(Turcz.) Koehne from the others, seems to us a more suitable place to look for this species. Bailey described the calyx of his plant as prominently six-ribbed; the latter is an obvious character of the New Guinean collections.

SONNERATIACEAE

Sonneratia Linnaeus f.

Sonneratia ovata Backer, Bull. Jard. Bot. Buitenz. III. **2:** 329. 1920.

British New Guinea: Western Division, Daru Island, *Brass 6264,* March 3, 1936, plentiful in landward edge of mangrove forests (handsome thick foliaged tree 15–20 m. high; branches spreading, short; a few large pointed pneumatophores over 30 cm. high and ± 6 cm. diameter; thick fissured, suberose, brown bark; leaves fleshy, nerves more prominent beneath; flowers white; fruit depressed, ± 5.5 × 3.5 cm.).

This species is based on specimens from Riouw, Java, Karimon Djawa Islands, Celebes and Moluccas. To this geographical range we now add New Guinea.

Duabanga Buchanan-Hamilton

Duabanga moluccana Blume, Mus. Bot. Lugd.-Bat. **1:** 109. 1849.

Netherlands New Guinea: 2 km. southwest of Bernhard Camp, Idenburg River, *Brass & Versteegh 13514,* March 1939, alt. 750 m., occasional on slopes of primary rain-forest (tree 35 m. high; flowers yellow); Bernhard Camp, Idenburg River, *Brass & Versteegh 14015,* April 1939, alt. 75 m., occasional in primary rain-forest on lower mountain slopes (tree 27 m. high; fruit green). British New Guinea: Palmer River, 2 miles below Black River Junction, *Brass 7289,* July 1936, alt. 100 m., river flood-plain forest (branches stiff, robust, 1.5–2 m. long; petals in bud yellow-green).

Except for slightly larger (up to 4 cm. long) and possibly more conical fruits, these collections are a good match for the Malaysian specimens of *Duabanga moluccana* Bl. in our herbarium. It is to be noted that Knuth, in separating his *D. borneensis* from this species, mentions only the difference in the size of the capsule. We have not sufficient material at hand to determine the range of variation in the size of the fruits of *D. moluccana* Bl., but we are a little wary of using such a character without other supporting differences. This is apparently the first record of the genus from New Guinea.

CRYPTERONIACEAE

Crypteronia Blume

Crypteronia Cumingii (Planch.) Endl. Gen. Suppl. **4**(2): 39. 1847; Merrill, Enum. Philipp. Fl. Pl. **3**: 139. 1923.

Henslovia Cumingii Planch., Hook. Lond. Jour. Bot. **4**: 478, *t. 16, C. f. 1–4.* 1845.

NETHERLANDS NEW GUINEA: Bernhard Camp, Idenburg River, *Brass & Versteegh 13584,* April 1939, alt. 450 m., occasional in primary rain-forest (tree 24 m. high; buds green; bark dark brown, scaly).

Although this specimen has only very young flower-buds, we are reasonably sure it represents *Crypteronia Cumingii* (Planch.) Endl., a species previously known from the Philippines and Borneo. If we have not overlooked some reference, this is the first record of the genus in Papuasia.

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THE 1938–39 EXPEDITION TO THE SNOW MOUNTAINS, NETHERLANDS NEW GUINEA

L. J. Brass

With seven plates

INTRODUCTION

The 1938–39 expedition was the third of a series undertaken by Mr. Richard Archbold, Research Associate, American Museum of Natural History, for general biological exploration on the still imperfectly known and partly unexplored island of New Guinea. The first of these expeditions[1] covered in 1933–34 a section from Hall Sound on the south coast of the Territory of Papua to the summit of Mt. Albert Edward (3980 m.), and visited the Oriomo River, between the Fly River and the border of Netherlands New Guinea. The second expedition,[2,3] in 1936–37, examined the Fly River from the coast to the foothills of the central mountain complex, and the country of the Wassi Kussa River, also in Papua. The chief objective planned for the 1938–39 expedition was a cross section of the northern slopes of the Snow Mountains, from the Idenburg River to Mt. Wilhelmina, in Netherlands New Guinea.

The Snow Mountains, the most lofty section of the high central range of the island, rise to an elevation of 5000 m. in Mt. Carstensz, and six of the peaks — the Idenburg Mts., Mt. Carstensz, Mt. Wilhelmina, J. P. Coen Mts., Prins Hendrik Mt. and Juliana Peak — are capped with eternal snow. A large lake (Lake Habbema) was known to exist at an altitude of over 3000 m. on the north fall of the range, near Mt. Wilhelmina, and on this lake it was proposed to land a party by airplane and there establish a base for operations up and down the slopes.

As early as 1912 the Wollaston Expedition had penetrated from the south coast and reached the edge of the permanent snow on Mt. Carstensz; and in 1936 Colijn had led an expedition to its summit. Mount Wilhelmina was climbed from the south side by the Lorentz-van

[1]Archbold, Richard and A. L. Rand. Summary of the 1933–34 Papuan Expedition. Bull. Am. Mus. Nat. Hist. **68**: 527–579. 1935.

[2]Brass, L. J. Notes on the vegetation of the Fly and Wassi Kussa Rivers, British New Guinea. Jour. Arnold Arb. **19**: 174–190. 1938.

[3]Rand, A. L. and L. J. Brass. Summary of the 1936–37 New Guinea Expedition. Bull. Am. Mus. Nat. Hist. **77**: 341–380. 1940.

Nouhuys Expedition in 1909, and again in 1913 by the Herderschee Expedition. In 1921 the Kremer Expedition, approaching from the north past Lake Habbema, had also reached the summit of Mt. Wilhelmina. These expeditions, all but the last, had brought back collections from high altitudes on the Snow Mountains, but, owing to the difficult conditions under which they were made, and the short time spent at the upper levels, none was very extensive. In 1920, Lam, botanist to the van Overeem Expedition, made large gatherings of plants on the outlying Doorman-top. Several expeditions had made zoölogical and botanical collections on various parts of the Idenburg River.

