few noteworthy myrmecophilous plants belonging to the genera *Myrmecodia* (nos. 1517, 1536; Fig. 16 A, m) and *Hydnophytum* (nos. 1475, *H. vacciniifolium* Val.*, and 1516). I have amply discussed and illustrated these four species elsewhere,²¹ so that I shall only indicate them here with a reference to the article in question. The two species of *Myrmecodia* are particularly abundant here. Probably they occur everywhere in the region between 300 and 1600 m., but nowhere have I seen them in such large quantities as in the neighborhood of Goenoeng Boetak-bivak. One of the most striking peculiarities of all four species is the fact that they hang from the branches of trees. Only the very young plants are sessile. As soon as the wood begins to develop in the thickened stem, the main root elongates, and one sees the mature plant hanging sometimes 0.5 m. or more from the branches. In the literature I found a similar habit mentioned only once: this in the report of the

²¹ H. J. Lam, Vegetationsbilder aus dem Innern von Neu-Guinea, Myrmekophyten und Insektivoren—H. Schenck und G. Karsten, Vegetationsbilder, Reihe XV, Heft 7 (Jena 1924).

First Lorentz Expedition, where a similar species of *Myrmecodia* is mentioned as occurring on the south side of the mountains at an elevation of 2320 m.²² Whereas *Myrmecodia* appears to prefer the more exposed habitats and therefore is most striking along steep slopes, both species of *Hydnophytum* (particularly no. 1475) remain within the closed forest, where they grow on the lower branches.

I shall omit discussion of the somber climate. It is an evident fact that this region is extremely poor in animal life. Also, the natives never seem to visit it; we saw no trace of a Papuan path at any point, and later we concluded that probably this slope never had been used as a connecting route between the interior populated mountain-valley and the Meervlakte. Possibly the native trail may be along a river, perhaps the Swart River. As to animal life, the larger birds of warm regions do not come here. For many which feed on insects, the scarcity of the latter may be one of the reasons for the absence of these birds. In any case, the typical New Guinean bird-sounds of the plain are lacking here: the scream of the cockatoos, the creaking wing-beat and the hoarse cry of the hornbills, the clear call of birds of paradise, and the dull somber cooing of the large pigeons. The crown-pigeons do not occur here. We are unable to establish with certainty whether the cassowary is still present. Their tracks are never seen and the call is never heard. One of the zoologist's assistants thought he had seen indication of its presence in the neighborhood of the Goenoeng Boetak-bivak, and later, as the natives of the Swart Valley had rather large quantities of cassowary feathers, one might assume that this bird still lives here. It is also possible that it, like a number of other animals and plants, does not ascend so high on this inclement slope but it may occur in the sheltered valleys in the interior, where we heard birds of paradise up to 1300 m. In the literature two instances were mentioned giving 1000 m. as the highest elevation for the occurrence of the cassowary. Ogilvie Grant²³ says that *Casuaris claudii* is still found at this altitude in southern New Guinea, and Stresemann²⁴ reports that the genus reaches the same height in Seran. Smaller birds are still numerous here; among these are king-fishers and species of *Dicaeum*, which eat the fruits of species of *Myrmecodia* and *Loranthus*, thus spreading the seeds. Among the largest birds regularly seen here are a few cinnamon-colored pigeons and a much-variegated parakeet, *Eos fuscata*. According to van Heurn's statement,²⁵ this species lives in the region between 1000 and 2000 m. altitude. Another parakeet, *Chalcopsittacus duivenbodii*, assembles in huge flocks in the Meervlakte, and in the afternoon they fly over with loud screeching. I have mentioned in a previous fragment (Fragment IV) that we observed them also at Prauwen-bivak. Lastly, the large *Microglossus aterrimus* is worthy of notice; it is a robust black parrot with heavy-framed head and beak, bare flesh-colored cheeks, and a beautiful crest.

Small marsupials are fairly plentiful. Repeatedly we could recognize the pungent odor of the opossum, *Phascogale*, and once we caught a *Dasyurus* in a snare. The mammals are represented by rats, which are very numerous. Here there are almost no mosquitoes and leeches, but frogs, like the abundant

²² Maatsch. t. Bevorder, v. h. Natuurk. Onderz. d. Ned. Kol. Bull. no. 56 (1907) p. 11.

²³ The Ibis, Suppl. 1915, p. 326; also in Report Wollaston Exped. Dutch New Guinea, 1916, 233.

²⁴ Novitates Zool. XXI (1914), 35.

²⁵ W. C. van Heurn, De Expeditie 1920—21 naar Nieuw-Guinee—Feestnummer v. d. "Club van Nederlandsche Vogelkundigen" (Sept. 1921).

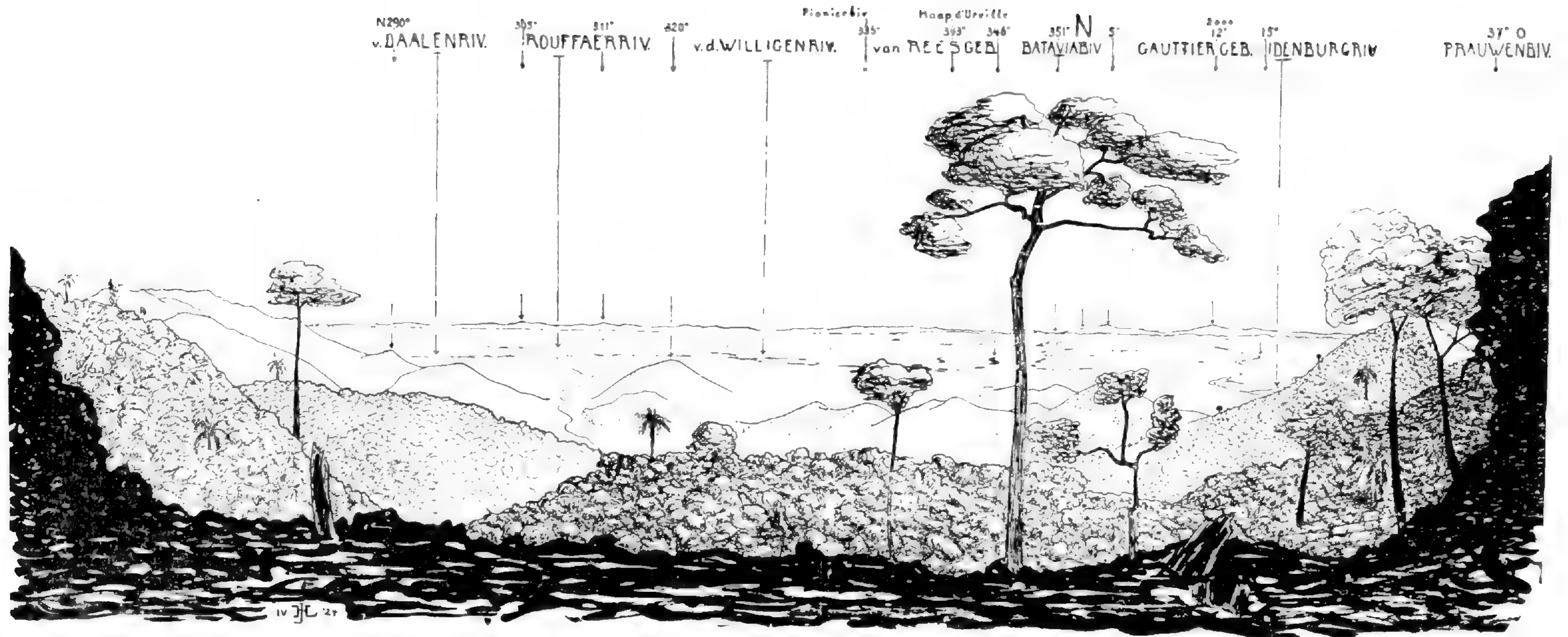


FIG. 17. Panoramic sketch of the view from Goenoeng Boetak-bivak toward the north (Meervlakte); on the slopes in the foreground relatively too few *Kentia* palms are illustrated.

New Guinean ferns and orchids, are numerous, at least if one judges by the noisy concerts they favored us with each evening. It appears that most of these are tree-frogs, the sound that they produce being a quivering whistle.

How wretched and gloomy the perpetual fogs and rains are! Sometimes in the early morning and the late afternoon we had a compensating outlook (*Fig. 17*) over the wide Meervlakte. At such moments I hurried to the edge of the plateau to complete bit by bit the panorama here sketched. This was prepared at the cost of much time. During a great many mornings a low and vast cloud always covered the plain. Shortly after sunrise this cover rose and, joining the clouds, contracted, and immediately the plain was clear, the mountains still being wrapped in fog. Then we caught a glimpse of the silvery sparkling rivers, but a moment later the mists surrounded us, and the view vanished for the day.

The bivouac itself was one of the worst of the expedition, low, with a muddy floor, poorly constructed, and incompletely closed. Here we suffered more from the cold and wet than was good for us. On October 10 the Dyak transport, which was planned to continue directly to the Swart Valley, arrived unexpectedly. It was the first time that Dyaks had served as carriers on the overland journey. It was a comfort to see these continually cheerful men again after many weeks of association with convicts and soldiers. The latter were always strangers to the environment, not to mention other less agreeable characteristics. The Dyaks, however, are at home in the forest; their bearing is that of true dwellers in the wilderness, and they fit as harmoniously with the New Guinean landscape as with the New Guinean rivers. Contr. Jongejans, Dr. Bijlmer, and First Lieut. Droog came with the transport from the detachment at Radio-bivak. In the day of rest following their arrival, the Dyaks erected sacrificial offerings, eagerly sought for food in the forest, and also assisted in improving the huts, but the soldiers, who had nothing to do, remained idle. Then an egg brought from Borneo was placed on a four-pronged stick, and the mountain-spirit was appeased by the pronouncing of a long formula, in order that the entire journey should be successful. October 12 we departed; only the zoologist remained here. In Fragment I, I have already mentioned that I twice made the journey from Goenoeng Boetak-bivak to Doormantop because circumstances permitted. For the sake of continuity I shall combine the observations of both trips in the following.

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After the departure from Goenoeng Boetak-bivak, the trail lies over marshy ground covered with low *Pandanus* part-way across the broad plateau mentioned above, then upward along the bed of a small stream that plunges down at the side of the bivouac. Gradually the slope becomes steeper, finally ending in an almost perpendicular cliff a few meters high, the muddy and mossy trail bringing us to another plateau. Here the trail is level again and is deeply covered with a thick layer of moss; it has become a passage through the more than man-high vegetation of *Gleichenia* and *Dipteris conjugata* Reinw. Here, too, the terrain is marshy, but the aspect of the vegetation is not less attractive, with the globose plump moss-cushions, the many entangled ferns, the profuse semi-scandent bamboo with its slender green foliage, and everywhere a scattering of colorful melastomataceous flowers. The climbing *Medinilla* has white

flowers and orange-colored fruits, while on the ground are small Melastomataceae (nos. 1533, 1907). This vicinity is permeated with the sharp odor of *Phascogale*, and even beyond the plateau I once saw a track which I could attribute with some certainty to that of a tree-kangaroo (*Dendrolagus*).

With the attaining of this plateau we have arrived at the extensive ridge which rises from the plain to Doormantop. On the west side we now look down into the luxuriant ravine which extends from the summit (*Fig. 18*), of which we here have a view through the trees. We slowly ascend, partly following the margin through somewhat denser forest, with *Pandanus* everywhere abundant, until we stand before a rather large counter slope (*Fig. 13* at 2). At this point we find the remains of one of Doorman's overnight camps, a dismal collection overgrown with moss, consisting of partly rotted and collapsed poles so far destroyed that it gives us little knowledge of how Doorman and his men

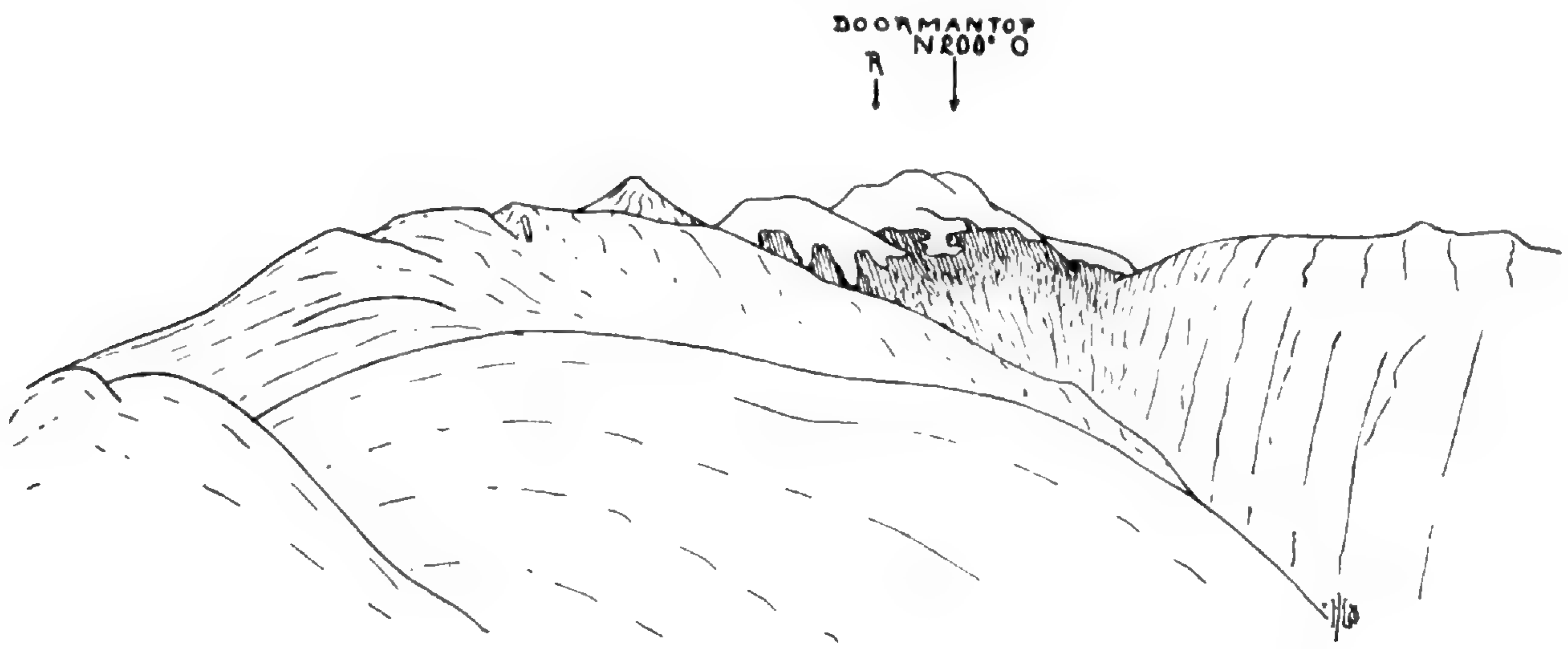


FIG. 18. Doormantop seen from a point on the ridge at 1550 m.; the irregular shaded line is the forest-limit; the white part is above the forest-limit; R = Radio-plateau.

spent the night here September 7, 1914. In the relatively low undergrowth of this denser forest lay the rusty oil-tins. The often-repeated story of the difficulties or impossibilities of finding a predecessor's camp after the lapse of a short period, because of quick tropical growth, is mostly a myth and applies only to tropical lowland and then only to open secondary growth on the terrain. In the dense rain-forest, bivouac sites, even in the lowland, are evident after some years, provided that the forest-roof is left undamaged. But if this is not the case, the practised eye can define the limits of the old camp by the locally more robust undergrowth of unmistakable type, and in the mountain-forest, where growth is certainly slower, the same holds true for even longer time. As far as the margin of the forest we see the trail blazed by Doorman, the thin trunks ending abruptly. Constantly, under the moss-covering, we find the smoothly chopped-off surface of branch-ends.

A rather steep and very muddy downward slope follows for a few hundred meters and then the terrain rises again. The ridge is now broad and the forest again high. It is the forest-type which has gradually developed from the rain-forest to a misty forest. The transition from the thinly covered narrow ridges is so striking that we, having forgotten somewhat the true rain-forest type, have difficulty at first in recognizing this as a true misty forest. However, more precise observation indicates very quickly that this 30–35 m. high forest, with

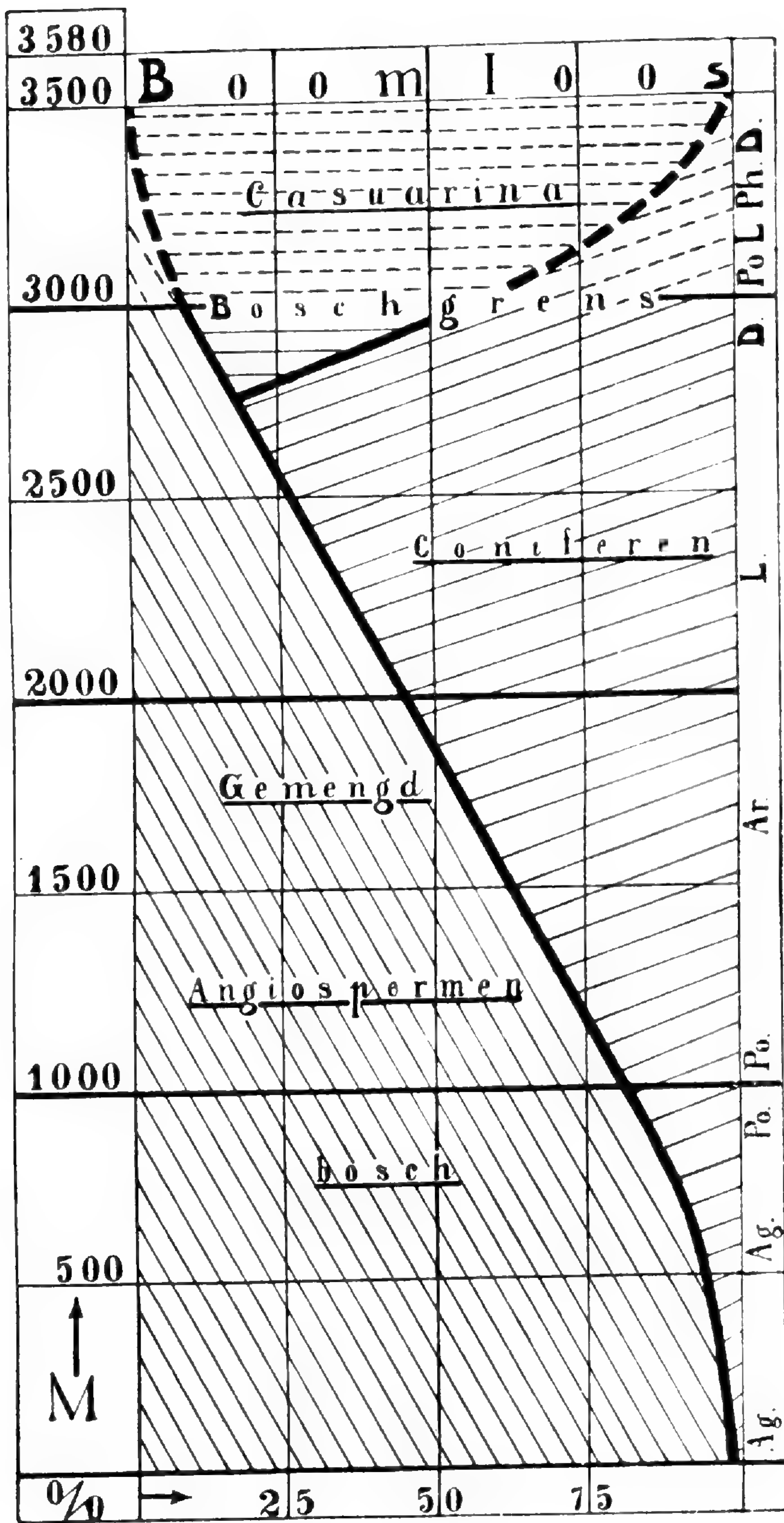


FIG. 19. Schematic representation of the percentage composition of the forest according to the number of individuals; Ag = *Agathis alba* Foxw.; Ar = *Araucaria*; D = *Dacrydium*; L = *Libocedrus*; Ph = *Phyllocladus*; Po = *Podocarpus*; boomloos = treeless; boschgrens = forest-limit; gemengd = miscellaneous.

its very slender straight trunks thickly covered with *Freycinetia*, ferns, and mosses, is indeed a true misty forest. With the gradual slope before us and with the width of the ridge, we shall not find again the subalpine forest-type characteristic of the narrow ridges at Goenoeng Boetak-bivak below an altitude of 2600 to 2700 m. The flora here indicates more clearly than the general type of the vegetation that we are in the misty forest. With almost each hundred meters' elevation one can observe distinct modifications, and already the vegetation at 1400 m. on narrow ridges and at 2700 m. on broader ridges is practically alike in general aspect, but the composition of the flora is entirely different. At every turn we see persisting species; every moment new forms appear. Thus the genus *Kentia* rapidly disappears, whereas the Coniferae increase (cf. Fig. 19). Everywhere one finds young plants of beautiful *Libocedrus* in the undergrowth and older specimens can frequently be recognized. At about 1700 m. I saw a *Podocarpus*, perhaps *P. costalis* Prsl. (no. 2163; Phil.). Somewhat lower, I still found fruits of *Castanea* or a related genus. Almost at the same altitude is the boundary between two species of *Argostemma*, which perhaps are vicarious. *Argostemma nanum* Val. is found in the lower hill-forest, 400–1000 m., and *A. Lamii* Val.* in the lower part of the misty forest, 1000–1700 m.; these suddenly disappear at the last elevation and are superseded by *A. montis Doormanni* Val.*, which ascends to ± 2500 m. The latter—a common fact with increasing altitude—has larger or relatively larger flowers than either of the other species, and immediately appears in abundance. The species of this genus are attractive plants with large white flowers and fresh green foliage. The buds and newly opened flowers are pendent. During the development of the fruit they slowly begin to straighten, so that the fully ripe fleshy but firm fruits are erect.

At 1750 m. altitude the terrain is somewhat more level. Again there is an abundance of *Pandanus*. This genus seems to be exceptionally well-represented in New Guinea. In some regions one might even speak of *Pandanus* forests, because they predominate in the undergrowth. Pulle²⁵ repeatedly emphasizes this in describing the southern slope of the mountains.

In this vicinity, on a flat section close to the ridge, the First Parkieten-bivak is established. This day's march is very short, since running water is available within a quarter of an hour's walk. For a regular party consisting of a fairly large number of men, the presence of water is a *conditio sine qua non*; water from moss is sufficient only for small patrols. The next brook is at 2430 m. elevation, and the distance to that place for heavily loaded ascending carriers is too long for a single day's march. Moreover, the space available naturally plays a part when it is a question of accommodating a large number of men.

Noons it rained; this saved us trips to the running water, but kept us under cover and in the mist. Evenings we heard the calls of the common whistling frog and a deeper sound sometimes dropping a half-tone, which we likewise attributed to a frog. Also in the twilight we heard the same cicada with which we had become acquainted at a previous camp. As it grew darker, we repeatedly heard the flocks of screaming parakeets fly over on their homeward journey from the Meervlakte. They do not come much higher than this. This camp received its name from them. The Second Parkieten-bivak lies on the south slope from Doormantop, in the Dika Valley, where we observed the same phenomenon.

²⁵ Maatsch. t. Bevorder. v. h. Natuurk. Onderz. d. Ned. Kol. Bull. no. 68 (1913), 34.

On a moonless night, in the complete darkness, I saw luminous spots everywhere in the forest. It is a singular sensation to see great phosphorescent places which seem so level and so tangible, whereas the following morning the forest-floor is observed to be so irregular and uneven as well as covered with great quantities of debris. It is difficult to describe this beautiful and fantastic light. Probably it was produced by the mycelia of fungi.

In the course of the night the rain stopped. The second day's march in this section carried us back toward the ridge. Steeper parts alternated with more level places and the forest-type remained almost the same. Some places were very mossy, others much less so; the causes of these differences were not clear to me. Gradually, however, the vegetation took on the facies of the mountain-forest. Long untidy strands of moss were everywhere pendulous from trunks and branches. Incessantly the water dripped from the wet moss and, although the sun appeared, nevertheless the continuous drip in such a forest made a disconsolate impression.

At about 1900 m. altitude I saw the first specimen of the giant *Myrmecodia* (no. 1804) which occurred in such enormous numbers above the forest-limits. Here its huge tubers stood upright on an almost horizontal branch of a tall tree. Also in this vicinity I saw a couple of beautiful epiphytic species of *Dendrobium*, one with orange and yellow (no. 1820), the other with pretty purple flowers (no. 1834); the latter strongly recalled the Javanese *D. Hasseltii* Lindl. Another orchid found here is *Aglossorhyncha biflora* J. J. Sm.

About an hour after our departure we stood at the base of a very sheer slope. Here for the first time we actually became acquainted with what the geologist, who also knew the terrain on the southern slope of the mountains, called a most wretched trail even for New Guinea. One had to take high steps leading from one trunk or root concealed under the moss to another. Brushing against and sliding along moss-cushions filled with water-like wet sponges soon resulted in our being soaked to the skin. The terrain was full of unexpected dangers: rotten small trunks thickly covered with moss and apparently sound, but snapping off at the slightest touch; deep crevices and holes among sharp rocks under a blanketing layer of moss. At few places on the entire slope did I see as much moss as here. It was a golden carpet covering everything as snow covers the Alps. Halfway up, at about 2100 m. elevation, we had an outlook on the Meervlakte; through the branches we saw the silvery sparkle of the river, and for the first time we saw the hill behind which was Prauwen-bivak: the 1050 m. peak sloping toward the west into a series of lower peaks, among them the Casuarisnest.

Above, on the incline, the trail was somewhat better. Slippery slanting tree-trunks without lateral branches lying over deep holes with a chaos of plant-debris, the bottoms invisible, were the most disagreeable spots. After marching three and one-half hours we reached Beek-bivak (cf. Map B, Fragment I) at an altitude of 2430 m. On my second journey I stayed four days at this camp collecting in the vicinity.

I never have seen such an extraordinary wealth of ferns, both species and individuals, crowded together as here. Schlechter²⁷ rightly testified of New Guinea: "Es gibt wohl wenig Gebiete auf der Erde in welchen die Farne eine derartige Entwicklung erfahren haben, wie in Neu-Guinea und wohl nirgends treffen wir eine solche Fülle von Arten an, als dort." Schumann & Lauter-

²⁷ Engler's Bot. Jahrb. XLIX (1913), 1.

bach²⁸ in 1901 enumerated about 250 species; in 1921, according to Brause,²⁹ the number had increased to 509 (of which not less than 351 were endemic), and one can accept the fact that the species at present known are far more than 600. The total number of fern-species in New Guinea is difficult to estimate, but might certainly be placed at more than 1000. In 1917, Copeland recorded³⁰ 697 species of ferns for Borneo, which was, he thought about 60% of the number actually growing there. Borneo is much better known than New Guinea.

Immediately there is a great diversity to be found on the ground. In addition to the always present species of *Trichomanes*, such as *T. pallidum* Bl. (S. E. As.—Polyn.), with fronds silvery gray on the lower surface, and *T. meifolium* Bory (Mascarenes, Arch.—Polyn.), one finds *Tapeinidium obtusatum* v.A.v.R.* and the small tree-fern *Cyathea perpeltigera* v.A.v.R.*, here with a trunk 2.5 m. long. The most noteworthy of the terrestrial ferns at this altitude, however, is *Gleichenia ornamentalis* Rst. (end.) var. *lanuginosa* v.A.v.R.* The rootstocks of this plant creep forward at a depth of some decimeters under the thick network of roots of trees and shrubs, and I obtained a few small pieces only with much difficulty. From these rootstocks the brittle shining dark brown or almost black rhachises grow at regular intervals; they are erect, less than a centimeter thick, and up to 3.5 m. long, bearing at their apices the graceful multi-dichotomously branched fronds.

There are also a number of climbing and semi-scandent species of ferns. Close behind the hut, the protruding root-system of a fallen forest-giant was covered with light green fern-vegetation consisting of two species, which, with long flexible stems, had grown together; both have very fine pale green foliage: *Gleichenia pseudoscandens* v.A.v.R.* and *Paesia Lamiana* v.A.v.R.* Trunks of trees, their thin foliage permitting the transmission of an abundance of light in sunny weather, are thickly covered with clinging ferns. *Oleandra Whitmeei* Bak. (Celebes, Phil., N. Guin., Samoa) is unusually common; everywhere the long narrow fronds of this species protrude beyond the tangle of other ferns and mosses (nos. 1931, 1954–8, 1980, 1982, 1993–4), and at first glance whole trunks seem to be covered with only this species. A typical plant of the same habitat is *Dryopteris pseudoparasitica* v.A.v.R.*, the rootstock of which grows forward along the host-trunk, dying away behind as quickly as it grows forward. This phenomenon is very common in ferns but seldom so strongly pronounced as here. Among the epiphytes again are species of *Polypodium*, namely *P. gracillimum* Copel. (Arch., Phil.), *P. Yoderi* Copel. (Phil., N. Guin.), *P. verrucosum* v.A.v.R. (end.), and *P. pyxidiforme* v.A.v.R. (end.). The smallest forms are found in the genus *Pleopeltis*, such as *P. remigera* Ridl. (end.) and *P. linearis* Moore (trop. As., Afr., Polyn.). Epiphytic also are representatives of the genera *Lindsaya*, *Hymenophyllum*, and *Asplenium*.

I began the description of the flora of this territory with the ferns, since they dominate the vegetative picture in such an important measure, but the flora of the higher plants is not less interesting. Of the lower trees in the undergrowth, one might mention a *Gynotroches* (no. 1970), belonging to the Rhizophoraceae, with greenish flowers and black-purple fruits. One of the Saxi-

²⁸ Flora der Deutschen Schutzgebiete in der Südsee.

²⁹ Engler's Bot. Jahrb. LVI (1921); 24.

³⁰ See Merrill, Bibliographic Enumeration of Bornean Plants—Journ. Roy. Asiat. Soc., Straits Branch, Extra Nr. (Sept. 1921), 7.

fragaceae reaches greater dimensions—*Quintinia* aff. *altigena* Schlecht. (end.) is 20 m. tall. Further, the rutaceous *Acronychia emarginata* Lauterb. (end.) and the myrtaceous *Syzygium adelphicum* Diels* belong to this category. Among the taller trees, the Coniferae (cf. Fig. 19), such as *Libocedrus*, *Dacrydium* (no. 2152-3), and *Phyllocladus* (no. 1984), are preponderant, these also appearing in juvenile forms in the undergrowth.

One of the shrubs of this forest is a representative of the peculiar magnoliaceous genus *Drimys*, known from South America, Australia, and Polynesia. It is recognized by the absence of true vessels in the wood, and it resembles the Coniferae in the possession of pitted tracheids which serve exclusively for water-transport. Here is *D. Lamii* Diels*, a widely branched shrub with white flowers; above the forest limit we shall meet still another species of this genus. *Antholoma papuana* O. C. Schm.* was a pleasant discovery. It is a vigorous shrub up to 4 m. tall, with very large flowers (4 cm.) for this family (Elaeocarpaceae); the flowers are axillary, solitary or in pairs, pendulous, and tinted in clear blending colors of red, yellow, and green. This species belongs to one of the genera which, as research progresses on the flora of New Guinea, appear to be common to this country and New Caledonia in constantly increasing numbers. In several families in recent years a relationship between the floras of the two islands has been established. Up to this time, only one New Guinean species of *Antholoma*, *A. Tieghemi* F. v. Muell., was incompletely known. Naturally some Rubiaceae are found here, for example the semi-scandent *Psychotria Lorentzii* Val. (end.), *Timonius* no. 1989 and *T. avenis* Val. (end.). In other families there are also *Symplocos doormanensis* Brand* (also found at 2200 m.), *Evodia aneura* Lauterb.*, *Eurya* (no. 1975), and the semi-scandent *Ilex spicata* Bl. (no. 1978; Arch.). *Utricularia* is very abundant in the moss but is rarely seen in flower.

Here are no large lianas. The only ones are single species of rattan, representing the highest ascending palm species, and also the lowest descending specimens of *Alyxia Lamii* Markgr.* and a single *Rubus* (no. 2037). The clinging *Freycinetia* is very plentiful and is showy because of its salmon-colored inflorescences amongst the green foliage of the ferns and the golden moss-cushions. *Pilea Lamii* Hub. Winkl.* climbs along the lower tree-trunks.

In the closed forest of the broader ridges, apart from a few Urticaceae, herbs are not numerous. *Argostemma montis Doormanni* Val.* occurs here, but this seems to be almost its altitudinal limit. *Dianella carinata* Hall. f. grows everywhere along small brooks and in damp places.

On the sunny narrow ridges, flowers of typical mountain-orchids (nos. 1950-1, 1953) impart color to the moss on the ground and on the lower tree-trunks. Among these are species of *Mediocalcar*, such as *M. crenulatum* J. J. Sm. (also another species, no. 1662), common and striking because of the almost entirely connate inflated and fleshy floral parts with frequently different-colored apices. In such places we find *Glomera palustris* J. J. Sm. var. *subintegra* J. J. Sm., *Dendrobium Lamii* J. J. Sm., *D. mitriferum* J. J. Sm., and *Bulbophyllum acutibrachium* J. J. Sm. A common epiphyte in the moss on tree-trunks here is the zingiberaceous *Riedelia sessilantha* Val. (no. 1845; end.), with orange-red flowers, likewise *Rhododendron Vonroemeri* Koord. (end.), with light yellow and rose flowers, and *Vaccinium igneum* J. J. Sm.* and *V. brevipedunculatum* J. J. Sm.*, also found at Goenoeng Boetak. In addition, I saw a single pendent *Hydnophytum*. On the open crests a couple of peculiar parasites belonging to

the Santalaceae appear: *Henslowia Ledermannii* Pilger*, closely related to another species of the same genus very common above the forest-limits (*H. acutata* Pilger*), and the much larger *Exocarpus Pullei* Pilger*. The last seems to have its greatest frequency at about this altitude. The first indication I found of its presence was in the form of fallen branchlets at about 2300 m. altitude, but Pilger records³¹ the species as occurring from 1440 m. upwards. This parasite disappears with the forest, apart from some very small specimens which I found growing on roots near the highest point of Doormantop. It is here a rather large, about globose, shrub 2–3 m. in diameter, growing on a branch of one of the tallest trees, to which it is attached only in one place. The plant has long protracted phylloclades. The flowers and fruits are located in small receding angles on the sharp sides of the phylloclades, which never are pure green, but which vary between yellow-green and red-brown. The last color is particularly characteristic of the young parts of the plant.

In Beek-bivak, on darker nights I repeatedly saw the phosphorescent phenomenon caused by the mycelium of fungi (no. 1991). Here I had a better opportunity to collect some of it, and I enjoyed the fantastic glimmer uninterruptedly diffused during the night from a part of a thick branch, recalling by its glow the light of Geissler tubes. It was a curious thing to note that, although the fungus did not give the impression of being very heavy, yet it had a weight of some kilograms. Other fungi were also collected here (nos. 1948–9, 1959–60, 1981, 1995).

We did not notice much animal life. A few mosquitoes were seen during the day, but apart from that, as on the whole overland journey, it was not necessary to use the mosquito-net at night. Leeches also were very rare. However, without making any special efforts, we saw almost nothing of larger animals. Everywhere we observed the pungent odor of *Phascogale*, but we never saw the animal. *Koekoeks* (*Phalanger*) and a few other marsupials still occurred here. For that matter it is known that the Papuans use caved-in places in which to trap marsupials above the forest limit, and our expedition also found *koekoeks* above the forest-border. The zoologist, who remained some days longer, caught a number of rats, which appeared to be common everywhere.

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The trail ascending from the camp first leads over a gently undulating plateau toward the crest. It is a particularly beautiful stretch of forest, with tall trees and a great wealth of ferns in the undergrowth; among these are a few scattered small clusters of pretty tree-ferns (*Cyathea perpeltigera* v.A.v.R.*); the thin crowns of the trees permit a good deal of sunlight to reach the ground. On still mornings there is no sound in this forest other than the gentle patter of the drip from the moss-cushions, no movement except, under the fall of the drip, the up and down swing of leaves of terrestrial plants and of fern-fronds on the tree-trunks. Here suddenly an exceptionally robust species of sterile moss appears in great quantity on the ground. It is a dark green plant with a *Polytrichum*-like habit, about 2 dm. tall and with long divergent leaves; possibly it belongs to the Australian genus *Dawsonia*, and perhaps it may represent *D. gigantea* C. Muell.

On the narrow crest the vegetation is at once entirely different. There are no upright tree-trunks; all are crooked and gnarled, and the moss-covering is

³¹ Engler's Bot. Jahrb. LIX (1924), 120.

still heavier than on the ridge in front of Goenoeng Boetak-bivak. The processes which I have previously recorded in the discussion of a similar flora develop quickly here. Rapidly the layer of epiphytes, at first confined to the forest-roof, mingles with the flora of trunks and ground (cf. *Fig. 15*). The undisturbed moss-cushions, at the side of the deep rambling trail, cover every unevenness like snow. There one is not safe from sinking unexpectedly between blocks of stone or between the roots of trees. Now the trail is like a flight of steep rocky stairs; again it follows along roots and a tangle of fallen trunks; in other places it is a muddy trampled slope so much used that it no longer affords any purchase for hands or feet. To the right, far below, a mountain-stream rushes unseen in the endless forest-wilderness of the ravine.

Gradually various known plants disappear; new forms appear, the forerunners of the colorful flora of the treeless territory above the forest-limit. The trees are mostly Coniferae (cf. *Fig. 19*), young specimens being abundant. Everywhere *Nepenthes* with red-green pitchers and *Freycinetia* (no. 1846) with beautiful salmon-colored inflorescences climb through the shrubs. Amongst these, in addition to the young coniferous plants, *Symplocos doormanensis* Brand*, the earlier-mentioned *Quintinia*, *Antholoma papuana* O. C. Schm.*, and *Drimys Lamii* Diels* are very common. Both the last-named species and *Mearnsia ramiflora* Diels extend to the forest-limit. At Goenoeng Boetak the latter was a robust tree; here it is only a shrub about 2.5 m. high, attractive because of its dark red flowers. Here at first *Pandanus* is still very abundant (nos. 1884-5), but at about 2600 m. altitude it suddenly disappears. Now many specimens are seen along the slopes, but a few score meters higher not a single one appears. This altitudinal limit seems to hold everywhere for the genus. Independently of the fact that Pulle³² named exactly the same height-limits for the southern side of the range, I found the limit to be 2600 m. elevation not only here but also on the southern slope of Doormantop. Somewhat higher still I saw *Utricularia* in great quantity, but at 2700 m. it, too, vanished. At this altitude I saw a specimen of *Podocarpus imbricata* Bl. (no. 2160) for the first time, but apparently this plant, which can be a very tall tree, occurs more abundantly at lesser heights, and about here it reaches its upper limits. Already the vicinity is gay, colorful, and fresh. This forest has no longer the somber oppressive atmosphere of that of the lowlands; the cool mountain air meets us; all day we are in a state of excitement because of the various influences and particularly at the prospect of arriving eventually above the depressing forest. The large *Myrmecodia* (no. 1804) which I first saw at 1900 m., and which has its optimum frequency above the forest-border, becomes increasingly abundant but still remains epiphytic. A number of bright-colored Orchidaceae (nos. 1835, 1997-8) grow amongst the golden-yellow moss, such as *Calanthe manis* J. J. Sm., *Dendrobium mitriferum* J. J. Sm., *D. Lamii* J. J. Sm., *Glomera subeciliata* J. J. Sm., and *Mediocalcar compressicalcar* J. J. Sm. Every moment new species appear. There are here a few other Orchidaceae, the distribution of which seems to be limited to a narrow zone. I saw a couple of species with no greater difference in elevation than perhaps 100 m., which were seen neither above nor below these limits.

In the neighborhood of 2700 m. altitude, I find the first specimen of *Didiscus*, a beautiful plant of the Umbelliferae, one of the commonest herbs above the forest-limits. *Dianella carinata* Hall. f. grows here amongst the moss, but

³² Maatsch. t. Bevorder v. h. Natuurk. Onderz. d. Ned. Kol. Bull. no. 68 (1913), 35.

nevertheless it has reached the upper limit of its distributional area at about this altitude. Among the epiphytes the colorful *Riedelia* is more abundant.