To carry out the work projected it was necessary to seek the aid and co-operation of the Government of the Netherlands East Indies. This was given in full and generous measure, and a joint expedition, called the Indisch-Amerikaansche Expeditie, was formed under the general leadership of Archbold. A military covering party of 56 officers and men, under the command of Staff Captain C. G. J. Teerink, was provided by the Indies Government. Doctor L. J. Toxopeus was attached as entomologist, Dr. E. Myer-Drees as forester, and Mr. Ch. Versteegh as assistant forester. The American staff consisted of Dr. A. L. Rand, ornithologist and assistant leader, Mr. W. B. Richardson, mammalogist, and the writer in charge of botanical collections. Seventy-three Dyaks from east-central Borneo were recruited as carriers and field assistants for the scientific party. The military escort had a carrier force of 30 convicts — mostly Javanese. As finally constituted the expedition personnel numbered about 200 men.

For aërial transport, Archbold provided a two-engined Consolidated P.B.Y.2 flying-boat — the "Guba" — with a crew of four in charge of Pilot R. R. Rogers. To assure the co-ordination of operations essential to an expedition of the kind, the equipment included portable radio sets by means of which the various field parties could keep in touch with each other, maintain communications with coastal headquarters, and with the airplane while in flight.

* * * * * *

The expedition yielded about 6000 numbers of plants in all, of which 69 per cent occurred above 1000 m. and 20 per cent at elevations exceeding 3000 m. With the exception of about 600 numbers from coastal localities and the Idenburg River, which Myer-Drees collected independently for Buitenzorg, these collections are deposited at the Arnold Arboretum. Before returning to Java in October, 1938, Myer-Drees assisted in general botanizing on Mt. Wilhelmina; and included in the

main collections are 602 numbers representing trees from which Versteegh took wood specimens for the Forest Research Institute, Buitenzorg.

The Pandanaceae, Ulmaceae, Pittosporaceae, Rosaceae, Geraniaceae, Oxalidaceae, Rutaceae, Meliaceae, Aquifoliaceae, Celastraceae, Sapindaceae, Rhamnaceae, Barringtoniaceae, Rhizophoraceae, and several other families represented by very few numbers have been determined by Dr. E. D. Merrill and Dr. L. M. Perry; the Theaceae and Oleaceae by Dr. C. E. Kobuski; the Myristicaceae, Monimiaceae, and Hippocrateaceae by Dr. A. C. Smith; the Musci by Dr. E. B. Bartram; and in part, the Boraginaceae by Dr. I. M. Johnston, the Selaginellaceae by Mr. A. H. G. Alston, the grasses by Mrs. Agnes Chase, and the ferns by Prof. E. B. Copeland. Numbers following a generic name in the text of this paper are the field numbers of the writer, under which collections made conjointly with Myer-Drees and Versteegh also appear. With some few exceptions, the generic names thus used are from a list of preliminary sight identifications kindly supplied by Dr. Merrill.

ITINERARY AND ROUTES

In April–June, 1938, a coastal base was established at Hollandia, a civil administration post and small settlement on the west side of Humboldt Bay, connected by monthly steamer with Makassar and Java. Then followed, between June 21 and 27, a series of four preliminary flights for the purpose of examining the country in which the inland party proposed to operate. The first aim of these flights was a reconnaissance of Lake Habbema, which, from its large size and situation among not too high ridges, proved eminently suitable for a high altitude air base. Mount Wilhelmina and its approaches were also examined at this time.

To ensure a safe retreat to the coast in the event of a mishap to the airplane, it was necessary to find a route, as short and direct as the nature of the country would allow, from Lake Habbema to the Idenburg River, and to select a site for an emergency supply base on the Idenburg. In successfully carrying out this part of the aërial reconnaissance, there was discovered, to the east of the route followed by Kremer's party, in country previously unexplored and unseen from the air, a very extensive system of heavily populated valleys that commenced little more than a day's walk from Lake Habbema and extended far north and northwest towards the Idenburg.

The northernmost of the new valleys drained to the Wal or Hablifoert River, a tributary of the Idenburg. Most of them were, however, laterals of a great central valley, to which the name "Groote Vallei" was given

by the Netherlands members of the party. About 80 km. long and up to 20 km. wide, this central valley had a bottom elevation of 1500–1700 m. and was found to be drained by the Balim (or Baliem) River, the headwaters of which were discovered by the Kremer Expedition in 1921. Flowing first west-northwest from the slopes of Mt. Wilhelmina and receiving the waters of Lake Habbema, the Balim described a wide loop to the east and southeast, then cut through the Snow Mountains in a deep gorge to join the Reiger, the main branch of the Lorentz River, which flows to the south coast.

The Grand Valley of the Balim, and many of its laterals, had been almost completely deforested up to elevations of 2300–2400 m. on the sides of the surrounding mountains. The utmost limit of cultivation was in the neighbourhood of 2500 m. Whole mountain ridges had been stripped of their original vegetation and their contours laid bare under a pale coating of grass. On these bald ridges were many village groups of gardens walled with stones, and marking their surface, in pleasing native irregularity, were the old walls which had enclosed former cultivation plots. The pock-marked effect given by sinkholes indicated that most of the country rock was limestone. In the main valley the plane flew low over numerous walled or stockaded villages and beautifully patterned gardens laid out on rich alluvial flats. Broad ditches in these gardens were in many cases full of water, for much of the valley bottom was low lying and swampy. A first estimate of 60,000 people in these, for New Guinea, highly cultivated valleys, was probably too conservative.

The usual direction flown from Hollandia on the reconnaissance and subsequent transport flights was approximately 240° for 200 km. to the Idenburg, then 220° for 100 km. to Lake Habbema or Mt. Wilhelmina. On this course, after leaving the hilly shores of Humboldt Bay, with their discontinous fringe of secondary grassland, the Cyclops Mts. were passed on their inland side and the plane flew over Lake Sentani.

Lake Sentani, beginning 10 km. from the coast, has a length of about 25 km., a width of 1–12 km., and lies at an elevation of 80 m. above sea level. From the air the lake is seen to be surrounded by hills partly covered with rain-forest but mostly by treeless grassland. Remarkably distinct lines of trees border the shores at the foot of the grassy hills and fill the gullies that score their sides. In some parts the shores are fringed with sago swamps. Off-lying valleys on the south and west sides look like dry arms of the lake. The lake carries a population of 7000 people, most of whom live in villages built on piles over the water. The grasslands are undoubtedly a secondary condition following deforestation by the natives. Clearing for gardens, the process by which these

grasslands are formed, can at any time be seen in operation on the forest edges. In the comparatively dry "winter" season of the southeast trade-winds, the fires which secure the invading grasses against the re-establishment of the original forest are almost a daily occurrence on some part of the area.

A somewhat scattered population continued westward on the line of flight for a distance of perhaps 30 km. from Lake Sentani. There, and in a parallel flat valley to the south of the lake, were extensive grassy areas, some of them secondary, others apparently patches of marshy land not suited for the growth of trees.

Beyond the disturbed area of Lake Sentani was a broad tract of low mountain country, completely forested, and carrying a very sparse population living in small villages or scattered solitary houses. Apparently of limestone, the mountains attained a fairly even elevation of perhaps 800 to 1000 m. and lay in closely parallel ridges trending east-southeast and west-northwest. When passing over them in early morning, there could be seen, when the weather was clear, two snow-capped peaks of the Central Range, far to the south. On one occasion, when flying at 3500 m. after a period of storms, Mt. Wilhelmina, with snow far down its sides and its top clear cut and icy, presented a magnificent sight, heightened in effect by a dark overcast and the blue-black of the lesser heights.

Between these still largely unexplored low mountains and the central mountain mass lies the valley of the Idenburg — the Meervlakte or Lake Plain. About 60 km. wide where it was crossed, the Meervlakte, as the name implies, is flat and swampy. Muddy tributaries loop over the plain to join the main river, which flows along the southern side, near the base of the central mountains. The Idenburg is a broad stream, winding and silt-laden, with an amazing number of cut off U-bends and often islands formed by the shifting of the channel. Out on the plain are big lagoons and areas of open grass marsh. Forests of swamp-inhabiting slender trees are conspicuous from the air and the open canopy and abundance of sago palms in more mixed forest further testify to the swampy nature of the ground. Later it was learned that even the dense closed forests are inundated to a depth of one to two meters for months on end in the season of the northwest monsoons.

The Meervlakte extends up the Idenburg for a distance of about 170 km. from the Mamberamo. Similar conditions are reported to prevail for about an equal distance on the Rouffaer River, the west branch of the Mamberamo. Probably the greater part of these areas is under water from December to May, when the rivers, dammed back by rapids on the Mamberamo, overflow their banks.

The first line of the central mountains rises sharply from the Meervlakte in a complex system of bold ridges which proved to consist of dark-coloured plutonic rocks. Except for one marshy valley draining into what is now known as Archbold Lake, areas deforested by natives, and the tops of the higher outlying peaks such as Angemoek and the Doorman-top, the ranges are forested up to high altitudes on the Snow Mountains. Practically every valley of consequence on the course from the Idenburg to the Balim carried some population. But not until Archbold Lake was passed did population have any great disturbing effect upon the forests. So far as could be seen from the air, the commencement of heavy population coincided with the change of the country rock to limestone.

The uniform reddish colour of the young leaves indicated some change, and a pronounced dominance, in the composition of the mountain forests (afterwards found to be of *Nothofagus*); for in their young-leaf colours the mixed rain-forests of lower levels presented a diversity of greens, yellows and browns, as well as reds. Above about 3000 m. on the slopes of the Snow Mts. the forests assumed a sombre hue, and soon after that long tongues of grassland, very different in appearance from the grasslands of the deforested valleys, descended in hollows from the alpine heights.

Lake Habbema lies in the outermost and shorter of two broad grassy valleys that run parallel to the axis of the range on a high, shelf-like plain. The Habbema valley is perhaps twice as long as the lake, which has a length of about 4 km., a width of 2 km., and is 3225 m. above sea level. The inner valley, in which a headwater stream of the Balim proper flows westward and the Wamena tributary eastward from an almost imperceptible divide, continues for an undetermined distance far to the west in the direction of Mt. Carstensz. The bottoms of these valleys of the high plain are flat and treeless. They contain many little pools and are drained by winding streams lined with the curious *Cycas*-like tree-ferns peculiar to high altitudes in New Guinea. There are also numerous pools on the tops of the smooth ridges that separate the two high valleys and form the rim of the Grand Valley. These ridges rise 75–125 m. above the plain, and carry shrubberies and mossy scrubs in which numerous slender conifers (*Libocedrus*) rise above the lower vegetation. There is little closed forest. From the air, cushions of golden-brown moss are conspicuous on the trees, and patches of the same colour appear in the shrubberies.

On the rugged main ridge of the Snow Mts., there was considerable low tree growth under bluffs and in other sheltered places up to an eleva-

tion of about 3900 m. The higher parts west of Mt. Wilhelmina consisted mainly of bare grey-white rock, frequently with a smooth weathered surface exhibiting a criss-cross pattern of cracks. On the summit of the strongly stratified knife-edged limestone ridge of Mt. Wilhelmina peak was a small area of permanent snow. Several small lakes and shallow ponds occurred on both sides of Mt. Wilhelmina about 1000 m. below the summit. A long narrow lake lay between two sharp ridges that formed a double crest to the range about a dozen kilometres to the east of the peak.