At about 2750 m. elevation, we suddenly come to the lower boundary for the mountain *Casuarina*, which immediately appears in large numbers and which, from here upward, with the Coniferae, is practically the only genus of trees represented (cf. *Fig. 19*). In the undergrowth locally is an abundance of fine semi-scandent bamboo. The *Timonius* of Beek-bivak, *T. avenis* Val.*, a robust shrub with yellow-white flowers, grows here, too. Among the remaining herbs new forms continually attract attention, but of the woody plants practically all the species present occur also above the forest-border. However, all are here much more vigorously developed and more slender in habit. At 2800 m. altitude are a couple of specimens of the peculiar orchidaceous genus *Corysanthes* (no. 1815), in which the solitary flower is subtended by a single leaf, the odd purple perianth-segment arching over the others.

The contour of the terrain, particularly here near the critical height of the forest-boundary, has a strong influence on the picture of the vegetation. But where the ridge is somewhat broader and therefore less exposed, or where a depression occurs, everything immediately becomes taller. The strong winds retard the development of plants on exposed places. Somewhat after the appearance of the *Casuarina* we found the first specimens of *Oldenlandia asperima* Val.*, with large white or pale lilac flowers, a plant very plentiful above the forest-limits. At this altitude also the zoologist finally discovered the long sought-for *Peripatus* in a specimen of *Hydnophytum pauper* Val.* The latter plant grows as well on the lower branches of *Casuarina* and of the Coniferae as in the moss on the ground. Above the forest-limits it is very common and is there naturally only terrestrial. The tuber is gray-white, bare, and irregularly ovate. In terrestrial specimens the tubers lie with the long side in the moss, often almost entirely buried therein; meanwhile the basal end is attached to the substratum by roots; from the apical end a number of short erect stems develop. The small white flowers are in the axils of the rigid thick leaves. The openings of the tuber are very numerous and often, particularly in old specimens, very large, so large sometimes that whole parts of the outermost passages lie exposed. I have recorded³³ elsewhere that this myrmecophilous plant, in the first place, does not harbor ants (perhaps the younger specimens do) but a number of other much larger forms of animal-life. According to the observations of the zoologist, among these are small lizards, beetles, earthworms, a small frog which apparently cares for its brood here, and lastly, often a number of specimens of the noteworthy *Peripatus*, belonging to *Paraperipatus vanheurni* Horst.³⁴ This genus has gained as much fame as a transition-form between the Annelida and the Arthropoda as through its peculiar distribution (New Zealand, the Cape, N. Guin.). Up to now two species were known from New Guinea: *P. papuensis* Sedgw. from the Arfak Mountains and *P. Lorentzii* Horst from the Wichmann Mountains.

In the neighborhood of 2800 m. the gentle slope changes into a small plateau full of pits and holes. We are still hemmed in by *Casuarina* trees up to 10 m.

³³ H. J. Lam, Iets over de botanische resultaten van de Noord-Nieuw-Guinea-Expeditie 1920—*Teysmannia* XXXII (1921), 318 and *Rectificatie*, ibidem XXXIII (1922), 52. Also, *Vegetationsbilder aus dem Innern von Neu-Guinea, Myrmekophyten und Insectivoren*—H. Schenck & G. Karsten, *Vegetationsbilder, Reihe XV, Heft 7*, text with Plate 42a.

³⁴ *Zoöl. Meded. Rijksmus. Nat. Hist. Leiden* VII (1922-3), 113.

high and by thick coniferous shrubs. After the plateau, the trail again steeply ascends and we reach the first forest-free small summit at about 2850 m. altitude. From here we can enjoy a spacious view for the first time. For a long time we all sit together, gratified at the overwhelming panorama on this exceptionally clear day. Before us to the north lies the Meervlakte, and the long undulating ridge by which we reached this point. To the right and left, we look below into the heavily forested almost bottomless ravines, the view east of which is obscured by a magnificent 4000 m. notched summit. Along its enormous slope, ten white meandering small streams, noiseless and motionless at this distance, descend, unreal, as if drawn with a shaky pen. To the south behind us, but already close, rises the mighty double dome of Doormantop, bare and rocky, rose-brown in the intense sunlight and, even now towards midday, lightly wreathed by the first small clouds. After months of almost endless rains, this seems to be the first of two or three nearly cloudless days.

At the elevation of this small summit only the most exposed points are without trees. Doorman³⁵ informs us that this is also the case at still lower altitudes; south of the source-streams of the Rouffaer River he found a small peak at 2650 m. free of forest. This same peak was reached by the Nederlandsch-Amerikaansche Expedition of 1926. More than other vegetation boundaries, the forest-limits seem to be due to the contours of the terrain. Still clearer than, let us say, the lower border of the misty forest, that of the closed mountain-forest is sharply defined by sudden changes in the nature of the terrain. Nevertheless, the forest-limit is rather sharp compared to other vegetation-boundaries. As a strongly undulating line (*Fig. 18*), it extends along the 3000 m. elevation, descending on the narrow ridges, rising higher in protected ravines; and, just as more or less forest-free peaks may occur 300 to 400 m. lower than the average, similarly we see that the closed forest may extend as much higher, and indeed does so in the most sheltered and commonly sheer-walled ravines of this terrain. We shall describe this in Fragment VI. According to the scanty and perhaps not entirely trustworthy information which I received from members of the second expedition (Kremer Expedition), the closed forest of the Coniferae and *Casuarina*, under favorable circumstances, probably ascends to 3500 m. Sapper³⁶ names 3200 m. as the limit of the deciduous forest in tropical South America; he places that of the coniferous forest at 3800 m. The actual limits of trees are naturally much higher. From photographs of the region north of Wilhelminatop, I think that, apart from open marshy grassy terrain (± 3700 m.), I can recognize tree-ferns (specimens with a compact habit and short thick trunk), also *Phyllocladus*, the conifer which extends highest on Doormantop. In regard to tree-ferns, van Nouhuys³⁷ found a *Cyathea*, with a trunk 3.5 m. long, in a valley on the north side of Wilhelminatop, at about 3650 m. elevation. Probably in the middle of this broad mountainous country—and in general on higher ranges—the vegetation-limits lie on the whole higher than on the much more exposed outer slopes. In Siberia the forest extends much farther north in the sheltered river-valleys than on the ridges between them; possibly, however, other factors are involved, especially drought.

³⁵ De Aarde en haar Volken, 1918, p. 179, 180.

³⁶ Geologischer Bau und Landschaftsbild, 167.

³⁷ Von Rosenstock, Nova Guinea VIII (1910), 716; Wollaston (The Geogr. Journ. XLIII, 1914, 256) says the last tree seen on the very steep southern slope of Carstensztop was at an elevation of 3200 m.

The connection between the temperature of the air and the boundary is treated in a short article of Eckardt,³⁸ who records the opinions of A. Wegener, F. Ratzel, and H. Mayr.³⁹ Thus Wegener shows that the tree has the same temperature as the surrounding atmosphere, whereas the lower vegetation can profit by the shelter and by radiation from the ground and therefore can reach a greater altitude. Ratzel states as his opinion that the boundaries separating the biotic regions are not lines but zones, as we have already seen in the above discussion. Above the forest limits individuals can maintain themselves alone or in small groups through locally more favorable circumstances, but a continuous closed forest is no longer possible, since the climate of the most exposed areas hinders the growth of trees. Mayr introduces the concept of "Vegetationstherme"; by that he implies the mean temperature which is necessary for a known plant to thrive during a vegetation period (at least 1.5 months). Each species has its own vegetation-therm and it is thus clear that the forest-margin must lie in the annual isotherm for the warmest month which agrees with the vegetation-therm of the tree (or trees) which forms (or form) the most northerly (or the highest) forest. According to Mayr, in northern Europe this is the "Alpenlarche" (probably here is meant *Larix decidua* Mill.), which appears to have a vegetation-therm of 14° C. The forest-boundary must therefore coincide with the July isotherm of 14°, and that indeed appears to be the case. Also, the mean temperature for *Larix decidua* actually appeared to be 14° both during a vegetation-period of 1.5 months in the alpine region, and during a period of 4 months in the Bavarian highland, also one of 6 months in the Rhine plain and one of 8.5 months in southern France. Naturally the forest-boundary lies a little higher, about at 10°-isotherm for the warmest month.

After having descended the small foresummit, we come again into low forest consisting almost exclusively of Coniferae and *Casuarina*. The vegetation of the small peak consists chiefly of shrubs (no. 1866) such as *Elaeocarpus Pulleanus* O. C. Schm.*, with yellow-white flowers pendent in spiciform racemes, *Drimys Lamii* Diels*, *Mearnsia ramiflora* Diels var. *humilis* Diels, *Symplocos doormanensis* Brand*, and *S. topica* Brand*; within the forest the flora is about like that of somewhat lower regions. The small white- and lilac-flowered *Oldenlandia asperrima* Val.*, already recorded earlier, appears in increasing numbers in the undergrowth. Here is a species of *Cladium*, a very compact plant with stiff leaves spreading like a fan, which becomes very common in marshy places above the forest limits (nos. 1595, 1667). Gradually the trail ascends through the sunny forest wherein the yellow-green and golden-brown tints of the moss, sometimes even interrupted by dark red species, strongly dominate. On the left we can see far over the broad ridge through this shaggy desolate forest; at the right the terrain drops sheer and very deep to the ravine which is limited by the 2000 to 2500 m. high slope of Doormantop. Round about us is the untouched age-old vegetation of crooked thick trunks of *Casuarina* (nos. 1705, 1746), the foliage of this being erect, of thick *Dacrydium* shrubs (no. 2155), of queer compact and hard-leaved shrubs, of moss-cushions, amongst which are conspicuous the bright colors of Orchidaceae (nos. 1818, 1830, 1833), such as *Mediocalcar retusum* J. J. Sm., *Glomera palustris* J. J. Sm. var. *subintegra* J. J. Sm., and *G. Pullei* J. J. Sm., also of *Riedelia* (nos. 1843-4),

³⁸ W. R. Eckardt, Lufttemperatur und Baumgrenze, Peterm. Mitteil. LXX (1924), 126; cf. also W. Köppen, *ibid.* 1919, 201.

³⁹ Literature cited by Eckardt.

Freycinetia (nos. 1592, 1846), and single representatives of the Ericaceae (no. 1996) and the Myrtaceae (no. 1999).

A short and steep ascent over bare rocks brings us once more to a point, whence we cannot refrain from loitering to enjoy the beautiful view. After that we descend a little. Roughly estimated, we are at about 2950 m. altitude. A few new ferns appear, such as *Plagiogyria novoguineensis* v.A.v.R.*, a large terrestrial fern with dimorphic fronds, and *Gleichenia vulcanica* Bl., which occurs on all high mountain-peaks in the Archipelago and forms communities on Doormantop. Here also are the parasites already seen at lower altitude, *Henslowia* and *Exocarpus*, the latter constantly less in number and smaller in size, even as its host-trees become smaller and scarcer. *Henslowia*, however, is parasitic on all kinds of shrubs and is abundant here. As soon as the terrain becomes somewhat steeper we finally emerge from the forest. A small peak covered with a low shrub-growth lies before us, and behind it an extensive steep slope falls off to a vast depth. The end of the large ridge is reached. At this point, where a ridge running in a westerly direction leads to Doormantop, lies Uitzicht-bivak at 3120 m. altitude, the first night's stay above the forest-limit. It was a very special day for us, now that at last we felt the sun and dryness once more. The part of the trail still to be covered is almost wholly in sight; above we see the small white flag that distinguished the locality of Radio-bivak. The camp-location at Uitzicht-bivak was a small flat place covered with grass, somewhat marshy in the center, where a few depressions furnished us with some muddy water. The huts were built on the higher margins, and for the first time sleeping accommodations were arranged directly on the ground and consisted of a thick layer of resilient branches. Round about lay walls covered with low shrubs, and in many places the bare brown weathered rock-formation projected, with lichens here and there (nos. 1836, 2002). In marshy places I found the first specimens of the iridaceous *Patersonia novo-guineensis* Gibbs (end.) var. *auriculata* F. W. Went*; the genus is represented by a rather large number of species in Australia and a couple on Mount Kinabalu in Borneo. It is a small herb, with ensiform conduplicate leaves with sharp edges and a solitary beautiful purple *Crocus*-like flower. Some algae were also collected here. Near the bivouac are a couple of old trees of the mountain *Casuarina*, the wood of which imparted a delicious fragrance to the fire. On the branches of such a tree I found the handsome and large-flowered *Dendrobium simplex* J. J. Sm. (end.), which I had already noted at an altitude of 2000 m. The tuber-like leaf-bases are very hard, shining dark coffee-brown in color, and practically globose; the flower (its parts some centimeters long) is purple and yellow with a background of greenish white. Although the flora here is rather similar to that of the vicinity of Radio-bivak and for that matter can be discussed better in a Fragment devoted to the latter, I must mention a shrub which I saw nowhere else. It is a species of *Scaevola* (no. 1837), a shrub not more than 0.5 m. high, with small hard leaves and relatively rather large yellow-white sessile flowers concealed amongst the foliage.

This day we were all busy with our usual duties, roaming about in the delightful region, and resting at noon. But the approaching twilight brought us together at the margin of the plateau, to gaze over the broad landscape and watch the sun go down behind the western ridges of this rugged mountain land. Only rarely is the opportunity granted to modern man to look down upon a country covered beyond the reach of the human eye with a continuous and

unbroken forest centuries old. The Idenburg River, its bright course gleaming in the dull green of the Meervlakte, flows with huge meanders, with abandoned sections of the old stream-bed in many places, these forming numerous lagoons on either side. Far away in the distance, near the van Rees Mountains, the confluence with the van der Willigen River is to be seen, the latter, although invisible, betraying itself in the landscape by a lighter streak in the forest. The whole mosquito-infested plain lies open before us, and no detail of lagoons, pale green reed-fields, river channels, and various shades of green escapes us now. We recognize and locate the hills over which we left the plain. It seems like a dream, while we now sit here actually suffering from the lashing wind and the cold, with dry clothes and broken shoes, that the land below now literally gasps in the moist heat of the day, that its forests are filled with the screams of cockatoos and the harsh calls of the hornbills; so far away in time and space are these experiences. Once again we search for and find the location of Prauwen-bivak. Now we discover also the blanket stretched at the summit of Casuarinest, clearly lighted by the setting sun. With the fall of night it quickly becomes colder. The temperature at midday in the shade was 17° to 18° C. and at 8 o'clock in the evening the thermometer stood at not more than 8°. After supper we wrap ourselves in all available covers and lie down on the dry branches to sleep, breathing the fragrance of burning firewood and remembering winter nights full of sparkling stars after a day of skating.

The following morning is as clear and radiant as the previous one, but icy cold. Here and there clouds lie in the deep still dark valley, but the ridges and the highest crenate crests of the range, 80 km. distant, stand out sharply against the clear light. Wilhelminatop, which yesterday was concealed from us, is now entirely clear and is covered with a cloak of freshly fallen powdery snow. In the same excited frame of mind as yesterday we follow the narrow ridge to Radio-bivak. To the right of us is the wide view over the Meervlakte in the north; on our left the view over a series of parallel mountain-chains, back of which the great Baliem Plateau lies hidden, ending in the Central Chain, the Peninggalèh of the mountain-dwellers, wherein the Iniaga, our Wilhelminatop, uncontestedly dominates the scene. The trail is very easy and lies now across a marshy plain, then again over bare rocks, with here and there small clusters of low shrubs. On the other side the slope drops into heavily forested ravines, in which parts of white shimmering small streams are visible amongst the trees. Gradually the ridge becomes narrower and we pass a high landslip on the southern slope, a chaotic mass of huge blocks of rock. Sometimes, however, there is a broader area, and, in such places where depressions occur, a luxuriant small forest of Coniferae develops immediately, with *Plectronia ovalifolia* Val.*, *Ilex spicata* Bl. (no. 1874), *Casuarina*, climbing *Nepenthes*, *Alyxia*, and *Rubus*, and many colorful flowers on the thick moss-covering. Beyond this protected small forest (in which also no. 1869 occurs), immediately follows the last steep climb to Radio-bivak, a barren slope 150 m. in extent. The highest part is irregular; in the sheltered places small trees and shrubs grow. And so on October 16, 1920, we reach the beautiful gently undulating plateau of Radio-bivak (3330 m.), to which I owe one of the most glorious memories of my life. Another Fragment must be dedicated to this and a picture given of the vegetation and the flora of the highest part of this mountain.

VI. Above the forest limits: Doormantop and its vegetation ¹

THIS IS not the first time that botanical collections have been made at about this altitude in the mountains of Netherlands New Guinea. It is, of course, not surprising that, in connection with the different research-expeditions, a strong tendency has developed to attempt to reach, in particular, the region above the timber-line. This tendency is explained not only by modern man's instinctive dislike of a long stay in the sultry forest, but also, since botanists are concerned, by his wish to examine the subalpine flora. The latter frequently promises many surprises and is particularly easy to survey. Rather important collections from above the forest-limits are thus brought together. One of the most important of these is certainly that of Miss L. S. Gibbs,² the daring English traveler, who, after expeditions to Kinabalu in North Borneo, Tasmania, New Zealand, and Fiji, visited the Arfak Mountains. Supplementing the large collection of material which she assembled, she prepared an outstanding phytogeographical work on that region. Collections have been made also on the southern side of the Central Chain in the higher mountain-districts. Von Roemer³ and Pulle,⁴ as botanists of their expeditions to the crest of the Hellwig Mountains (2650 m.), collected there. Pulle brought from these mountains and from Wichmanntop (3100 m.) in all some 200 numbers. In addition, van Nouhuys collected single specimens on his expedition with Lorentz toward Wilhelminatop, while Boden Kloss on the Wollaston expedition⁵ collected on the slope of Carstensztop. He reached 4150 m., but from that height he brought only a few specimens. Then we have a small collection of preserved material, about 40 numbers, collected by Doorman; these were mostly orchids not definitely labeled, but likely a large part of them came from Doormantop. Finally, the collection of the Australian forester, C. E. Lane-Poole,⁶ on some high peaks in the Australian part of the island, the highest of these being Mt. Sarawaket. His description of the vegetation of this peak as well as that of other high mountains is of little value for our purpose, since the treeless areas of this explorer are topographical rather than botanical. His descriptions of the forest at different altitudes, however, are very interesting. Summarizing, we have very complete and well labeled material to about 3100 m. (Gibbs, von Roemer, and Pulle), some specimens from greater heights (Doorman, van Nouhuys, Boden Kloss), and a phytogeographical description of high mountains up to about 3000 m. (Gibbs). My collection and the following floristic sketch can be arranged according to these data. The first consists of 304 numbers,⁷ of which about 280 were collected above 3300 m. I believe that the collection of the

¹ *Natuurk. Tijdschr. Nederl.-Ind.* 89: 67-130. 1929.

² L. S. Gibbs, *A Contribution to the Phytogeography and Flora of the Arfak Mountains, etc.* (London, Taylor & Francis, July 1917).

³ *Maatsch. ter Bevorder. v. h. Natuurk. Onderzoek. der Nederl. Koloniën*, Bull. no. 63 (1910), 22.

⁴ *Maatsch. etc.* Bull. no. 68 (1913), 33.

⁵ H. N. Ridley, *Report on the Botany of the Wollaston Expedition to Dutch New Guinea, 1912-13*—*Transact. Linn. Soc. Lond., 2nd Ser., Bot.* IX, 1 (1916)—see also: *The Geograph. Journ.* XLIII (1914), 265.

⁶ C. E. Lane-Poole, *The Forest Resources of the territories of Papua and New Guinea* (Commonwealth of Australia, 1925).

⁷ All named in the text below.

flora from this mountain-top might well be considered complete, apart from the possibility that perhaps I have not observed some plants flowering at other seasons of the year.

The starting point for the discussion of the flora above the timber-line, in this case from about 3000 m. to 3580 m. (the highest part of Doormantop), is the plateau on which Radio-bivak (*Fig. 20, a*) was established. Between Radio-bivak and Uitzicht-bivak very little has been collected. Some plants of that region were already named at the end of the previous Fragment. The others, especially of the slope northeast of the camp, will be treated again below.

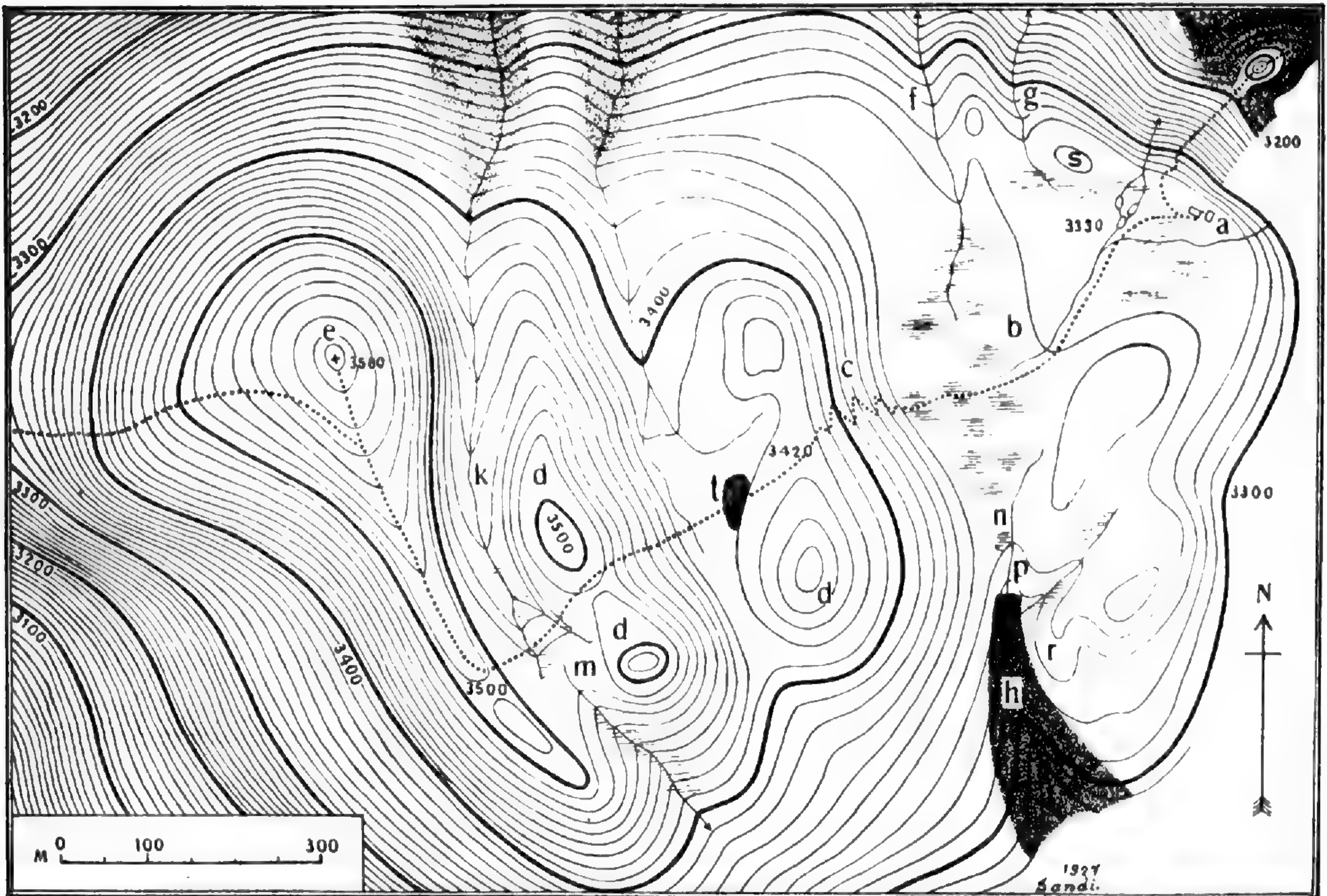


FIG. 20. Sketch map of Doormantop; contours at 10 m. intervals, those at 100 m. intervals indicated by a heavier line; a = Radio-bivak; explanation of the other letters in the text; = transport route; the stippled parts are more or less closed low forest.

This plateau has an altitude of about 3330 m. It is an undulating high plateau with an altitudinal variation of several hundred meters, situated east of the true summit. The eastern slope is especially sheer and deep, frequently 1500–2000 m. without interruption, except at the point where the ridge which formed our path joins the plateau and where the steep part is not more than about 150 m. high. Along the entire western side of the plateau the steep part rises, a great crumbling wall of the summit-plateau about 100 m. high; the real summit is rather broad and indented, as was already observed from the Meervlakte. The highest point lies directly west and is separated from the broad eastern summit by a deep ravine (*Fig. 20, k*) descending in the direction of the northern slope and near the south ending blindly in a high saddle (*Fig. 20, m*) which binds the two summits together. The eastern summit shows again this character of an undulating stone-plateau, the western falls away steeply on all sides except towards the south-southeast slope, being by far the most precipitous

towards the southwestern side which cannot be scaled without aids, and where the slope of 60° and more continues for several hundred meters. On the north side of the bivouac-plateau some small ravines (*Fig. 20, f, g*) with a luxuriant flora lead from the margin. On the south side one finds a broader and deeper sheltered ravine, its very steep sides (*Fig. 20, h*) covered to the margin by an upward extension of the forest.

The bivouac-plateau is characterized by three outstanding types of vegetation, naturally showing many transitions.

- A. The rocky terrains.
- B. The fern- and shrub-scrubs.
- C. The marshes.

In the discussion I shall consider each in turn.

The largest area is that of the rocky terrains.⁸ Here are convex folds and gently sloping areas where the surface is covered with boulders of all sizes. These are all formed from the basic eruptive rock-formation that Gisolf⁹ has further described and they show a typical Karst topography [i. e., marked by sink-holes, interspersed with abrupt ridges and irregular protuberant rocks, and by caverns and underground streams]. The newly broken surface is green-gray in color, but when weathered is of a smooth light gray-brown tint in which brown is dominant. At disintegration frequently rows of furrows are formed, separated by narrow and often very sharp edges. This makes traveling in bare feet over this area very difficult. Furthermore, the rock-formation, according to Gisolf, consisting of magnesium-olivine and a colorless mineral (antigorite and antigorite-serpentine), is permeated everywhere with magnetite (polar magnetic iron ore, FeO and Fe_2O_3) which lies enclosed in parallel bands in this rock-formation; meanwhile on the surface the magnetite stands out some centimeters on account of its greater hardness. This magnetic iron had already played a trick on Doorman. He found, when making a survey of Wilhelminatop with regard to the spot earlier placed at the south side, an error of not less than 14° , which he could not explain. Capt. Kremer, who repeated the survey, with Doorman's results in mind, first obtained a deviation of -8° , thereafter at another place one of $+25^\circ$. Still later, the compass needle, even on two places close together, appeared to differ 180° . Now it became clear that the earth itself must play a role in these phenomena; indeed then very quickly the magnetic ore was found, and the geologist and I took along samples of it. The rock-formation, from which the iron-mass was removed as much as possible, contains still, according to the analysis, 7.69% FeO ; 40.46% SiO_2 ; 40.2% MgO ; 4.12% Al_2O_3 , and 7.74% H_2O . Although the rock-formation in itself is tolerably heavy (S. G. 2.5-3.5), the iron ore with its specific gravity of about 5-6.5 increases the weight very considerably; hence the transfer of the samples did not particularly please the carriers.

In the humus collected in crevices between these boulders, a very dwarf flora of small crowded or creeping shrubs and a few herbs has taken root, while the stones here and there are covered with lichens (nos. 1836, 2002, 2015-7). Amongst the shrubs here species of *Styphelia* in particular, such as *S. Van-*

⁸ See the illustration of Doormantop in Schenck & Karsten, Vegetationsbilder, Reihe XV, Heft 5/6, Tafel 34.

⁹ W. F. Gisolf, Over het gesteente van den Doormantop in Centraal Nieuw-Guinee—Verslag Gew. Vergaderingen Wis- en Natuurk. Afd. Akad. v. Wetensch. Amsterdam, XXXII (1923), 160.

nouhuysii J. J. Sm. (end.) and *S. Dekockii* J. J. Sm. (end.), are strongly represented; these are small compact bushes 1–2 dm. high, easily recognizable by their somewhat stiff and frequently pointed small leaves with curving veins, crowded and appressed along the stem. *Styphelia Dekockii* J. J. Sm. is a larger shrub up to 1.5 m. high. In the smaller species the stem often creeps forward some meters along the ground. Also here is *S. abscondita* J. J. Sm.,* with white flowers. The Epacridaceae, to which these plants belong are, just as the nearly related Ericaceae, true mountain-plants in the tropics, although a few species occur in the lower regions. Whereas the Ericaceae have a very wide distribution, the Epacridaceae belong especially to the Austro-Papuan area, with off-shoots to British India on the one hand, and to Oceania and South America on the other. Another very common shrub here is *Xanthomyrtus Klossii* Diels (end.) var. *brevipedunculata* Diels*, with more or less dark yellow flowers. This shrub, like the common *Decaspermum prostratum* Diels*, with pale cream-colored flowers often tinged with purple, remains very low, the long branches creeping some meters over the bare earth. Both species possess very small and coriaceous leaves. Another plant characteristic of this region is the low-growing (about 0.5 m. high) *Drimys fistulosa* Diels*. The few branchlets bear, on the distal portions only, a number of densely crowded leaves, which near the tip are closely appressed against the stems and are revolute for almost their entire length (hence the specific name); the small white flowers occur near the tips of the branches, hidden among the leaves. Both *Drimys* and *Oldenlandia asperrima* Val.*, mentioned in the previous Fragment, grow by preference in sheltered places among taller shrubs, although they still seem to choose the stony ground rather than the fern- and bush-scrubs. The Rubiaceae are represented here by many other species, such as *Oldenlandia nutans* Val.* (end.), *O. coprosmoidea* Val.*, *Coprosma ulicoides* Val.*, and *Plectronia ovalifolia* Val.* In some places a few larger shrubs 1–1.5 m. high appear together. A number of these belong to the Ericaceae, especially to *Vaccinium*, *V. ciliatipetalum* J. J. Sm.*, *V. cyclopense* J. J. Sm., and nos. 1596, 1676–7, and 1679. Rather common among them is a singular species of *Eurya* (no. 1720), the whole plant being laterally compressed with oblique branches lying in a single plane and hence suggesting the form of a fishbone. Moreover, the plant is shaggy in all parts and compact in habit, with small green-white flowers. There are still a few larger shrubs 2–2.5 m. high always growing in somewhat protected areas. Some of these are *Vaccinium molle* J. J. Sm., *Quintinia Schlechteriana* O. C. Schm.*, and *Acronychia murina* Ridl. (end.). Somewhat smaller are *Syzygium Chamaebuxus* Diels*, with yellow flowers (of the known species of *Syzygium*, this one reaches the highest altitude), and *Drimys pitto-sporoides* Diels*.

Whereas most bushes, except *Xanthomyrtus* and a few Rubiaceae and Ericaceae, have comparatively small and dull-colored flowers, among the herbs several immediately attract attention because of vivid colors and the relatively large size of the flowers. In this connection a beautiful orchid deserves particular mention. It is *Dendrobium Vannouhuysii* J. J. Sm. (end.), a small plant which, with its comparatively large deep-orange flowers and its thick purple-orange fruits, is found everywhere among the rocks on the ground. Also striking because of their color are the few dark cobalt-blue gentians. One of these (no. 1623) is identical with or closely related to *Gentiana singalagensis* Backer, described from Central Sumatra; another specimen (no. 1624) is a near

relative of the endemic *G. Lorentzii* Koord. Number 1778 is perhaps a third species, growing in somewhat moist places. The size of the first-mentioned species of *Gentiana* is strongly influenced by its habitat. The height of the plant varies from 2 cm. in the most exposed places to 25 cm. in the shade of taller plants. The second (no. 1624) is always more slender than the first and has thinner and more acute small leaves.

Another conspicuous and exceedingly common plant of these bare rocky fields is a mountain-form of *Nepenthes Vieillardii* Hook. f., previously known only from New Caledonia. One finds climbing plants of this species everywhere up to the forest-margin, but as soon as the trees disappear only very short terrestrial individuals are seen. These are observed as far as the summit. Unfortunately no specimens of the climbing forms were collected, and so it cannot be said with certainty that the two forms represent the same species; hence further investigation is necessary to discover the lower limits of this species. The terrestrial form never grows taller than a few decimeters; even in shrubberies I did not find any longer specimens. The thick rosette of stiff boat-shaped somewhat twisted leaves scarcely rises above the ground, and the pitchers lie all around the plant on the bare earth or in the moss. Older plants have a stiff crowded terminal inflorescence. The young leaves are green but quickly become red to red-brown. The pitchers likewise are green or brown, the margin and the lid being flecked with red. The new unopened pitchers contain much water, in older ones remnants of insects can always be found. In both sexes the floral envelope is dull brown outside, dark violet within; the young filaments are green, becoming violet-red, with light yellow anthers; the style and the stigma are green-red. The entire flower very quickly becomes brown; the perianth is marcescent, the fruits dull brown.

In addition to *Nepenthes*, we note a few very small Compositae (nos. 1589, 1629, 1700, 1754); one of these (no. 1700) grows by preference in small rain-pools on hard ground otherwise without vegetation. This plant is related to *Crepis* and has bright yellow inflorescences (small flower-heads), which contrast prettily with the dark brown-green of the stem and the basal rosette. Number 1629 also prefers moist habitats. In this plant-association numerous orchids occupy an important place. Two of them are wholly green, *Habenaria Lamii* J. J. Sm. and *Peristylus ciliolatus* J. J. Sm. and its var. *apiculatus* J. J. Sm. Both have a small basal rosette and a very tall sparsely leafy scape. These plants are scattered in clefts of rocks or in open spaces between them. *Calanthe Versteegii* J. J. Sm. is more showy with its larger greenish white flowers, and more abundant. In moss-cushions or amongst ferns are *Glomera Dekockii* J. J. Sm. var. *Lamii* J. J. Sm.* and *G. grandiflora* J. J. Sm. var. *minor* J. J. Sm.; whereas *G. Pullei* J. J. Sm. and *G. fruticula* J. J. Sm. prefer more open land. Other Orchidaceae of the habitats discussed are *Bulbophyllum cavibulbum* J. J. Sm., *Chitonanthera suborbicularis* J. J. Sm., *C. trigona* J. J. Sm., *C. Lorentzii* J. J. Sm., *C. calceiformis* J. J. Sm., *Octarrhena tenuis* J. J. Sm., *Phreatia nutans* J. J. Sm. with nodding flowers, *Pedilochilus terrestris* J. J. Sm. and *P. obovatus* J. J. Sm., both on somewhat damper areas hidden among ferns, and lastly *Dendrobium erythrocarpum* J. J. Sm., which is usually epiphytic on shrubs.

A pretty *Euphrasia*, related to *E. borneensis* Stapf of Kinabalu (N. Borneo), is likewise common in dark humus among bare rocks. It is a small erect herb (no. 1587) with nearly orbicular leaves and fairly large white flowers crowded together or a few at the apex of the stem. In the same habitat the

yellow-orange-flowered *Dendrobium Vannouhuysii* J. J. Sm. grows abundantly, with a species of *Cladium* (no. 1595). The leaves of the latter are ensiform, as are those of *Patersonia novo-guineensis* Gibbs, and conduplicate, spreading in one plane, the plants hence being somewhat fan-shaped. In the sterile condition one could easily confuse the two plants¹⁰ were it not for the fact that, in addition to being much more rare, *Patersonia* is recognizable by the rough brown-hairy margin of the folded leaf. Moreover, *Patersonia* always prefers damper situations, but the species impressed me as being somewhat more rare here than at 3100 m. altitude. Another common plant is *Gahnia* (no. 1748, perhaps *G. psittacorum* Labill., known from N. Guin., Austr., N. Zeal.), conspicuous on account of its growth in thick clumps and its waving inflorescences of shining brown color extending above the lower plants; the glistening fruits are yellow-gold and hang on thin brown stalklets outside the floral envelopes. In open areas a species of *Schoenus* (no. 1810) and a number of grasses (nos. 1638, 1682, 1745, 1774, 1816) form similar isolated clumps which frequently protrude somewhat through the washing away of the soil. Often a few plants of *Lycopodium* creep forward between these small clumps. I collected seven species of that genus on the highest part of Doormantop. *Lycopodium scariosum* Forst. (Mindanao, Austr., N. Zeal.) grows among the rocks, and *L. carolinianum* L. (trop. and subtrop.) var. *pedunculatum* v.A.v.R. on moister earth. The latter is very short since the older parts die quickly as the tip grows forward.

I mention last one of the most striking plants, almost dominant in some stretches, the large *Myrmecodia* (no. 1804) which I observed first as an epiphyte at an altitude of 1900 m. (Fragment V). It is epiphytic in all forest-margins, but at the highest point of the naked summit it is a very common terrestrial plant. On account of its frequency as well as its size, this species forms a characteristic element of the vegetation. In the plant-association now under discussion, the flora of the barren terrains, it is outstandingly terrestrial, in the shrubberies more often epiphytic. In the first instance the giant tuber-like base is often 1 m. high, upright, with numerous long stems stretching out in all directions. As an epiphyte the plant may be attached in a variety of ways to the trunk or branches, on the trunks frequently being lateral and then with a somewhat elongated curved tuber-like base and upright stems; on horizontal branches it is often upright. The roots then usually extend over long distances along the branches and the trunk of the host, and sometimes thus even reach the ground. One might ascribe¹¹ to such roots not only the function of clinging, but also the function of water- and mineral-transport. Pulle noticed the species on the south side of the Central Mountain Range,¹² the Second Lorentz Expedition found it as a terrestrial¹³ at an elevation of 2550 m., if one may assume that, in all these cases, we are concerned with the same as yet undescribed species. I have elsewhere dealt with the species in greater detail with the aid of a number of illustrations,¹⁴ so that here I merely give a reference to

¹⁰ This apparently was done by F. W. Went (Nova Guinea XIV, 1, 1924, 114), who determined a sterile specimen with glabrous leaf-margins as *Patersonia* sp. Doubtless he had this *Cladium* before him.

¹¹ O. Beccari, Malesia II, p. 177.

¹² A. Pulle, Naar het Sneeuwgebergte van Nieuw-Guinea, p. 158, fig. 25b.

¹³ Maatsch. t. Bevorder. v. h. Natuurk. Onderz. d. Ned. Kol. Bull. no. 62 (1909), 41.

¹⁴ H. J. Lam, Vegetationsbilder aus dem Innern von Neu-Guinea Vegetationsbilder, Reihe XV (1924), Heft 7, Tafel 37c, 38-41.

the detailed consideration. I shall only point out that these plants are spread by birds (or ants?),¹⁵ as often an enormous number of young plants and seedlings may be found on the tuber-like stems and in the immediate vicinity of these plants. The dwellers in this species are always ants; the entrances to the cavities are small and few in number and are located on the lower side of the tuber-like stems.

Another myrmecophyte in this region, already mentioned in a previous Fragment, is *Hydnophytum pauper* Val.* (no. 1641; Fragment V). This plant, also discussed elsewhere,¹⁶ is very abundant in the dense margins of fern- and shrub-scrubs, so that by mentioning it, a suitable transition is formed to the discussion of that plant-association. I have already noted that this species often harbors, in addition to ants, a number of larger forms of animal life (among others, *Peripatus*). At this altitude, in particular, it probably is a small frog which lives and rears its brood here. At night one hears its shrill whistling cry, but one never catches sight of it during the day.

The fern- and shrub-scrubs are level but not marshy, frequently being gently sloping portions of the terrain, which, without being noticeably sheltered in comparison with the surroundings, are covered with very densely crowded herbs and shrubs. They well illustrate the extraordinary sensitiveness of the vegetation-habit to extremely small differences in local climate. We must suppose that these plants develop on those parts of the drier stony terrains which, either through their situation or the nature of the slope or its form, have provided more favorable living conditions than have the surrounding areas. The borders, either on stony land or on the edges of small marshes, are formed of thick moss-cushions and fern-associations. In the center is a more or less high growth of shrubs, giving one an impression that this difference in plant-covering is due to slight elevations of the land. The measurements and the height of the shrubby forest differ much in connection with the stands, the contour of the ground, the altitude above the forest-limits, and the exposure. Various transitions from the small shrub group to the closed rain-forest are found, so that these places may be compared with small islands, adjacent to a continental coast, formed by surf-erosion. In such a plant association one may expect to encounter a number of species which also occur in the rain-forest of higher altitudes, and that is indeed the case. The margins, either narrow or broad and meadow-like depending upon the steepness of the slope, are overgrown with two fern-species rooting in the dense moss-covering. Both *Gleichenia vulcanica* Bl. var. *plumosa* v.A.v.R.* (type collected near forest edge: Fig. 21, left) and *G. subulata* v.A.v.R.* (Fig. 21, right) form closed associations. The first extends nearer to the margin of the plant-association beyond the protection of the taller-growing plants, its numerous and pretty dichotomous fronds (brown-woolly beneath) standing somewhat oblique. Entire zones of the second species occur especially along the margin of the shrub-vegetation, frequently partly shaded, the shining fronds being elegantly arched on their dark stipes. In the shelter of this thick fern-vegetation, rooting in the thick mossy layer, one finds a number of herbs more luxuriant than in the open terrain. The mossy layer contains *Macrohymenium laeve*, *Macromitrium recurvum*, *M. perobtusum*, *M. armatum*, *Brotherobryum latifolium*, *Schlotheimia*

¹⁵ W. Docters van Leeuwen, Mierenepiphyten, De Tropische Natuur, XVIII (1929), No. 4, p. 57.