On one occasion the plane passed over the summit of Mt. Angemoek, an outlying, unexplored peak rising to 3950 m. a little to the west of the regular route. This peak was forested almost to the summit on the north side, while to the south it sloped down in a grassy plateau, perhaps 200 acres in extent, on which were two small ponds some 500 m. below the summit.

After the reconnaissance flights, a military detachment commanded by Lieut. V. J. E. M. van Arcken was landed on the Idenburg with carriers and stores for three months, for the purpose of establishing a river base, building canoes for use in case of an emergency, and exploring a route to the newly discovered Balim Valley. A trial landing with the airplane was then made on Lake Habbema. On July 19 began the transport flights to the lake, where, by the end of the month, 105 men, comprising scientific party and military covering party and carriers, with full equipment and food for ninety days, were landed in eleven trips.

Meanwhile, van Arcken was making his way in to the Grand Valley, where he was to be met by Teerink with a patrol from Lake Habbema. Guided by aërial photographs, notes and sketch maps made on the reconnaissance flights, and provisioned by parachutes dropped from the airplane, the two patrols met at a pre-arranged spot on the Balim River on August 13. This was a fine achievement, and an excellent illustration of the speed and precision with which exploration can be carried out with modern facilities and the efficient co-ordination of operations on land and in the air. Good contacts were established with the natives, the way prepared for work planned for the scientific party in the Grand Valley, and a land route opened up by which the highland party could, if necessary, withdraw from Lake Habbema to the Idenburg in 14 days of travel.

The month of August was occupied in collecting at Lake Habbema, and excursions were made to the slopes of Mt. Wilhelmina and down the slopes from the lake to examine possibilities for collecting and to choose sites for camps. On such excursions advantage was taken of

well defined native tracks which, ascending from the inhabited valleys, passed over the highlands in all directions and even crossed the summit of the range at an altitude of 3800 m.

September was spent at collecting camps established at 3560 m. and 3800 m. on the northern slopes of Mt. Wilhelmina. Attempts to reach the summit of the peak, extending over two weeks, were frustrated by bad weather. The highest point reached was attained by Archbold and Rand, who, approaching by the main ridge from the west, climbed through mist to an altitude of 4500 m.

Leaving a small military unit to maintain Lake Habbema Camp as a supply base, early in October the main party moved down the slopes toward the Grand Valley and established camp in high *Nothofagus*-forest at an altitude of 2800 m., five carrier hours from the lake. A subalpine type of forest dominated by *Podocarpus papuanus* Ridl., superior to any hitherto seen, extended down the slopes to 3100 m. The new camp was placed on the edge of a planted *Pandanus* grove, in which stood a well built hut roofed with bark. A sizable opening, resulting from the fall of several big old trees, had been enlarged and kept open by felling the smaller trees with stone tools and by ringbarking. The *Pandanus* (probably *P. brosimos* Merr. & Perry), called Weramo by the natives of these parts, was grown for its nutritious oily seeds. Large-seeded species of *Pandanus* are widely cultivated by the mountain peoples of New Guinea. They were seen at the head of the Fly River by the Archbold Expedition of 1936–37, and *P. Jiulianettii* Mart. and another species were planted very extensively in the mountains visited by the 1933–34 expedition.

On November 9 the collecting party moved down the slopes another 5½ hours, by the path that had been followed from Lake Habbema, to a camp established by Teerink at 2200 m. elevation on the right-hand bank of the Bele River, a tributary of the Balim. This was near the upper limit of permanent native habitation. Although narrow here, and very steep, the valley carried on its lower slopes an old established population of several hundred people who lived in hamlets of small round houses thatched with grass. Surrounding the hamlets and extending up the slopes to approximately 2400 m. were considerable areas of cleared land occupied by producing gardens, second growth forest and grass. Scattered gardens occurred in the tall *Nothofagus*-forest as high as 2480 m. The subsistence crop was sweet-potatoes, supplemented by sugarcane, very good bananas, cucumbers, a gourd, spinach and taro. Tobacco was also grown, and the people were rich in pigs. So great was the demand for the small cowrie shells carried by the expedition as

trade that, in the interests of the natives, who sold without regard for their own needs, the purchase of foodstuffs had to be curtailed.

During November, a new base was formed by the military party, and supplies laid down by the airplane, on the Balim River, three days' march below the meeting place of the Teerink and van Arcken patrols in the Grand Valley, and three days from the camp on the Bele. The Lake Habbema base was then abandoned. On December 5, Teerink having rejoined the scientific party with all the carriers, the Bele River Camp was in turn vacated.

For the first of the three days' march to the Balim, the route followed the east slopes of the Bele Valley. After skirting a deep limestone gorge by a climb to 2500 m. through virgin forest, in two hours the path dropped down to 2400 m. on the edge of the heavily populated slopes of the lower valley. From there on, intensively cultivated village groups of gardens, alternating with open grass and scrubby fallow lands, were traversed hour after hour. Population was equally heavy and gardens as numerous and extensive on the opposite slopes, and ahead was always the Grand Valley itself. Above the gardens on either side the forests continued in narrowing strips on the crests of the mountain ridges, beginning at first at about 2400 m., but following the ridges to 2200 m. as they dropped down to the edge of the Balim Valley. Below that only remnant clumps of primary forest, mostly of *Castanopsis* and oaks, dotted the slopes down to the rocky bed of the river. In most parts cultivation seemed to have been pushed up the slopes to the climatic limit at which, in this valley, crops could be grown. There was, however, on the upper slopes, still some activity in bringing new land under production. Where timber was available, logs piled one above another, or split stakes placed upright in the ground, were used for fencing the gardens and constructing contour works which, in conjunction with drains, were designed to control surface run-off and the resulting soil erosion. Often, however, stones were the only material available in quantity for such purposes. All these works — the destruction of the original heavy forest, the fencing, ditching, measures of soil conservation, and the carefully tilled fields — were the achievements of a people whose only implements were stone axes and adzes for cutting and sharpened sticks for digging.

At 7 o'clock on the second day, having camped at 2200 m. on the slopes of the Bele, high above the river, the party came out on the edge of the Grand Valley. A white cloud field, above which the high enclosing mountains rose clear and blue, filled most of the valley at that early hour. At 9 o'clock the clouds were entered as at 2000 m. the path swung

east away from the Bele. About this level were seen the last of the cultivated *Pandanus,* which hitherto had been conspicuous on old garden lands and in the neighbourhood of villages. At 1900 m. *Araucaria* trees, shaggy with lichens, began to loom up in the mist. Soon, on the ridges, there were many of these striking trees of the mid-mountain levels, growing in patches of primary oak and *Castanopsis* forest. In the hollows were secondary forests of a flat-topped *Albizzia.* For the rest of the day the way lay through attractive park-like country cut by streams and traversed by broad pebbly paths and narrow tracks through the grass, the ground often corrugated by old garden beds. Although scattered now, and inclined to be hostile, a heavy population once occupied this part of the valley.

The fertile and thickly populated plains of the Wamena tributary of the Balim were crossed early on the third day. Here the people were placid and cordial, and while some gathered to watch us pass, others continued digging in the rich black earth of the gardens. There were no fences. Surrounding and intersecting the sweet-potato fields were trenches, about 2 m. deep and nearly as wide, which served the double purpose of draining the land and keeping out the cherished, but always troublesome, village pigs. An hour was spent in getting the party across the Wamena — a rapid stony stream fringed with lines of tall casuarinas.

The Balim base camp was on the right-hand or south bank of the river at an altitude of 1600 m., four hours from the crossing of the Wamena. About 100 m. wide at that point, strong-flowing and deep, about a kilometre below camp the river began to fall away in rapids and break up around little islands upon approach to the gorge through which it joined the Reiger. In this narrowing lower end of the valley occurrences of sandstone were frequent, but the rock appeared to be chiefly limestone containing quantities of fossil coral. On the south side of the valley the slopes of the Snow Mts. arose to a jagged high crest of limestone cliffs, and were deforested and cultivated up to an altitude of about 2300 m. A huge erosion cut in soft yellow sandstone, and below it an extensive spoil fan extending to the river 1 km. above camp, made a conspicuous landmark. Across the river, on the north side of the valley, a limestone range, completely deforested but for a clump of araucarias, rose to an altitude of about 2400 m. A numerous population occupied both slopes and especially the bottom of the valley. The gardens of the slopes were walled with loose stones; those of the alluvial flats were drained by deep ditches and enclosed in wooden fences or walls of puddled earth.

On this part of the Balim, as in much of the Grand Valley, a species of *Casuarina* (*No. 11172*), wind-dispersed from its original habitat on the banks of streams and perhaps sometimes planted, played an important part in the domestic economy of the people as practically the sole source of fuel and wood for building. Although the species was very abundant and formed forest stands about the expedition base, *Casuarina* poles for camp construction and wood for cooking could be had only by purchase with the coveted cowrie shells. Care was taken in the preservation of the few relic trees of the original forests. For some species, protection seemed to be assured by tabu. Permission was denied to take wood specimens from their trunks, which was not surprising under the circumstances, and even the collection of herbarium material was viewed with horror by the natives who followed every activity of the expedition in the field.

Collecting at the last of this highly successful series of Snow Mountains camps was concluded with the evacuation of the last of the party to the Idenburg by air on December 20.

Only 50 m. above sea level, Bernhard Camp, the expedition base on the Idenburg, was situated on an old cut-off bend of the river about 1 km. from the foot of the mountains that rise from the southern edge of the Meervlakte. From there the way into the mountains was made easy by the explorations of van Arcken, who, with the view of facilitating the work of the scientific party, had penetrated a distance of 18 km. to the southwest and opened up a route by which an altitude of 2250 m. could be reached in 2½ days from the river. Beginning at 1800 m., camps were occupied at 2150 m., 1200 m. and 850 m. in the four months January to April. The field work of the expedition terminated at Bernhard Camp on May 10, 1939.

In the next eleven sections of this account the vegetation of the various camp localities is described in a geographical sequence, beginning with the coast and ending with the alpine heights.

Humboldt Bay

Only small collections of plants, comprising about 200 numbers in all, were made in this area. Attention was confined to the lower southeast slopes of the Cyclops Mts., the shores of the inner harbour known as Jautefa Bay, and the vicinity of Hollandia itself. A few species were also collected at Lake Sentani. The average annual rainfall at Hollandia is 2336 mm., of which 64 per cent falls in the six months November to April, and 36 per cent during the period May to October. February,

with an average of 310 mm. of rain, is the wettest month; September, with 86 mm., is the driest.

The terrain is ridgy to mountainous and both calcareous and non-calcareous rocks are present in the area. The primary vegetation cover, at the levels examined, consists of rain-forest, broken by occasional sago swamps. On the limestone ridges *Pometia pinnata* Forst. is one of the most abundant large trees in fairly luxuriant forests with a plentiful herbaceous undergrowth characterized by mesophytic ferns and especially tall-growing *Selaginella caudata* (Desv.) Spring. The other ridges carry a drier type of heavy forest in which rough-barked *Syzygium* spp., **Gordonia papuana* Kobuski, *Anisoptera 9000* and at least another dipterocarp are common trees, woody undergrowth plentiful, and the harsh fern *Syngramma pinnata* J. Sm. the characteristic floor plant. Oaks appear in the forest at an altitude of about 350 m. on the Cyclops Mts. Two hundred metres higher, mosses and liverworts are abundant on both trees and ground of tall moist forests containing many small tree-ferns (*Cyathea melanoclada* Domin and **C. pulcherrima* Copel.), and in which climbing *Nepenthes 8942* and *Cyathea biformis* (Ros.) Copel. are striking features of the undergrowth. Growing at still higher elevations, and conspicuous on the skyline, is an uncollected species of *Araucaria*.