¹⁶ H. J. Lam, Vegetationsbilder, Reihe XV, Heft 7, Tafel 42A.



FIG. 21. (left) *Gleichenia vulcanica* Bl. var. *plumosa* v.A.v.R. (Darmosoediro del.); (right) *Gleichenia subulata* v.A.v.R. (Sandiwiro del.).

Lamii, *Thysanomitrium MacGregorii*, *Braunfelsia scariosa*,¹⁷ and nos. 1680–1681. At the margin the plants are still small and there we also find the low-growing species which toward the center cannot compete with the higher-growing plants, for example, two species of *Gentiana* (much larger here), a *Euphrasia* with white flowers, and the orange *Dendrobium Vannouhuysii* J. J. Sm. *Mediocalcar crenulatum* J. J. Sm., with variegated flowers, is abundant. The flowers of this species are deep red in both forms, the tips of the short lobe in one (no. 1599) being bright green, in the other (no. 1642) white or yellow-green. A few species of *Lycopodium* grow on the very outer margin of this plant association, such as *L. complanatum* L. (north of the equator and

¹⁷ I am indebted to Professor Max Fleischer for his kindness in determining the mosses.

alpine tropical regions) var. *angustiramosum* v.A.v.R. (end.), with creeping stems and upright branchlets, and *L. hydrophilum* v.A.v.R. (end.) var. *eciliolatum* v.A.v.R.*, also growing in small marshes. *Bulbophyllum muricatum* J. J. Sm., with yellow and purple flowers, occurs here, and also rather scattered plants of the liliaceous *Astelia alpina* R. Br. (high mountains of N. Guin., Queensl., and Tasm.); the latter is a small plant with silver-white, hairy, thick, perpendicular stems entirely hidden in the moss, above which the narrow white hairy leaves hardly protrude; the inflorescence of greenish and somewhat membranous flowers reminds one of the Juncaceae rather than of the Liliaceae. The peculiarity of this plant, however, is the root-system, which is much larger than the rest of the plant, a number of thick pale brown soft lateral roots penetrating the moss-layer almost perpendicularly for a few decimeters. Still further from the margin in these fern-scrubs one observes *Lycopodium laxum* Pr. (S. E. As.—Polyn., Austr.), with dark green foliage creeping among other plants, also *L. tomentosum* v.A.v.R. (end.) and *Schizaea fistulosa* Lab. (Madag., Austr., Tasm., N. Zeal., N. Caled., Chile).

All these plants prefer a certain zone within these shrubberies, in almost all of them the beautiful *Didiscus* (nos. 1586, 1674; aff. *saniculifolius* Stapf) occurring in the margins and among the taller-growing ferns. The lower limit of its range seems to be 2700 m. The genus is known from Australia, New Caledonia, and North Borneo (Kinabalu; type of the species collected on this mountain). Not only the previously mentioned *Gentiana* and *Euphrasia*, but also this *Didiscus*, are subject to the growth-inhibiting influence of light. In open places strong evaporation is also an influencing factor. In fully exposed places I observed plants scarcely 6 cm. tall, whereas those growing in the *Gleichenia* association were up to 40 cm. tall. In open exposed places the plant consists of a small basal rosette of leaves and a short peduncle; in the thickets the ascending stem develops long internodes from the basal rosette with long peduncles. The basal leaves are thinly and shaggily long-hairy, long-petiolate, and spatulate with a gradually narrowed base and a rounded dentate apex. In full light the leaves lie, as if asleep, pressed against the ground,¹⁸ among other plants pointing obliquely upwards. The peduncle is brown-yellow, the umbel surrounded at the base by protecting bracts frequently showing in all parts a more or less strong purple coloring. The corolla is pale pink, but the fruit and pedicels, wherever exposed to direct sunlight, are dark purple. Sometimes I observed and collected inflorescences illustrating continued growth, in which one or more flowers were replaced by a secondary peduncle.

In this plant-association, the only representative of the Zingiberaceae which I observed in this region was *Riedelia montana* Val. (no. 1678; end.) as a scattered terrestrial among the ferns and once as an epiphyte on a small tree. The corolla is pink, the calyx and pistil dark purple, the violet bracts being covered with a waxy bloom.

The shrub-zone of these scrubs is surrounded by a girdle of *Gleichenia subulata* v.A.v.R.* In between are numerous more or less stiff Orchidaceae, such as species of *Glomera* and *Chitonanthera* with small salmon-colored or pale

¹⁸ Senn is of the opinion (Untersuchungen über der Physiologie der Alpenpflanzen—Verh. Schweiz. Naturf. Ges., 1922, II, sep. p. 13) that, for some alpine plants the leaves of which lie close against the rocks warmed by the sun, one must accept positive thermotropism, but I do not believe that would apply to *Didiscus* as it grows here.

orange flowers, tough long leafless stems, and small thick leaves at the apices of the branches. *Glomera manicata* J. J. Sm., with white flowers except for the blood-red lip-tip (in other species the tip is frequently black or brown), is common here. A few lianas wind themselves through this vegetation and around the branches of shrubs; among these are two species of *Alyxia*, *A. Lamii* Markgr.* and *A. cacuminum* Markgr.*, and a species of *Rubus* (no. 1585) with leaves densely rust-brown-hairy underneath and pale cream-colored flowers.

Among the shrubs of this terrain, in addition to the ubiquitous Coniferae, which in the more protected places become trees, and *Casuarina*, we observe many of the same Ericaceae mentioned above for stony ground, but frequently here with a more robust habit. The often dominant species of *Vaccinium* and *Rhododendron* have mostly reddish flowers. Usually represented are *Styphelia obtusifolia* J. J. Sm. with yellow and *Symplocos mamberamo* Brand with white flowers, and particularly *Drimys pachyphylla* Diels with revolute firm leaves and fairly large white flowers. A few previously mentioned species of Rubiaceae, such as *Plectronia ovalifolia* Val.*, occur. In more open places among the shrubs, but always on sheltered ground, is an occasional dwarf tree-fern, *Cyathea imbricata* v.A.v.R.* A fungus (no. 2013) grows on dead wood.

In the middle of the small forests are the tall shrubs and small trees, the branches covered with isolated moss-cushions (among others a liverwort, no. 1698), a few epiphytic ferns (no. 1699), and orchids (no. 1767). The woody genera here are almost exclusively coniferous, such as *Dacrydium* (no. 1773), with dark, thick and hard foliage, *Phyllocladus* (no. 1742), with thinner branches and phylloclades often touched up with red-brown color, *Libocedrus* (no. 1788), frequently showing a clear story-structure, the lower surface of the phylloclades usually covered with a waxy bloom, and lastly, the more rare *Podocarpus*, which mostly prefers still more protected places in these small shrubby forests. Also in the middle are a few plants of the previously mentioned *Casuarina* (nos. 1705, 1746). This tree, however, apparently does not assume a shrub-form, and in addition prefers a manifestly more open habitat. Nevertheless, it is not at all particular as far as its location is concerned; it grows as well in the midst of a mossy cover as among bare rocks, and just as well on level as on steeply sloping ground. This tree and *Phyllocladus* grow closest to the summit. Up to about 3500 m. altitude, I observed specimens 1.5–2 m. high. Earlier I mentioned that the lower limit of this *Casuarina* lies at about 2750 m.; the upper limit is not far from 4000 m. altitude. In free growth it is a robust but usually crooked gnarled tree giving a peculiar impression with its broad yet very thin crown of upright slender shoots. The latter, especially in the flowering staminate specimens, bear an unusually strong resemblance to *Equisetum*. In both Javanese forms, *C. equisetifolia* Forst. (for which the specific name is less apt than it would be for the species here discussed) and *C. Junghuhniana* Miq. (the mountain-plant which perhaps is not more than a montane form of *C. equisetifolia*), and in other species of the Archipelago, the longer shoots are more or less pendent. Probably we have here a representative of an Australian species of *Casuarina*. Bentham and von Mueller¹⁹ recorded 19 species; later, Moore²⁰ described a few more, among them one with upright shoots. The

¹⁹ Flora Australiensis VI (1873), 192.

²⁰ L. Moore, Journ. Linn. Soc. Bot. XLV, no. 302 (1920), 193.

genus is chiefly Australian, but a few endemic species occur in New Caledonia.²¹ *Casuarina equisetifolia* Forst. is the only one of wide distribution (E. Afr.—Polyn.), and this is because the fruits may be dispersed by sea-currents. It is found chiefly on very sandy coasts.

The Doormantop *Casuarina* grows about 8 m. high. The staminate inflorescences are beautiful dark red; this tree frequently furnished us with firewood which emitted an agreeable odor suggesting that of resinous pine. The large branches are often covered with the large *Myrmecodia* and its numerous seedlings. The tree forms a very picturesque entity, with its broad base surrounded by shrubs and yellow-green moss-cushions, and its branches covered with brown-red or even dark red moss.

Finally we come to the discussion of the third plant-association, that of the small marshes. They are shallow boggy sunken places which may or may not have water-drainage; the vegetation is very scanty; the margin is formed by the more moist vegetation of fern- and shrub-scrubs or by miry spots between bare rocks. The real marshes are covered with widespread clumps which stand out as little islands above the water. These consist chiefly of a species of *Cladium* (no. 1595), more rarely *Schoenus* (no. 1810), and an occasional species of grass. In addition, one finds Compositae (nos. 1629, 1700) in these clumps, and generally *Euphrasia* (no. 1587), which is dominant after *Cladium*; its small white flowers protrude everywhere above the stiff clumps of the cyperaceous plants.

The water of some of these swamps is rusty brown. Whether this is to be attributed to bacteria rather than to iron-content, or perhaps to both, I am unable to say. Everywhere are many green, and probably also blue-green algae (nos. 1731-3, 1756, 1761-3, 1775, 1787, 2004-5), especially in places where the water flows in broad shallow streamlets over gently sloping rocks, amongst a vegetation of *Lycopodium carolinianum* L., or in crooked little channels among higher-growing grasses and sedges. They show all shades of light green to brown- and purple-green. On the border of these small marshes and the stony bare ground, we usually find characteristic creeping Myrtaceae, such as *Xanthomyrtus Klossii* Diels var. *brevipedunculata* Diels* and *Descaspermum prostratum* Diels*, with its branches, often several meters long, lying flat on the ground and taking root; during a rain they frequently stand under water.

I observed another type of marsh-vegetation in the upper parts of some ravines which descend on the sides of the Radio-plateau. Here the flora is richer; this is particularly true of the largest of these marshes (*Fig. 20, n-p*), lying at the entrance to the large ravine on the southeast side of the plateau (*Fig. 20, h*). When one descends through a shrub-forest with tall grasses and light green *Lycopodium laxum* Pr., one comes upon a gently sloping miry valley-bottom²² lying somewhat sheltered between the high slope of the second plateau on one side and a small foresummit on the other margin. The water flows slowly between tall grass-clumps which are dominant here; and the many small waterways at the lower end form a brooklet which falls somewhat further along into the bottomless mossy ravine. Among the grasses are many plants of an attractive robust *Potentilla* (nos. 1702, 1764), strongly resembling and without doubt closely related to the silver-weed (*Potentilla Anserina* L.) and

²¹ Id., l. c. no. 303 (1921), 414.

²² Vegetationsbilder XV, Heft 6, Pl. 26b.

perhaps identical with *P. leuconota* D. Don of the Himalayas and high peaks of intermediate regions. The very large flowers are bright yellow with frequently reddish calyx-lobes. Another reminder of the northern flora is a *Cynoglossum* (no. 1765), which resembles a *Myosotis*, a very small shrub or undershrub with white flowers and very firm thick small leaves. A third is a much rarer *Viola* (no. 1673), growing at its lower limit; in the highest saddle at almost 3500 m. altitude it is much more plentiful. Among the grass-clumps is *Lycopodium scariosum* Forst., and on the drier margins other species of the same genus.

I searched in vain for a species of *Ranunculus* occurring not only on the mountain peaks of Java, but, according to Pulle²³ and Ridley,²⁴ also on the south side of the Central Mountain Range.

The large ravine (*Fig. 20, h*)²⁵ mentioned above has a much richer flora than the valley-bottom at the entrance. Without doubt this is due to the fact that the walls suddenly slope steeply, so that the deep-lying valley is entirely sheltered on three sides. A picture of the vegetation, therefore, makes one think of that of much lower regions, a true pontic²⁶ flora, with unexpectedly tall forest for this altitude (3320 m.), in which everywhere pairs of white butterflies flit to and fro and a number of other insects are swarming about. The characteristic plant of this ravine is a tall coniferous *Libocedrus* (no. 1788), a large tree attaining a height of 15–20 m., with a thick straight trunk and a beautiful umbrella-shaped crown. The sharply ascending branches of this stately and decorative tree are covered with yellow and red moss-cushions; often it also supports a number of plants of the large *Myrmecodia*. This ravine is most beautiful in the mist. The silence is unreal and is still more striking when the fog limits the sphere of vision and the orbit of interest to the immediate surroundings—a silence broken only by the uncanny creaking of trunks and branches grating against each other in the plaintive howling of the wind, and the patter of the drip falling incessantly from the moss-cushions on the leaves of the low flora. Even on us such customary sounds as these have a strange effect at times, as if they represented another world. Still, these surroundings impressed me as a much more harmonious whole in the mist than in the sunshine, perhaps because, in the presence of the mist, the isolation was felt unconsciously rather than consciously and seemed to be the strongest feature of the landscape. The fantastic cypresses appear as capricious silhouettes against the fog; those close by are dark and clear, those more remote are lighter, and those farthest away can scarcely be distinguished from the streaks of light which flow into each other and the gliding shadows of the clouds; the bleakness of the wind forcing the clouds through the ravine is in perfect harmony with the ghost-like tree-forms and the inexplicable sounds. Suddenly the nearby familiar guttural

²³ A. Pulle, *Naar het Sneeuwgebergte van Nieuw-Guinea*, p. 158, and *Maatsch. t. Bevoud. v. h. Natuurk. Onderz. d. Ned. Kol. Bull.* no. 68 (1913), p. 36.

²⁴ H. N. Ridley, *Report on the Botany of the Wollaston Expedition to Dutch New Guinea 1912–13—Trans. Linn. Soc. London*, 2nd ser. Bot. IX, 1 (1916), 8, 10.

²⁵ *Vegetationsbilder*, l. c. Pl. 27, 28a, 39.

²⁶ This expression is used for plants really belonging in warmer or more southern regions rather than those corresponding with the geographic latitude or altitude of the habitat. The word is derived from "Pontus" (a mountain region in N. E. Asia Minor), because there, in favorable habitats, one encounters some plants characteristic of the more southern and warmer regions. In Europe such pontic plants are mostly considered as relics of a widely spread steppe-flora in the diluvium, which withdrew by reason of a climatic change owing to the glacial period or some other cause and survived only in favorable places. They form a counterpart for the glacial relics, i. e., plants immediately following the ice-covering instead of fleeing from it.

sound of a lizard recalls one to reality, or the loud chirp of a swallow skimming by is like a bit of reality which unexpectedly appears, passes through, and vanishes from the small mysterious world of the mist.

It soon appeared that the real valley-bottom of this ravine is impassable. Wherever one descends along the steep slopes, one reaches the margin of harmless-looking moss-coverings which, however, conceal treacherously deep crevices and masses of decayed wood. It is almost impossible to penetrate more than a few meters into the moss-covered area, except with the sacrifice of much time and the possibly good chance for an unexpected fall. Deeply hidden under the moss an unseen brook murmurs and gurgles. Most of the plants which are common in the barren mountain-meadows occur here, but with a more robust habit and larger size. In addition are two species of *Dacrydium* (nos. 2151, 2154) and a *Podocarpus* (no. 1789), a thick robust tree-shrub with small firm leaves; the last genus does not occur here above the forest-limits. A fact immediately attracting attention is the large number of hygromorphic plants, the leaves of which are large and thin compared with those previously mentioned. This is most apparent in a species of *Homalanthus* (no. 1801), a large tree-shrub with the usual aspect of this genus, which looks strange in these surroundings. It is also peculiar to find here an abundance of tall tree-ferns, three or four species in the undergrowth. I obtained only one specimen representing a moderately tall *Alsophila aeneifolia* v.A.v.R.* var. *subglauca* v.A.v.R.*, with a trunk 4 m. tall and 13 cm. in diameter. In an earlier Fragment I mentioned that van Nouhuys, in a ravine on the south side of the mountain at an altitude of 3650 m., found a *Cyathea* with a trunk 3.5 m. high,²⁷ while the Kremer Expedition in 1921 brought photographs from the Upper Baliem Plateau (3300 m.) and from the approaches to Wilhelminatop (base 4100 m.), in which are seen a number of robust stunted plants which I take to be tree-ferns.

Among the shrubs and tree-shrubs in this ravine I also found a *Symplocos* (no. 1803), a widely branching shrub 3 m. tall, with white flowers, *Drimys pachyphylla* Diels*, likewise more robust than the specimens previously mentioned, *Styphelia nutans* J. J. Sm. var. *axillaris* J. J. Sm.*, about 1.5 m. tall, with pale yellow-green flowers, *Sericolea Lamii* O. C. Schm.* with white, and *Dimorphanthera parsifolia* J. J. Sm.* with dark red flowers, *Xanthomyrtus longicuspis* Diels (end.), with very noticeable golden-yellow flowers, and finally *Timonius avenis* Val.* (end.) and one of the Araliaceae (no. 1735). The only liana in this forest is one of the Araliaceae, perhaps a *Schefflera* (no. 1792), with dingy light purple flowers, the corolla dropping off unopened; the petioles and fruits showing the typical purple discoloration of mountain-plants. More or less scandent, sometimes epiphytic, is *Diplycosia Lamii* J. J. Sm.*; some other representatives of this family are epiphytes, such as *Rhododendron nummatum* J. J. Sm.*

The mossy covering forms a colorful layer under the trees, colorful particularly on account of the flowers protruding from it. Here is a pretty *Corysanthes* (no. 1779), a small plant with white stalk, white roots, and a bright purple flower above the single leaf. In addition there are species of *Glomera*, such as *G. acutipetala* J. J. Sm. and *G. Pullei* J. J. Sm., and many plants of the previously mentioned species of *Mediocalcar*, with its conspicuous red and violet-green color. Other Orchidaceae (nos. 1776-7, 1780) found at lower altitudes were also collected here. In addition to *Astelia alpina* R. Br., here growing in the

²⁷ v. Rosenstock, Nova Guinea VIII, 4 (1910), 716.

moss are many ferns and species of *Lycopodium*, as *L. clavatum* L. (all temperate zones and tropical subalpine territories) var. *tamariscispica* v.A.v.R., a light green plant creeping through and over the moss. Of the terrestrial ferns, I mention *Polypodium allocotum* v.A.v.R.*, *Dryopteris stereophylla* v.A.v.R.*, *Hymenophyllum Reinwardtii* v.d.B. (Java, Sumatra, Borneo, N. Guin.), and *Elaphoglossum sclerophyllum* v.A.v.R.*, in which the lower surface of the coriaceous fronds is entirely covered with a thick mass of brown sporangia. Only as epiphytes I observe *Polypodium subulatipinnum* v.A.v.R.*, *P. vernicosum* v.A.v.R.*, of which the upper surface of the fronds appears as if varnished, another species of *Polypodium* (no. 1786), and *Pleopeltis gracilipes* v.A.v.R. On a boulder protruding from the moss *Pleopeltis cretifera* v.A.v.R.* grows. Finally I mention another epiphyte, *Hydnophytum crassicaule* Val.*, with a black tuberous stem.

The smaller ravines on the north side of the plateau are shallower and the vegetation on the floor is much less protected.²⁸ The forest does not grow to any considerable height. When one moves westward from Radio-bivak through the low shrubby forest in which the Dyaks had offered an egg-sacrifice, one descends somewhat to the half marshy bare muddy areas limited on the north by a beautiful small *Casuarina* forest and on the south by a low shrubby slope; in front is a small elevation with a border of *Casuarina* plants at the base, the slope being covered with Coniferae and *Drimys*. On the other side a slope, covered with scattered shrubs (among others undetermined, no. 1749), tall ferns (species of *Gleichenia* and *Lycopodium tomentosum* v.A.v.R.), and grasses, descends to a small ravine. On this slope I observed a young *Libocedrus* with a load of five heavy specimens of *Myrmecodia*, and the shrub *Polyosma longibracteolata* O. C. Schm.* The nearer one approaches the bottom of the ravine, the thicker the moss-layer becomes among the tall ferns, the more hygrophilous ones being hidden in the mossy covering. I found here *Trichomanes lasiophyllum* v.A.v.R.* and *T. compactum* v.A.v.R.* var. *pauperculum* v.A.v.R.*,²⁹ with fronds curving downwards, just as in *Hymenophyllum nutantifolium* v.A.v.R.* from Goenoeng Boetak (1420 m. alt.). Also concealed in the moss are a number of Orchidaceae, such as *Glomera fruticula* J. J. Sm., *Chitonanthera trigona* J. J. Sm., *C. obovata* J. J. Sm., and *Peristylus ciliolatus* J. J. Sm., all fragile plants frequently with very long stems, which seldom or never extend above the moss (also no. 1712). The species of *Glomera* have beautiful dark salmon-colored flowers; the finer ones of *Chitonanthera* show all variegations of orange. All these plants seem to be entirely adapted to the life within the moss-covering.

Below on this bushy slope is a place where the gray bare rock comes to the surface. On the side the perpendicular wall is green with mosses (such as *Campylopodium euphorocladium*, *Braunfelsia subulata*, *Bryum porphyreoneuron* var. *giganteum*, *Schlotheimia Lamii*, and no. 1715, the last two fiery red in color). The foot of the decline is surrounded by a growth of *Gleichenia subulata* v.A.v.R.*; in front of it lies a small gently sloping gravelly field.³⁰ This area is covered with a few dense clumps of a grass (no. 1682) having rolled spear-like blades and a few young plants of a very small *Dipteris* (*D. novo-guineensis* O.

²⁸ Vegetationsbilder XV, Pl. 29–31.

²⁹ This type occurred as an epiphyte at Goenoeng Boetak (1420 m.).

³⁰ Vegetationsbilder XV, Pl. 29A.

Posth.*);³¹ it is further strewn with small pale rose fruiting bodies of a fungus (no. 1714) and of a lichen, *Baeomyces novoguineensis* Zahlbr.*, as well as with ♂ plants of a species of moss, *Dawsonia crispata*; the ♀ plants of this species grow close to the surface of the slope and have very large capsules.³² Another fungus (no. 1739) occurs on dead wood. The narrow ravine-floor shows little new in the vegetation. Above on the margin, which descends steeply at this point, is the shrub-like *Alyxia Lamii* Markgr.* On the ground itself³³ various robust ferns grow, such as *Alsophila aeneifolia* v.A.v.R.* This plant is the type of the variety which was collected in the pontic ravine. In this much more open, small ravine the plant, less than 1 m. tall, grows on a tree-trunk 4 dm. in length. Another tree-fern is *Cyathea imbricata* v.A.v.R.*, which is 3 m. high (trunk 2 m.). Much smaller but nevertheless still robust is *Lomaria revoluta* v.A.v.R.*, attaining about the same size as the previously mentioned *Alsophila*. Here *Polypodium subpinnatifidum* v.A.v.R.* grows as an epiphyte. In some places the shrubs suddenly become dense; among them *Coprosma ulicoides* Val.* is particularly conspicuous, with long thin branches leafy for long distances and protruding high above the rest of the vegetation. Here also is *Quintinia Schlechteriana* O. C. Schm.*, with pale green-yellow flowers, a *Litsea* (no. 1747), with yellow-green flowers, and *Sericolea Lamii* O. C. Schm.*, with white ones. A *Rubus* (no. 1585), with long flexible sharp prickly branches, twines through the shrubby growth, here and there adorned with its large white flowers.

We shall presently leave the Radio-plateau and follow the changes taking place in this flora at a still higher altitude. The trail used for the ascent to the summit carries us over bare stone ridges and through a few marshes to the foot of the enormous steep crumbling declivity (*Fig. 20, c*) cutting off the plateau on the west side. Along the foot are still a number of robust *Casuarina* plants, the branches covered with *Myrmecodia*.³⁴ The slope consists of a chaos of huge boulders with deep crevices between them exceeding the height of a man, thus forming a very irregular surface. The trail of trampled plants, of earth on bare rocks, of scratches of hobnailed shoes on the stones is difficult to follow but for the small flags—pieces of bandage-gauze tied to long stakes—which were placed at regular intervals. In the beginning the distinctive marks were very useful. Once lost among the boulders, one must frequently search a long time for the lost trail, as the crevices between the boulders were so deep that one had no view over the land. Eventually we knew each stone, each turn, each jump, and it became a sport to cover this mighty rugged slope in record time.

The flora here is very rich, a fact surely to be ascribed to the presence of the crevices, not only because these offer shelter against the worst extremes of the climate, but also because humus and plant-seeds collect therein as the rain-water runs off the rocks. For this reason the crevices have a more or less thick growth of shrubs. Strongly dominant here are *Vaccinium* (no. 1631), species

³¹ In British New Guinea is another high montane form about 2 dm. high which, according to Seward, resembles the fossil species of *Hausmannia*, especially *H. crenata* Richter (of the Rhaetic period) more than the living species of *Dipteris*. Perhaps there is reason to relate this species, which is also found on Daymantop (Papua), to *Dipteris* (cf. Rec. Trav. Bot. Neerl. XXVa (1928), 244.

³² Vegetationsbilder.

³³ Vegetationsbilder XV, Pl. 30–31.

³⁴ Vegetationsbilder XV, Pl. 41.

of *Rhododendron* such as *R. toxoides* J. J. Sm.*, *R. simulans* J. J. Sm.*, and *R. Lamii* J. J. Sm.*, and *Diplycosia Lamii* J. J. Sm.*; these also are most conspicuous because of the usually red flowers. In addition one observes *Styphelia Vannouhuysii* J. J. Sm., the *Eurya* (no. 1666) before-mentioned, with its stiff branches all obliquely directed upward in one plane, Myrtaceae such as *Decaspermum Lamii* Diels*, with yellow-white flowers and dark red fruits, closely related to *D. Lorentzii* Lauterb. from the south side of the mountain, and *D. prostratum* Diels* with pale cream-colored flowers; the last naturally occurs only in open places between the rocks, not in the crevices. Here too are a few species of *Evodia*, among others no. 1679 and *E. Doormani montis* Lauterb.*, a robust shrub with flowers wine-red outside and almost white within, and also the small *Haloragis fruticosa* F. W. Went*, with dark gray bark and dark red flowers. Other shrubs here are *Ternstroemia papuana* Lauterb.* (no. 1613), or a species very closely related to it, with pale yellow flowers and red fruits, *Polyosma longebracteolata* O. C. Schm.*, with curled leaf-margins, the flowers green within and brown-hairy outside (I found here a double flower among them), *Drimys* (no. 1630), and finally an undetermined shrub (no. 1627). Of the conifers I observed only *Phyllocladus* (no. 1628), and a poor specimen of *Casuarina* is practically the only plant which stands out above the profile of the slope. Among the woody plants I mention finally the parasitic *Henslowia acutata* Pilger*. The vegetative parts of this plant, like those of *Exocarpus*, show all colors from green-yellow to red, and its long thin stems grow as thick and tangled over the host as, for example, *Cassytha* on the shore, or *Cuscuta* on the Dutch heath. In contrast to the Loranthaceae, the two previously mentioned parasites, the santalaceous *Henslowia* and *Exocarpus*, fasten themselves on the host at only one spot. The small flowers and fruits are a beautiful warm dark red.

The herbs here are relatively few. In small flat places or in shallow crevices are clumps of the beautiful *Gahnia* (no. 1748). Among the mosses on the margins of the small shrub-forests grow *Chitonanthera obovata* J. J. Sm. and *Glomera Pullei* J. J. Sm. Here and in more open places are a few other Orchidaceae, such as *Calanthe Versteegii* J. J. Sm. (end.), with green-white flowers, and particularly the beautiful *Dendrobium vexillarius* J. J. Sm. var. *purpureo-viride* J. J. Sm. Higher up, the last becomes more common and is immediately noticed because of its flowers. Each plant has a pair of erect flowers turned toward each other, with the perianth-segments more or less spread in one level; they are very large and of a peculiar color: very dark green with all shades to lighter green and green-white.

Above us the slope suddenly becomes much more easily passable; the second plateau is reached. Large flat rocks, small level patches of white sand, or earth, dark-colored because of the presence of humus, offer an easy path over this narrow saddle which, between two small elevations, leads to an indentation of the plateau. Before us lies this widely undulating and forsaken world of rocks; the brown color of the rock-formation dominates in the distance; but at close range the eye is captivated by the lilac *Patersonia*, the yellow Myrtaceae, the rose and cream-colored *Styphelia*, and the fiery red Ericaceae; *Nepenthes Vieillardii* Hook. f., with its green and red pitchers and its brown flower-clusters, contributes to the picturesqueness of the small alpine gardens. The trail leads through an indentation (*Fig. 20, t*) wherein immediately again the shrubs extend to the height of a man. Then it ascends again as a muddy track

clearly recognizable upon the rocks lying along the naked slope. When we have climbed this trail the real summit (*Fig. 20, e*) lies open before us, on the opposite side of a steep ravine sloping towards the north (*Fig. 20, k*).

Here the path carries us through a richly flowering forest of low trees with small evergreen leaves, and some distance further through a small group of tall and slender *Casuarinae*. *Nepenthes* is exceedingly common here on the bare spots among flat stones. And, although we do not find a number of plants which occur on Radio-plateau, it is not only impoverishment which changes the floral picture. Thus here is the thin elegant *Rhododendron extrorsum* J. J. Sm.*, with light gray branches, very few small leaves, and large wide-open light citron-yellow flowers. The large *Myrmecodia* is exclusively terrestrial. Apparently we are now above the range of the greatest frequency of this species, the number of plants being smaller as well as the measurements of each individual.

A high grassy saddle (*Fig. 20, m*) forms the link between the two parts of the summit; here is the indentation which is seen from the plain. Among the tall clumps of grass (no. 2027) and Cyperaceae such as *Schoenus* (no. 1691) on rain-washed earth, a small *Viola* (no. 1673) grows; I had found a few scattered specimens of it at lower altitudes; the plant is not more than 4–5 cm. tall, with purple-striped white flowers and firm thick leaves. In the small streamlets which in some places flow over fine white sand, in others over stones covered with thick layers of waving algae, I found a peculiar grass (no. 2029) which forms small hard shaggy convex clumps not more than 4–5 cm. in diameter and 2–2.5 cm. high, growing in the water or on the margin of it; the short stiff leaves are sharp and the inflorescences of but one or two flowers scarcely protrude above them. A small liverwort-like plant also grows here at the side of the water.

In the small alpine gardens, *Henslowia acutata* Pilg.* is still very common; also I observed here one very small specimen of *Exocarpus Pullei* Pilg.*, a single stem a few decimeters tall, parasitic on the roots of a shrub. The few phylloclades were thickly beset with galls.

The tallest tree-like plants are *Casuarina* and *Phyllocladus* (no. 1647), in a small group at about 3500 m. altitude (where the path cuts the slope, cf. *Fig. 20*); these trees are 2 to 3 m. tall. In that small forest are also *Drimys fistulosa* Diels* and a few Ericaceae, all about 1.5 m. high. The ground is covered with a thick moss-layer, and on the branches of the trees hang thick bunches particularly of red mosses, such as *Schlotheimia pilicalyx*, *S. MacGregorii*, *Thysanomitrium MacGregorii*, and no. 2034. In more open alpine gardens on the slope and particularly in small hollows, where a thick moss-layer covers everything, a number of smaller shrubs grow, such as *Styphelia trilocularis* J. J. Sm. var. *quinquelocularis* J. J. Sm., *Evodia Doormani montis* Lauterb.*, and a few Ericaceae such as *Rhododendron simulans* J. J. Sm.* and *Vaccinium molle* J. J. Sm. Herbs are not at all scarce on this terrain. *Euphrasia* and three species of *Didiscus*, *D. aff. saniculifolius* Stapf (no. 1659) and two others (nos. 1645, 1692, 1694), occur here. One (no. 1645) is a somewhat xeromorphic small plant about 1 dm. tall, with the basal rosette of thick small leaves dark green above and purple beneath; the petioles and peduncles are often purplish, the umbels with flowers purplish outside, white within. One readily observes that young parts protected from the light do not become purple; from this, it might be deduced that the ability to develop this color is present definitely in the imma-

ture flowers. In the moss-covering I collected a fern (no. 2028), and on a rock *Polypodium trichocarpum* v.A.v.R.*, a species observed at 2540 m. altitude. The number of Orchidaceae here is still large. *Mediocalcar crenulatum* J. J. Sm., with its deep red and green color, the light green *Calanthe Versteegii* J. J. Sm., and the large-flowered dark and light green *Dendrobium vexillarius* J. J. Sm. var. *purpureo-viride* J. J. Sm. grow here in undiminished numbers and undiminished splendor. The last-named species in the floral parts is likewise strongly inclined to purple coloring under the influence of light. Should this fact have been considered sufficient reason to establish a variety, it will have to be reduced. The large *Myrmecodia* occurs here but is continually less in number and smaller in size. However, on mossy places the gray *Hydnophytum* and *Nepenthes* are still common.

The ravine (*Fig. 20, k*) on the east side of the highest peak slopes very steeply toward the north and is more continuously filled with shrub-groups. The saddle, however, is devoid of all shrubs. Unexpected and surprising is the scene which unfolds before him who climbs a few scores of meters higher to the margin of the long narrow ridge sloping from Doormantop toward the southeast. Before he arrives at the top, already a cutting wind blows in his face, and a little later he stands on the margin of an enormous precipice which continues from the southwest side of the summit some distance toward the west. As the relatively regular and broad terrain rises on the north side to the outline of the dominating Doormantop in the distance, so abruptly it falls on the south side many hundreds of meters, bare, crumbling, and loose, with a slope of 60° to 70° continuing unbroken 600 to 700 m., to where the tall forest with its rounded tree-crowns covers the ridges. There below lie the rolling mountain slopes of the Swart Valley in the luxuriant beauty of green forests and succulent meadows under a mild sun. And thereafter crest after crest rises to the very horizon, where the Central Chain cuts off the field of vision at a distance of 80 km., and where, small but clear, the perpetual snow-field of Wilhelminatop glistens in the sunlight.

Before closing this Fragment, we shall once more cast a glance over this impressive world of unspoiled beauty from the point at which one may enjoy an uninterrupted view, Doormantop itself. And I shall finish this floristic survey with a short sketch of the flora of that point, one of the highest in the extensive surroundings. The fact that this open greatly exposed summit still has a very large number of taller plants reminds us that we have not yet, at this altitude, nearly reached the vegetation-limit in a region so close to the equator as this. On the small plateau of the summit itself a low shrub-flora grows, which, however, does not rise above the edges of the protecting clefts. Among them we find three red-flowered Ericaceae, *Rhododendron toxoides* J. J. Sm.*, *R. gaultheriifolium* J. J. Sm.*, and *Vaccinium ciliatipetalum* J. J. Sm.*; in addition the thymelaeaceous *Drapetes ericoides* Hook. f., with very light cream-colored flowers, *Styphelia Dekockii* J. J. Sm., with rose flowers, the large-flowered *Oldenlandia coprosmoidea* Val.*, with lilac campanulate flowers, a firm-leaved compact *Cynoglossum* (no. 1658), *Decaspermum Lamii* Diels, and the creeping *Xanthomyrtus Klossii* Diels var. *brevipedunculata* Diels*. *Nepenthes Vieillardii* Hook. f. is still common here, likewise *Euphrasia* (no. 1644), *Gentiana singalagensis* Back. (no. 1660), *Cladium* (no. 1667), and two Orchidaceae, *Microtorchis terrestris* J. J. Sm. and *M. Lamii* J. J. Sm., with at first light green flowers which later become yellow or yellow-orange. Finally

here is a species of grass (no. 1664), showing a strong purple color in all parts exposed to light. This highest plateau has therefore 15 or 16 species of higher plants, of which eight are shrubs; 16 species of the perhaps 8000 to 10,000 native to New Guinea are suited to this habitat and thrive on the mountain-top. On all sides below lie zones continually richer in species, and as soon as one descends somewhat from the highest point, this richness of species increases at once, because the stands are partly sheltered. Immediately one observes shrubs 1-1.5 m. high. I find the light yellow *Rhododendron extrorsum* J. J. Sm., *Evodia Doormani montis* Lauterb.*, *Styphelia Dekockii* J. J. Sm., *Drimys fistulosa* Diels*, *Henslowia acutata* Pilg.*, *Phyllocladus* (no. 1647), and so many other species of shrubs and herbs which I have already mentioned above.

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A few ecologically important observations must be associated with this floristic survey.

In the third Fragment I have mentioned in passing why Schimper's xerophytic theory cannot be accepted. However, at present we cannot offer any substitute explanation in its place which is as satisfactory as that proposed by Schimper and, from the following brief observations, one may conclude from the *choc des opinions* that the truth has not yet been discovered.

Senn,³⁵ whom I have already quoted a few times, comes to the following conclusion in his article on the physiology of alpine and other plants: "So dürfen wir die Mehrzahl der Alpenpflanzen jedenfalls nicht zu den Trockenpflanzen oder Xerophyten zählen. Ihre bisher als xerophil aufgefassten morphologisch-anatomischen Charaktere sind keine ökologischen Anpassungen, sondern notwendige Folgen der niederen Temperatur und der hohen Lichtintensität; diese Faktoren sind es, und nicht die Trockenheit, welche ihre Wachstums- und Gestaltungsvorgänge bedingen." And rightly Blagowestschensky³⁶ says at the end of his paper: "Zu einer richtigen Lösung des Problems sogenannter Schutzvorrichtungen, des Xeromorphismus und der Pflanzentypen gegebener Standorte bedarf es einer weiteren Ansammlung von Tatsachen aus dem Gebiet der vergleichenden Pflanzenphysiologie, da die Ansiedlung der Gewächse hauptsächlich durch innere Faktoren bestimmt wird." Indeed, we must not look for an explanation of the adaptation of mountain-plants in the field of morphology or of anatomy, but rather in that of physiology. Not in the first place, as Schimper believed; but I still think we must be on guard and not go to the other extreme of denying all influences of outward conditions on form and structure. I believe that it is possible to indicate a number of morphological peculiarities, even be they of secondary nature, which can be explained satisfactorily in no other way, but their importance is surely not primary. Therefore, one should not go further than to say that a certain xeromorphy can be determined in some mountain-plants, but one can conclude that plants in exposed situations are for the most part not hygrophytes in any case. For a number of plants the visible quantity of water is small; in addition the low temperature works strongly as a limiting factor even though sufficient water be present, as, for example, in the case of plants which root in moss-cushions and which are exposed in part to temporarily strong dehydration

³⁵ G. Senn, Verh. d. Schweiz. Naturf. Ges. (1922), II, 154.

³⁶ W. Blagowestschensky, Der osmotische Wert bei den Gebirgspflanzen Mittel-Asiens. Jahrb. f. Wiss. Bot. LXV (1926), 279.

(radiation and wind). Also, resistance against great temperature-changes must be present, and, although the plant resists these influences principally through physiological adaptation, the outward form and the inner structure have not remained uninfluenced.

In another place in the above-quoted article Senn says: "Da jedoch das Klima in bedeutenden Höhen über dem Meeresspiegel in allen Erdteilen die charakteristischen Merkmale unseres Alpenklimas aufweist, werden sich vermutlich auch die Pflanzen anderer Hochländer durch ähnliche physiologische Eigentümlichkeiten auszeichnen wie diejenige der Alpen, wenigstens da, wo wie bei uns, die Niederschläge reichlich bemessen sind." It must be admitted that this assertion contains much truth, but I still believe that one must use foresight in establishing analogies between plants of temperate and of tropical mountains. Previously, errors have been made in the field of plant-geography through the application of the laws known to apply to temperate floras, without further research on their application to that of the tropical mountains; such remarks as the one mentioned above show that one could take the same road in the ecological-physiological field. Apart from the fact that an altitude of 3000–3500 m. in an equatorial region is not comparable with that in the Alps, where Senn experimented (namely, 2450 m., i. e. 300 m. above tree-limit, which lies at about 3800–4000 m. in the tropics), seasonal changes in temperate regions clearly provide a point of difference which is very important. The winter there has a strongly limiting influence on the summer-flora. In addition, the range between high and low temperatures in the tropics is quite different (cf. Fragment II, Table I).

A short discussion of what more recent researches have indicated in this field must here find a place. Senn found that alpine individuals of a species not only can withdraw more water from the earth than those of the lowland, but also that they can transpire more strongly independent of light-intensity, at least in a temperature lower than 6° C.³⁷ On the other hand, experiments have proved that alpine plants in drought remain turgid longer than lowland plants under—*mutatis mutandis*—similar circumstances. This can be the result of the ability thereby either to inhibit strong evaporation or to transfer water more quickly, and also by less water-content of the soil, or possibly of both. I shall herewith point out that this is truly an adaptation in a xerophytic direction, and when it can be demonstrated that the stopping of evaporation—be it only in part—is made possible through the peculiarity of form or structure (and therefore not only through the closing of the stomata), then one would be able to speak certainly of more or less xeromorphy in such a case. In this connection I shall therefore recall that, with reference to this question, the gist of the xerophytic theory also is touched. One thinks only of so many xerophytic epiphytes and desert plants, in which the water-accommodation is the entire governing factor, and it becomes important to examine in such plants, or in truth in such matters, the "bisher als xerophil aufgefassten morphologisch-anatomischen Charaktere"; indeed correlations by younger authors show the indicated physiological adaptation. Besides Senn, Maximov³⁸ has demonstrated, for steppe-plants, that those plants in drier places have a stronger water-transportation, a stronger transpiration, and a higher root-pressure.

³⁷ Again a temperature at the indicated altitude which in the tropics is encountered only very temporarily and locally.

³⁸ N. A. Maximov, Physiologisch-ökologische Untersuchungen über die Dürre-resistenz der Xerophyten. Jahrb. f. Wiss. Bot. LXII (1923), 128.

Turesson³⁹ has therefore rightly pointed out the difficulty: that all these experiments were done not with hereditary units, but with populations. He therefore experimented with pure lines of alpine and arctic plants and found that there exist hereditary differences between ecotypes of the same species. He demonstrated that alpine plants have a much lower plasmolysis-limit and therefore lower osmotic pressure in the roots than lowland forms, so that the stronger osmotic suction-force unquestionably shown in alpine plants can be induced only as a modification, for example by temperature and light, and therefore is not hereditary. In themselves, therefore, alpine plants can be considered to be much less able to utilize the available water than lowland plants, and a hereditary strong suction-force of the roots is an adaptation of the utmost importance for mountain-plants. Turesson also refuted the opinion of Blagowestschensky that each systematic species would have its own osmotic pressure, although the critic admits that the osmotic pressure in some species is extraordinarily constant, whereas in others it can vary within certain limits. He notes too that xeromorphy and high osmotic pressure need not occur together. I believe, however, that Turesson's opinion that the higher suction-force of alpine plants would be induced by light and temperature requires further confirmation. According to my idea, the question is whether one must not think rather of a direct, or, if need be, an indirect influence of evaporation; such apparently is the case in steppe-plants. Even if Senn demonstrated, by comparative evidence from alpine and lowland plants, that the first sometimes possess a more intensive water-transport, I shall still maintain that the progress of many other life-processes has no other significance than that the optimum for alpine plants is much lower than for plants of the lowland, similarly, as we shall see, with relation to the discoloration of flowers. This related in particular to carbon dioxide assimilation and transpiration.

* *
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I have inserted these theoretical considerations first, to call attention to the doubt and uncertainty which exists at present in this field of plant-geography, and second, to mention some of the modern ideas regarding the solution of the problems by quoting some of the recent authors. We shall now return to Doormantop and consecutively subject the various ecological factors of this high mountain-territory to a brief consideration.

From table I of Fragment II one sees that the observed minimum temperature on Radio-plateau (under the shade of a pent-house 0.5 m. above the ground) amounted to 8.4° C. Lower temperatures, however, doubtless occur near the earth, as witnessed by the hoarfrost which was seen a few times at sunrise after a clear night.

The observed minimum relative condition of humidity amounted to 51%, mostly, however, values between 80 and 100% were obtained. On high summits in Java much lower minima (6%) have been observed.⁴⁰

That the light here is very intense is evident, among other reasons, from the shorter exposure-time necessary in photography. A short time ago Denis Mulder, in an interesting article,⁴¹ has shown that the ultraviolet rays increase

³⁹ Göte Turesson, Untersuchungen über Grenzplasmolyse- und Saugkraftwerte in verschiedenen ökotypen derselben Art.—Jahrb. f. Wiss. Bot. LXVI (1927), 723.

⁴⁰ See F. C. von Faber, Die Kraterpflanzen Javas in physiologisch-oecologischer Beziehung—Arbeiten aus dem Treub-Laboratorium I (1927), 29, fig. 4.

⁴¹ Handelingen 4de Ned. Indisch Natuurwetenschappelijk Congres, Weltevreden, 1926, p. 151.

both quantitatively and qualitatively with increasing altitude, whereas the ultrared heat-rays decrease in the same measure. The ultraviolet rays are most important, not only for the photographic plate, but also for living things, and one may accept that they particularly form the active agent in the retarding influence of light on the growth in length. Among the plants recorded I have mentioned beautiful examples of this. Species of *Gentiana*, *Didiscus*, *Glomera*, and *Chitonanthera* grow as tall as their surrounding or shading flora as well as in the shade of shrubs, and therefore reach an unusual length, whereas on open land they remain unusually small. Proportional differences of more than twelve to one were noted in this connection. This influence of light prevails in much stronger measure for the vegetative than for the floral parts. In a specimen of *Gentiana* (no. 1623) growing in a shaded habitat, I found the relative length of the plant to be 12.5 times the diameter of the flower, while in a specimen growing on open ground the relation was 3.3. The length of the plant in the latter instance was 2/15 of that of the former. The diameter of the flower was reduced one-half. Doubtless herein we may find the explanation for the previously mentioned fact that the relative size of the flower increases with the altitude. As a nice example I earlier listed the different species of the genus *Argostemma* (*A. nanum* K. Schum.—*A. Lamii* Val.—*A. montis Doormanni* Val.) which succeed each other in the different altitudinal zones of the slope; each has relatively (and perhaps absolutely) larger flowers than the preceding one. It would be worth while to consider whether, when mountain-species are transferred to lower levels, their flowers also would become relatively smaller.

Another phenomenon, which must be attributed to the influence of light, is the formation of purple (red) coloring matter (anthocyanin), mentioned above as occurring in exposed plant-parts. I have noticed similar discolorations in some grasses (no. 1664), *Dendrobium vexillarius* J. J. Sm., *Gentiana*, *Didiscus*, *Decaspermum prostratum* Diels, *Euphrasia* (only the vegetative parts), and some species of *Drimys*. With respect to this matter I have observed, particularly in *Gentiana*, that the parts which have been covered by others—as parts of the corolla by the calyx-lobes—remain practically white not only in naturally white flowers, but also in the cobalt-blue ones of the gentian. The critical period in the formation of anthocyanin is very early in the development of the part; the color appears only in the young exposed parts, while in parts at first almost covered, but later exposed to light, this is not the case. Not only the flowers but also the vegetative parts are sensitive to the formation of anthocyanin, though in a lesser degree, and this can develop so far that the whole plant becomes more or less purple. I could also note that individuals of some species near the highest point of the summit (3500 m.) clearly possessed more purple color than those of Radio-plateau (3330 m.), and that near Uitzicht-bivak (3120 m.) in a number of species the coloring matter was entirely lacking, whereas higher up these species were definitely colored. According to Bouget,⁴² the discoloration in flowers at greater altitudes is the rule, always tending to violet. The optimum for different species, however, may vary greatly; for some it is found at low altitudes, these frequently becoming white-flowered at higher altitudes, while others exhibit their strongest color-form at high altitudes. The classic work on this subject is that of Bonnier.⁴³ It

⁴² J. Bouget, Observations sur l'optimum d'altitude pour la coloration des fleurs—Compt. Rend. Acad. Sciences Paris CLXXIV (1922), 1723.

⁴³ G. Bonnier, Ann. Sci. Nat. Bot. XX (1895), 217.

is also discussed in an article of Weisse,⁴⁴ which gives a summary of the literature which has been published on color-variation of flowers under the influence of external conditions. Some see in the presence of this coloring matter—also in young leaves—a protection against high temperatures through radiation, at least as far as it concerns the vegetative parts, since the red color does not absorb the red heat rays. Others⁴⁵ deny this, and think the development of anthocyanin is a direct result of the allied processes of carbonic acid assimilation. Perhaps therefore the explanation of alpine coloring must be explained otherwise, since we have seen that the heat-rays are much weaker than the ultraviolet ones. Possibly the occurrence of strongly shining leaves in some shrubs and even ferns (*Pleopeltis vernicosum* v.A.v.R.) is a defense-medium against too strong light-rays.

An adaptation against the drying-out effects of the wind is the presence of very thick fleshy scales on young buds, and in addition these buds are usually surrounded by the erect youngest leaves. The most general phenomena pointing in the same direction are: leaves closely pressed against the stem pointing upward (*Drimys*, *Eurya*, *Styphelia*, *Rhododendron*) and often rolled up (*Drimys fistulosa* Diels, grasses, *Gleichenia vulcanica* Bl.) or folded together (*Cladium*, *Patersonia*); the plants on exposed places do not grow outside of the crevices; others form cushions (grasses, *Schoenus*, a few Rubiaceae, also *Gahnia* to a lesser extent); some possess hairy leaves or fronds (*Rubus*, *Gleichenia vulcanica* Bl. var. *plumosa* v.A.v.R., *Potentilla*, *Lycopodium tomentosum* v.A.v.R.); while a number of herbs have water-storing tissue (*Euphrasia*, *Gentiana*, *Viola*, *Didiscus*, *Myrmecodia*, *Hydnophytum*, many Orchidaceae). This last-named category is still the most xeromorphic, but it is at once clear that most of these are not xerophytes; moreover, a number of plants which sometimes may be found xeromorphic can thrive as mesophytes (perhaps even be hygrophytic) and in another place also can live as true xerophytes. A mountain-peak, such as this, is not a habitat where we must expect real xerophytes, for in the first place xerophytic life is adapted to dryness, and there is no question of that here. True, there may be a few hours each day when a very strong wind may produce great atmospheric dryness; but almost everywhere there is enough water in the soil so that only a slight adaptation is sufficient to help the plant through these hours. And the temperature is not low enough so that one can speak of a strong "physiological drought."

The fact that the leaves of almost all shrubs here are firm (though often brittle)—which earlier was considered as a xerophytic adaptation—seems to me more a response to the strong wind (strengthened mechanical tissue).

I have already mentioned that a large number of true hygrophytes occur here. First there are the plants living entirely within the moss-cushions, such as *Trichomanes compactum* v.A.v.R., *T. lasiophyllum* v.A.v.R., and a few species of *Glomera* and *Chitonanthera*. The moss itself, which absorbs the capillary water, naturally belongs to this group. In protected places we find even tall-growing hygrophytes, such as a species of *Homalanthus* and tree-ferns, which I encountered in the pontic ravine.

Finally I should like to point out a fact which I have been unable to explain: the frequency of either light gray or black as the color of the bark of most shrubs (not to be confused with the same colors caused by lichens).

In recapitulation I supply here the accompanying ecological table:

⁴⁴ A. Weisse, Verh. Bot. Ver. Prov. Brandenb. LXV (1923), 31.

⁴⁵ Cf. G. L. Funke, Ann. du Jard. Bot. Buitenzorg, XL (1929), 52.

	Favorable factors		Unfavorable factors		
	Much water and high relative humidity	Strong radiation		Low temperature (strong radiation)	Strong wind ¹
<i>Physical results</i>	Slight evaporation	Local and short periods of high temperature	Strong evaporation	Low average temperature in ground and moss-cushions (= 10° C.)	Strong evaporation, locally low temperature
<i>Physiological results</i> in view of:	Little transpiration of absorbed water or none	Easy absorption of water from the soil		Difficult absorption of water from the soil ²	Transpiration of much absorbed water
<i>a.</i> Water-transport					
<i>b.</i> CO ₂ Assimilation	Strong transpiration (stomata open)	Strong		Retarded (delayed) ²	Retarded
<i>c.</i> Growth			Retarded	Retarded ²	Retarded, plants restricted to crevices
<i>d.</i> Tendril-movement		Nyctitropism (and positive thermotropy?)			
<i>e.</i> Transpiration	Strong (stomata open)			Optimum prevention at low temperature	Slight (stomata closed)
<i>Adaptations</i>	Thin tissues, little mechanical tissue; many leaves		Shining leaves		Small thick leaves with much mechanical tissue and/or water-tissue; few leaves; leaves compact, rolled, folded together, or hairy; fleshy bud-scales; cushion-shape
		Purple coloring of flowers and vegetative parts			
			Few small hard thick leaves; small-sized plants; strong root-pressure; strong resistance to withering; strong transpiration		

¹ Gentle trade-winds; the local winds of short duration, preceding a rain, are here dominant.

² Here it is observed that a number of plants perhaps take the optimum for these processes, just as is apparent for transpiration, at relatively low temperatures.

This survey is far from complete; for instance, here are lacking the physiological factors of seasonal influence, temperature changes, slope, atmospheric pressure, etc., the action of all of which is still less completely known than is the case with the factors discussed above. It is therefore another indication of our insufficient knowledge of this interesting field of plant-geography, and possibly will be a stimulation for others to study these problems further.

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The classification of my collection at the moment does not permit dealing amply with the problems of genetical plant-geography, to which the flora of a high mountain-summit such as Doormantop should give the opportunity. In expectation of a later study, I must therefore limit myself to a few general observations.

Above the forest-limit I collected 304 numbers. Of these 18 are algae, six lichens, 31 mosses, three fungi, 26 ferns, and nine lycopods—altogether 93 cryptogams. In the remaining 211, four numbers are still undetermined as to the family. The whole can be divided as follows:

Indeterminatae.....	4
Cryptogams.....	93
Gymnosperms: Coniferae.....	9
Angiosperms	
<i>Monocotyledons:</i>	
Orchidaceae.....	54
Gramineae.....	8
Cyperaceae.....	5
Liliaceae.....	2
Iridaceae.....	1
Pandanaeae.....	1
	71
<i>Dicotyledons:</i>	
Ericaceae.....	29
Rubiaceae.....	15
Myrtaceae.....	9
Epacridaceae.....	8
Magnoliaceae.....	7
Umbelliferae.....	6
Apocynaceae.....	4
Compositae.....	4
Gentianaceae.....	4
Rutaceae.....	4
Santalaceae.....	4
Saxifragaceae.....	4
Elaeocarpaceae.....	3
Rosaceae.....	3
Symplocaceae.....	3
Ternstroemiaceae.....	3
Araliaceae.....	2
Boraginaceae.....	2
Casuarinaceae.....	2
Nepenthaceae.....	2
Scrophulariaceae.....	2
Aquifoliaceae.....	1
Euphorbiaceae.....	1
Goodeniaceae.....	1
Haloragaceae.....	1
Lauraceae.....	1
Thymelaeaceae.....	1
Violaceae.....	1
	127
	304

While we may suppose that the number of species is divided about proportionally in the major groups, then the Coniferae would be 4.4% of the Phanerogams (the real numbers show a much larger representation), the Monocotyledons 34.3%, and the Dicotyledons 61.3%.

For a long time, apparently under Wallace's influence, the idea was accepted that New Guinea was a land that was populated on the one hand from the Asiatic continent and on the other from Australia. The idea was so fascinating that one scarcely thought of the possibility of a native fauna and flora, at least in part. The result was that one spoke almost exclusively of the Asiatic and Australian forms when specimens of the New Guinean fauna and flora were received for examination.

Even if New Guinea in its modern form is still young in geological terms, in such a gigantic country one may expect without doubt a certain and probably an important amount of independence. I think that Schlechter⁴⁶ was the first to suggest (in connection with the Orchidaceae) that New Guinea itself has been and still is a center of development and distribution. Moreover, many genera, which earlier passed for Australian, can with more right be counted as belonging to the native flora of New Guinea. In a lesser degree, this is also the case with a number of Asiatic (Malaysian) and Polynesian forms. As an example of this Schlechter mentioned the genus *Corysanthes*, of which at present New Guinea has the largest number of species.

Ridley,⁴⁷ under whose guidance the botanical collections of the Wollaston Expedition were organized, and Miss Gibbs,⁴⁸ who has investigated the plant-geography of a high mountain of New Guinea in detail, both agree with this opinion. On good grounds the latter vindicates the position that the island is the center of distribution for many other plant-groups besides the Orchidaceae. Her most forcible arguments are (1) the richness in species, (2) the great differentiation of forms, and in particular (3) the wide distribution of endemic high mountain-plants. As examples of the first two she names *Libocedrus*, *Drimys*, and *Myrtus*, whereas *Pandanus*, *Freycinetia*, *Rhododendron*, *Vaccinium*, and *Styphelia* show a richness of forms exceeded in few other regions. Instances of the wide distribution of mountain-plants, on the basis of my collection at present, cannot be given, although I shall indicate here species of *Gahnia*, *Riedelia*, *Didiscus*, *Gentiana*, *Dacrydium*, *Styphelia*, *Rhododendron*, and *Vaccinium*, and a number of Orchidaceae such as *Dendrobium Vannouhuysii*, etc. Meanwhile, we may consider that the flora of Doormantop will furnish new arguments in favor of Miss Gibbs' position. Rightly she points out that *Didiscus* positively is an example of the original and relatively ancient period of the New Guinean flora; the oldest type occurs here and toward the west, the younger to the east and south.

Therefore, coming to the conclusions to be drawn from my collections, I shall once more point out that, lacking determinations at this time, it is possible to make only a few definite statements. Sometime I hope to have the opportunity to write more accurately on this subject. Provisionally I should like to treat the flora of Doormantop as composed of the following elements: (1) endemic species and genera with New Guinea as a probable center of develop-

⁴⁶ R. Schlechter, *Die Orchidaceen von Deutsch Neu-Guinea* (1911-1914), I, 14, XX.

⁴⁷ H. N. Ridley, *Report on the Botany of the Wollaston Expedition to Dutch New Guinea*—*Trans. Linn. Soc. London*, II, Bot. IX, 1 (1916), 9.

⁴⁸ L. S. Gibbs, *A Contribution to the Phytogeography and Flora of the Arfak Mountains, &c.* (London, Taylor & Francis, July 1917), 39-49.

ment and distribution; (2) species of Asiatic origin or relationships; (3) species of Polynesian origin or relationships; (4) species of Australian origin or relationships; (5) species known only on high mountain-peaks, frequently far remote from each other.

I intend to include the following plants ⁴⁹ in these different groups:

I. Endemic genera or genera with New Guinea as the probable center of distribution, or at least with a strong differentiation there.

1. *Libocedrus*—circum-Pacific, particularly New Guinea.
2. *Chitonanthera*—endemic.
3. *Corysanthes*—particularly New Guinea, also Australia, some species in the western part of the Archipelago.
4. *Glomera*—tropical Asia, Polynesia, America, strongly developed in New Guinea.
5. *Mediocalcar*—New Guinea, also Amboina.
6. *Microtatorchis*—New Guinea, New Caledonia, and Fiji.
7. *Octarrhena*—endemic.
8. *Pedilochilus*—endemic.
9. *Phreatia*—particularly New Guinea, westward to Asia, eastward to Polynesia.
10. *Riedelia*—particularly New Guinea, also some species westward.
11. *Didiscus*—particularly New Guinea, some species also in the west, in Australia and in Polynesia.
12. *Dimorphanthera*—about 30 species in New Guinea, one in Amboina, and two in the Philippines.
13. *Sericolea*—endemic.
14. *Xanthomyrtus*—endemic. [Philippine Islands, Borneo]

II. Species and genera with western (northern) relationships (see also V for * species and genera).

- *1. *Gleichenia vulcanica* Bl.—Archipelago.
- *2. *Lycopodium complanatum* L. —Northern hemisphere and tropical alpine regions.
3. *Libocedrus*—circum-Pacific.
4. *Podocarpus*—Eastern Asia, Africa.
5. *Peristylus*—Madagascar, Abyssinia to New Guinea.
6. *Acronychia*—Asia—Polynesia.
7. *Alyxia*—Archipelago.
- *8. *Cynoglossum*—Northern hemisphere.
9. *Decaspermum*—Archipelago.
- *10. *Drapetes ericoides* Hook. f. —New Guinea, North Borneo.
11. *Elaeocarpus*—Archipelago.
12. *Eurya*—East Asia.
13. *Evodia*—Asia (the New Guinean species, however, perhaps related to eastern species?).
- *14. *Gentiana*—Northern hemisphere.
15. *Henslowia*—Archipelago.
16. *Homalanthus*—Archipelago.
17. *Hydnophytum*—Asia—Polynesia.
18. *Ilex*—Northern hemisphere.
19. *Litsea*—Archipelago.
20. *Myrmecodia*—Asia—Polynesia.

⁴⁹ For this the following literature is used:

- Engler & Gilg, Syllabus d. Pflanzenfamilien, 7th ed. (1912).
 L. S. Gibbs, l. c. (Phytogeography of the Arfak Mountains).
 ———, Notes on the Phytogeography and Flora of the Mountain Summit Plateaux of Tasmania—Journ. of Ecology VIII (1920), 1, 90.
 E. D. Merrill, A bibliographic Enumeration of Bornean Plants—Journ. Roy. As. Soc. Str. Branch, Spec. Number, Sept. 1921.
 ———, Enumeration of Philippine Flowering Plants, I–IV (1923–26), particularly part IV, pp. 77–105 (Floristic relationships of the Philippines).
 H. N. Ridley, Report on the Botany of the Wollaston Expedition, etc.—Trans. Linn. Soc. London, II, Bot. IX, 1 (1916).
 Nova Guinea, Botanique.

21. *Polyosma*—Archipelago.
- *22. *Potentilla*—Northern hemisphere.
- *23. *Rhododendron*—Northern hemisphere and tropical alpine region.
24. *Rubus*—Northern hemisphere.
25. *Syzygium*—Asia.
26. *Ternstroemia*—Eastern Asia.
27. *Timonius*—Asia—Polynesia.
- *28. *Vaccinium*—Northern hemisphere and tropical alpine regions.
- *29. *Viola*—Northern hemisphere.

III. Species and genera with eastern relationships.

1. *Glomera*—Asia, New Guinea, Polynesia, America.
2. *Microtatorchis*—New Guinea, New Caledonia, Fiji.
3. *Casuarina*—Archipelago, New Guinea, Australia, New Caledonia.
4. *Mearnsia*—One Philippine species, one in New Guinea, and one in New Caledonia.
5. *Nepenthes Vieillardii* Hook. f.—New Guinea, New Caledonia.
6. *Quintinia*—Philippines (one species), Australia, New Zealand, New Caledonia.

IV. Species and genera with southern relationships (see also V for * species and genera).

- *1. *Lycopodium scariosum* Forst.—Mindanao, Australia, New Zealand.
2. *Dacrydium*—Tasmania and New Zealand, also a few in the western part of the Archipelago.
3. *Libocedrus*—circum-Pacific.
4. *Phyllocladus*—Tasmania, New Zealand, one species in North Borneo and Luzon.
- *5. *Astelia alpina* R. Br.—Australia.
6. *Cladium*—Particularly Australia, eight species westward to the Philippines.
7. *Corysanthes*—Australia, some species extending to the western Archipelago.
- *8. *Gahnia*—Southern hemisphere, some species in the Archipelago (*G. psittacorum* Lab.: Australia, Tasmania).
- *9. *Patersonia*—Australia, some species extending to North Borneo.
10. *Schoenus*—Particularly Australia, four species westward to the Philippines.
11. *Casuarina*—Archipelago, Australia, New Caledonia.
- *12. *Coprosma*—Australia, New Guinea, North Borneo.
- *13. *Didiscus*—New Guinea, Australia, one species in Mindoro and North Borneo.
- *14. *Drapetes*—Australia, west to Kinabalu (Borneo) (*D. ericoides* Hook. f.).
- *15. *Drimys*—Australia, South America, one North Borneo-Luzon species.
- *16. *Euphrasia*—(related to *E. borneensis* Stapf of North Borneo and Luzon and to species from New Zealand).
17. *Exocarpus*—14 species in Australia and Polynesia, some extending into the Western Archipelago and the Philippines.
18. *Haloragis*—60 species in Australia, some west to southeast Asia and Japan.
19. *Quintinia*—15 species: New Guinea—Australia—New Zealand—New Caledonia, one Philippine species.
20. *Scaevola*—Australia.
21. *Styphelia*—240 species in Australia, New Zealand, New Caledonia, six species in the Archipelago.

V. Species and genera of high mountain peaks.

The following plants already named in II and IV and indicated by an asterisk are known especially from high mountain-summits, which frequently are far apart.

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|--|--|
| 1. <i>Gleichenia vulcanica</i> Bl. | 10. <i>Drapetes ericoides</i> Hook. f. |
| 2. <i>Lycopodium complanatum</i> L. | 11. <i>Drimys</i> |
| 3. <i>Lycopodium scariosum</i> Forst. | 12. <i>Euphrasia</i> |
| 4. <i>Astelia alpina</i> R. Br. | 13. <i>Gentiana</i> |
| 5. <i>Gahnia</i> | 14. <i>Potentilla</i> |
| 6. <i>Patersonia</i> | 15. <i>Rhododendron</i> |
| 7. <i>Coprosma</i> | 16. <i>Vaccinium</i> |
| 8. <i>Cynoglossum</i> | 17. <i>Viola</i> |
| 9. <i>Didiscus (saniculifolius)</i> Stapf) | |

It has been long known that the "islands" of alpine flora in the Archipelago have species nearly related to or even identical with species of northern regions, for example, from the Himalaya Mountains, and scientists have tried to find an explanation for this. A very early theory, apparently originating after the analogy of glacial relics, was that the glacial periods could have given such plants opportunity to transfer themselves via the lower lying regions from one mountain-peak to the other. Wegener⁵⁰ and others have, however, made apparent that the drift in this part of the tropics has been only of lesser significance. Later the influence of the trade-winds over high mountain-summits was considered. Miss Gibbs⁵¹ has pointed out the relationship between the flora of high Mount Kinabalu in North Borneo and that of mountain-plateaus of Tasmania with the flora of high mountains in New Guinea; and Merrill⁵² has noted that a number of species on Kinabalu also occur on high summits in the Philippines. In her publication on the Arfak Mountains (l.c. p. 46), Miss Gibbs has focused attention on the possibility of wind-transport of objects, much heavier than most seeds, over great distances, while in her article on Tasmania (l. c. p. 104) she mentions a report by Griffith Taylor⁵³ on meteorological conditions in the Archipelago investigated in the interests of an air-service between Asia and Australia. In two illustrative diagrams, Taylor very clearly presents the dominant upper and lower winds in January and July and indicates that, above 3000 m. altitude, a strong polar wind blows over New Guinea the whole year; it also blows above Melbourne at 1200 m. altitude and apparently extends over the South Pole to South America. Miss Gibbs thinks that the connection between these and the occurrence of some plants (*Drimys*, *Libocedrus*, *Glomera*, *Styphelia*) in both Australia and South America is not necessarily problematical; whereas, it is very possible that plants (*Rhododendron*, *Vaccinium*, *Gentiana*, *Potentilla*, *Rubus*, *Euphrasia*) may be transported from the Himalaya Mountains via isolated peaks in the Archipelago toward New Guinea and Australia by the northwest monsoon,⁵⁴ and then by the continuous wind mentioned above. Nevertheless, the wind must blow likewise in a westerly and northerly direction—and then apparently lower—as witness the occurrence in New Guinea of the Australian *Astelia alpina* R. Br., of the New Caledonian *Nepenthes Vieillardii* Hook. f., and particularly note the New Guinean species which also occur on Kinabalu and in the Philippines (*Drapetes*, *Drimys*, *Didiscus*), and still farther to the west are species of *Haloragis*, *Exocarpos*, *Styphelia*, *Corysanthes*, *Quintinia*, *Dacrydium*, *Phyllocladus*, *Patersonia*, and *Scaevola*. This does not mean that all plants are spread by the wind. For a number of species genetic phytogeographical factors must be considered,

⁵⁰ A. Wegener, *Die Entstehung der Kontinente und Ozeane*, 3rd ed. (1922), 86—See also Irmscher, *Pflanzenverbreitung und Entwicklung der Kontinente*—Mitt. a. d. Inst. für Allgem. Botanik in Hamburg, V. (1922), 29.

⁵¹ L. S. Gibbs, *A Contribution to the Flora and Plant Formations of Mount Kinabalu and the Highlands of British North Borneo*—Journ. Linn. Soc. Bot. XLII, no. 285 (1914), 1—See also Id. *Phytogeogr. Tasmania*, l. c., and O. Stapf, *On the Flora of Mount Kinabalu in North Borneo*—Trans. Linn. Soc. Bot. II, IV (1893), 69.

⁵² E. D. Merrill, *Enumeration of Philippine Flowering Plants*, IV (1926).

⁵³ *Air Routes to Australia*—Geogr. Review VII (1919), 259, figs. 1–3.

⁵⁴ According to C. Braak (*Het Klimaat van Nederlandsch-Indië*, I, 1923–25, p. 75), easterly winds blow above Batavia from May to October at all levels from 1000 to 7000 m. altitude. In November these still blow above 2000 m., whereas below that height westerly winds prevail. From December to April westerly winds blow up to an altitude of 4000 to 6000 m., and above that easterly ones prevail.

as, for example, *Nepenthes Vieillardii* Hook. f. Danser⁵⁵ is of the opinion that this species originated apparently before New Caledonia was separated from New Guinea. The most primitive forms of the genus occur in India (proper) and a general direction of distribution must be accepted from west to east.

In these considerations I make some provisional assertions on which it may be possible to build later. I should like to draw attention for a moment to the possibility of distribution by powerful cyclones which sometimes arise between North Australia and the southeast part of the Archipelago, and also between the Philippines and the continent of Asia.⁵⁶ If this communication proves to be an inducement to initiate the study of plant-geography in the Archipelago, I shall think its aim is largely accomplished. Up to now this important branch of science has been the subject of research by few. It is understandable that, although the zoögeography of the Archipelago has been studied more than 75 years, the much less surveyable field of plant-geography began to be developed only a very short time ago; nevertheless, I believe that the time has come and that there is at present a sufficient amount of material to test the results of geology and zoögeography by possible conclusions drawn from the dispersal and the mutual relationships of plants.

I shall close this discussion with a quotation from Miss Gibbs' article on Tasmania:⁵⁷

"The mountains of New Guinea, therefore, on the strength of both geological and meteorological data, may be considered as the focus of development and distribution of the so-called 'antarctic' plants, justifying the term Papuan austral-montane for this group, of which, even on the limited basis of our present knowledge, nearly one-half of its most characteristic genera are now known from New Guinea. This number will increase in proportion as further work on the vast and barely known ranges of that country add to the little knowledge we possess of their plant covering between the tree and the perpetual snow levels."

* *
*

The days spent at Radio-bivak (October 16–29, November 14–17, 29, 1920) belong without doubt to the happiest of my life. October 18, the day the vanguard started towards Swart Valley, I remained behind in company with the radio Lieutenant, a European corporal-signaller of the Marines, our boys, my native helpers, and a Javanese sergeant with some fusileers and convicts.

In the early morning our first walk was to the south margin of the plateau, from which we could observe the Central Mountain Range, and each morning that view was different. Sometimes the majestic landscape lay before us almost cloudless, the sharply toothed ridge 80 km. distant traced on the far horizon against a cold clear sky, in the midst of which is the small white gleaming perpetual snow-field of Wilhelmina-top; then again parts of the parallel mountain-ridges lay concealed below an extensive shining white cloud-cover, through which Wilhelmina-top made its appearance covered with freshly fallen powdery snow extending far down the slopes from the highest point. Sometimes a soft blue clear winter sky, with a yellow mist on the horizon,

⁵⁵ D. H. Danser, The Nepenthaceae of the Netherlands Indies—Bull. Jard. Bot. Buitenz., III, IX (1928), 425.

⁵⁶ C. Braak, l. c., 118, 127. E. D. Merrill, Enumeration, etc., l. c. IV, 15.

⁵⁷ l. c., 106.

appeared out of the darkness of the night; then again a massive clear stratus stood out high above all mountains; the ridges lay shadowless and gray one behind the other, the finest serrations of the Central Chain being outlined clearer than otherwise against the smooth gray of the clouds.

The 3820 m. summit so near us displayed various moods. In the morning, after enjoying a cup of hot coffee as we started off shivering and shuddering to see Wilhelmina-top, it stood against the still pale light of the rising sun as a powerful black screen with fantastic margins on the eastern heaven, threatening as a phantom because of its still unknown details. At noon, it towered frequently hundreds, yes even thousands of meters above the vast mass of clouds, which from the plain pushed their long woolly tongues into the mountain-ravines. It seemed lower and friendlier to us when showing itself in its finest details; in the light of the low western sun it lay before us in all its glory of color, sometimes sharply outlined against the threatening darker background of a rainfall far in the distance.

The Meervlakte, too, our third great attractive view, came before our eyes in an endless variety of color and light effects. In the morning, when the central highlands were mostly clear, the wide plain lay covered with low clouds, but in the afternoon after a rain, before sunset it was frequently visible, just when the view to the south was mostly obstructed. The outlook over this enormous valley made an even more majestic and powerful impression than the view over the mountain-ridges to the south. Sometimes we stood a long time speechless, on a projecting boulder, staring at the wonderful play of lights over the plain, over the mountain-ridges which shut off the horizon toward the north, and particularly at the magnificent cloud-scene above. Then the plain was entirely clear except for a few small bright white cloud-streaks, after which it quickly disappeared. Rivers and lakes before us were all definitely outlined and reflected glaring white the summits of the enormous alto-cumulus and cumulo-stratus [clouds] lighted by the sun. Many towered above the Gauttier and the van Rees Mountains, one next to the other, from east to west over a distance of hundreds of kilometers. The enormous cloud-piles in all colors of sharp white to yellow, orange, and red, changing to the gray shadow of rain beneath it, produced an effective scene not only because of the colors but also because of the incessant flashes of forked lightning extending through the clouds.

But the days were not always so pleasant. Sometimes a biting wind and falling rain forced us to return to our low hut surrounded by a meter-thick layer of branches, covered with a three fold layer of canvas, where we lay on a thick floor of elastic branches under the covers. After the shivering morning walk a scanty breakfast followed. Scanty, since the upward transport began to falter; once, out of 32 tins of rice assigned to the carriers at Prauwen-bivak, only three were delivered; they had eaten the rest in transit as rations due them. Very soon the result was a shortage of food for the vanguard, and an untimely break in the exploration of the valley could be prevented only by the timely sending below of all men not strictly necessary. How I was a victim of this circumstance is briefly recorded in Fragment I.

However, the usual clear sunny morning hours were spent in collecting and making notes. During this time the Lieutenant organized the affairs of the bivouac and made himself very useful by installing, with very primitive tools, a

simple radio-apparatus which, although too weak to send out reports, enabled us to receive a very important communication and to pass it on to the valley.

But when the mist began to settle and shortly thereafter the rain began to fall, I emerged now from a ravine, then again from the summit, lured by warm coffee or chocolate which I knew was prepared. These, with the morning coffee, were really the only happy moments as far as the culinary situation was concerned. After dinner, differing somewhat from breakfast and supper only in quantity, I dove into the mantri's quarters to take care of my collections of the morning, while the rain tapped on the canvas and the wind whistled around the hut. The tea-hour sometimes brought good weather and a short walk, and the evening after supper was spent in developing, in a kneeling position, a few dozen photographic plates in ice-cold water, or lying down and writing diaries and notes. But then, while the candle-lantern cast flickeringly fantastic shadows in the dusky corners of our cold cave, we pulled our blankets over our ears—we usually slept fully clothed and sometimes with a cap on—and fell asleep surrounded by an endless silence, accentuated by a few monotonous sounds. Everywhere the little frogs, which spent the day in the gray plants of *Hydnophytum pauper* Val., croaked shrilly, making one think of the warbling of a swallow which we heard during the day. This swallow, an ousel-like bird,⁵⁸ and a single mountain-duck, the only larger bird occurring here, probably with *koeskoes* (*Phalanger*), and possibly still an opossum, are about the only representatives of animal-life here. And when it neither rained nor blew, the thick drip trickled from the moss-cushions on the branches of the old *Casuarina* tree onto the canvas over our heads.

Naturally the view from Doormantop was in general similar to that from Radio-plateau, at least towards the north, east, and south. Towards the west and southwest, however, one has, in addition, an outlook over the course of the Swart River; furthermore, the impression of the view from there is still more powerful because of the unhampered range of vision, comprising 360°, and because of the high position in a barren world of naked rocks, sloping on all sides and in every direction into massive fixed rock-bays down to the darker forest. Already Radio-bivak lies far in the distance, somewhat lower and very insignificant: a small spot of canvas shining in the sun, and a very small smoke-plume.

The broad Swart Valley lies directly west, separated from the plain only by a mountain-chain, and near Doormantop bending towards the south. A descent into the Dika Valley, the ravine of a mountain-stream joining the main stream at the bend, appears almost impossible. It seems hardly practicable at all to attain the level of this small undulating cloudy forested ridge below, the softly arching lines of which extend downward toward the inhabited valleys, separated from the ridge of our summit by an exceptionally steep and high wall. There

⁵⁸ This bird was particularly tame. In the lower mountain stretches also, I repeatedly had the opportunity to observe the tameness of small mountain-birds, which agrees well with what Buytendijk (*Psychologie der Dieren*, Uitg. Volksuniversiteitsbibl. no. 3, 1920, p. 105) writes: "At first birds in uninhabited islands and in newly discovered lands show no fear of man." Notwithstanding the noise that a climbing European makes on a difficult slope, small birds frequently remained sitting without any fear, even if one came so close that they could be grasped with the hand. Once I surprised a forest-fowl family of cock, hen, and half-grown chickens, which were quite undisturbed in their busy search for food, even when I tried to get into the midst of the little flock to observe more closely what they were doing.

lie the sunny unforested slopes below us. On these slopes opposite us—by air-line only 8 km. distant—are the enclosed fields of the Timorini, distinguishable to the naked eye only as small sections; but field-glasses reveal in addition the presence of small round dwellings, while everywhere fires in fields being cleared are visible. On the other side of the Swart River a mighty unforested slope extends gradually upward to about 3600 m. This view is almost like a vision of Paradise.

The next and last Fragment will contain some data on the landscape, flora, and people of these valleys.

VII. Land and people of the Dika and Toli Valleys ¹

ON NOVEMBER 17, 1920, I set off on a three-day trip to the sunny valleys inhabited by the very recently discovered Timorini.² In doing so I made use of the last Dyak transport about to proceed to the vanguard in the Swart Valley, before the return of the van Overeem Expedition should begin. In another Fragment, I noted that the shortage of food a few weeks before had forced me and my assistants to leave Radio-bivak and to return to Goenoeng Boetak. Subsequently, through measures taken in the meantime, conditions had grown less alarming, and I, with one of my assistants—the other having been sent back to Prauwen-bivak—my boy, and three Dyaks, had been able to work some days longer in the vicinity of Beek-bivak. In the nick of time I heard, from a downward transport, of the plans to return. Since I did not wish to deprive myself of the opportunity to get acquainted with the recently discovered natives and their culture, I hastened once more to Radio-bivak. Unfortunately, on account of the insufficiency of food, I had to send my second mantri back. It was impossible to transport the heavy zinc tins, and for collecting purposes I had to content myself with 30 glass tubes and a notebook.



FIG. 22. Outlook from Doormantop toward the west and southwest; — — — = visible, and = not visible part of the route followed; 1 = Mos-bivak; 2 = Dika-bivak.

As indicated earlier, the trail from Radio-bivak to the Swart Valley lies over Doormantop. The western slope is steep and difficult. Beyond this we come to a long ridge running toward the west and joining a western peak. Toward the north the slope is at first gradual, and then it quickly becomes steeper; to the south it drops precipitously; for hundreds of meters the bare debris continues (*Fig. 22*). This steep incline is entirely inaccessible without climbing aids. We follow the margin for a long time, thereby enjoying a wider outlook in both directions.