Considerable areas of secondary grassland occur on the coastal fringe. This condition seems to obtain chiefly on the non-calcareous ridges, which have suffered more disturbance than the more fertile but generally more rugged limestone ridges. Also, the *Macaranga-Homalanthus* second growths that spring up after the destruction of primary forest on calcareous soils are more vigorous than the communities of *Commersonia Bartramia* (L.) Hieron., *Deplanchea 8975, Xanthostemon 8801,* etc., that appear on non-calcareous soils. About Hollandia township, where disturbance is comparatively recent, lalang grass (*Imperata*) has taken firm hold. On Jautefa Bay, and at Lake Sentani, are old-established grasslands dominated by *Themeda triandra* Forsk., one of the principal grasses of the dry *Eucalyptus* savannas of southern parts of New Guinea, with which occur many common southern associates, such as *Euphorbia serrulata* Reinw., *Knoxia corymbosa* Willd., *Sopubia trifida* Hamilt. and *Uraria* sp.

Seemingly long deforested slopes, touching on the bay to the northeast of Hollandia, support distinctive communities of grass and fern and also woody growths. There the red, non-calcareous, lateritic soil has a powdery texture, sets hard when exposed to the sun, and appears far

* denotes a new species, ** a new genus and new species described from this collection.

from fertile. A good part of the area carries a tangled growth of *Dicranopteris linearis* (Burm.) Underw., which is replaced on the more sterile soil by scattered tufts of *Eriachne pallescens* R. Br. and the clump sedges *No. 8802* and *Vincentia 8803*. Pure growths of *Ischaemum pubescens* Merr. cover extensive slopes. This grass would appear to follow the fern as a stage in succession and to set up conditions allowing the establishment of secondary forest. Associated in scattered order with stunted examples of second growth trees found elsewhere, and lending a distinctly Australian aspect to the fern and grass communities, are the small trees *Acacia Simsii* A. Cunn. and *Casuarina 8820,* and also shrubberies of *Myrtella 8887*. Dense pure scrubs of the *Acacia,* whose seeds germinate freely after a severe burning of the fern and grass, provide another characteristic feature of the area.

A peculiar xerophytic primary brush occupies some low coastal hills in Jautefa Bay. The hills are of raw coral limestone with a very rough surface in which are numerous pits and pockets of rich-looking though very dry red soil. In these accumulations of soil root such small trees and shrubs as *Mallotus 8844, Pittosporum ferrugineum* Ait. and *Myoporum papuanum* Kränzlin. The most conspicuous element of the brushes is the *Yucca*-like *Pleomele multiflora* Warb., which attains a height of 5–6 m. and raises its stout branches above the general level of its associates.

Bernhard Camp, Idenburg River

The cut-off bend on which this camp was situated received the waters of several creeks rising on the mountains nearby, and at its lower end was connected with the river. The outlet was a brisk hour's paddling or about 8 km. below the camp. For one-third of the distance, flood plain forests came out to the banks and ended in dense fringing growths at the water's edge. With the silting-in and narrowing of the channel from about 400 m. to 100 m. at that point, the forests began to give way to open stands of swamp-inhabiting trees and bodies of floating grass in quiet bays too deep for trees. Below the narrows the channel meandered through extensive grass marshes, dotted with low trees and containing forested islands, and then cut through a silt levee covered with a tall stand of purple-plumed wild sugarcane to join the river. The old river-bed above the upper end of the "lagoon" was almost filled with silt and so choked with marsh vegetation and encroaching swamp-forest that a canoe could not be got through to the river.

The lagoon rose and fell with the fluctuations of the Idenburg. A datum pole for observations on water level was erected by van Arcken

on July 11 and series of levels recorded up to October 18, after which regular daily records were kept until May 8. The water was at its lowest in August. September was a wet month locally, and early in October a brief flood of 8 m. occurred. November marked the beginning of the rainy season at Bernhard Camp; from November 3 to the end of the year, minimum water level was 4.5 m. and maximum 7.3 m. on the datum pole. The lowest level between January 1 and May 8 was 5.9 m., and for periods of 11 consecutive days in January, 12 in February, 22 in March and 16 in late April and early May, the level exceeded 8 m. The highest flood, in March, rose to 9 m. Absolute low level, estimated at minus 1 m., was not formally recorded. Since in this case the duration of inundation and of dry surface conditions is more important ecologically than extreme levels, the difference between absolute high and low water, whether 9 or 10 m., is not of great moment.

Rainfall records kept by the military party indicated a total precipitation of 4934 mm. between July 11 and May 8. The driest full month was August, with 259 mm., the wettest April, with 802 mm. of rain. The wettest months at Bernhard Camp coincided with the highest and most sustained floods, and the driest month with the lowest water; this denoted for the upper drainage basin of the Idenburg a seasonal rhythm which, for Bernhard Camp, could be assumed from the character of the vegetation of the lower mountain slopes, namely, a wet season corresponding with the incidence of the northwest monsoons, and a relatively dry season during the period of the southeast tradewinds.

The observations of the writer were limited to the wet season. When, from April 6 to May 10, collections were made here, the marshes were too deep in water to be sounded with a pole, and most of the flood plain forests could be traversed by canoe. At one time all but the highest ground in camp was under water, and only two other dry spots could be found out from the narrow strip of rising land that fronted the mountains. A comparison of soundings with the flood tables of van Arcken gave some idea of the depth and duration of inundation as affecting the various types of flood plain vegetation.

The plant communities of the flood plain, some of which were observed under dry season conditions on the Fly River in 1936, fell into two groups, viz. permanent marshes and semi-permanent swamp-forests, and communities inundated only in the flood season.