At 3100 m. the forest gradually begins. The bare rocky slope, broken below by a few small marshes, changes little by little into a terrain with here and there groups of shrubs. Somewhat farther away these scattered groups increase in size until they finally merge and form a thin forest, consisting almost wholly of *Casuarina* and a few Coniferae, particularly *Dacrydium*.

¹ *Natuurk. Tijdschr. Nederl.-Ind.* 89: 291-380. 1929.

² In some older articles on the expedition the name "Oeringgoep" is used. Later on it became evident that "Timorini" is a better name for this part of the mountain-folk.

Meanwhile the mists had closed in around us. While I was traversing this thin forest, the mist becoming thicker, I suddenly heard a weak but clear whistling behind me. I looked around just in time to see a rather large bird, apparently a mountain-duck, fly by, each stroke of its wings producing the whistling noise.

At half-past ten, through increasingly thicker vegetation, we reach a point where the slope to the south is less precipitous than formerly, and a descent is possible. This is the place where the vanguard spent the first night, Mosbivak (Fragment I, Map B, no. 13). Now the entire vicinity was concealed in the mist. Later from this point we had a clear outlook over the valley so well known to us then.

A decline of 600 m. along a mossy slope dripping with water and covered with a thin forest lies before us. The track is very steep but neither difficult nor perilous. It is a fortunate circumstance that the trail is still undisturbed and therefore many small trunks and roots are unbroken. Shortly after the beginning of the descent we cross a narrow but high and still very recent deposit of debris. Next we slide from tree to tree part way along the slope, at every step passing wet tree-roots and moss-cushions soaked with water, to the next marshy place. Thus we proceed for several hours, a seemingly endless trip. Toward noon we pause for a short rest on a level place, where it is evident that the Dyaks have rested previously. At this point I see the first *Pandanus* plants, which begin here as suddenly as they disappear on the north side. Judging from the length of elapsed time in the descent, we can, with reasonable certainty, estimate the altitude of this place at 2600 m. Here also *Gentiana singalagensis* Backer grows at the lower limit of its range. The vegetation-type of the forest below this location is very noteworthy. The forests, ever higher and thicker, are light green from the overwhelming mass of fine bamboo which, with many *Pandanus* plants, completely dominates the undergrowth. It impressed me as representing the same species which I encountered so many times on the north side of the mountain at 2700 m. Apart from that, the other floral-types are comparable to those on the ridge toward Doormantop. The difference is still more striking in the neighborhood of Bamboe-bivak (2450 m., Fragment I, Map B, no. 14), where the steep slope ends abruptly. After crossing a beautiful mountain-brook, we arrive there at half-past twelve. Rain threatens, but before it falls I examine the region to obtain an impression regarding the above-mentioned differences. The overwhelming quantity of ferns, which there make up almost the entire undergrowth, is lacking here. The undergrowth of this forest is chiefly of higher plants, among which the Urticaceae occupy a much more important place than on the north side, where the family is very rarely represented at this altitude; on the other hand, here particularly few Ericaceae are seen. With the statement of these facts, I cannot refrain from recalling again what Pulle³ writes with relation to the flora of the south slope of the Central Mountain Range. In the mountain-stretches there appear to be two types of primary forest, one with Urticaceae as ground-covering on limestone, and one with Ericaceae especially in the mossy forest on sandstone. The difference is so striking that one would almost doubt the justice of the geological assertion that this entire ridge still consists of basic eruptive rock and that sedimentary rock begins only to the north side of the Dika layer.

³ Maatsch. t. Bevorder. v. h. Natuurk. Onderz. d. Ned. Kol. Bull. no. 68 (1913), 35.

Also I was beginning to have some doubts concerning the explanation of the mossy covering, of which I have already spoken.⁴

In a few minutes I collected nine species unknown to me; among these were three Urticaceae (nos. 2040-2), that is to say, an epiphyte, an herb, and a shrub, also a scandent *Piper* (no. 2038), of which genus a number of species occur here. Along the stream I found *Scutellaria luzonica* Rolfe (no. 2039; Phil.) or a closely related species, in addition a *Rubus* (no. 2037), and a beautiful and terrestrial club-moss with reddish brown stems, *Lycopodium rubricaula* v.A.v.R., also found by Pulle at the same altitude on the south side of the mountain. The forest in this vicinity is still somewhat open but now the trees are robust and tall; the bamboo grows in great quantity only on the steep slopes; apparently it needs considerable light. On the more moderate slopes near the camp are many conifers. I thought I recognized *Araucaria* (on the north side I was never able to determine this genus with certainty), *Dacrydium*, and *Podocarpus* among the tallest trees; *Phyllocladus* is a common shrub in the undergrowth. In addition the undergrowth is very rich in *Pandanus* plants of all sizes, and for that reason the forest is difficult to traverse.

While I orient myself, one carrier comes in after another, several hours elapsing between the arrival of the first and the last on account of the difficult traveling. Meanwhile at 2 o'clock the rain commences to fall, thus hindering bivouac-making considerably. The Dyaks, however, show an unusual almost unsuspected cordiality and are very attentive; a friendly act, the purpose of which I first realized the following day. The entire afternoon they are merry and clamorous; they take turns begging for empty tins, clothing, and shoes or trying to induce me to promise these at the end of the expedition. It rains heavily all afternoon while a violent thunderstorm rages about us. The previously quiet and clear brook has become a wild dirty brown torrent which, with thundering force and alarming power, rushes down behind the camp. But toward dark the rain begins to lessen, and everywhere around us we hear the sound of the drip from the moss-cushions mingling with the well-known noise of the whistling frog, possibly the same species that lives above in the *Hydnophytum*. I do not see the plant here but perhaps it is epiphytic in the crowns of trees,

The morning of the 18th is clear and still. It is remarkable how much milder the climate here suddenly becomes in comparison with that of the exposed northern slope; this place is sheltered by a great cliff on the north side and subject to the influence of the deep open sunny valleys to the south. At 6:30 A.M. I proceed in advance of the Dyaks. The path, although little traveled, is rather poor. Felled trunks have not all been removed; rattans are not entirely cut. It is a beautiful forest, with constantly changing views and also much that is new to the botanical world. Now the trail descends steeply for 50 m. then again extends for some distance along the slope. The slender bamboo is still present everywhere but dominant only in few places. The undergrowth is rich in shrubs and small trees; the number of ferns is still strikingly few. An hour after my departure I reach the first stopping-place of the Dyaks, recognizable by the places where they sit. Here the Dyaks catch up with me. They show an unusual desire to let me go ahead, and so at nine o'clock, at the head of the procession, I arrive at the ample Jachthut-bivak (Fragment I, Map B, no. 15). The forest here, at about 1900 m. altitude, is

⁴ See Fragment V, and Pulle l. c. 33.

tall and thin on gently undulating ground. In passing the camp, after we have forded a mountain-creek flowing from the east, the vegetation-picture varies considerably; the number of bamboos increases again, but this is now a species with stems a few centimeters in diameter. In this vicinity I still found a young *Cupressus*-like coniferous plant (no. 2164). Also increasingly more ferns are found here in the undergrowth, including many which I had observed on the north slope. This is also the case with a number of higher plants, such as *Argostemma* and *Balanophora*. Moreover, the undergrowth here is much less difficult to traverse, owing to the presence of fewer *Pandanus* plants, and the level parts of the ridge are covered with a beautiful open forest. At 1850 m. elevation, I see the first specimens of a peculiar melastomataceous plant (no. 1533) and a few orchids previously observed elsewhere. Twenty minutes after leaving Jachthut-bivak, we reach the hunter's hut from which it takes its name. This stands on an open place, evidently an old landslip now covered with a vegetation composed of grasses intermingled with *Dianella* plants with blue and white flowers. The forest-margin is colored by a broad strip of tall *Melastoma* (*M. malabathricum* L.?, no. 2046) plants in full flower, and a patch of a robust red-flowered *Impatiens*, strongly suggesting the common *I. platy-petala* Lindl., occurs in a marsh developed along the bank of a small stream. I collected the clinging *Nephrolepis humatoides* v.A.v.R. on the trunks in the forest-margin.

In the middle of this small open area stands the hunter's hut, the first sign of the large Papuan tribe in the interior. It appears to have been recently constructed. Possibly the Timorini sometimes come here to hunt pigs, cassowaries, opossums, porcupine-anteaters, and various kinds of birds. The hut consists of only a roof of palm-leaves and grasses. The floor is covered by small poles. I stand here a long time examining and touching the rough notches in the wood, which reveal the work of a stone axe. So strongly does this hut suggest the proximity of natives that I almost expect to see a group of Papuans appear from the forest-margin. How the vanguard may have felt on reaching this point, with the immediate future uncertain, is not known!⁵

The Dyaks sit together on the grassy slope. At the sight of the shabby hut, their hilarity is completely silenced and they say with emphasis: "roemah papoe, toean dokton," a Papuan hut, Sir. Then they invite me by word and above all by gestures not to wait for them but by all means to proceed. They would not be so impolite as to go ahead of me (although earlier they were always anxious to do this). I then leave the brave fellows quietly behind and proceed alone, convinced that they will quickly follow. The path continues through miry places and across brooks. The underlying rock is still of the eruptive type. The bivouac where we will pass the night lies at about 1700 m. altitude near one of the streams. We named this the Second Parkieten-bivak (Fragment I, Map B, no. 17), because at night we heard the same harsh noise of the parakeets (perhaps even the same species, *Chalcopsittacus duivenbodii*, observed earlier) quickly flying over. For the same reason the First Parkieten-bivak, situated at the same altitude on the other side of the mountain, was so named. At 10:15 A. M. I make camp, and immediately after my arrival the Dyaks appear with innocent-looking faces. The rest of the morning is spent in bathing and in examining the surroundings. Unfortunately, however, not

⁵ See Bijlmer, Tijdschr. Kon. Ned. Aardrijksk. Gen. XXXIX (1922), 170, and De Aarde en haar Volken LIX (1923), 170 (sep. 39).

much collecting can be done. Here, at the lower limits of its distribution, on the highest branches of a tree, is a plant of the large *Myrmecodia*, which at the summit grows on the ground. Also here is the tallest of the *niboeng* palms, *Kentia*, which was so well-known to us on the north side, particularly because of its delicious palm-cabbage. I further recognize various ferns, a couple of climbing species of *Elatostema*, a *Podocarpus*, and in addition a scandent melastomataceous plant with white flowers and orange-red fruits, which reminds me of Goenoeng Boetak.

In the afternoon there is a short but heavy shower. The Dyaks are still in a noisy frame of mind. They talk very noticeably about the Papuans; and they introduce into their conversation all the Malayan phrases that they know in order that I too can understand what they say. Under cover of a joke, though with an anxiety which they can hardly conceal, they prepare me to face the fact that the Timorini are a dangerous people. With this conversation I recall the vague and distorted rumors concerning the pig-incident which happened in the Dika-bivak. There the Dyaks had clandestinely stolen a pig from the natives and had butchered it. This offence against custom was cleverly exploited by the Timorini who, after much clamor and exaggerated boasting, were pacified by being presented with several chopping-knives. The following morning the puzzle of the Dyaks' friendliness was solved. At other times there was always much movement and hubbub when the first rays of the sun began to appear above the horizon, but now most of my comrades are very quiet at dawn. All are busy cooking rice, taking their time, but of preparation for departure not a word is said. A fairly sarcastic talk with Anji Nau, the leader of the group, intrigues the others, and it now becomes clear to me that their unusual behavior is caused by fear. I had least expected this. I had known the Dyaks as spirited and intrepid oarsmen. They knew the Timorini from previous experience; but I did not know then that the Dyak, in the face of hostile people, is timorous and is accustomed to destroy his enemies by assassination. Therefore, when they anticipated this procedure from others, it was conceivable that, on this day, they were actually afraid of these peaceable mountain-natives.

It appears that they can be persuaded to proceed with no other argument than my own departure. Nevertheless I grant myself the pleasure of firmly ordering Anji Nau to lead; I shall follow. But as they begin again to exhaust themselves by deep and repeated bows, I have enough of the theme and silently proceed in front. Meanwhile, I do not feel entirely at ease. I did not know of the timorous characteristic of the Dyaks; I knew of their courageous attitude on swift rivers; they knew the Timorini and I did not, and also I did not know how to evaluate the pig-incident fairly. With my revolver ready, I thus precede the group which was armed with spears and with shields made from oil-tins, because I cannot imagine that the fear of my companions and the precautions taken are baseless. Later, when I became acquainted with our good-natured friends in the Swart Valley, how I laughed over this incident!

The journey begins with an unexpectedly long ascent. The forest on the ridge is again open and traversable; the undergrowth is thin, but as we once more descend, we find ourselves suddenly surrounded by masses of bamboo and increasingly more ferns. From 1400 m. downward I saw *Dipteris conjugata* Reinw. and *Oleandra cuspidata* Bl. in profusion. At these same elevations there are suddenly more Urticaceae, particularly *Elatostema*; perhaps the sedimen-

tary rock-formation begins here. The undergrowth becomes continually more luxuriant and more dense; in it are giant Zingiberaceae with their obliquely standing stems surely 10 m. long, and a species of bamboo which does not form clumps, the 2–3 cm. thick stems being scattered through the shrubs.

The Dyaks stop on a narrow ridge. They treat me now as a valuable and indispensable being and think I must act as guide through this easy terrain. During the rest, contrary to habit, they remain standing; they encourage each other in boisterous ways and brandish their spears with warlike gestures, and although I do not understand what they say, I frequently catch the word "papoe" (Papuan).

As we continue, the warmth of the valleys greets us, a delightful sensation after all the wet and cold which we have encountered. The sounds of the birds from the warmer regions also affect us pleasantly. At 1400 m. we hear the first parrot screech, and a hundred meters lower the calls of the first birds of paradise. Here the flora is more luxuriant than any I saw on the north slope. A mountain-stream which we cross at 1250 m. altitude is decorated on the banks with broad margins of colorful *Impatiens* and *Spathoglottis* with tall stems. A little later we pass a landslide and, through the opening that it made, we see nearby on the other side of the valley a small settlement with natives going to and fro. After that we enter the forest and a moment later locate a Papuan path, which was already known to me from the report of the leader.

Entirely occupied with the many new things awaiting me, I was not conscious that this path, this sign of native culture on the outermost margin of their territory, would induce my Dyaks to lose the rest of their courage; and when, a hundred meters farther on, I reached a sunny open clearing, I was . . . entirely alone! The clearing was abandoned, the single house therein closed, a silent witness of Papuan activity on the edge of a well-shaded banana-plantation. When I had assembled my brave companions—they stood close together by the last bend in the path, still deep in the forest, waiting, the foremost man trying to save face by fashioning a piece of wood with a small knife—we continued, now through cleared secondary forest. For the first time we hear the sound of the Dika on the left. Later we cross an open grass-field at the side of which a low shed is built over a series of beehive-like objects constructed of *Selaginella* fronds. According to Wirz (l. c. 54, fig. 9, 10) these miniature houses are erected for the benefit of the souls of the departed (*koegi*). Next is a descent over a very steep and narrow ridge, on both flanks covered with thin and young forest and on both sides hemmed in by thundering mountain-torrents. To the left the white foaming Dika roars in its channel; on the right a stream with abundant water plunges down in a high waterfall. This is the same stream which we crossed at 1250 m. altitude. Instantly I could very well imagine the suspense felt by the vanguard, who, on October 23, 1920, descended this same path without the certainty that this mountain-torrent could be crossed and without any knowledge as to how they would be greeted in their first contact with the natives. At the foot of the waterfall lies a level spit with gravelly shores at the bottom of the chasm, luxuriantly covered with vegetation. Growing together here are some plants of the beautiful coniferous *Callitris robusta* R. Br. (no. 2166; Austr.), a small tree with very fine pendent foliage which at once reminds one of a *tjemara* (*Casuarina equisetifolia* Forst.). Immediately after this, the trail extends towards the left and we stand before a bridge (Fig. 23). It is a beautiful place. The Dika, a wild raging river with

much water, is visible only for a relatively short distance, and the cliffs rise so sheerly that the slopes above cannot be seen. Without doubt this is one of the few places where the river is crossed; and indeed it was by a great good chance that the vanguard chose this ridge and thus came to the bridge. On the other side is a bridgehead constructed of poles. From that, the bridge slants upward to the top of a cliff four or five meters above the water, where it is fastened to a couple of trees, the roots of which provide the necessary support. The trail is reached on the other side by climbing the slope. At the arrival of the vanguard, the Dyaks, who in such cases always know the way out and in addition have a great disdain for all that is not Dyak, established a

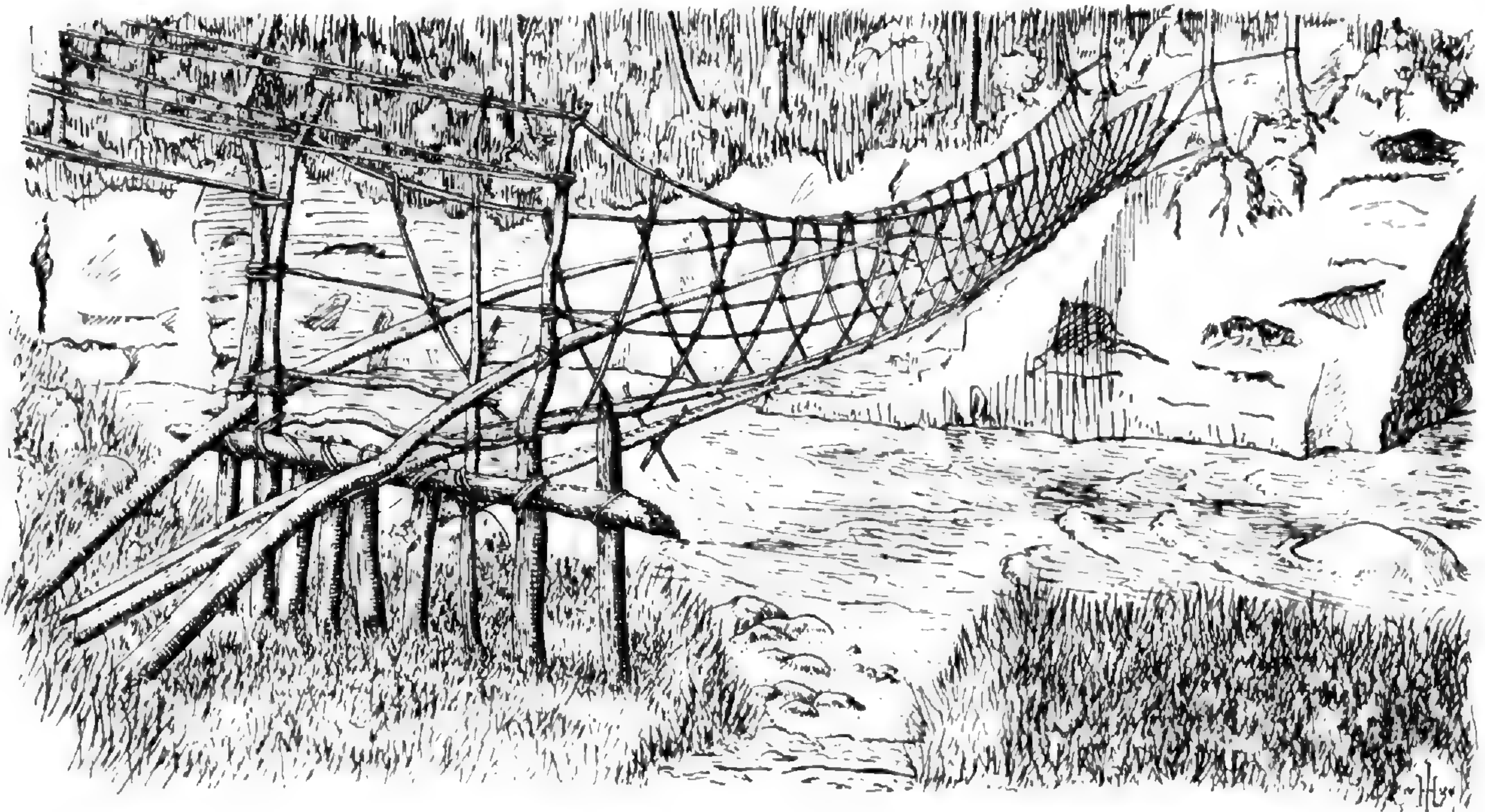


FIG. 23. Timorinese suspension bridge over the Dika River (somewhat schematic).

secondary bridge adjacent to the existing one by skillfully felling a notched tree-trunk across the river. But this bridge was not adaptable to Europeans wearing boots, and so we used the Timorinese bridge which, although it appeared to be somewhat unsteady, was reinforced with rattan. This masterpiece of Timorinese technique was, singularly enough, made of slender trunks, lianas, and roots. In its original construction no rattan was used; nevertheless, rattan of excellent quality is present in the forest in almost unlimited quantities. Possibly the working of this plant with the stone axe was too onerous; but with the rather ample use of the split rattan, the structure was strengthened. Be that as it may, the suspension-bridge belongs to the type which one finds mentioned for other regions,⁶ and the cross-section of it shows a V-form. At the north bridgehead the supporting lines pass through the forked end of the outermost erect and strongest stakes, and are fastened to trees on the bank. The other stakes are cut off at 1.5 m. above the ground, and here is the beginning of the V-form structure. The supporting lines, i. e. the rails, carry a series of V-forms, thus forming the sides. The floor consists of two long slender trunks thrust into the rising bank and resting on the bridgehead, their more slender

⁶ Cf. *Verslag v. d. Militaire Exploratie van Nederl. Nieuw-Guinee, 1907-1915*, pl. 46 and 47, and the sketch opposite p. 198.

ends reaching part-way across the river. Near the center of the span they are paralleled with and tied to the thin ends of two trunks extending from the other bank. The structure is 15 to 20 m. long.

Even before we arrived at this place, we had already noticed that people must have been there a short time before but apparently had hastily fled at our approach. Here and there the earth was somewhat disturbed and pieces of sugar-cane lay ready for planting, while other pieces were already planted. The Dyaks, who, when they see water, forget even their fear, have cast off their loads and their *tjawats* [native dress] and are bathing in the cool clear mountain-water. Meanwhile, as I stand looking at this pleasant scene, all at once I hear above the roar of the water, weakly but clearly, a strange long drawn-out call, and looking up, I see a few dark figures above the rocks on the other side of the bridge. As they see me looking they call again and make reassuring gestures. But they are evidently nervous and appear to be trying to find out what our attitude is. I shout back immediately and beckon to them. These good-natured and inoffensive primitive men at once cross the bridge. In front walks a small full-bearded man, a younger one follows after him, then a woman with a long carrying net supported from the forehead, and finally a blind old man who feels his way over the narrow wobbly bridge cautiously groping with his stick but in the main confident. With slow, sure, almost elegant steps, the first man arrives, although somewhat hesitating in his movements and with a nervous twitching of his face, but still looking fixedly at me, this new and unknown white man. So I have a quiet opportunity to take stock of him and to recall another impression which the first sight of the Boromesso and Takoetamesso, at Pionier-bivak, made on me. There a band of brutes, wild, more bush-animal than man, bold, and in every respect uncivilized; here, gentle friendly fellow-man, primitive as the first, but not without the inward refinement of a quiet and established citizen. He is slender but well built and very dark. His face, with its friendly although still somewhat fearful smile, is completely encircled with a curly beard. On his head is a greasy hair-net which hangs to the shoulders, such as adorns the mature men of the Timorini. On his right shoulder rests a stone axe, on his left a carrying net with its daily supply of food and other small possessions. With quiet dignified movement he approaches, and his bearing unconsciously conveys the impression of a certain national pride, a sense of being the proprietor of this land, in short, in contrast to us the host. But when he is near he again becomes somewhat afraid and, blinking his eyes, he walks straight to me across the bridge. During the whole period occupied in crossing the river, he has continually called to me with various reassuring-sounding words. The modulation of his voice somewhat compensates me for its unintelligibility, and in the talk that follows—held in a circle of already relieved, now again confident, crowding Dyaks—we understand each other in a certain sense very well. If there were any further salutation necessary for understanding hosts to offer, in order to make guests feel entirely welcome, then that salutation would surely be given. As I approach, he speaks to me with outstretched hand. We exchange a firm handshake in the European manner and I listen to his warm guttural sounds, which I answer with eloquently modulated Dutch or Malay. Nevertheless, with all his self-control, it is clear that he frankly would like to end the conversation, and, somewhat relieved, with a friendly smile he points above to where his work waits. He gives me a friendly pat on the arm and leaves, after I, in similar

fashion, have made clear to him that I shall proceed to the other side of the bridge and towards the camp. Quietly he disappears without looking back, his hands behind his back, followed by the youth, and then by the woman who, bent under the load on her back—in which load in a separate net sits a very young child—somewhat shy and tense, glances quickly at us as she passes. Finally comes the tottering gray-haired old man, whom age has made indifferent to new impressions, and, with the appearance of someone awaiting nothing more from this world, he kindly receives my handshake. And Anji Nau thinks he owes it to himself and to his status as Dyak head-man and number two of the group, to take up his position next to me and, with a certain “savoir vivre” and condescending friendliness, likewise to shake hands with the two men.

Such was then my first meeting with the inhabitants of this distant interior of New Guinea. I shall communicate some further details concerning them in the following pages.

In the meantime the Dyaks, having bathed, are preparing to continue the journey. Now all earlier courtesy has disappeared and each one tries to lead so as to be the first on the bridge. Just as on the rattan bridge at Brug-bivak, here also it was deemed advisable to permit only one person to cross at a time. The cliff on the other side appears easy of ascent because of the many projections and tree-roots, and very soon we are actually in the Timorinese territory and ascend along a steep but excellent path through the light and sunny forest. Higher up over gentler slopes, we pass native clearings surrounded by strong fences, and a quarter of an hour later we reach the Dika-bivak (Fragment I, Map B, no. 17), situated at about 1250 m. altitude in an open place on one of the horizontal paths leading toward the slope. Here I found the leader, the geologist, the doctor-anthropologist, and the controller-ethnologist. Happily my unexpected visit was well-timed, for it appeared even to tip the scale in favor of carrying into effect a plan that had been under consideration to terminate the expedition with a five days' journey into the principal valley.

Thus I received a number of impressions which are outside the limits of strictly scientific ethnology but perhaps have some claims to interest, which I present, with the observations on the country and the flora. Occasionally I have tested the impressions by, and in some measure modified them in accordance with, the scientific results of the work of Dr. Paul Wirz, the ethnographer of the Kremer Expedition, but in general I have restricted myself to the recording of personal impressions which, although without scientific pretence, nevertheless may possibly amplify the observations of professional ethnologists in some points. The fact, however, that I resided only a week in this remarkable region will certainly influence some of my comments where feeling has played a greater role than reason (cf. Wirz, p. 41).

I shall not discuss the difficult problem of the origin and composition of the race, which was recently treated by Bijlmer ⁷ and Wirz.⁸ Wirz thinks ⁹ that the

⁷ H. J. T. Bijlmer, *Anthropological results of the Dutch Scientific Central New-Guinea Expedition A° 1920*, followed by an essay on the anthropology of the Papuans. *Acad. Proefschr. Leiden* 1922, also in *Nova Guinea* VII, 4 (1923), 355—See also: *Idem*, *Tijdschr. Kon. Ned. Aardrijksk. Gen.* XXXIX (1922), 156, and *De Aarde en Haar Volken* (1923) 97, 121, 145, 169, 193, in 1924 published in book-form; *J. Jongejans*, *Indië* V, no. 35–37 (1921) and 41 (1922).

⁸ Dr. P. Wirz, *Anthropologische und Ethnologische Ergebnisse der Central Neu-Guinea-Expedition 1921–1922*—*Nova Guinea* XVI, 1 (1924)—See also: *Idem*, *Im Herzen von Neu-Guinea, Tagebuch einer Reise ins Innere von Holländisch Neu-Guinea* (Zürich, Rascher & Cie. A.-G., 1925, illustrated).

⁹ *l. c.* p. 5–8.

pigmy tribes in the Central Mountain Range are related particularly to tribes from the south, and even to Australians; the Papuans from the northern coast diverge rather strongly from the mountain-inhabitants and show more Malayan-Polynesian features. According to Bijlmer, however, one should not speak of two races; he thinks that a Papuan in the wider sense should be "for three quarters—and as for the New-Guinea pigmoids . . . for four fifths, a negrito and for the rest a Dravido-Australoid" (l. c. 79 and diss. 434, Nova Guinea).

Apparently the Timorini¹⁰ have been in these valleys a long time. Wirz comes to the conclusion that the central race must be very old. We shall not become engrossed in the question of how they came to be here, whether they perhaps were forced inland from the plain by stronger tribes and finally abandoned nomadic life here to become settled farmers. The established fact that the contact of the mountain-dwellers with the natives on the northern side of the plain is relatively small is sufficient for us. We have incontrovertible evidence¹¹ that such contacts exist. Not only do the Timorini possess sea-shells which they obtained either by barter or by combat, but also their gestures left no doubt about their being acquainted with the presence of natives of larger stature to the north of whom they were positively afraid. By gestures they clearly indicated that a striking characteristic of these people was their nose-ornaments. However, that the contact with the plainsmen is slight is evidenced from the very few sea-shells in their possession, and the constant scarcity of these is best illustrated by the fact that the Timorini use the common cosmopolitan cowrie-shells (*Cypraea moneta*) as money, and that with one or two of these shells valuable articles or services may be purchased. In addition to the cowrie, which the Timorini call *tigalèh* (according to Wirz, *tinalèh*), they also have fragmentary parts of a larger sea-shell, possibly *Nautilus*. These pieces, called *melli*, form one of their most expensive ornaments; they are worn on a string around the neck. Even for a chopping-knife we could not obtain a single *melli*, but later it appeared that they could easily be secured in exchange for *tigalèhs*.

Apparently the contacts between the northern plainsmen and the people of this part of the Central Mountain Range occur only at one or two places, where the Swart or Iliem River and the Baliem flow from the mountains into the Meervlakte (cf. Wirz l. c. 123). The members of the Kremer Expedition noticed that the mountain Papuans call not only the great tributary which rises near Wilhelminatop, but also the Idenburg the Baliem; whereas, the name Iliem is applied to the Swart River (below the Dika) as well as to the van der Willigen River. When we reflect on how thinly the vast Meervlakte is populated,¹² and furthermore how poor in marine products these people are as compared with the men of Pionier-bivak, then it is clear that apparently the lapse of many centuries has been necessary for the Timorini to accumulate such a relatively large number of these shells.

¹⁰ According to Wirz (l. c. p. 2, footnote 2) the names such as Timorini, Oeringgoep, Pesegem, and so forth, do not have the significance of tribal names as we understand them. They are more in the nature of geographic designations.

¹¹ Cf. Wirz' account of some Timorini accompanying the Kremer Expedition on the return journey to Prauwen-bivak (l. c. p. 125).

¹² According to the cited report, Verslag Mil. Explor. Ned. N. Guin. 1907-1915, the total population of Netherlands New Guinea was estimated at about 180,000 people (p. 240); those on the banks of the Rouffaer River at the junction, where apparently the Swart River empties into it, number about 10,000; cf. also the population map opposite p. 296.

In addition to the shell evidence, I suggest another means by which one may reach the same conclusion, this being in the domain of cultivated crops and ruderal plants. From the phytogeographical point of view the last category is the most important. The adventive plants have been spread indirectly through the contacts of peoples and through their trade-routes. Cultivated plants are directly distributed by the people themselves. We shall begin with these.

The plainsmen in New Guinea have grown ¹³ *oebi* ¹⁴ *djawa* [sweet potato] (*Ipomoea Batatas* Lamk.), cassava (*Manihot utilissima* Pohl), *ketimoen* (*Cucumis Melo* L.), *laboe* (*Lagenaria leucantha* Rusby = *vulgaris* Ser.), tobacco (*Nicotiana ?Tabacum* L.¹⁵), *watti* (*Piper methysticum* Forst.), *lombok rawit* (*Capsicum frutescens* L.), banana (*Musa* sp.), *pinang* (*Areca Catechu* L.), coconut (*Cocos nucifera* L.), *katjang* (bean) species, taro (*Colocasia esculenta* Schott), papaya (*Carica Papaya* L.), soursop (*Annona muricata* L.), sugar-cane (*Saccharum officinarum* L.), and maize (*Zea Mays* L.). In the Arfak Mountains potatoes are also cultivated. Most of the species are to be considered as secondary foods. The chief food in the plains is sago; that of the mountainous region is sweet potato.

The Timorini cultivate the sweet potato (Tim.: *bei*), banana (*lawi*), *pandan* (*Pandanus* sp.), *sirih* (*Piper Bette* L. or a related species), taro (*kôm*), sugar-cane (*ên*), *pinang*, *katjang ketjipir* (*Psophocarpus tetragonolobus* DC.), *laboe* [*Lagenaria*], and tobacco (no. 2075; *Nicotiana Tabacum* L.). Wirz (l. c. p. 86) records the cucumber (*gita*, *koemak*). He mentions also (p. 87) a shrub with "gelappten Blättern und gelben Blüten," which was grown and used as food by many tribes in New Guinea. Possibly this was the pantropically cultivated *Abelmoschus esculentus* Moench. When we now trace what is known of the origin of these plants, we find the following. The sweet potato is native in tropical America. The time of its introduction into Asia is not definitely known. During the time of Rumphius (1650–1700) the plant was already in cultivation everywhere in the Archipelago. Possibly the sweet potato, with the tobacco,¹⁶ belongs to the very anciently cultivated plants which were spread

¹³ Verslag Mil. Explor. . . . p. 298 et seq.; L. S. Gibbs, Dutch N. W. New Guinea (1917), 17.

¹⁴ Van Nouhuys (Nova Guinea VII, 1 [1913], 8) identified *oebi* as *Dioscorea*. The tubers of both *Dioscorea* and *Ipomoea* have been called *oebi*; to distinguish the two, *Ipomoea Batatas* Lamk. is usually called *oebi djawa*, or *bataten*.

¹⁵ Van Nouhuys reported to me in a personal letter that he encountered, among the Pesegem, a species (according to his recollection) with greenish yellow flowers, which perhaps was *Nicotiana rustica* L. Whether this species occurs in New Guinea is uncertain, partly owing to the indifference of members of the various expeditions to the collection of cultivated plants, and partly because the opinion of a specialist is necessary to determine the collected material. Chevalier (see footnote 16) names a large number of species of which surely various ones might be expected to occur in New Guinea. So far as New Guinea is concerned, only two specimens of *N. Tabacum* L. are in the Buitenzorg Herbarium, one from the Kaiserin-Augusta River (Hoofd-bivak, *Gjellerup* 368) and one from Temena (Northern New Guinea, *Wichmann* 188). *Nicotiana rustica* L. is not represented by any specimens from the Netherlands Indies.

¹⁶ It is remarkable that the Timorinese words for tobacco (*tabo*) and for pipe (*taboaak*) appear to be derived from the Malayan (*tabako*) and thus indirectly from the [American] Indian word. This may be an indication that the plant reached the Timorini through direct or indirect contacts with the Malaysians. The Pesegem have different words, *mbali* for tobacco and *kanoem* for pipe. Van Nouhuys (l. c. 11) reports that tobacco is not known by the tribes along the lower course of the Lorentz River, but only by the Pesegem. Otherwise the plant is widespread in New Guinea, and the reason for its absence in the Lorentz River region is probably owing to the fact that the tobacco plant does not thrive where there is too much soil moisture. According to Heyne (*De Nuttige Planten van Nederlandsch-Indië*, ed. 2, 1927, p. 1354)—who lists only *N. Tabacum* L.—tobacco flourishes best in dry soil, which condition apparently is not character-

from America to this region seemingly long before the arrival of the Europeans (Spaniards, 1545) in the Archipelago. Thus it is not necessarily surprising that this plant now appears even in the remote valleys of the Timorini. The banana,¹⁷ *pandan*, and betel may be native. The use that is made of the betel-leaf is possibly not autochthonous. Taro, *laboe*, and *Areca* are indigenous in southeastern Asia. From time immemorial sugar-cane has been cultivated in Old World tropics; perhaps the primitive form (*Saccharum spontaneum* L.) is indigenous in the Archipelago. *Katjang ketjipir* [*Psophocarpus*] is likewise a plant of tropical Asia; it is an important fact that it was introduced into Amboina during Rumphius' time, because apparently the plant reached New Guinea shortly thereafter. These cultivated plants may have been introduced by bird-hunters and traders, but once introduced they gradually extended from the coastal regions into the interior. Undoubtedly a long time was necessary for this distribution.

Now we come to the ruderal plants. In Fragment III, I have defined these. I group them here as follows:¹⁸

I. COSMOPOLITAN IN TEMPERATE TO TROPICAL REGIONS:

1. *Oxalis corniculata* L. (no. 2059)
2. *Eleusine indica* Gaertn.

II. TROPICAL COSMOPOLITAN:

3. *Sida rhombifolia* L. (no. 2064)
4. *Drymaria cordata* Willd.
5. *Urena lobata* L.
6. *Ageratum conyzoides* L.
7. *Bidens pilosus* L.

III. TROPICS OF THE OLD WORLD:

8. *Adenostemma Lavenia* O. Ktze. (no. 2087)
9. *Cyathula prostrata* Bl. (no. 2069)
10. *Polygonum nepalense* Meisn. (nos. 2054, 2066)
11. *Senecio sonchifolius* Moench (no. 2052)

IV. TROPICAL ASIA AND AUSTRALIA:

12. *Crepis japonica* Benth. (no. 2053)

istic of the Lorentz River region. If it is a fact that tobacco is not grown there, it seems strange that the natives of this region should not know and smoke tobacco, because tobacco is an important article of commerce in New Guinea. It is known that the Timorini pack tobacco for barter with the Meervlakte dwellers for *tigalèhs*, etc., and it might be expected that the Pesegem would do the same with the inhabitants of the adjacent lower regions.

Long after the above opinion on the time of introduction of tobacco and sweet potatoes into New Guinea was recorded, I received a paper from a well-known French specialist in the field of tropical cultivated crops, Dr. A. Chevalier (*Les Origines du Tabac et les débuts de sa culture dans le monde*, Edit. d. I. Revue internat. des tabacs, Paris, 1927). The author reaches the conclusion (p. 13) that the peoples of the southwestern parts of the Pacific Ocean and of southeastern Asia knew the tobacco and the sweet potato before the discovery of America by Columbus. In view of the high degrees of civilizations which were developed centuries earlier in Central America, and the seafaring proclivities of Polynesian peoples, this need not be surprising. These and other cultivated plants, according to Chevalier, through the agency of man, perhaps also by birds or even on driftwood, might have extended via the numerous islands of the Pacific Ocean far to the west. I suppose that here in particular the influence of man must be considered. Tobacco was first introduced into Java by the Dutch in 1601, but one might assume that it was known much earlier in the Moluccas and seemingly also in New Guinea. Van Nouhuys informs me that, from old travel-records, it is apparent to him that tobacco occurred in Ternate in 1599 and that slaves (Papuan?) especially used it.

¹⁷ Cf. Cammerloher, Zur Frage der Heimat der Banane—Oesterr. Bot. Zeitschr. (1922), 262.

¹⁸ There was very little opportunity to collect, and hence not all the ruderals could be assembled. Those actually collected are listed with their herbarium numbers. In other cases I have taken the names from my notebook. The determinations were made by Mr. C. A. Backer.

V. TROPICAL ASIA:

13. *Nasturtium indicum* P. DC. (no. 2086)14. *Oenanthe javanica* DC. (no. 2076)

VI. JAVA:

15. *Plectranthus* (aff.) *javanicus* Benth. (no. 2057)16. *Lobelia succulenta* Bl. (no. 2061)

VII. AUSTRALIA:

17. *Mitrasacme elata* R. Br. (no. 2077)18. *Oldenlandia tenelliflora* K. Schum. var. *papua* Val. (nos. 2065, 2085)

The difference in altitude partially explains the dissimilar ruderal floras of Pionier-bivak and Swart Valley.¹⁹ Only two of the plants named are common to both areas, *Ageratum conyzoides* L. and *Eleusine indica* Gaertn., both of which occur in Java and which extend into the mountainous region. Some, however, have become established because a certain type of selection is associated with adaptation for dissemination.

We shall now try to trace the means by which these plants may have reached these isolated valleys. The first approach to this question is by an examination of the peculiarities of fruits and seeds. Apparently the natural methods of distribution in this case, as far as the region is concerned, are perhaps more applicable than the possible coöperation of man. But man's work in the preparation of the land becomes a premise to natural dispersal. In the following survey we shall confine our remarks to 15 of the ruderals mentioned—nos. 17 and 18 are not true adventives—and *Plectranthus javanicus* Benth. is omitted because of its somewhat uncertain determination. We find then:

A. Wind-dispersed:

1. *Ageratum conyzoides* L., fruits with pappus.2. *Senecio sonchifolius* Moench, idem.²⁰3. *Crepis japonica* Benth., idem.4. *Polygonum nepalense* Meisn., with winged fruits. This species belong in category B equally well; the seeds are very small and round.

B. Possibly distributed by men and animals:

(The fruits and seeds of this category of plants are very small and without particular characteristics; often one thinks that such seeds lend themselves to distribution by man, although wind-dispersal is not impossible)

5. *Lobelia succulenta* Bl.6. *Drymaria cordata* Willd.7. *Eleusine indica* Gaertn.²¹8. *Oxalis corniculata* L.; the seeds are ejected in much the same way as those of *Impatiens*, by the bursting of the fruit.9. *Oenanthe javanica* DC.; seeds somewhat larger than in the previous species.10. *Nasturtium indicum* P. DC.

C. Can be spread by animals, particularly birds:

11. *Bidens pilosus* L., fruit with two barbed awns.12. *Adenostemma Lavenia* O. Kuntze, seeds with four stiff projecting pappus-hairs, and glutinous.13. *Cyathula prostrata* Bl., fruits with numerous tiny hooks.²²14. *Urena lobata* L., seeds with curving hook-like prickles.15. *Sida rhombifolia* L., seeds with a stiff hard awl-shaped prickle.

¹⁹ In addition perhaps one should add to the ruderal flora a few unnamed representatives of *Jussiaea*, *Aneilema* (no. 2073), *Commelina* (no. 2074), a few Scrophulariaceae (nos. 2063, 2078), Compositae (no. 2050), Gramineae (nos. 2055–6, 2068), and Rubiaceae. The number of ruderal plants in the vicinity examined is apparently about 30.

²⁰ Cf. Docters van Leeuwen, Ann. Jard. Bot. Buitenz. XXXI (1920), 127.

²¹ Docters van Leeuwen records the distribution of this plant by birds (l. c. 130).

²² Docters van Leeuwen, l. c. 126.

We sum up the data obtained in a small survey of the ruderal flora of Pionier-bivak and the Swart Valley:

DISTRIBUTION	Pionier-bivak		Swart Valley ²³	
	Number	%	Number	%
	17 ²⁴	—	15 (± 15)	—
Tropical cosmopolitan	9	53	7	47
Tropics of the Old World	12	71	11	73
Tropical S. E. Asia	17	100	14	93
<i>Possible means of dispersal</i>				
Man	14	82	7-6	47-40
Wind	2	12	3-4	20-27
Birds	1	6	5	33

Naturally many and important conclusions cannot be drawn from so few data. From the above survey, however, it is striking that the components of the ruderal flora in both regions are practically the same, in spite of the vastness of the area. This doubtless is an important factor, since it perhaps implies that the ruderal flora in both regions has reached about the same state of development. In the easily accessible Pionier-bivak, the ruderal flora was at most seven years old. In the vast central mountainous region much more difficult to reach, where the ruderal flora is in about the same condition, but more abundant, it must have taken a long time to develop thus. Since we do not know the comparative value of the accessibility-factor for both areas, it is impossible to estimate the length of time. We know that hundreds of kilometers of primeval forest separate the mountain-valleys from the nearest cleared areas outside, and further we know that communications between the two are sporadic. Opposed to these hindrances, the vastness and age of the cleared land in the mountain-valleys ²⁵ is a favorable factor. Hence we must conclude that a very long time can be the balancing factor between the two. In connection with this, the fact is clearly brought out in the survey that probably distribution by man is preponderant (82%) in Pionier-bivak; whereas the same factor in the Swart Valley applies to less than half of the ruderal flora observed there ($\pm 45\%$).

Contacts of the valley people with the northern tribes have been much discussed, and this surely claims our attention. We noticed it on the northern boundary of the inhabited territory. The Kremer Expedition, however, has shown that a well-beaten path traverses the Central Chain via Wilhelmina Pass (Fragment I, Map A) to the south. The trail extends some tens of kilometers across uninhabited territory, connecting the region settled by the mountain Papuans north of the Central Chain (Peninggalèh) with that occupied

²³ Nos. 15 (determination uncertain), 17, and 18 (apparently native) from the list as given are not included.

²⁴ The numbers given for Pionier-bivak are not the same as mentioned in Fragment III. Here *Momordica cochinchinensis* Spreng. (nos. 629, 630) is included, a plant indigenous in S. E. Asia and apparently imported here by man. The leaves are eaten as greens; the fruit is rather large and studded with obtuse prickles; the seeds are surrounded by an aril and the juicy flesh of the fruit; possibly these are eaten by birds and thus dispersed.

²⁵ A possible thoroughfare from Etna Bay and Geelvink Bay to the east through the longitudinal valleys of this central mountain-land ought to be considered.

by their congeners, the Pësëgëm (pronounced with soft g). These Pësëgëm,²⁶ discovered in July 1907 by the First Lorentz Expedition, further studied in 1909 by the Second Lorentz Expedition and in 1913 by the Franssen Herderschee Expedition, dwell in valleys having much more convenient communications with the plain than has Swart Valley. Barter with the plainsmen is probably very easy, and likewise there exists a rather heavy traffic with the Timorini; that is, assuming that a number of the possessions of the latter have come to them from the south. On the other hand, various writers, such as Pulle,²⁷ Snell,²⁸ and van Nouhuys,²⁹ mention the fact that the Pesegem informed them that shells³⁰ in their possession came from the north. Snell (l. c. 71) surmised that the stone of their axes also—probably not chloromelanite but andesite, perhaps of the northern mountain series—came from the north. The Kremer Expedition learned, in agreement with the reports of the other writers on the Timorini in the southern valleys, that they are on good terms with the dwellers on the other side of the Peninggalèh. Thus on this degree of longitude, the mountainous area of New Guinea over its entire breadth, excluding the uninhabitable alpine parts, is populated by the same mountain-tribe. That this tribe, however, extends still farther toward the west and the south we may determine from the reports of de Kock³¹ and van den Broek³² on the Goliath Papuans (the abominable combination Goliath-pygmy has frequently been used, and thus by analogy one should likewise expect David-giants), Wollaston's report³³ on the Oetakwa Papuans and the Tapiro, and Detzner's³⁴ on the tribes inhabiting the mountains far east in the Australian part of the country. Doubtless the tribes to the north of Carstensz Peaks investigated by Leroux and Stirling of the Nederlandsch-Amerikaansche Expedition belong to this same race.

To illustrate the conformity between the Timorini, the Pesegem, and the Oetakwa Papuans, I briefly enumerate some points of likeness and difference among these tribes. We begin the comparison with the Pesegem. First, numerous words in the speech are identical or show some resemblance. The stature and the height are strikingly similar in both this tribe and the Timorini. Among the Pesegem the women have shorter hair than the men, and the children frequently have reddish-colored hair. Again among the Pesegem one observes finger-mutilation such as is practised chiefly by women of the Timorini. The Pesegem wear a gourd penis-sheath, arm-bands, and necklaces like those of the Timorini, as well as a hair-net and small carrying pouches. The ropes are of the same type in both tribes and are smeared with oil (Snell speaks of wax); the entire body also is greased. Pigs' tusks, bandoliers made of pig-

²⁶ Maatsch. t. Bevorder. v. h. Nat. Onderz. d. Ned. Kol. Bull. nos. 58, p. 18, and 62, p. 17, and 68—H. A. Lorentz, *Zwarte Menschen, Witte Bergen* (Leiden 1913)—Van Eerde, *Tijdschr. Kon. Ned. Aardrijksk. Gen.* XXVIII (1911), 49—Pulle, l. c. (see footnote 27)—Van den Broek, *Nova Guinea* VII, 3 (1915), 233—Van Nouhuys, l. c. (see footnote 29)—Fischer, *Nova Guinea* VII, 2 (1915), 145.

²⁷ A. Pulle, *Naar het Sneeuwgebergte van Nieuw-Guinea*, p. 172.

²⁸ L. A. Snell, *Maatsch. t. Bevorder. v. h. Nat. Onderz. d. Ned. Kol. Bull.* no. 68 (1913), 57.

²⁹ J. W. van Nouhuys, *Der Bergstamm Pesechem*, *Nova Guinea* VII, 1 (1913), 91.

³⁰ Perhaps the muddy southern coast does not provide shells!

³¹ *Tijdschr. Kon. Ned. Aardrijksk. Gen.* XXIX (1912), 154.

³² *Ibidem* XXVIII (1911), 821.

³³ A. F. R. Wollaston, *An Expedition to Dutch New Guinea—The Geographical Journal* XLIII (1914), 248—*Idem*, *Pygmies and Papuans* (London, 1912).

³⁴ H. Detzner, *Vier Jahre unter Kannibalen* (Berlin, 1920).

skin, seashells, and orchid stem-fibers are ornamental articles sought by both. The stone axes of the Pesegem have the same form as those of the Timorini. Their wives, who also do the field work, use the same kind of net-sacks, while, on the top of these, they carry their babies in a small net. The larger children sit astride a woman's shoulders and grasp her hair. The Pesegem are described as peaceable and gentle, the young men being noisy and the older calm and composed. The Timorini can be characterized in the same way. The fire-making methods in the two tribes are almost identical. When surprised the Pesegem tap the penis-sheath. The arrows used by both tribes are almost alike, three or four types being exactly the same. Both have pigs for live-stock and shelter them in their houses. The dwellings differ greatly, but both tribes have in common a preference for living on mountain-ridges, and in both the sexes live separately. Both practise intensive cultivation and raise the same crops on their steep enclosed fields; the chief food of the Timorini and the Pesegem is the sweet potato. Both eat their food raw or after roasting it in pits covered with stones. The tobacco pipes observed in the two tribes are very similar. The "mouth organ" of bamboo or *gelagah* stem is used by both tribes; the Pesegem also chant monotonous choral songs with short repeated refrains. The same ceremonial is used in establishing a blood-friendship as is encountered amongst the Timorini.

Although the Timorini and the Pesegem resemble each other in very many ways, there are, nevertheless, important differences to be enumerated. The usual costume of the Pesegemese women consists of two small grass cushions, that of the Timorinese women is a string skirt. The few times that we encountered the grass costume among the Timorini, it was inferred that the wearer was of Pesegemese origin. The Pesegem too have a peculiar raincape made of *Pandanus* leaves, not found among the Timorini; possibly it rains more on the south slope of the mountain-range than in the high valleys of the interior. The women of the Pesegem wear the carrying net not from the forehead, as do those of the Timorini, but from the crown of the head, this practice at times producing a localized bald spot. The most important difference between the two tribes, however, except in the speech, lies in the fact that the houses for women are four-sided and stand on piles, whereas, the house for men, usually one per kampong, is circular (similar to all the houses of the Timorini) and built on the ground. The Pesegemese men usually surround their kampongs with a fence, this being seldom the case with the Timorini. Lastly the Pesegemese men wear a number of rattan bands around their waists; this is unknown to the Timorini. The latter also lack the strings which are pendent from either side of the penis-sheath of the Pesegem.

The Oetakwa Papuans, who live so much farther from the Timorini, show hardly any differences. They appear to be nearly related to the Pesegem. Their houses are four-sided; they grow sweet potatoes as their principal food, and in addition sugar-cane, taro, ginger, bananas, and tobacco, frequently in terraced fields on steep slopes. The highest cultivated land there was at an altitude of 2000 m., but deforested areas were seen up to 2400 m. The people were very friendly and not at all frightened. "They were quite fearless from the first; they strolled into our tents or huts as if they had been accustomed to do so all their lives," says Wollaston in the above-cited publication. The build and height of the Oetakwa are similar to those of the Pesegem and the Timorini. The photographs illustrating Wollaston's article are strongly Timorinese in

character. We see the same stature and features, the same necklaces of seeds and *Echidna* spines, the same bags woven of string. We recognize the high caps of cassowary feathers and the ornaments of *koeskoes* fur. Wollaston mentions penis-sheaths for men, small grass cushions and large carrying nets for women. Ornaments of *Dendrobium* fibers are as widely known as cowries and other sea-shells; when questioned as to where the last came from, they pointed always to the east (the Pesegem?), never in the direction of the coast. The Oetakwa had a few iron axes of unknown origin and many stone axes made of "metamorphosed slate" (slate rock? ?), according to Wollaston. Small stone knives also were in their possession. Pigs' tusks and tails were used as trimmings, and fire-making was like that of the Timorini. The Oetakwa have similar tobacco pipes. They salute an acquaintance in the same fashion as the Timorinese people. Wollaston mentions the very characteristic manner of pulling knuckles. He also records that when surprised they tap the thumb-nail against the penis-sheath. Their temperament is cheerful and noisy and they likewise have a "Jew's harp," undoubtedly the same as the "mouth organ" of the Timorini and the Pesegem.

Involuntarily the question rises: Did the Timorini know of the existence of white men before our arrival? I think the answer is definitely in the affirmative. Centuries ago the coastal native knew the white man, and during the course of years such an important fact in some form doubtless penetrated far into the interior. Probably the facts that the dwellers of the Meervlakte first in 1909, and the Pesegem in 1907 and 1909, really came into contact with the white people have been no more than affirmations of something which, for many, must have sounded like a kind of fairy tale. Nevertheless, really getting acquainted with us must have been a big event in the lives of the Timorini. I once tried to imagine what went on in the minds of these people, not only in the individual life of each, but also in the lives of their associates, when we appeared for the first time, engaged in a multitude of, to them, completely incomprehensible matters. It will be sufficient to refer to the description of the first contact given by Bijlmer and Jongejans. In the later days of our sojourn particularly, we were often surprised that we Europeans proper were always much more amazed and interested than our hosts. As we try to explain this fact, we must consider that a people in this stage of evolution are as children compared to us. The Timorinese individual is, even in our eyes, an excellent man but primitive; that is, his mental processes are much more unconscious than ours, much less complicated, and lack the power of coördination. We can consider him as a kind of intermediate form between the "intelligent" mammals, such as dogs or horses, and ourselves. I do not discuss the position of this intermediate form. In his inner being are the same seeds of good and evil as in ours. Every day, every hour, every minute, we are again touched by expressions which we encounter in our own race. His society is like ours but on a strongly reduced scale. Can one say the same of the mongoloid races? (East is east . . . etc.) Why did we find the Mamberamo Papuans such unredeemed brutes, and yet accept the Timorini, likewise primitive, as our fellow-men? Surely not because they have climbed a few steps higher on the ladder of refinement! Can it be that there are two kinds of primitiveness, crude and cultured? And did our own race in its primeval condition belong to the first type? I leave the answers of these questions wholly to the ethnographer and philosopher. But it is strange to observe how

there exists among such primitive and isolated people the same proportion between old age and youth as amongst us. The children are true children, the boys real street boys, the girls are genuine girls, and the old men real old men. Nevertheless, there remains a child-like standard. They are, as it were, ghostly neoteinic forms undeveloped in depth and breadth of conscious outlook, and this is an indication of the phylogenetic youth of such a people. Ontogenetically, probably the Timorini can be developed as most Europeans. Their present stage of development as a people apparently does not separate them from us by an insurmountable gap; the phylogenetic development is not to be forced. Here agents are at work which need a very long time for each change or else are inactive. So the ratio between age and youth during the phylogenetic development remains constant. Whereas the nature of the child of phylogenetically young and old nations hardly differs appreciably, we find at the end of life a very great difference, since that is in proportion to the phylogenetic age of the people. As is true of our own people, we find the Timorini courageous and cowardly, honest and dishonest, reserved and demonstrative, noisy and quiet, wags and thinkers, coquettish and modest, boasting and unpretentious, naive and suspicious. We observe a people here who developed undisturbed in peace and quiet, a people who have refined a large measure of good nature and flexibility from the influence of the earth and its surroundings. In such a people we find the best of the animal elevated to the status of humanity. We feel much nearer to him than to the young Javanese. The latter has already arrived through the elimination of isolation. Originally his soul was pure in nature, but now it is troubled by a multitude of ideas which properly belong to a society phylogenetically older; hence, these ideas promote a dissonance with the sound of chords tuned to entirely different standards.

Why was it that these Timorini appeared to be so much less affected by our arrival and its accompanying wonders than we had expected, than we ourselves were? I believe it was because they, in phylogenetic youth, therefore like children, are simple. That inconceivable something which we brought them, they accepted as they accept so many other incomprehensibilities. In their largely unconscious spiritual life, they try not to estimate these; whereas we, frequently at the cost of our tranquillity, cannot desist from so doing since we have eaten of the fruits of the tree of knowledge.

The Timorinese individual is slender and slight but well-built. Bijlmer gives as average height of the men 154.7 cm. (Wirz, 155.7), for women 143.2 cm. (Wirz, 147.3). Thus the Timorini certainly are not pygmies. Of 40 Dyaks who accompanied the expedition, the average height was 155.9 cm., but one never hears this tribe spoken of as pygmies. The children almost all have the characteristic "sweet potato" stomachs, but this feature disappears in later life. Whereas the men generally retain their beautiful supple figures, the women, who do all the heavy work, age early and become plain.

In men frequently the entire body is covered with small tufts of frizzy hair; most of them have a full beard and mustache. The facial expression is usually friendly and good-natured, sometimes alert and sometimes gentle. The deep-set eyes appear open and intelligent under the projecting heavy eyebrows and impart to the face something of candor. The men go naked, since the penis-sheath is considered as an ornament rather than as clothing, although, on the other hand, a sense of shame is not lacking in the Timorini. The small net of

knotted string,³⁵ often locally wrapped with yellow orchid-fiber and decorated with colored leaves or with feathers, is worn by mature men on the head. It is firmly attached to the curly black hair with pork-fat colored black by soot and will remain in its place many years. An end hangs at the back and appears to consist of several layers, for often I saw the outside layer raised in order to place some object beneath it. Nevertheless, we observed mature men with uncovered heads of curly hair.

Many men wear thin or thick rattan sticks or more or less sharpened pigs' tusks through the nasal septum or through the ear-lobes, and sometimes two such tusks are bound to a ring. Coarse twisted rattan bands are worn on the neck, and strings of seeds, such as those of Job's tears (*Coix Lacryma Jobi* L.), or internodes of thick-stalked grass. Most of these strings are long and one short end, consisting of the spines of porcupine ant-eaters (*Echidna*), hangs down. An unusually valuable ornament is the previously mentioned *melli*, a piece of large sea-shell (*Nautilus?*); relatively few men had it, and many young men indicated a vehement desire for the white paper leaves from our notebooks as a cheap substitute.

An ornament worn much by men is a bandolier of knotted string (Wirz, l. c. pl. X, fig. 5) on which a number of objects are hung, particularly short sticks of bamboo or rattan on which a piece of long-haired pigskin is fastened, also larger pieces of pigs' feet or those of cassowaries. Each man has a shoulder-bag in which he carries some useful things and some luxuries: a small dagger fashioned from a cassowary leg, a pipe (*Fig. 29*) made from an excavated fruit with a hollow grass stem, a small case for lime, made from a *laboe* fruit, a couple of betel leaves and an *Areca* nut, a few leaves of tobacco, and, if he is well-to-do, a few *tigalèhs* [cowrie shells]. With that he carries some provisions or tidbits, a couple of roasted sweet potatoes, a small piece of sugar-cane, and some beetle-larvae.

The arms are often decorated with a few plain finely or coarsely twisted rattan-bands (Wirz, l. c. pl. VI, fig. 2-5); they are either the customary short cylindrical form, or the horizontally projecting type [somewhat flange-like] wherein the outer and inner margins form two concentric circles (Wirz, l. c. pl. XII, fig. 1-3). Perhaps the latter were originally arm-protectors against the springing back of the bowstring, but the band is worn also on the upper arm.

Descending along the body we now come to the penis-sheath or *keboaak*. The strangeness of this frequently very provoking article was that it very soon was no longer striking. In youth the boy is girdled with a small-size child's *keboaak*. It is made of the basal part of the *laboe* fruit (*Lagenaria leucantha* Rusby = *vulgaris* Ser.) or gourd. Heyne³⁶ mentions that these old or mature fruits with hard woody walls are used as containers for various liquids; in Java these are artificially moulded by bands tied around them during the growing period. In view of the many different models which occur amongst the Timorini, one must suppose that this custom is also in vogue here, but neither Wirz nor myself were able to ascertain it. The *keboaak* rests on the base of the penis which is almost entirely concealed; it is attached in the middle to one or usually more bands fastened around the waist and by a thin band under the scrotum. There is a band around the waist to fasten the article in position. As for the difference in models, perhaps that is a question of age or social status.

³⁵ For finery, etc., see the ample report of Wirz (l. c. 102 et seq.).

³⁶ K. Heyne, *De Nuttige Planten van Nederlandsch-Indië*, 2nd ed. (1927), 1423.

There is a type which might be called that of the common citizen, the predominant and less conspicuous model, the short straight sheath. Most are thin and sometimes closed at the end (fruit-stalk), but there are also some of the model of the old blunderbuss (Wirz, fig. 2, fig. 7, middle man), being wide, thin-walled, or even thick sheaths, the outer end of which is closed with a wad of grass. According to Wirz, similar models are used as depositories for small articles such as *tigalèhs*. The exceptional models differ in length and form. We saw some which were coiled and curved, a few even recurved. I also remember a very old man whose *keboaak* projected upward to his hollow chest (cf. Wirz, fig. 32).

Some writers consider the *keboaak* as ornamental rather than as an article of clothing; one cannot deny the Timorini a sense of shame. I never saw a mature man without a *keboaak*, and when such an article was to be bartered, always an extra one was first brought from home and the "change of clothing" took place behind a bush.

As is to be expected of an article so closely connected with sexual aspects, the *keboaak* takes a particular place in the life of the Timorini. Without exception, the expression of astonishment, at the sight of our remarkable possessions for example, the guttural sounds are constantly accompanied by a repeated tapping of the nail of the index-finger or thumb against the *keboaak*. Perhaps this may be considered as an appeal to the saint of the sexual organs as exorcism lest the stranger whom he beholds shall bring him calamity.

In addition to the daily equipment previously described, the Timorini have a number of other occasional bags. They have a beautiful, woven, firm, strong, and very flexible piece of armor (Wirz, l. c. pl. XII, fig. 5), a kind of coat-of-mail made of fine rattan, the supple upper part of which covers the shoulders, while the coarser part protects the torso against arrows. They have various kinds of head-dress: caps of cassowary feathers pompous as a hussar's busby easily spoiled by rain, caps of *koeskoes* fur, head-bands for dances consisting of a broad strip of *Pandanus* leaf bound in U-form and decorated with bits of *koeskoes* fur and feathers of different birds (Wirz, l. c., pl. VIII, fig. 1). Finally they brought a ring-shaped rattan object with singularly long cassowary feathers attached to one end (Wirz, l. c. pl. VIII, fig. 3), and, holding it erect on the head, danced to and fro before us.

We frequently wondered of what material the beautifully twisted and strong string of the Timorini was made. I was unable to obtain definite information. The Industrial Section of the Department of Agriculture, Industry, and Commerce at Buitenzorg answered my inquiry, stating that it does not come from *Pandanus* aerial roots. Perhaps the origin must be sought in *Gnetum Gnem on* L., the bark of which is used everywhere in the Archipelago for manufacturing a fine type of string. Wirz (l. c. 110) proposed the same source. Snell (l. c. 68) reported that the Pesegem use string made from the bark of a shrub resembling cotton. The *waroe* (*Hibiscus tiliaceus* L.) does not occur here. Possibly another species of *Hibiscus* (*H. sabdariffa* L.; *roselle*), is meant.

The weapons possessed by these strange mountain-people conform entirely to their build. The bows are small and light, and the arrows look more like children's toys than arms. These bear no conspicuous ornamental motives, only somewhat singular outline figures. Four types of arrows can be differentiated. Two of these have a long and sharp point of bamboo or bone, the one with barbed hooks, the other without. These two are intended for human

enemies. The third model is tipped with a very broad gently convexo-concave bamboo point sharpened at the end; this is the hunting arrow which is used in killing pigs for food. The fourth type has four short somewhat divergent points; this is used in hunting birds. Perhaps the form was developed because the arrow often remains in the body of the bird, and thus its possible loss is guarded against in the dense forest. Children practice shooting when very young, using small bows and short arrows with blunt points. The arrows are of bamboo or rattan, the bow of palm wood (*Kentia?*).

In contrast with the Mamberamo Papuans, the Timorini as a whole are not inseparable from their bows and arrows. They frequently called unarmed and usually seated themselves quickly when visiting the camp. As peaceable farmers, the Timorini are less attached to their weapons than to the stone axe. Two models of these are known. The one most often seen is the man's axe (*Fig. 24A*), which one might call a field-axe, the instrument being used in

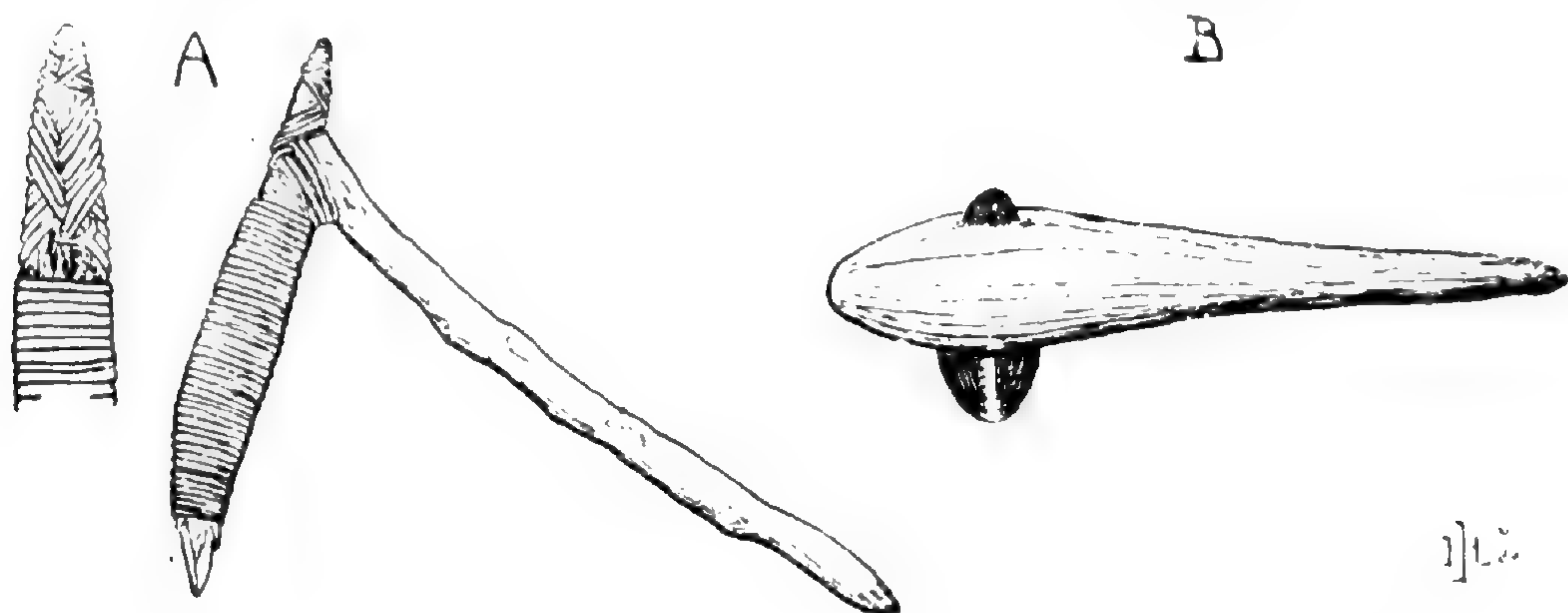


FIG. 24. Timorinese axes: A = man's axe; B = woman's axe.

breaking up new land. It is made of a strong flexible branch with a part of the wood of the trunk still attached, the latter standing at an angle of about 60° . The branch is the handle; a sharpened stone is attached to the short part and reinforced by binding with a thick strong strand of split rattan. The stone is hard and tough, not flaking off, and has the dark green color of andesite. It is not clear where these stones were obtained. Possibly they were found in the eruptive Doormantop series. In this connection I recall Snell's remark on the probable origin of the Pesegemese stone axes, which evidently came from the north. Moreover, it is known that there is an active barter in this valuable article in New Guinea; one might even speak of it as a local industry, as van Eerde³⁷ reported. The asymmetrical sharpened half-protruding stone is easily removed from its binding, and this occurs frequently in order to grind out the nicks caused through its use. Often we saw a man occupied a long time with the sharpening of the stone, moving it to and fro over a wet piece of slate with great patience. This tool may cut the tree-trunks almost horizontally, or at least at a wide angle. It is astonishing that the Timorini are able to fell a tree of sizable girth, and in a relatively short time, with this, to our eyes, primitive tool. The axe is carried over one shoulder, the stone at the back, the point of the forked wood turned slightly outward.

The other kind is the woman's axe or house-axe (*Fig. 24B*), consisting of a straight club-shaped piece of wood with a thin handle; in the thick end a

³⁷ Van Eerde, *Inleiding tot de Volkenkunde van Nederlandsch-Indië—Volksuniversiteitsbibliotheek no. 1* (1920), 57-58.

symmetrical sharpened stone is set in an opening which narrows towards the upper side. This axe is used for chopping wood.

In lighting a fire³⁸ the Timorini employ this method: a long stick split at one end, the two parts slightly separated by a small stone, is used. Associated with this stick is a piece of split rattan, the larger part of which is wound around the wrist in a thick armband, the rest, 1-1.5 m., being free. Some dry leaves, *Selaginella* and such, are piled in a small heap on the ground. On top is placed a small handful of a fungus-like substance resembling the material gathered from the leaf-axils of the sugar-palm in Java. Now the stick, already showing some grooves burned black, is laid on the heap of dry material and the free end of the rattan string is pulled through under the stick. Then the man presses the stick down on the pile with his foot, takes the free end of the rattan in one hand, the wound part in the other and draws the rattan quickly and forcefully to and fro. After a few pulls, smoke appears, and a moment later a flame which immediately attacks the fungus-like substance, then the leaves. Quickly the burning heap is taken up and fanned, the whole work taking hardly more time than we would need to light a small fire with the help of a match. Nevertheless, this method appears to the Timorini to be too time-consuming or is not satisfactory in unfavorable circumstances, for frequently we saw men carrying a piece of *Pandanus* trunk in the cavity of which a fire smouldered.

Although the women of the Timorini do all the house- and field-work, nevertheless they are not complete slaves. A woman is very clearly the minor part of the household, but the privilege of expressing her own opinion is not denied to her. As a rule her outfit is simpler than that of the men. She wears no permanent head-net on her short curly hair, and her few adornments consist of armbands, necklaces, or a single pigs' tusk. Her clothing is very seemly; we found three different types. By far the most common is the string-skirt (Wirz, l. c., pl. V, fig. 3; also fig. 24), composed of numerous bits of string hanging close together from a cord wound two or three times around the waist, which adjusts itself to the form of the body. In addition to these string-skirts, there is another piece of clothing consisting of two arched pendent draperies of string-network (Wirz, l. c. fig. 23), one front, one back, tied together on the hips. The third type, of which we saw only a few examples, is that commonly in vogue among the Pesegemese women; the skirt consists of a set of small grass-cushions (Wirz, l. c., pl. V, 4, and fig. 26), very thick and similarly cut in front and back. Probably the women who wore this model were originally from the Pesegemese region.

The women also wear net bags, but resting on the head is a bulky sack, which is worn with a broad band on the forehead and hangs down the back frequently to the bend of the knees. In this the daily harvest is carried from the field, and toward the end of the day women of all ages may be seen, but particularly older ones, trotting by the camp, bent under the load of field-produce.

The kampongs are generally small, at least in the part visited by our expedition. A few, two to five, houses stand together on a more or less flat piece of ground, always on a ridge, never in a ravine, which is often the only forested part of the slope. The ground around the huts is usually good, and is kept clean and clear. Close to the houses only a few cultivated plants, such as

³⁸ Cf. the descriptions and illustrations of the same method used by a mountain-tribe visited by Wollaston (apparently likewise in vogue with the Timorini) in Lorentz, *Zwarte menschen, Witte bergen* (Leiden, 1913), 137.

tobacco (*Fig. 25*), sugar-cane, gourd, or banana, are grown. A few times we encountered larger groups of houses such as in the Toli Valley (*Fig. 32 at 1*) where we counted some thirty houses scattered over a broad ridge.

As I have already noted, the sexes live in separate quarters; there is a hut for men, and others for women, children, and pigs. The men's houses (*Fig. 25*) are fewer in number; they occupy the best sites, are of better construction, and frequently have two exits. The walls are made of more or less flat planks 1.5–2 m. high, set upright adjacent to each other and bound or held together by long flexible roots or branches. The diameter of the house is 3.5–4 m.



FIG. 25. Men's house in the Dika Valley; a tobacco plant at the left.

The doorways can be closed with transverse planks, and often a large flat stone serves as a threshold. The roof is made of grass-leaves (apparently *alang-alang*) radially arranged and resting on a number of timbers also radially sloping from the peak of the house (Wirz, l. c. pl. XIII). On the first floor is the meeting room, the earth being tamped, and frequently in the middle a fire is kept. Under the roof is a sleeping loft, which the dwellers can reach via a notched beam leaning against the wall and leading to a manhole.

The women's houses, as a rule, are much less carefully finished. The openings between the planks of the wall are mostly closed with grass, and in place of a loft occupying the entire upper part of the hut, one finds two rooms, one above the other, the upper being the larger. Under the lower part is a closed-off area in which the pigs are kept, usually all sows, which from time to time are set free to mate in the forest.

The Timorini are not unmusical, but their music is exceptionally primitive (Wirz, l. c. p. 113, et seq.). The one instrument is the same as that described and illustrated by Snell (l. c. 73) for the Pesegem; it is a small bamboo-strip (*Fig. 26*) carried on a string around the neck; the free end is split into three adjacent parts, the two outer being the longer. According to Wirz, this primitive instrument, apparently widespread over all New Guinea, is very ancient. It is used to blow against as they hum, but we obtained the impression it was used more as a child's toy than as a musical instrument. Wirz, in his chapter on music, places much more emphasis on the singing.

The Timorini practise³⁹ intensive cultivation in agriculture, and this in such an extravagant way that one wonders how long the valley-tribes can still exist here without reaching the starvation-point. One might rightly consider that the vast *alang-alang* [*Imperata*] fields are not suitable for further culture. Cleared places are observed in all forms and stages of development; frequently the steepest are terraced. It seems that the Kremer Expedition to the interior encountered better-kept fields, properly weeded and drained by a system of ditches at right angles to each other. The cleared places which I saw were ill-kept and poorly weeded, so that the cultivated plants (sweet potatoes) were

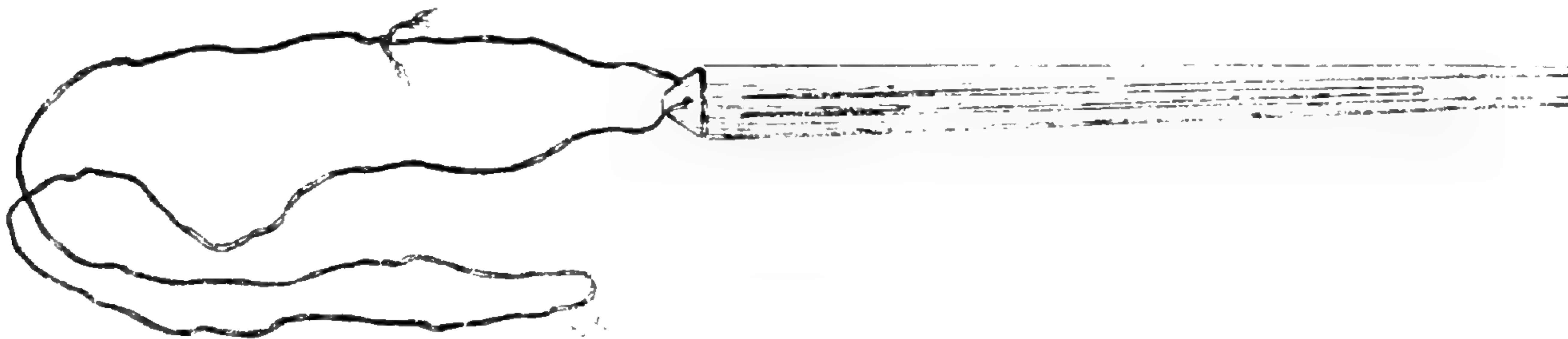


FIG. 26. Timorinese mouth organ.

practically hidden under the weeds. Neither blocks of stone nor tree-trunks were removed, but we must believe that we speak here of apparently newly cleared land on the margin of the inhabited region.

Likewise it has been mentioned that the sweet potato is the chief food and is almost exclusively the only plant cultivated in the fenced fields. Fencing is a necessary protection against the depredations of pigs, for failure of the *oebi* crop would have serious results. The fences (*Figs. 27, 28*) are real works of art. How poor the farm-lands of this primitive people must be, where agriculture, the oldest and most important business, has forced the inhabitants to develop such a remarkable technique with such primitive tools! These fences consist of a number of planks, not unlike those which are used for houses. They are placed horizontally one above the other to a height of 1-1.2 m. above the ground and are held in this position by perpendicular stakes on either side; the pairs of stakes are bound together and project two to four decimeters above the fence. In turn these stakes are supported by oblique ones braced against them, so that the whole structure is very firm. Frequently the upper side is covered with a broad layer of grass-leaves (*Fig. 27*), apparently for protection against rains which would soon cause the wood to decay. In this covering an epiphytic flora often develops, reminding one involuntarily of the attractive covering of the Balinese small hereditary walls.

³⁹ H. J. Lam, Iets over den akkerbouw bij een Papoeastam in Centraal Nieuw-Guinee, benevens eenige opmerkingen over land en flora van dat eiland.—Handel. IIde N. I. Natuurwetensch. Congr., Bandoeng 1922, p. 156.

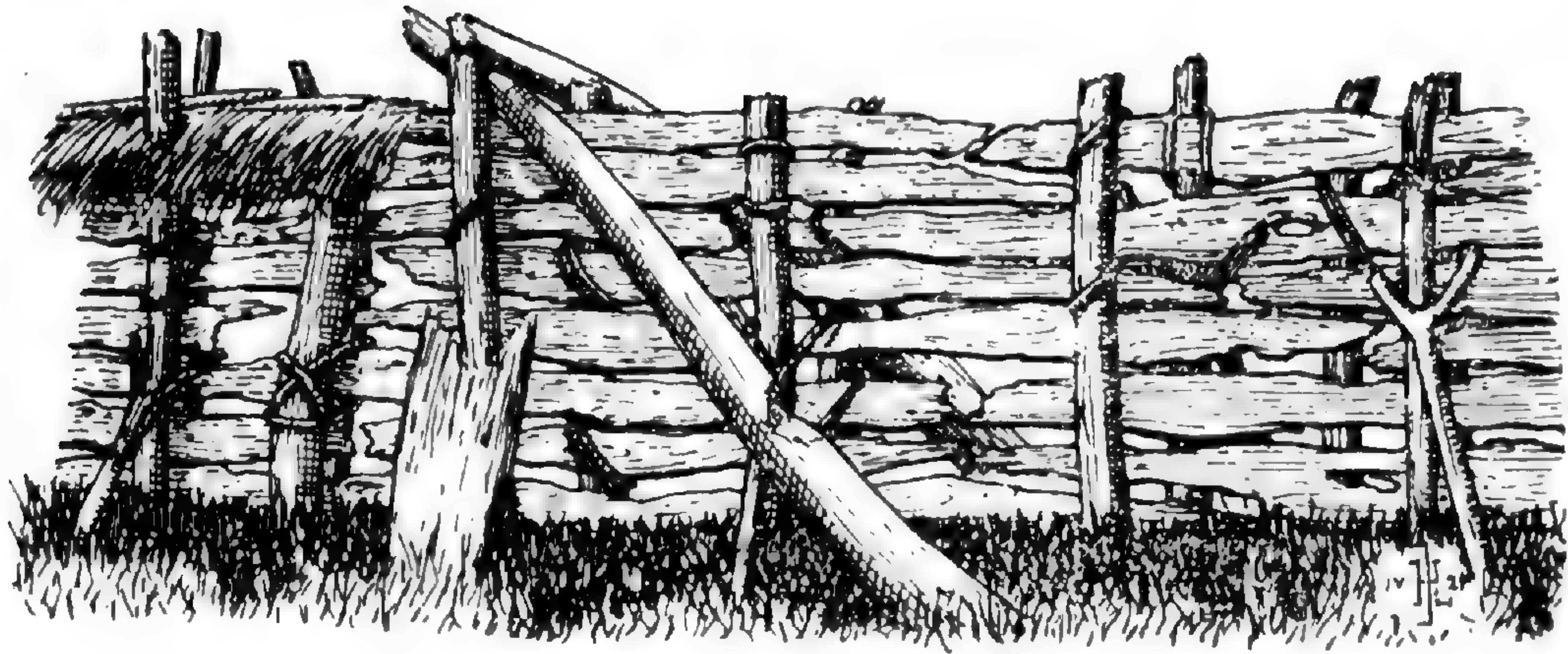


FIG. 27. Stile over a *ladang*-fence, made of two inclined tree-trunks; a part of the fence at the left covered with grass.