In the first category, in order of depth of inundation, were:

1) **Permanent grass-marsh:** Present in sluggish creeks and covering extensive areas of old riverbed as dominant of the open marshes was the

grass *Echinochloa stagnina* (Retz.) Stapf, whose long buoyant culms root on the bottom. With it were associated *Commelina 13992, Polygonum 14068* and *Jussiaea repens* L., of similar habit. *Pistia stratiotes* L. was present as a floating aquatic. Similar marshes occurred on the Fly River.

2) **Adina swamp-forest:** The clear-boled slender *Adina 13909,* averaging 25 m. in height, formed pure open forests of limited extent on ground covered to an average depth of about 4 m. by the highest flood and continuously under water for 38 days in November–December and for the 128 day period January 1 to May 8. The smooth grey trunks of the trees carried quantities of fleshy sun-epiphytes such as *Dischidia 14048, Hydnophytum* spp., *Hoya* spp. and *Cyclophorus lanceolatus* (L.) Alston. Forests of this kind covered large areas on the Fly River.

3) **Barringtonia swamp-forest:** The bushy, briefly deciduous *Barringtonia spicata* Bl. formed extensive pure stands 5–6 m. high. The highest flood inundated this forest to an average depth of about 3 m., so that in general the habitat was flooded continuously for 13 days in November, and for all but two days between January 1 and May 8. The closely related *B. tetraptera* Lauterb. forms swamp-forests in south New Guinea.

4) **Sago-swamp:** Although very extensive on other parts of the Meervlakte, forests of sago palms (*Metroxylon*) occupied but a few small areas within tall rain-forest at Bernhard Camp. The river flooded this habitat to a maximum depth of about 1 m. In the southeast season, local rains no doubt suffice to maintain the more or less swampy conditions essential for this palm. Sago-swamps occur in rain-forest throughout the lowlands and lower mountains of the island.

5) **Swampy rain-forest:** On the edge of the flood plain were patches of a rather open type of mixed rain-forest inundated by the river to depths of under 1 m. to about 1.5 m. (flooded about 50 to 98 days between January 1 and May 8). From the uneven ground surface and the presence as characteristic herbaceous undergrowth of *Hypolytrum 13974,* the amphibious fern *Microsorium pteropus* (Bl.) Copel., and *Oryza Ridleyi* Hook. f., more or less swampy conditions would appear to be maintained after the fall of the river waters. The principal trees *Campnosperma? 13963, Couthovia 14097, Parkia 13824* and *Serianthes 13970* attained a height of 30–35 m. and developed in some cases heavy prominently buttressed trunks. *Styrax 13953* and *Ardisia 13897* were characteristic of a rather open woody undergrowth, while *Pandanus peni-*

cillus Mart. and the fan-palm *Borassus 13775* figured conspicuously in the substage.

The second category included:

6) **Cane brakes:** *Saccharum spontaneum* L. (?) formed extensive brakes 8–10 m. high on the silt levees of the river, and also grew on gravel beds in creeks draining from the mountains. As peak floods inundated the levees to depths of 2.5–3.5 m., on the average they would be under water on all but two days between January 1 and May 8. Whatever plants occurred on lower banks of silt and mud were under water and out of sight during the period of observation; but species growing on old drift logs afloat in backwaters, such as *Torulinium ferax* L. C. Rich., *Fimbristylis miliacea* (L.) Vahl., *Pouzolzia zeylanica* (L.) Benn., *Jussiaea 13928* and *Abelmoschus 13777,* probably belonged to such a community.

7) **Timonius-forest:** Pure forests of *Timonius 14034,* about 25 m. high, occupied, at the lower end of the lagoon, extensive siltbeds submerged to a depth of 1.5–2 m. by the highest flood (flooded on an average 73 days, and dry 45 days between January 1 and May 8). Breadfruit trees (*Artocarpus communis* Forst.), no doubt brought there in the first place by the scattered nomadic natives of the river, were frequent marginal associates. *Pothos 13943,* climbing on the trees, was a characteristic feature. The *Timonius*-forests appeared to represent the one successional stage between cane-brakes and mixed rain-forest on the silt levees of the river.

8) **Nauclea-forest:** Pure stands of the 6–7 m. high small tree *Nauclea 14033,* remarkably like a low *Sonneratia alba* mangrove community in appearance, covered flat islands in the lagoon and sometimes fringed its banks. They grew on ground submerged to a depth of about 2.7 to 3.7 m. by the highest flood. Complete flooding was therefore the average condition from January 1 to May 8.

9) **Wormia-forest:** Plains generally inundated to a depth of 2.25 to 2.5 m. at highest flood level, and therefore under water 117 to 120 days in the period January 1 to May 8, carried distinctive mixed rain-forests in which *Wormia 14114* took a prominent part and formed nearly pure stands of considerable extent. Readily distinguished by its reddish flaky bark and large leaves, the characteristic tree attained a height of about 30 m. and a diameter of 1 m. The trees were well spaced and, there being little woody undergrowth, the forests were open underneath. Any herbaceous undergrowth they may have contained was under water

in the flood season. Strangling figs, whose great crowns rose high above the forest roof, were a conspicuous feature. *Stenochlaena palustris* (Burm.) Bedd. and *Pothos 13943* were prominent root-climbers. But the feature that impressed most, as one travelled through the forest by canoe, was the wealth of large shade epiphytes, such as *Asplenium ellipticum* (Fée) Copel., **A. pseudophyllitidis* Copel., **Goniophlebium subcordatum* Copel., *Microsorium punctatum* (L.) Copel., *Humata heterophylla* (Sm.) Desv., *Selaginella Hieronymiana* v. A. v. R. and Zingiberaceae, that crowded the tree trunks down to about 2 m. from high water mark and provided a wet season refuge for innumerable ants and other insects. *Wormia* entered the swampy rain-forest, described above, and possibly these forests also remained somewhat swampy after the floods.