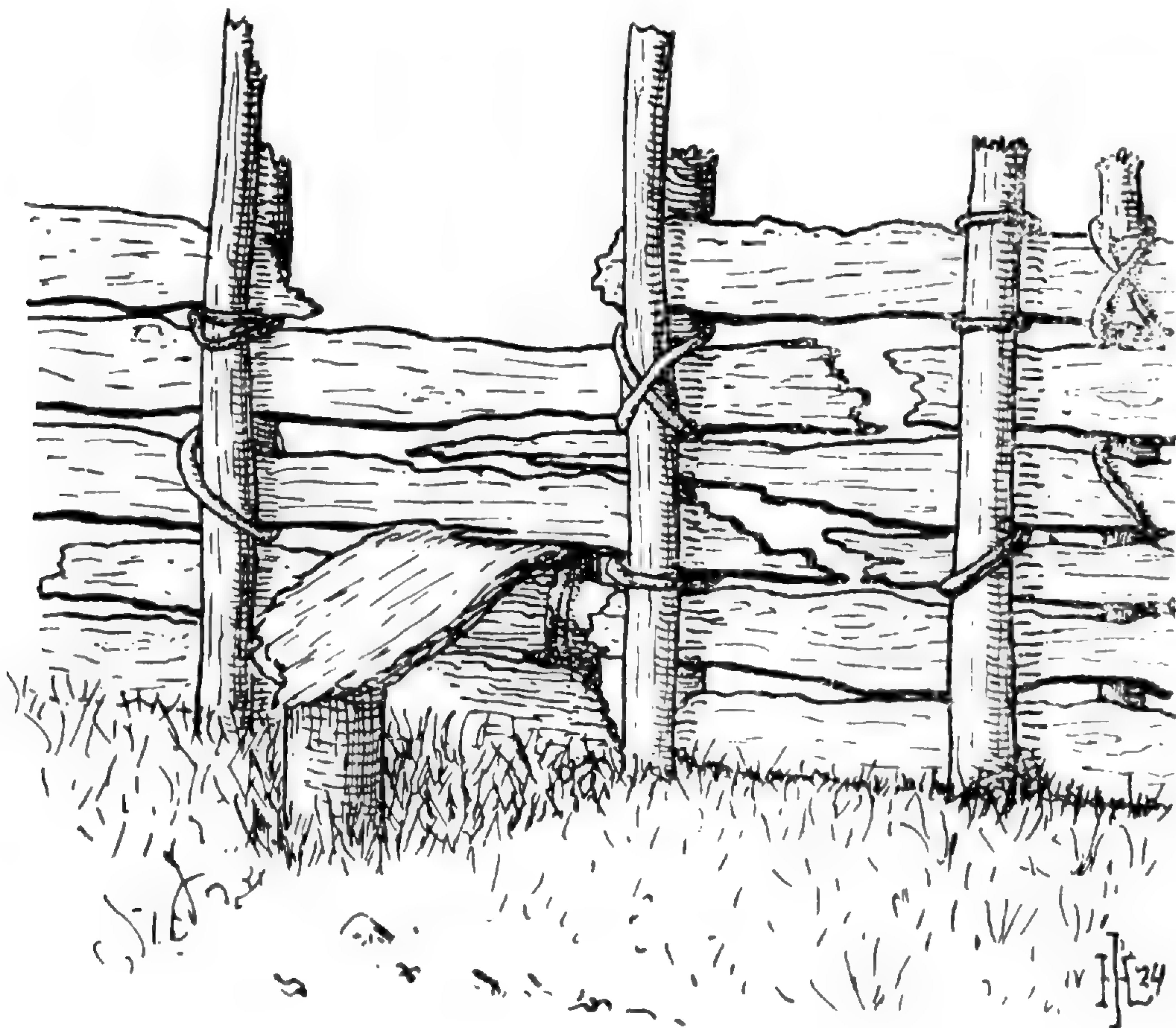


FIG. 28. *Ladang*-fence with horizontal stile.

For us, the most noteworthy thing about these fences, however, is the fact that, where the path crosses, they have just such small stiles as we use in our Dutch meadow-fences. With his sense of travel, the Timorini keeps his paths in good repair, and where numerous fields must be passed, quick passage is not impeded. Sometimes the stile is made of thick tree-branches (*Fig. 27*) which, provided with notches, rest obliquely against the fence; then again it is made of horizontal small plank-steps (*Fig. 28*), in which case the fence is somewhat lower to facilitate crossing.

Near the huts small plantings of less important crops were frequently found, a small patch of sugar-cane, or in damp places a small *kladi* [*Colocasia*] field. Tobacco is usually grown near the houses (*Fig. 25*). Wirz thinks that this is done with an eye to protecting this valuable commercial material against

possible theft. Here and there are clusters of banana-plants with very small fruits; in another spot are a few *Pandanus* trees, of which the very often large infructescences approaching maturity are tied up with leaves like the *nangka* [*Artocarpus*] of Java, as protection against birds and bats. Betel also is cultivated near the house. Close to the large kampong in the principal valley I found a small planting of *katjang ketjipir* [*Psophocarpus*] which was trained over a kind of scaffold. In the neighborhood of this populous village I saw a rather extensive regularly laid-out *Pandanus* plantation. Repeatedly the places where these *Pandanus* fruits had been roasted were seen. They were small pits covered with flat stones, in which a fire had been built.

I shall now devote a few words to the Timorinese proper names, which Wirz does not discuss. Among the numerous clan-names which he reports, I found none which agreed with what we accept as proper names. We thought, moreover, that two categories could be clearly distinguished, one of which we considered the real name, and the other the reputed surname. In the first category we noted chiefly two endings, -gěnak⁴⁰ and -ěgom (frequently -boerěgom) for men, and one, -kwé⁴¹ (often -boerěkwé) for women. Here are a few examples of these, a number of which sound not unharmonious with the cadenced pronunciation; the emphasis frequently falls (men, a and b; women, a) on the antepenult:

- Men: a. Ending in -gěnak—*Maingěnak*, *Aligaingěnak*, *Moelijěngěnak*, *Těrěngěnak*, *Oendigěnak*.
 b. Ending in -boerěgom—*Woebiliemboerěgom*, *Kalanboerěgom*, *Wolimanboerěgom*, *Digienboerěgom*, *Moelijěnboerěgom* (child, compare the same name with the ending -gěnak), *Dahiendienboerěgom* (child).
 c. Ending in -gom—*Joekerónegom*, *Niengaragoenoegom* (child).
 d. Ending in -kělěh—*Bongkokělěh*, *Anamboekělěh* (child).
 Women: a. Ending in -boerěkwé—*Kwamboerěkwé*, *Jemberaboerěkwé*, *Meniengěnboerěkwé*.
 b. Ending in -kwé or -kwa—*Daroealěkwé*, *Kwamoekwa*, *Toemakwa* (child).

We encountered names of another kind,⁴² in part perhaps surnames; for men, for example: *Wawa*, *Oewe*, *Oewiněg*, *Djimawěh*, *Enggabitme*, *Tebiengěk*, *Adien-gěk*, *Wégawòg*, *Endábòh*, *Didáralóe*, *Kwáloe*, *Djiwerái*, *Aboelòm*, *Ellemběroe*, *Oenaròh*. It becomes apparent that a few of these must be accepted as surnames. Snell mentions that in the Pesegemese "oewe" indicates father and "wawa"⁴³ an infant, which were aptly chosen as surnames and could very well refer to the appearance of the bearers.

Although we were convinced of the peaceable intentions of these people, we did not go about unarmed since the possibility of a misunderstanding could not be excluded. Besides, it again appeared that the Timorini, although on familiar terms with us in the camp, were not at ease if encountered alone. Frequently I noticed that individuals, whom one saw arrive, hastily tried to conceal themselves, or so they thought, in order to remain unseen. But in the open terrains such as cleared lands or grass-fields, this could not happen without being conspicuous. Now one must "faire bonne mine à mauvais jeu," for, as true primitive men, the Timorini have a strong sense of false shame. In such

⁴⁰ Also among the Pesegem; cf. Lorentz, l. c., p. 258.

⁴¹ Among the Pesegem -kwe or -kwa(kwamie) means woman.

⁴² Wollaston also reports (l. c. p. 260) that "many of them appear to have two names."

⁴³ In the Pesegemese this is also the name of a bird (*Ailaroedus buccoides* Temm.); cf. Lorentz, l. c. 468.

encounters they were frequently shy, sometimes also nervous, and I have noticed many times, particularly among individuals who did not know us, that they began to tremble with fear. But even people well-known to us, if met alone unexpectedly, often showed an ill-concealed terror by a clamorous cordiality and an exaggerated inclination to shake hands and embrace, this all being invariably accompanied by the tapping of the thumb- or index-finger-nail against the *keboaak*.

On the second morning of my sojourn in the Dika-bivak, after crossing a fence-stile in the margin of the secondary forest, I suddenly met a Timorinese family, man, woman, girl, and two boys. Apparently they had watched me cross the stile but had seen no chance to slip away. And now they stood as far to the side of the path as the slope permitted, lined up rather anxiously: the man in front, somewhat nervous but, nevertheless, controlling himself with the idea of keeping up his prestige; behind him the woman stood, more curious than frightened, the girl giggling half-hidden behind her, watching furtively to miss nothing of this meeting and yet poised for flight if I should make any move in their direction; the boys, bold and defiant, next to the father. The latter stood awkwardly waiting, and when I approached he began to shout reassuringly. Then followed an earnest handshake, then a fingerclap which I imitated. The female contingent pressed modestly into the background during this ceremony, but the two boys looked on undaunted, ready for severe criticism at seeing how papa would comport himself. When this ponderous and noisy ceremony was over, the usual gestures followed, each indicating his intention of proceeding on his journey, with which the scene ended. Here I have spoken of the method of salutation which was one of the factors in establishing our easy familiarity with these people. The Timorini (cf. Wirz, l. c. 45) greet one with a certain stately earnestness and firm handshake which meanwhile appears to be only a part of the ceremony. Frequently the handshake is preceded by an action in which the two individuals produce a clapping sound, the index finger and the middle one of the right hand curve and grasp tightly those of the other, the hands then being pulled with a jerk (the "pulling knuckles" of Wollaston). Often the handshake following this is less seriously, even somewhat carelessly exchanged; also it is superseded by the clasping of each other's forearm, apparently indicating greater cordiality. It appeared to us that they were more cordial when the ceremony was completed by a protracted embracing (cf. also Snell, l. c. p. 74, with the Pesegem), in which one laid his chin on the shoulder of the other and gently patted him on the back.

In another field a couple of women worked and smoked their pipes. They did not look up when I passed. The pipes (*Fig. 29*) which we saw are exactly like those of the Pesegem⁴⁴ illustrated by van Nouhuys, only the stem is not wrapped. The bowl consists of a hollowed-out fruit and has only a small space for tobacco. Van Nouhuys mentions that *Elaeocarpus* fruits are used for this, but of that I am not certain. Tobacco also is rolled into a kind of cigar or wrapped in a green leaf and smoked thus. One sees tobacco carefully wrapped with *Pandanus* leaves and split rattan and tied up in packages. According to Wirz (l. c. p. 125) this is the commercial form which is purchased with *tigalèhs* by the Meervlakte people. Fermentation is not practiced, the flavor being very sharp.

⁴⁴ Van Nouhuys, l. c. Pl. 1, fig. 3; cf. p. 11.

As with many primitive people, so with the Timorini, the name is very important, really an integral part of the person. One hesitates to call himself by name, as if he were yielding a part of his personality; on the other hand, one is in an advantageous position if he knows the name of another, particularly in confidential matters such as barter, since it is apparently understood that the mention of a name is a kind of guarantee for trustworthiness and honor. How weakened this is in our society! However, if one must give a name, it is preferable not to do it oneself but to enlist the help of another. Conversely, we were never directly asked our name but inquiry was made through another person. Nevertheless, these primitive men, who so easily affect a settlement with the higher power, were careless enough in these matters, not taking everything seriously; we saw this in regard to the surnames and we experienced it also in

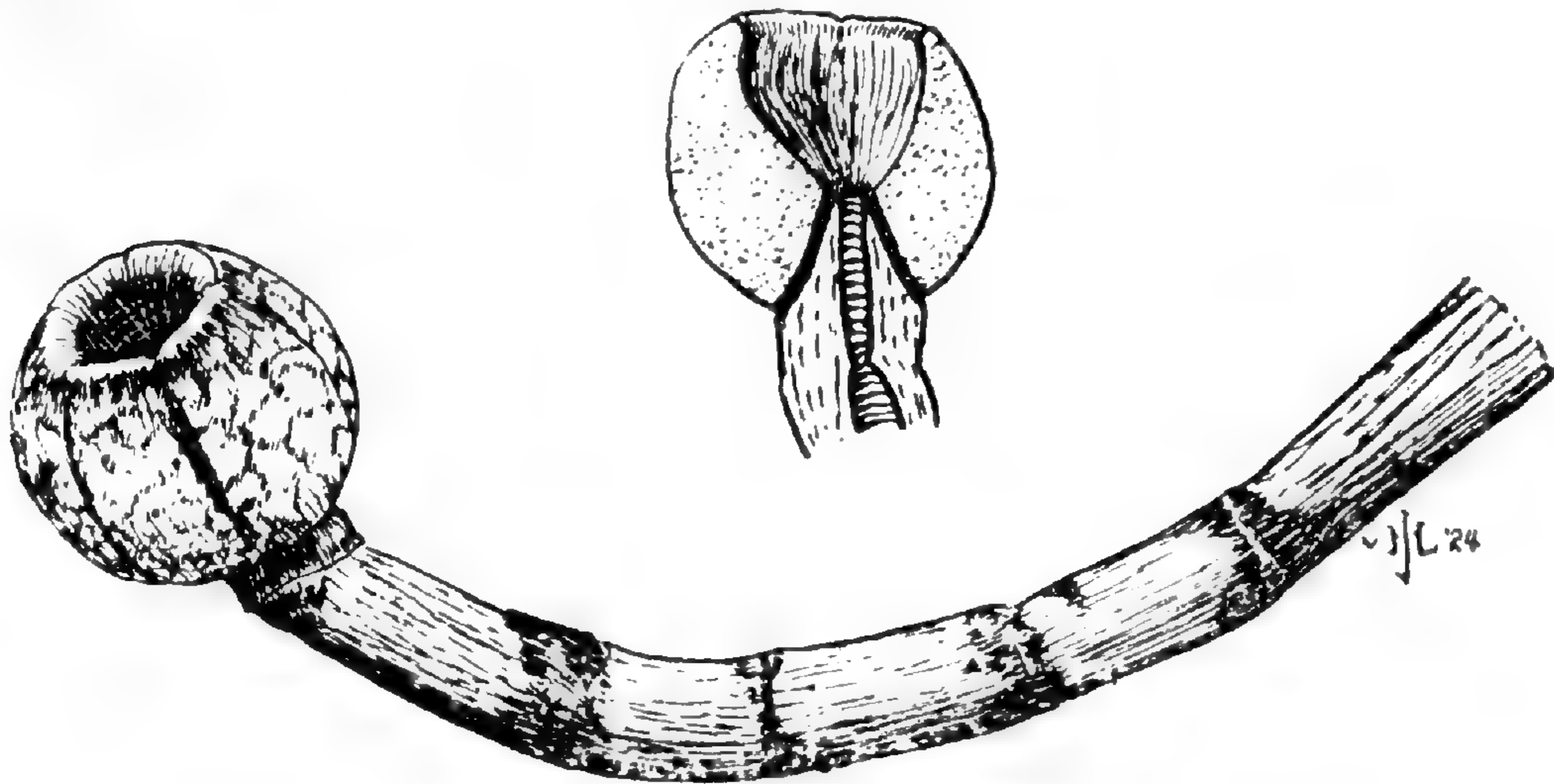


FIG. 29. Timorinese pipe, also a longitudinal section of the bowl.

the play which one—even in this remote region—knew how to make on my family name, jestingly naming me “wam” (pig). This I may consider to have been a great honor, for according to Wirz (l. c. p. 85) “verkörpert sich (in Schwein) nach Ansicht des Papua alles Gute, Reine und Edle,” and “wam . . . war daher auch das erste und letzte Wort das ich . . . täglich und zu unzähligen Malen zu hören bekam.”

When we thus, for example at mealtime, all sat in a row on our small mattresses in the hut, and the lords of the land then passed in front of us and, as “frequenters of the fair” who were now out for a day and wished to enjoy everything, inspected us as if we were wild animals, handled and examined us, then we felt ourselves to be more as a somewhat ridiculously interesting sight, than as members of the “dominant race.” Frequently it was really as if we sat there on exhibit for the pleasure of our hosts, so self-assured they appeared, so convinced of their good right to see everything, as if they had paid a *tigalèh* for it. They came in groups of three or four, all talking, demanding of us, not unfriendly nor whining, but with something commanding in their voices, to open our tins, to empty our sacks of everything, and to hand over our watches and rings. And they rested not until this demand was satisfied; then like children they immediately turned their thoughts and attention to something else. Once we hesitated to trust expensive things such as rings out of our hands, but it was explicitly made clear to us that they only wished to see the article and that it would be returned after a time. Nevertheless, they frequently

hoped that it might be offered as a present, but when this proved not to be the case, they laughed good-humoredly at their misfortune. On the other hand, they were easily pleased with small gifts which had less value for us, for example, small sheets of paper from our notebooks much valued as a substitute for *melli*, shoelaces to be used as necklaces, and milk-tins without top and bottom as armbands. Matches, on the contrary, were not valued. Once on the following day they uneasily returned a small box of matches untouched. Strange material was before their eyes, so thin and yet so strong. When we removed the cover of a baggage-tin, the hollow noise repeatedly frightened them, and I once made a small group solicitous for my welfare by striking my head with such a cover.

During a noon-hour, one of the few annoyingly intrusive men, named Djimaweh, by his insistence discovered one of my glass tubes for preserving material in alcohol. I thought that I would demonstrate that one can produce a whistling sound by blowing such a tube, and that immediately awakened his desire to possess it. Realizing very well that it was of no real value to him, he did not wish to give anything in barter but rubbish; I did not enter into the bargain and would not trust it out of my hands. Finally, somewhat annoyed, he came and stood in front of me, his face set with an expression that meant "I can do without your tube," stuck his fingers in his mouth and tried to imitate the noise; it miscarried so pitifully that he hastily retreated.

I continually produced great surprise with my metal measuring tape, a steel centimeter roll 2 m. long which, with the pressing of a small button, disappears into the case through the action of a spring. Being very much in vogue with "the public," I must repeat this ceremony some ten times a day: I draw the tape out and let it hang down, then I invite one of the "lords of the public" (an uninitiated one) to grasp the end. Because of the laughter and tense expectation of his companions at the somewhat strange preparation, the victim comes somewhat suspiciously nearer, and, with the very complaisant confidence of "I shall not run into it now," slowly and cautiously stretches out his hand. All become very tense, and one could hear a pin drop. Temptingly the tape swings to and fro, but just as his hand makes a grab, I, unnoticed, press the button with my thumb and the tape swiftly vanishes into the case in the twinkling of an eye. A shout bursts from the onlookers, and the victim is noisily taunted but disappears in the crowd. He is the first to avenge the scorn suffered by bringing a new victim.

These people are practical in trading, but they also have their pride. When we did not concur quickly enough with their opinion or were not open-handed enough with our return present for an offered small lot of sweet potatoes or sugar cane, then they would either give it to us as a present and go proudly away, or, without saying a word, would present the article to the Dyaks or soldiers.

With these few and but little coherent anecdotes, I have tried to give a few impressions obtained by a layman in the ethnological field. These perhaps to outsiders, non-professionals such as myself, tell more than a scientific treatise, particularly as they throw light on another side of the matter. I have not by any means striven for completeness. There is no need to consider data which have already been scientifically treated by Wirz. I think therefore that it must suffice to indicate the illustration [omitted] of a grave of which Wirz also pictured a few (l. c. fig. 15, 16), or particularly a fenced-in place where a crema-

tion had taken place. I also give a sketch of a sacrifice-table [omitted] (cf. Wirz, l. c., fig. 13) on which, among leaves, the remnants of meals of pork are offered to the "koegi," the spirits of the ancestors. For further information on the rôle which these "koegi" play in the life of the Timorini, and in general on the animistic ideas which appear to rule them, I refer to the author mentioned (l. c., p. 52 et seq.). Before I close this Fragment with a story of our trip into the principal valley, I here insert a few remarks on the landscape and the original flora.

From the Dika Valley, Doormantop hardly gives the impression of dominating the mountain-series. The entire chain rises as an enormous wall nearby, steep above, heavily covered with vegetation, and deeply cut by numerous ravines, of which the lowest parts of the walls frequently are perpendicular (Figs. 30, 31). The high 3820 m. summit is not visible from here, or at least

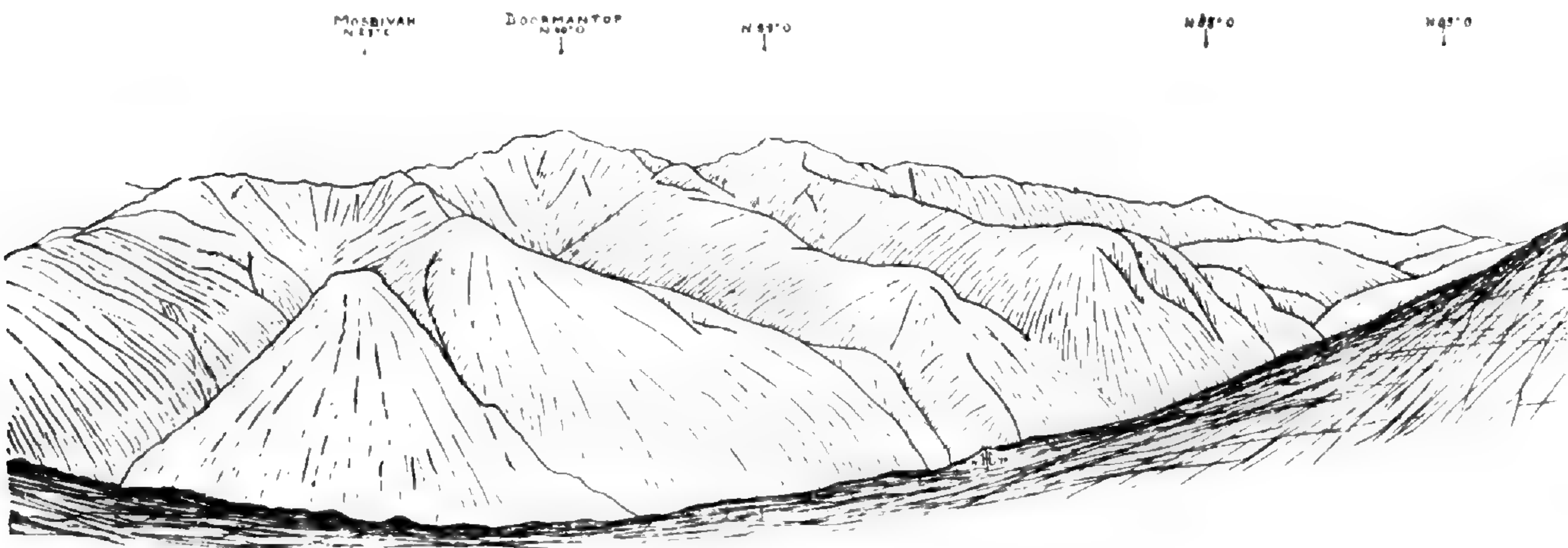


FIG. 30. Doormantop Chain seen from the Dika Valley.

was not recognized. Relatively soon the Dika Valley shuts off the view to the east, and the Swart Valley (Fig. 31) stretches far away to the west. Almost endless is the series of wing-like ridges lying successively behind each other, the comparatively gentle slopes of which suddenly drop off perpendicularly or almost perpendicularly into the narrow gorge containing the sinuous and almost always unseen mountain-river. This erosion-form, which is a distinguishing feature of young mountain-ranges, is very characteristic of this landscape.

The Dika-bivak lay on an open part of the slope. Eastward from there is a very large clearing, westward a smaller one with a few small houses, and in front of us one of the well-kept paths, which have been developed through long years of use and which make traveling in this region so agreeable compared to that through the difficult forested terrain. Toward the east one very soon meets with the old forest. Here we are on the boundary of the inhabited territory; the population is very thinly scattered there and a very small part of the overlying slope is still forested. But to the west in the main valley all is cleared from the margin of the steep gap to very high against the slope. In this part of the mountains the highest limit of inhabited territory lies at about 1800–2000 m., but, more towards the Central Chain, the Kremer Expedition came across kampongs at an altitude of 2800–2900 m., there practically all the forest was cleared. Near the Dika one sees forest on the ridges. Narrow forest-strips have also been left standing along the short streams which cut through the slopes, but, in the little original forest remaining, species of *Pan-*

danus are very common, apparently having been saved on account of their fruits.

The deforested land appears in three forms: as cleared fields, as *alang-alang* [*Imperata*] meadows, and as secondary forest. The last originated either by the extensive destruction of the old forest or by natural reforestation of abandoned fields. In many instances it is not easy to say with which of these two forms one is dealing. But it appears to me that the first type is characterized especially by the large number of tall Leguminosae (*Parkia*?) with white trunks, frequently practically the only tall trees, and a slight undergrowth; whereas the forest on old cleared land now has the character of a shrub wilderness with some smaller trees, then again of a young forest with a thick under-

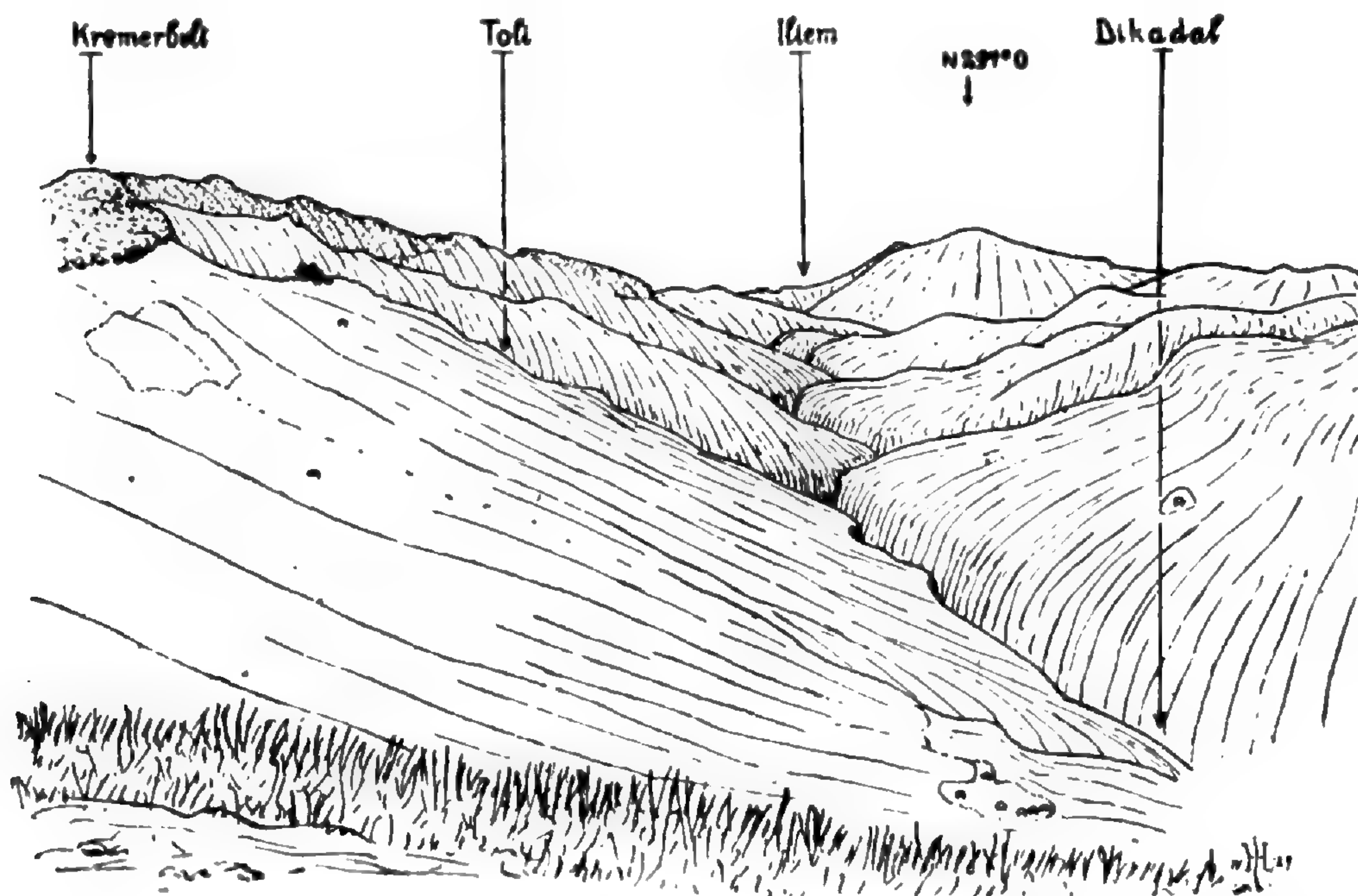


FIG. 31. View through the Dika and Iliem Valleys toward the west; behind the first ridge at the left lies the Toli Valley; below Kremerbult a clearing; right below a kampong; the stippled part of the left ridge farthest back is primary forest; to the right of Kremerbult some houses with large *Araucaria* trees.

growth and often very many ferns. Under the circumstances described, I was scarcely able to collect in this terrain. In a shrub-wilderness I found a few plants of *Callicarpa longifolia* Lamk. (trop. As.—Austr.), a species of *Melastoma* (no. 2060; aff. *M. polyanthum* Bl.), the Australian coniferous *Callitris robusta* R. Br. (no. 2166), and lastly a beautiful *Rhododendron*, a robust shrub with very large orange-red flowers about 10 cm. in diameter. In such places were large masses of *Polygonum chinense* L. (trop. and subtrop. S. E. As.—N. Guin.). In a newly cleared field, I found as epiphytes *Pleopeltis recedens* Moore and *Davallia dissectifolia* J. Sm.

The *alang-alang* fields are treeless, open, and frequently very extensive. In the more thickly inhabited region they certainly occupy the greatest percentage of the land. Apparently they take over old cultivated terrains which, finally, through the loss of humus and through drying out, have become valueless for crops, and the *alang-alang* has hindered the growth of young forest. A few herbs grow in the tall grass, such as *Osbeckia chinensis* L. (no. 2084; trop. As.—Austr.), *Wahlenbergia marginata* DC. (no. 2083; eastern O. W.), *Mitrasacme*

elata R. Br. (N. Guin., Austr.), *Oldenlandia tenelliflora* K. Schum. var. *papuana* Val. (nos. 2065, 2085), and *Burmannia disticha* L. (no. 2079; trop. As.—Austr.). In the margin of the secondary forest I observed *Hydrocotyle javanica* Thunb. (no. 2067; trop. As.—Austr.), *Coleus scutellarioides* Benth. (no. 2058; Arch.—Austr.), *Rubus rosaefolius* Sm. (no. 2062; trop. As.), *Melastoma malabathricum* L. (S. E. As.—N. Guin.), *Desmodium Scalpe* DC. (trop. O. W.), and in addition some species of *Ophiorrhiza*, *Impatiens*, and *Cordyline*. According to Gibbs, *Desmodium Scalpe* DC. must be considered as an introduced plant growing near dwellings.⁴⁵ Possibly a few of the other plants named above may be considered as adventive in the broader sense.

The first evening after I arrived in the valley, it was decided to make the proposed five-day trip to the chief valley. With seven days' supply, we still would have a margin of two days to reach Doormantop in case the allocated rations might have spoiled or disappeared. Leaving provisions behind is somewhat risky, since we cannot foresee what people may do with the supplies in our absence, although they are mostly in thickly soldered tins. A newly constructed house nearby was chosen as a storehouse (*Fig. 32, 2*), whose owner, Aligaingenak, was informed of our plans. He apparently was flattered by the trust placed in him and explained, everything in gestures, that he would deliver our property to us intact after four nights of sleep (gesture: the hands flat against each other and against the right ear, the head bent to the right, the eyes closed, further explained by deep breathing or snoring).

This all happens before our departure, yet the report of our unexpected breaking up of camp is already on the way to the chief valley, and everywhere the long extended signal-call re-echoes announcing our coming, before we are even on the march. Immediately the Dika Valley is in a commotion and, from a place where I proceeded to take some pictures, I can see the inhabitants come hurrying out of the kampongs to witness our passage. From this point (*Fig. 32, 3*) there is a beautiful view toward the west (*Fig. 31*). While I am busy taking pictures, four or five young men come running toward me. I am alone. They are not frightened. All are unarmed, and good-naturedly they make a lengthy and loud speech during which they examine all my bags, pull at my clothes, and direct my attention in turn to various objects far away, and then pronounce a word, not content until I have repeated it with the exact pronunciation. After the first inquisitiveness is satisfied, they seem to recall the purpose of their coming and begin to explain to me, all talking at once, that we must not go forward, since the people ahead will be unfriendly to us (cf. Wirz, l. c. 38). However, we are acquainted with this old story. When they see that their efforts are fruitless they stay near and frolic merrily. Our group consists of three fusileers in front, then the Europeans, followed by the convicts, the Dyaks, and finally by three more fusileers. The group proceeds like a long sluggish centipede, only half-projecting above the tall grass along the narrow path. In front and behind the Papuans call to each other over our heads.

Having come to the next ridge, on all sides we see people hurrying along our path. After crossing one of the forest-strips which descends into a small ravine, we approach a grassy incline where three houses are grouped together (*Fig. 32, 4*). The men and youths come out to meet us and offer some food,

⁴⁵ L. S. Gibbs, *Dutch North West New Guinea* (1917) 48.—Miss Gibbs mentions only this ruderal plant.

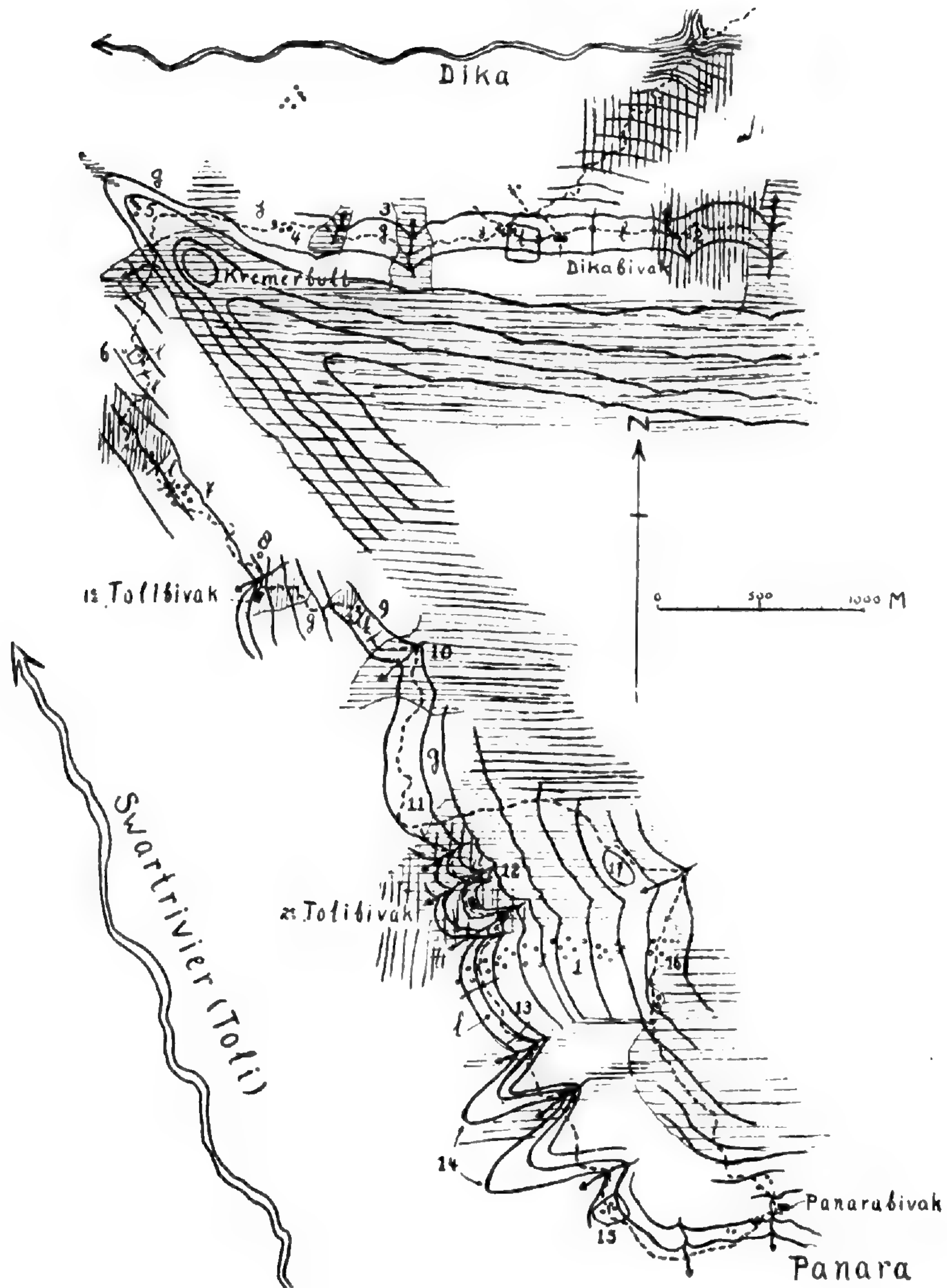


FIG. 32. Sketch map of the Dika and Toli Valleys; horizontally hatched = primary forest; vertically hatched = secondary forest; l = clearing; g = *alang-alang* field; o = Timorinese houses; - - - - = route followed; explanation of the numbers in the text.

such as roasted banana, or sweet potato, and some small pieces of sugar-cane. The women and girls stand in the rear near the huts. After we have acknowledged our favorable reception, we are considered accessible to the *mbok* story (*mbok* = enemy), but as that appears to be without effect, the inhabitants accompany us cheerfully to the next group of houses. This accompanying and passing on of our party to the dwellers in the next kampongs is continually repeated. The offer of refreshment was made only once. We now approach the small forested summit known to us as Kremerbult (about 1500 m.), since it had served Capt. Kremer as a fixed point in his survey of Doormantop. A small kampong (Fig. 32, 5) is located at the corner between the two valleys under a cover of stately *Araucaria* trees. The route ahead is discussed during

a short rest at this place. After we have passed through a strip of forest, we obtain a good view of the Toli Valley ⁴⁶ for the first time. We can survey some tens of kilometers to where a high mountain chain, 20 to 30 km. distant, runs east and west shutting off the horizon. In this chain the highest peak (3100 m.) is later named van Arkeltop. Ridge after ridge appears before our eyes, and in the valley-bottom is the narrow deep canyon wherein nothing but a small section of river is visible.

We descend a short distance, pass a few houses, where a couple of girls with arms around each other's necks giggle at seeing us pass, and enter again a somewhat cleared small forest-area with a solitary hut on the margin of a field (*Fig. 32, 6*). Later we arrive at a larger kampong (*Fig. 32, 7*), where again some beautiful *Araucaria* trees grow along the path. These trees, here called *tien*, seem to have been planted near the kampongs. It is a pleasant rustic scene. At our approach a pig, which is tied to a *ladang*-fence by a hind foot, tries to escape over it and remains hanging on the other side, squealing wretchedly. A woman hastily comes out of the dirty untidy women's house to free the animal, and we vaguely see through the open door in the inner darkness the figures of vacant-looking old women and the crowding of small children.

After the black mud of the forest-paths, the white or gray lime or clay soil in this valley is pleasant. The paths are hard and smooth. Here and there a milky brook overflows.

Toward eleven-thirty we reach an open place on which stands a large men's house (*Fig. 32, 8*). We find a large company assembled around the fire on the ground. There the leader, with a view to making proper contacts with the population, wishes to make a short day's march. He is resolved to look for a camping place with water here in the neighborhood. While he and the doctor go out, the geologist, the controller, and I have the pleasure of getting acquainted with a company of established citizens, well-mannered and of venerable appearance. They come out of the hut, one at a time without haste, to see and talk with us. The controller has a sudden impulse to unbutton his coat. The astonishment at seeing a white shirt under the coat is great, but the climax is reached when he takes off both coat and shirt, showing a white skin. Each personally must feel him to see whether this is now the final skin. While they in their astonishment bite vehemently on the bent index-finger and tap against the *keboaak*, they have enough scientific skepticism about his integument to verify it by examining the geologist and myself. Among those present were three bearded men, slender and of stalwart posture, conspicuous among the others. We tried to find out about their family relations and they immediately understood what we wished. Each of them struck himself on the chest, then that of another, and finally, not without laughter, grasped the *keboaak* of the oldest. The older man good-naturedly put up with this and affirmed that the two others were his children by the words *an apoet* (my children).

Near this house, in an open secondary forest close to a stream, a suitable camping place is found, and the Dyaks and soldiers busy themselves in erecting a few huts (First Toli-bivak, Fragment I, Map B, no. 18) (*Fig. 32*). Nevertheless it is four o'clock before we eat our meal. The entire midday is spent talking with Papuans, who are always in the way; but the friendly atmosphere is undisturbed and many pleasant minor incidents occurred. There are many

⁴⁶ Toli is the name of the part of the Swart River between the Dika and Panara (or Donda?).

children about. One of them, who begs continually but obtains nothing, tries to work on our feelings by simulating a fit of crying behind his hands, peeking between his fingers to see the results of his efforts. The doctor enjoys a great deal of confidence, not only because of his friendliness and tactful approach but also because of his success in healing some persistent wounds and inflammation of the eyes. Thus, this noon, there came a young man with inflamed eyes, led by another who suffered from this same disease. The latter had already been treated a few times with silver nitrate by the doctor. Although it was known that this treatment was painful, various men compelled the youth to submit to it. When he had courageously endured it, a mutter of approval went through the crowd. Repeatedly it was evident to the doctor that his services were valued. Almost always his aid was accepted. Almost always at the end they came with a few sweet potatoes, sugar-cane, or bananas, which—preferably in an aside—were pressed into the doctor's hands. Like the Pesegem,⁴⁷ the Timorini, when treated with medicine, blow on the thumb side of the closed fist, apparently the usual conjuration to exorcise the illness. The request for medical assistance is accompanied by this gesture, and it is peculiar that they also blow on the fist when being photographed. Probably the custom originated because they saw the doctor busy taking pictures. The result was that they came to understand photography as a beneficial act, a very favorable circumstance which facilitated the making of photographs in a welcome way. We were very glad to please this crowd of people by clicking the shutter every time they stood before the lens and wished to hear the shutter click.

Somewhat later in the afternoon, when the bustle of building and eating has passed, the older men come out of the large hut quietly to sit in front of the camp; and the doctor makes use of the opportunity to take impressions of hands and feet. None of the Papuans object to it. In giving an impression of their extremities, apparently they saw something entirely different than in the handing over of hair, as we were to see the next day. Moreover, the reward obtained for permitting this was enticing enough. Each one furnishing a hand- and foot-impression, made with printer's ink on a piece of paper placed on a metal plate, received a small quantity of the beautiful black thick-flowing printing ink, in his eyes a much improved form of the usual and indispensable cosmetic: pork-fat with soot. This liking is not so strange when we consider that, as some white folks purposely make themselves as white as possible, dark-colored folks might also wish to make themselves as black as possible. Then, to them, the deep black ink is the peak of splendor, for the Timorinese individual is only dark brown and wholly lacks the intense black color of the negro.

The same afternoon I had a lengthy comedy in negotiation with a tall slender full-bearded man, named Oendigēnak, one of the brothers who had explained so graphically that morning who his father was. He was a man of quiet nature, one of few words; for a long time he sat silently before us, his clear understanding eyes taking in everything he could see. In some way or other the glass tube, which Djimawèh was very eager to obtain in the Dika-bivak, attracted his attention by the noise which could be produced with it. At first he was loath to give it up, but when his efforts to secure it failed, he beckoned me to accompany him back of the camp. In such transactions the Timorini would not

⁴⁷ A. Pulle, *Naar het Sneeuwgebergte van Nieuw-Guinea*, p. 194.

think of spying on each other. Now, secure behind the camp, he wished to examine the tube at ease, and he really exerted himself with words, gestures, and intonations to obtain the gift. When I wished to see how great was his tenacity and whether he would persist in his purpose, I refused; then that part of the bargaining was ended. He took his place in front of the camp again and sat perfectly still opposite me, but whenever I even glanced in his direction, he secretly made a gesture as if blowing on the tube. Suddenly he vanished, but after a time he came back and, as inconspicuously as possible, laid a small bunch of green bananas under a small shrub. Then he sat down a few meters from the bananas and, apparently apprehensive of competition, he did not venture to fix my thought on the proposed barter-article in any other way than by throwing small stones and bits of wood near it, as I watched his side of the group. And when it was dark, he silently vanished with his bananas.

A man with a conspicuously handsome face was among the visitors; in Bijlmer's dissertation (photograph 44) he is described as the "nobleman." This man, named Enggabitme, notwithstanding his dignified aspect, made it very difficult for us with his intrusive familiarity. Without ceremony he crept in between us into the sleeping-quarters of the hut, with perplexing boldness, to rummage through all our possessions. Another, a quiet old man with a silent good-natured smile, suddenly, without ceremony, took my pipe out of my mouth and began to suck it. Such communistic ideas are very general. Often I have seen one, without asking and without being opposed therein, draw the pigs' tusk out of the nose of a comrade and stick it in his own nose. Nevertheless, the dish-washing in the creek by the camp roused an interest as something abhorrent, and bathing held many more astonished spectators.

At eleven o'clock the next day we break camp. A few efforts are made to stop us, but when these fail the Papuans cheerfully lead the way, first chopping a path for a half-hour through light secondary forest, where red *Impatiens* and *Coleus scutellarioides* Benth. occur in the undergrowth. Amongst the shrubs and lianas are a large number of Araliaceae, and here and there are the white trunks of tall Leguminosae. Next we come to an open grass-field with *alang-alang* almost as tall as a man, where even the Dyaks rest, to the great amazement of the Timorini, who repeatedly wish to pass through and pretend to find the Dyaks' loads immovably heavy.

It is a perfect day. A deep blue heaven arches cloudless above the massive bright green sides of the valleys. The fresh morning air is gentle and beneficent and above all is the joy of living, which harmonizes perfectly with the buoyant spirits of these mountain-dwellers. We get the feeling of being on a triumphal march. The path continually offers changing views of the beautiful valley. We have passed an abandoned clearing (*Fig. 32, 9*) and after that a small ravine with a fantastic *Pandanus* forest (*Fig. 32, 10*). On the other side of it we are again waylaid by a large group of men who stand together at the side of the path. The old acquaintances among them come forward with subdued pleasure, but at the same time with expectant dignity, and one by one shake hands with the Europeans. Many still do not recognize me, the latest arrival, and a formal introduction follows, stately and serious. After this ceremony, responded to as solemnly by us, we come again to a meadow (*Fig. 32, 11*); there the giggling women are grouped together somewhat back of the men. We now are approaching a place which we have already seen from a distance; here some mighty transverse ridges with almost level summits and

steep slopes, separated by deep ravines, extend toward the river. In front of us and on the crest of the first ridge we see the silhouette of a new group of waiting men. Here therefore our forward movement is known. After a bare ravine, we climb another grassy slope and halt on the level part. To our astonishment the men whom we saw before have vanished. The bare crest of the ridge is outlined above us against the blue sky. The controller makes use of this rest to photograph the group against the background of the northern chain from Doormantop, the bare crown of which projects above the forested ridge.

Meanwhile the doctor and I are curious as to the cause of the sudden vanishing of the Timorinese group on the ridge; once having climbed up and reached the top, we see the same panorama again but with another foreground, a new transverse ridge with stately tall forest to where it becomes level and crowned with a series of tall trees. However, no trace of men was seen. We took some photographs and looked down the path which leads to the forest-edge, and we asked ourselves what the sudden disappearance of these men could signify. Unwillingly, in such circumstances one thinks of an ambush, but, as quickly as the thought enters our minds, we laughingly abandon it, for two forms emerge out of the darker forest-margin. We beckon to them reassuringly and the two men approach. It appears that one of them is a newcomer; he is so nervous that his whole body trembles and cold perspiration stands in beads on his forehead. We restore his confidence by gestures and shaking hands and by showing him the camera and the folding stand, and when the others arrive, he is entirely over his fear. We proceed together and are soon within the high forest, half clear primary forest and half old secondary forest. At eleven o'clock, on a rounded ridge, bivouac is made (Second Toli-bivak; Fragment I, Map B, no. 19) (*Fig. 32*) in the light shade of tall Leguminosae, under which there is almost no undergrowth. While the hut is being built, the doctor and I go somewhat higher up the slope to talk a little with a group of Timorini who are stretched out there. Now that good feeling dominates, the anthropologist makes use of his opportunity to try to collect samples of hair. He has purposely postponed this to the last, since he feared that it might develop a disagreeable attitude, which, particularly in the beginning, could have damaged the whole undertaking. During five weeks these men had become accustomed to us, and now the chance must be taken. The doctor snipped off a small lock of hair from some men, overcoming the gentle protest by friendliness. An expression of unrest went through the group and there was even blowing on the hands, but small mirrors, small rings, etc., were accepted as reciprocal gifts, and in addition, for each lock of hair the anthropologist very tactfully gave a blond lock of his own in exchange. Nevertheless, it immediately appeared that the doctor's technique was very important, for the blond hair-lock was handled with the utmost care, whereas the earlier owners of the black curls showed the greatest uneasiness during the day about their own hair. Under the direction of the owner, this was carefully wrapped in a small leaf; that leaf was then wound around many times with a string and they were attentive as to where the doctor finally placed the packet. The blond lock was packed with the same care and vanished into the shoulder bag. Thus far all went well and the doctor soon had so much material together that he thought it advisable now to divert their attention, for the feeling of unrest remained and repeatedly they blew on their fists and tapped the *keboaak*. The diversion is

found by showing some small tricks such as balancing a stick on a finger-tip; this causes much admiration and is eagerly tried but without success. Finally the boys bring hot chocolate; we go to bathe in the clear brook back of the camp, after which we eat.

There are many visitors during the entire afternoon. The largest kampong of the region is on the next ridge, and we see ourselves watched till dark by women and children who squat on a large flat stone on the other side of a small ravine. After eating I proceed to reconnoiter the vicinity. Climbing the ridge back of the camp, I find at the top a path leading to one of these small, very steep, recently cleared fields, which one may encounter here and there at the edge of the tilled lands (*Fig. 32, 12*). The slope is sheer, perhaps at an angle of 40°, and terraced; a few sweet potatoes grow among many weeds on the small terraces. Tree-trunks showing the marks of the stone axe lie scattered about. At the left of the field a small stream rushes down, bordered by tall *Pandanus* trees, and the cleared place is surrounded by a fence still white in its newness. In this charming spot I sit down to try and realize fully the significance of this event in my life now, and later when I shall have returned again to my own society, this living in another world, a world which offers so many new impressions that it is altogether like a wonder-world seen in a dream. Here I sit in this field lost in a limitless past, in which the "Annus Domini" tells nothing more. Here I sit alone, before me the green slope in a frame of fine Leguminosae growth, topped by white clouds. Round about me is the work of man, the "diluvii testis"; a few hundred meters distant, there is the contact of this primitive man with the life of 1920, A.D.

On my return to the camp, the doctor was busy with the out-patients' department. Alas, during the consulting hour the drama of the hair-lock began. Seemingly the doctor had surprised them by his earlier procedure. Apparently it had been only owing to his good name and the trust which they had placed in him that the present protest was not more serious. Suddenly a man determinedly stepped up to him and with a brusque gesture returned the blond hair-lock. Pretending to misunderstand did not help. In vain the doctor still tried to prevent the others noticing it, but manifestly it was premeditated, and immediately others arrived who earnestly requested the return of their lock of hair in exchange for that given to them by the doctor. Refusing the last was no longer helpful. Finally the anthropologist was compelled to give up the hair collected with such difficulty.⁴⁸ With that the feeling of unrest entirely disappeared.

This all took place during the usual treatment of patients. Occasionally one comes, who has been home after the treatment, and now without saying a word places a few sweet potatoes and pieces of sugar-cane at the doctor's feet. Some women and girls are also in the crowd. A nursing mother quietly smokes her pipe, while she squats somewhat timidly among the crowding men. Toward the end of the afternoon the older women return from the field, heavily loaded with sacks of sweet potatoes and huge *Pandanus* fruits. They walk quickly past without looking up or back. Besides, the men do not permit the women to be too inquisitive, and as they pass by—this applies particularly to

⁴⁸ In contrast with this de Kock (*Tijdschr. Kon. Ned. Aardrijksk. Gen. XXIX, 1912, 158*) reports that the collection of hair-samples among the Goliath Papuans offered no difficulties, since they desire neither beard nor mustache and pull out each small hair. De Kock also scored a great success with a razor.

the younger women—they are pressed back by the men's threatening glances and loud abuse or are even hurried on their way. Towards dark all visitors suddenly disappear, and the evening is again quiet and peaceful, just as it was earlier in the primary forest.

I recall the exhilaration of awakening in this place in the fresh clear morning, where the soft blue sky showed through the pale green filigree-like pattern of the foliage of Leguminosae. At this time we were all in high spirits and none of us will ever forget the five perfect days which we spent in the midst of these mountain Papuans under the most favorable circumstances.

After eating our meal we first pass through the ravine, then come into the large kampong (*Fig. 32, 1*). Already the men await us at the boundary and the women and children stand among the houses. In the center of the kampong where the path widens into a small square, an unstable structure stands, in which a cremation must have taken place a short time ago. Refreshments are offered us, roasted sweet potato, banana, and sugar-cane. Here also a few thin yellowish dogs are running around. After a short stop, the march is continued, led by a large number of excited men. In addition to tobacco, I saw a small planting of *katjang ketjipir* (*Psophocarpus tetragonolobus* DC.). After that we come to a large and well-maintained clearing (*Fig. 32, 13*), and here from a small rock protruding at the top of a steeper slope, we have the first and only view of a small stretch of the Swart River.

Repeatedly forest-ravines alternate with unforested grassy ridges, which are all occupied by a waiting crowd. At each ridge a stop is made and the same scene takes place, introductions, talking, emptying our bags, etc. With all the very human scenes around us, it is difficult for us to reflect that we are in the midst of a "wild" tribe in the unknown interior of New Guinea. When the Dyaks put down their loads, a picture is taken, and a lively barter is carried on. The boldest girls, giggling and with their arms about each others' necks, come slowly nearer, ready to flee away screaming as soon as we look in their direction. The young men, nervous at all the new things, sit around everywhere, wishing to have everything opened, questioning us with their harsh voices, asking more than we can answer; after they have tried in vain to make themselves understood by constantly shouting louder, they finally stick their hands freely into our bags. The older men, with real or more likely feigned indifference, with the air of patriarchs, in groups of three or four, look on with a very dignified manner.

After we have hoped several times in vain that the next ridge will bring the expected view over the south part of the Swart Valley, it finally comes to pass. We cross a broad somewhat cleared ridge full of tree-trunks and then, on the corner between the chief valley and the next lateral one, we see a small kampong (*Fig. 32, 15*), the only one in this region⁴⁹ surrounded by a fence, and near it a tall *Araucaria*. A new panorama lies before us, the broad Panara Valley extends to the east, unforested, barren, and with scattered houses. Higher up the scene is closed in by the forest, much cleared at the edge; only a large number of tall *Kentia*⁵⁰ palms with white trunks are left. On the other side of the valley is a steep grassy slope which again shuts off the view to the valleys of the more southern tributaries.

⁴⁹ Farther inland later we found a number of similar kampongs (above Donda Valley).

⁵⁰ Van Nouhuys also calls this tree *niboeng*, but this name rightly belongs to *Oncosperma filamentosum*; cf. my remarks on this name in Fragment V.

In the middle of this region the last camp is pitched (Panara-bivak; Fragment I, Map B, no. 20), and soon visitors appear from all sides. Most are unarmed; these are old acquaintances, but there are also many newcomers who are formally introduced by others to us with exchange of names. Some look at us confidently and unafraid, but most are fearful and nervous. The bravest present themselves. I see them arriving from below, along the winding path, the full-bearded men, dignified and stiff, but under this demeanor they examine everything attentively with sharp glances from afar. Then they lay down their bows and arrows and come undaunted to us, stretch out their hands, and tell us their names. But most lose courage on approaching. I see them arriving still, a small family, man, woman, and a few half-grown children. The man, in front, is clearly as fearful for his prestige as of us. He remains at a distance standing a long time looking at the scene. The luggage and food carried by the woman are laid down; the man adds his bow and arrows, and, while he with nervously tense face stands looking on, the woman and children squat back of him awaiting his orders. Then suddenly a friend comes who fetches him over with the obvious gestures of "it is not so bad; they do nothing to you." Finally he coaxes him along, unwilling still, until he greets us. After the salutation he is relieved and proceeds to look around. One of the foci of interest is the kitchen, not only to observe how the boys cook our rice, but also perhaps to obtain some food or salt for which they are very eager and which they are sure of getting, and lastly, because Amat entices them there—they call him Omat—the one convict who, with his continually merry laugh and his incessant jokes and tricks, stands high in the respect of the Timorini. His reputation goes ahead of us and he is the only one other than we Europeans—and sometimes also the Dyak chief—to exchange regular handshakes with the natives.

During the busiest hours there were probably 150–200 men around the camp. Therewith amusing scenes arose such as I have already mentioned. Even I did not escape the barter rage. Tèrèngënak, a quiet young man with irregular features, readily gave me an axe for a pruning knife. There was also a small boy, who came and stood in front of me; he pulled off his only piece of clothing (a small mouth organ hanging on a string around his neck) and offered it to me in exchange for a small ring. The barter took place, and later in the afternoon I met him again and jestingly asked for the ring. Without hesitation he gave it to me, and without asking for his mouth organ in return. With another man I traded a pipe for a pair of tweezers. He immediately saw that this article might be used for pulling prickles out of his feet. As I did not stop at once and light the pipe, he did not understand the purpose of my barter and, astonished, he pointed out with emphasis how I must use it.

The following morning we are awakened at daylight by the Papuans. The weather is less clear than on the previous day and rain is expected. Even now new Papuans continually arrive from the south. They hastily look at everything. It appears that they had anticipated that we would stay here some time; for, as soon as it is clear that we are breaking camp, there develops a feeling of unrest, and various men spread the latest word. Some older men particularly, among whom Bongkokèlèh, with a cap of cassowary feathers like a hussar's busby, and Ellembëroe, and the crafty Enggabitme shout as loud as possible to each other, and something appears to be said. When we are a half-hour on our way and the last Panara houses are reached, it first becomes

clear to us what they wish. One stops us earnestly and points out that we must not leave before a blood-offering is made. An excited frame of mind exists. It is best to give in and we wait patiently for an hour until finally Enggabitme, panting and perspiring, comes running with a young pig over his shoulders. In a rough count I found about 170 men around us.

Enggabitme lays the pig at our feet, with much show of weariness. The animal has already been shot with an arrow but still lives; that apparently was to make it easy to carry. Now the usual method of killing pigs—the animal is held stretched between two men, while a third shoots it—is not necessary. Enggabitme shoots an arrow with a broad bamboo point into the heart of the animal lying on the ground. The point vanishes entirely into the body and as Enggabitme draws out the arrow, the blood spurts from the wound. With an indifferent countenance he dips two fingers into the wound and hastily gives each of us a smear over the back of the hand. A number of Dyaks prefer to withdraw from the ceremony, but Enggabitme makes it clear to the head-man that he must reciprocate; with obvious aversion Anji Nau satisfies them by smearing blood on the hands of a few Timorini with a hastily cut wood-shaving. With that the rite is ended. According to Wirz (l. c. 86) this is more a conjuration against malicious influences than a demonstration in our honor; it is thus uncertain whether one may speak of “establishing blood-friendship.” Moreover, the whole act is not especially solemn, particularly not when, immediately after the ceremony, around us the shout begins for “boeti.” Again it is Enggabitme who is the first and boldest to ask for a chopping knife, and it cost us a Dyak *mandau* and the last convict’s chopping knife before we are able to proceed unhindered.

Meanwhile it is getting along toward nine o’clock. Practically all the men accompany us part of the way, one of them carrying the pig by the forelegs, on his shoulders. But before we reach the mountain-ridge small groups repeatedly leave us. We proceed through and along a number of new and old clearings and over some partly cleared terrain, until we reach the forested ridge on the angle between the chief and the lateral valley. Here the first large group leaves us. They stand at the side of the path, and as we go along they begin to sing a loud song, the endless repetition of a four syllable refrain with strong emphasis on the fourth tone: ja—wa—ee—já, ja—wa—ee—já, and so on (cf. Wirz, l. c. p. 114).

The path now ascends slowly upward through the forest-margin. Rarely do we even have a view of the valley where the river flows 500 to 600 m. below us. The Papuans take turns carrying the pig. After some hours we pass the highest group of houses in the large kampong (*Fig. 32, 16*). Nearby is a vast cleared place with a plantation of low *Pandanus* plants and in between these is a crop of sweet potatoes (*Fig. 32, 17*). Along the path we saw several large pits with the remains of roasted *Pandanus* fruits. In the forest near here I found acorns and *Castanea* [*Castanopsis*] fruits lying on the ground.

After some time the Timorini became very weary of carrying the pig, and they tried to get the Dyaks or the convicts to take the load. However, when that was not successful, again we saw one of the men with the pig on his back running along in front of us. The animal was laid at the feet of the foremost fusileer, and it was made clear to us that the pig would not be carried farther. It was then decided to skin the animal on the spot and to divide it. This was done, and the Timorini were completely satisfied with the entrails as their part.

After this intermezzo, interest on the part of the Timorini flagged noticeably. Repeatedly small groups had separated from us after the singing of the first song, but now that the pig is divided, only those who live in the more northern kampongs continue further with us. Soon the path lies over a steep decline, and after some time we again reach the old path through the large *alang-alang* meadow. From here our escort consists of only five men, and with them we reach the First Toli-bivak in about an hour. It begins to rain and we decide to remain here. This afternoon there are few visitors. The doctor has only two patients to treat. Enggabitme has profited by the absence of competition and is more troublesome than ever. In strong contrast to his boisterous entrance and his unruly conduct, there sat before us an old man who silently looked at us with a friendly smile. He asked for nothing, but we made him childishly happy with a small box covered with red paper, after which he came out of his shell and told a long story to the controller in a gentle confidential tone. From it we only understood that he considered himself superior to the Meervlakte dwellers who wear ornaments in their noses. In connection with this he pointed to some *tigalèhs* which he carried in his small shoulder bag. It seemed to us an indication that the *tigalèhs* were obtained by barter from the north.

The next morning we are on the march again at seven o'clock, accompanied by the few men who live in the neighborhood. In the kampongs the inhabitants come out to see us, but there is no tumult such as there was at our departure. At ten o'clock we are back in the Dika-bivak. Aligaingenak delivered the supplies which we had left in his care, undamaged and complete. The rest of the day is spent in completing our ethnological collection. Every opportunity exists for this, now that our coming departure has been noised abroad. The market seems weak, and they come hurriedly bringing all kinds of things which we have not seen previously, or for which the price was too high. Dance-plumes of cassowary feathers, cuirass-like shirts made of woven rattan, and various ornaments are brought and displayed before us at the most tempting prices. Only *tigalèhs* and *mellis* have retained their old value.

It is noticeable that the demand for salt suddenly becomes greater. Perhaps in the beginning it was not so manifest, but now that it is discovered in the kitchen, our last bit must be defended against the eager people. Pulle mentions⁵¹ that the Pesegem likewise are fond of salt. Van Nouhuys⁵² reports that he searched a long time for the origin of their salt. Finally in a Pesegemese hut he saw a small bundle of leaves (of *Asplenium amboinense*). When he asked about their use, the Papuans burned them before his eyes, then took small quantities of the ash between the thumb and forefinger and placed it in their mouths. The flavor was more like saltpeter than salt, but when van Nouhuys spoke the word "majoe" (also the Timorinese word for salt), that was ostentatiously assented to from all sides. At first the Timorini did not recognize our salt, the usual briquette of Indian government-monopoly salt, since the product which they know is black. The Kremer Expedition brought from the interior a block of a black hygroscopic substance, which, judging by the flavor, must have a high percentage of salt. By analysis the salt-content appeared to be 74%. Wirz gives the following process as the possible origin of this salt-block: a piece of porous wood (from the trunk of a tree-fern or

⁵¹ Pulle, *Naar het Sneeuwgebergte van Nieuw-Guinea*, 190-191.

⁵² Van Nouhuys, *Nova Guinea VII*, 1 (1913), 10.

perhaps rather from a *Pandanus*) is placed in a salt-spring and then dried by artificial heat. This is repeated for a number of times. Perhaps a combination of the opinions of van Nouhuys and Wirz gives the solution. In Wollaston⁵³ we read that the members of the mountain-tribe whom he visited laid bundles of fern-fronds in a hot salt-spring, and later took them out and sucked them.

At noon a heavy rain falls, the first since my arrival in the valley. As soon as it is over, we have many visitors, and we try to make clear to the Timorini that, after sleeping twice, we shall go back over the high mountain. They immediately understand that we go away to bring back new knives; and they explain unequivocally that they will accompany us, taking along food for several days and bows and arrows for hunting. After this communication the market falls still more, and they are greatly astonished that we no longer appear to have a great buying capacity. The Dyaks organize popular games into which they draw the Timorini, so as to win from them; but the interest of the latter soon flags and they only wish to go into the kitchen to beg for salt. Old Bongkokelèh, the same fellow who had the final say in Panara, arrives, loaded from head to foot with various ornaments, weapons, and other articles, visibly disappointed when that does not seem to have the slightest influence on our wish to purchase. Towards dark Endaboh (Bijlmer, diss., fig. 49), a friendly unassuming man with a curly beard who has selected me for his confidant (such patronage fell to most Europeans in turn, from both Dyaks and Timorini), still whispering and emphatically confidential, says that he will go along on the journey back.

So the last day of our sojourn breaks, a rest-day for the carriers. The luggage is looked over again for articles to barter in exchange for small souvenirs of these, to us, very remarkable days. At every turn special friends come to say that they will accompany us in the morning. As I return to camp after a bath taken in the stream under the modest inspection of two Timorini, Endaboh calls me aside with a mysterious look and brings me a small bag of sweet potatoes which were hidden in the grass. Following the custom, I offer him a knife as counter-gift, but to my great astonishment he will not accept it. I take the gift therefore to the kitchen, but, notwithstanding his refusal, Endaboh remains, turning away from me as a waiter does who expects a tip. I give him a small bottle with a tightly fitted glass-stopper which he immediately puts into his sack with a familiar nod of the head and a wink. Nevertheless, he seems to be only half satisfied, but he brightens visibly when he sees another native give his whole necklace for a glass-tube, apparently finding that he is better off.

Some very old men come to visit, very gaunt, unusually slow, they stumble forward leaning on long sticks, panting from exertion, the entire bodies wrinkled, with grayish hair and huge *keboaaks*. One of them is about to sit on a stone to rest, and some of the younger men coming to give him a hand sit beside him.

This last morning the leader has decided to hold one more shooting exhibition. At the beginning of the sojourn of the vanguard in the valley, in this way, the people were given an impression of our power, and now again a flattened petroleum tin is bound to a tree as target. The distance is about 50 m., and one of the onlookers is invited to shoot a few arrows at it. After much hesitation

⁵³ The Geographical Journal XLIII (1914), 255.

he does but misses his mark. We exploit this poor result as much as possible, so as to prepare the bystanders for what is to come. Then the leader kneels and fires five shots in succession at the target. Endaboh stands next to me. At the first shot, all Papuans cringe in terror and more than half run away as fast as possible. Only one of the old men remains sitting, unmoved, he apparently is stone-deaf. Those who remain in the neighborhood stand with their backs to us, their hands closely pressed over their ears. At each succeeding shot new terror strikes them; when all the cartridges are used up, we wink reassuringly at the few men who have waited to examine the results. Endaboh is so frightened that he hesitates to come alone and, as I go to bring him, he takes my hand in his like a child, and so is brought to the tree, which is perforated by five bullets. The bystanders seem to understand very well what has occurred and are greatly astonished. A new cartridge is compared with an empty shell; then it is shown how such a bullet flies through the barrel of a rifle. They also seem to understand that such a bullet can go through a man and can kill him. This inspires new respect; nevertheless, they immediately see the practical use of the weapon and one of the men offers a pig for it.

Notwithstanding their terror, apparently they have sufficient trust in our goodwill, and, directly after the show, when quiet has returned to the camp, the visitors come again. At noon it starts to rain and that drives the visitors home. While it is growing darker, a black figure suddenly looms up before us; he appears to be a newcomer; from his bold story we conclude that he came from Panara; he has heard much of us and is very happy to meet us; he knows exactly how to report what he will see, and finally, after gazing and admiring a long time, he goes away content.

The next morning at daylight we break camp. Naturally we expect a large gathering to depart with us, but singularly, only a few youths appear. During the packing, the departure, and the trip down to the bridge, we do not see another living soul. What the first emphatic agreement and the subsequent absence of each signified has never been clear to us, and it in turn becomes still more enigmatic, since we now know that on the return journey of the Kremer Expedition, the old guide Wamgimi, with his entire family, joined in with the march back to Prauwen-bivak. There he carried on trade with the dreaded Meervlakte dwellers and stayed several days on the Idenburg River (cf. Wirz, l. c. 125).

Our trip back is told in a few words. We spent the first night in the Jachthut-bivak at 1900 m., the second in the Mos-bivak at 3000 m. Here it was cold and rainy, but the following morning we had a last look into the valleys, gloomy and shadowless under a cloudy sky, and we stood long on a projecting rock to gaze below at the Dika slope, of which we now recognized so many details. We located the site of the bivouac and the cleared field and house of Aligaingnak, who had stored our supplies.

The third day's march brought us over Doormantop into the old familiar Radio-bivak, not belonging to the other world but to that which we ourselves have made. We left the next morning. For myself, who had spent such delightful days here, this was not without sadness. One more day I roamed over this beautiful plateau to enjoy the recognized flora.

At Radio-bivak we heard that the rattan bridge at Brug-bivak had been carried away by a flood, but that three days later a new one had been constructed. This afternoon the mountain-region remained continually in rain

and clouds, and on the following morning we no longer saw the Wilhelminatop. Then followed a series of leave-takings of formerly known places, the old camps on the desolate uninhabited slope. At Goenoeng Boetak we found the weather somewhat mild, and without hesitation we proceeded to bathe in the stream. Our stay here was made agreeable by the receipt of mail from Java and even by Christmas packages, so that a rest-day was observed "for the carriers."

Thus we returned on Christmas day to Prauwen-bivak, and with that the inland journey was brought to a close.

Appendix ¹

1. LITERATURE

(In the following list, the most important articles published on or with reference to the Expedition are alphabetically arranged—in the original they are given in chronological order.)

1. ANONYMOUS (Bandung correspondent of "De Locomotief"). Naar den Wilhelminatop—Indische Gids XLIV, no. 6, p. 550. 1922.
2. BIJLMER, H. J. T. Met de Centraal Nieuw-Guinee-expeditie A° 1920 naar een onbekenden volksstam in het hooggebergte—Tijdschr. Kon. Ned. Aardrijksk. Gen. XXXIX, no. 2 (March 1922), 156—see also p. 242, 375, 395 (presented before the Kon. Ned. Aardrijksk. Gen. on December 17, 1921).
3. ———. Anthropological Results of the Dutch Scientific Central New-Guinea Expedition A° 1920, followed by an Essay on the Anthropology of the Papuans—Acad. Proefschrift Univ. Amsterdam (Leiden, 1922); also published in Nova Guinea VII, 4 (1923), 355.
4. ———. Met de Centraal Nieuw-Guinee-expeditie A° 1920 naar een onbekenden volksstam in het hooggebergte—De Aarde en Haar Volken LIX, pp. 97, 121, 145, 169, 173. 1923; published as a separate volume, 1924.
5. ———. Uit de Geneeskundige verslagen der Wetenschappelijke Centraal-Nieuw-Guinee-expeditie 1920–1921. De malaria—Geneesk. Tijdschr. voor Ned. Indië LXIV, 600. 1924.
6. ———. De vitamine-rantsoeneering—l. c. 657.
7. ——— and H. DE ROOK. Medisch verslag van den bergtocht en slotbeschouwingen—l. c. 670.
8. "D." De Wetenschappelijke Expeditie naar Nieuw-Guinee (Bandung, Visser). 1921.
9. GISOLF, W. F. Over het Gesteente van den Doormantop in Centraal Nieuw-Guinee—Versl. Gew. Verg. Wis- en Natuurk. Afd. der Kon. Akad. van Wet. Amst. XXXII, 1. 1923.
10. HEURN, W. C. VAN. De Expeditie 1920–1921 naar Nieuw-Guinea—Feestnummer van "Club van Nederlandsche Vogelkundigen," September 1921, p. 11.
11. ———. Over de vogels van het Mamberamo-gebied—l. c. 29.
12. ———. De strooperij in dienst der Ornithologie—l. c. 65.
13. HORST, R. Paraperipatus vanheurni, n. sp.—Zool. Meded. Rijks Mus. Nat. Hist. Leiden VII (1922–1923), 113. 1922.
14. HUBRECHT, P. F. Het Hooggebergte van Nieuw-Guinea, presented before the IInd Ned. Ind. Natuurwetensch. Congr., Bandung, May 13, 1922—Handelingen (Report of that congress), p. 38. 1922.
15. JONGEJANS, J. Eenige Mededeelingen omtrent den onbekenden stam der "Oeringgoep" in Centraal Nieuw-Guinea—Indië, Geill. Weekbl. voor Ned. en Kol. V, no. 35, p. 565 (November 1921), no. 36, p. 588 (December 1921), no. 37, p. 597 (Dec. 1921), no. 39, p. 634 (Dec. 1921), and no. 41, p. 664 (January 1922).
16. ———. Langs de Mamberamo—Indië, Geill. Weekbl. voor Ned. en Kol. VI, no. 14, p. 221 (July 1922) and no. 19, p. 302 (August 1922).
17. KREMER, J. H. G. [Short report] presented before the Kon. Ned. Aardrijksk. Gen. November 25, 1922—Tijdschr. K. N. A. G. XL, no. 1 (January 1923), 93.
18. KOPSTEIN, P. F. Liste der Scorpione des Indo-Australischen Archipels im Museum zu Buitenzorg—Treubia, III, 184. 1923.
19. LAM, H. J. Iets over de botanische resultaten van de Noord-Nieuw-Guinee-Expeditie 1920—Teysmannia XXXII, October 1921, 289, with corrections in this same periodical XXXIII (1922), 52.
20. ———. Nieuw-Guineesche aspecten—De Tropische Natuur, XI, no. 3 (March 1922), 38.
21. ———. Iets over den akkerbouw bij een Papoea-stam in Centraal Nieuw-Guinee, benevens eenige opmerkingen over land en flora van dat eiland—Handelingen IInd Ned. Ind. Natuurwetensch. Congr., Bandung, May 11–14, 1922, p. 156.
22. ———. Vegetationsbilder aus dem Innern von Neu-Guinea. Die Vegetation des Hochgebirges.—Vegetationsbilder, herausgegeben von Dr. G. Karsten und Dr. H. Schenck. XV. Reihe, Heft 5–6. 1924.
23. ———. Vegetationsbilder aus dem Innern Neu-Guinea. Myrmekophyten und Insektivoren—l. c., Heft 7. 1924.

¹ Natuurk. Tijdschr. Nederl.-Ind. 89: 381–385. 1929.

24. ———. Ademwortels bij Palmen—Handelingen IIIrd Ned. Ind. Natuurwetensch. Congr. Buitenzorg, September 24–28, p. 318, 477. 1925.
25. LAUTERBACH, C. Beiträge zur Flora von Papuasien XI—Engler's Bot. Jahrb. LIX, 118 (Santalaceae). 1924.
26. ———. Beiträge zur Flora von Papuasien XII—Engler's Bot. Jahrb. LIX, 505, 547 (Vitaceae, Liliaceae). 1925.
27. ———. Beiträge zur Flora von Papuasien XIII—Engler's Bot. Jahrb. LX, 1, 106, 144, 150 (Rubiaceae I, Melastomataceae, Gnetaceae, Cucurbitaceae). 1926.
28. ———. Beiträge zur Flora von Papuasien XIV—Engler's Bot. Jahrb. LXI, 1, 32 (Oleaceae, Rubiaceae II). 1927.
29. "MAMBERAMO." De Expeditie naar Centraal Nieuw-Guinea—Het Indische Leven II, no. 52. 1921.
30. SCHMIDT, E. Die Zikaden des Buitenzorger Museums—Treubia X, 1. 1928.
31. VARIOUS AUTHORS. Nova Guinea XIII, Zoologie, book 5. 1922.
32. ———. Nova Guinea XV, Zoologie, book 1. 1924.
33. ———. Nova Guinea XIV, Botanique, book 1. 1924.
34. ———. Nova Guinea XIV, Botanique, book 2. 1927.
35. WIRZ, P. Anthropologische und Ethnographische Ergebnisse der Central Neu-Guinea-Expedition 1921–1922—Nova Guinea XVI, Ethnographie, book 1. 1924.
36. ———. Im Herzen von Neu-Guinea, Tagebuch einer Reise ins Innere von Holländisch Neu-Guinea (Zürich, Rascher & Cie. A–G.).

2. STATISTICS OF THE COLLECTION

The collection assembled by the botanist consists of: 1408 numbers of herbarium material in alcohol in zinc tins (Schweinfurth method); 196 numbers of material in 70% alcohol; 84 numbers of fungi and lichens in 70% alcohol; 32 numbers of algae in 0.3% chromic acid and 0.3% acetic acid; and 10 numbers of fungi in 3% formaldehyde; total 1730 numbers; also 90 numbers of living plants from warmer regions and 31 numbers of fresh seeds or fruits; in addition flowers of 276 herbarium-numbers in 70% alcohol; wood samples of 33 numbers, and galls 20 numbers; finally 8 soil-samples from Pionier-bivak, the forest-margin of the Meervlakte, the foothills and Dika Valley, and some stone-samples from Doormantop.

With respect to the 1730 numbers of botanical material, I shall adopt the provisional lists of Versteeg² and von Roemer³ for purposes of comparison of the sequence of the families:

VERSTEEG (number of species)	VON ROEMER (total numbers: 1345)
Orchidaceae	Pteridophytes
130	155
Rubiaceae	Orchidaceae
38	131
Zingiberaceae	Fungi
31	80
Urticaceae	Mosses
16	69
Araceae	Zingiberaceae
15	66
Asclepiadaceae	Urticaceae
13	49
Euphorbiaceae	Gramineae
13	34
Leguminosae	Rubiaceae
12	34
(Pteridophytes, Fungi, and mosses not collected)	Melastomataceae
	33
	Begoniaceae
	30
	Ericaceae
	29
	Myrtaceae
	29
	Coniferae
	22
	Araceae
	20
	Leguminosae
	20

My own collection has been placed in 109 plant families. With reference to the relation of numbers and species, it can be mentioned that, of 19 families studied thus far, 467 numbers appear to represent 285 species, of which 103 are new. In the Pteridophytes the 344 numbers belong to 204 species, of which 66 are new.

² Maatsch. t. Bevoorder. v. h. Natuurk. Onderz. d. Ned. Kol. Bull. no. 57 (1907), p. 17.

³ Ibidem, Bull. no. 63 (1910), p. 23.

Here follows the arrangement of the principal families with the number of collections:

Pteridophytes (Filices, Lycopodiaceae, Selaginellaceae, Psilotaceae, Equi- setaceae)	344	Zingiberaceae	34
Orchidaceae	250	Urticaceae	33
Fungi and Lichens	140	Algae	31
Rubiaceae	103	Araceae (all but one of lowland habitat)	29
Mosses (Musci and Hepaticae) (57 above 1300 m.)	79	Euphorbiaceae	25
Ericaceae (36 above 1300 m.)	39	Moraceae	25
Cyperaceae	34	Melastomataceae	23
Gramineae	34	Acanthaceae	20
		Coniferae (18 above 1300 m.)	20
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