10. **Fringe communities:** The *Nauclea, Adina,* and sometimes the *Barringtonia* forests present open faces to the waterways, and the trees straggle out into the open marshes. These trees also occur with an entirely different set of species in a dense fringing vegetation that hides from sight the interior of other types of flood plain forest. It is in these fringe communities, their aërial parts rising from anything up to 3 m. of water in the wet season, that the richest assortment of woody plants is found on the river plains. *Gnetum latifolium* Bl. and the magnificent red-flowering *Mucuna 13789* are abundant as screening lianes on the face of the forest. Bordering the *Wormia* type of forest, and leaning low over the water, is a continuous line of *Syzygium 13930,* up to 20 m. high. Elsewhere, much of the fringe vegetation is made up of *Kleinhovia hospita* L., *Pongamia pinnata* (L.) Merr., *Hibiscus tiliaceus* L. and *Crataeva 13910* as trees, and such scrambling shrubs as *Combretum 13786, Faradaya 13918, Loeseneriella sogerensis* (E. G. Baker) A. C. Smith, *Caesalpinia nuga* Ait. and *Flagellaria indica* L. On the lowest banks *Ficus 14036,* with large scabrous leaves, forms level thickets that stand not more than 1–1.5 m. above water at high flood and support an abundance of *Cayratia 13947,* pink *Ipomoea 13940,* spinose *Acacia 13776,* and other climbing plants.

From a few metres to about 0.5 km. in width, the strip of rising ground between the flood plains and the lift of the mountains consists of low stony ridges and gently sloping flats for the most part somewhat swampy in the wet season. Here there are pronounced changes in the character of the forest. On the flats and lower ridges, flood plain trees such as *Couthovia* and *Parkia* occur in abundance, while many species found as high as 600 m. and 800 m. on the mountains come down to the edge of the flooded ground. *Intsia 13542,* up to 40 m. high and well over 3 m.

in girth, *Terminalia 13925, Elaeocarpus 13569, Sloanea 14029* and *Duabanga moluccana* Bl. figure as canopy trees, and *Gnetum gnemon* L., *Harpullia cauliflora* K. Sch. & Lauterb., and *Garcinia 14065* as substage trees. Palms are numerous on the flats, where *Calamus* spp. and a *Korthalsia* make their first appearance, *Borassus 13775, Rhopaloblaste 13809* and *Cyrtostachys 13807* abound in the substage, and *Licuala 13744* and *Linospadix? 13774* mix in a rather plentiful woody undergrowth. The palms, a plentiful herbaceous layer of *Elatostema 13816* and *Ophiorrhiza 13812,* the local abundance of the small climbers *Freycinetia Klossii* Ridl. and *Piper 13904,* mosses on the undergrowth, and an abundance of *Pellionia 13771* and ferns such as *Asplenium acrobryum* Christ, *Polypodium damuense* Ros., *Hymenolepis mucronata* Fée, *Campium heteroclitum* (Presl) Copel. and *Vandenboschia aphlebioides* (Christ) Copel., as mesophytic low epiphytes, give an appearance of lowland luxuriance to a forest which is, however, actually poor in species.

850 M. CAMP, 4 KM. SOUTHWEST OF BERNHARD CAMP

A steep climb of three hours from the edge of the flood plain brought one to the top of the first mountain ridge at 900 m. altitude. Up to about 700 m. the slopes carried a poor type of tall dry-appearing rainforest with a thin canopy, in which *Intsia 13542, Pometia pinnata* Forst., *Shorea 14001, Serianthes 13546, Cynometra 13572, Alstonia 14013, Syzygium 14030, *Parastemon Versteeghii* Merr. & Perry, *Myristica fusca* Mgf. and *Garcinia 13570* were frequent trees below 300 m., and Cunoniaceae *13505, Endiandra 13198, Pygeum 13187, Turpinia 13532* and *Dysoxylum molle* Miq. prominent above 600 m. Oaks (*Lithocarpus 13556*) appeared at 120 m. and became plentiful above 350 m., but were nowhere abundant enough to characterize or bring about changes in the forest. The lower tree layers were poorly developed, epiphytes few, and lianes almost absent. A sparse predominantly woody undergrowth contained *Astronia 13671, Clerodendron 13474, Antidesma 13832* and *Amaracarpus 13863* as slender trees of 4–6 m., *Ixora 13448, Lasianthus 13670* and *Ardisia 13676* as shrubs, the fan-palm *Licuala 13744,* and slender *Pandanus Krauelianus* K. Sch. Only on flat places on the spurs, where the coarse ferns *Craspedodictyum Schlechteri* (Brause) Copel., *Tectaria cesatiana* (C. Chr.) Copel. and *Taenitis blechnoides* (Willd.) Sw., *Lindsaya azurea* Christ, *Selaginella suffruticosa* v. A. v. R., etc., congregated in quantity, was there any massing of undergrowth plants.

At 750 m., the level above which clouds settled over this slope of the ridge as a regular thing after the middle of the forenoon, matted surface

roots covered parts of the spurs and the ground became slightly mossy. Some well grown specimens of *Agathis 13171* attracted attention as an indication of a changing flora. Undergrowth remained sparse as ever, but numerous epiphytes appeared in the tree trops. An unexpected find was the tree composite *Olearia 13179,* a member of a genus most common in the subalpine zone, and not met with above 850 m. on these slopes or below 2600 m. on the Snow Mountains.

In an abrupt change, within 50 m. of the summit, the very mixed tall rain-forest gave place to a forest altogether different in character and composition and rapidly diminishing in height. While lower on the slopes the mist hung in the tree-tops, here it drifted through the forest to be absorbed by the thick coating of green and brownish bryophytes that covered the root-matted ground and enveloped the trunks of the trees. In places the carriers had worn the path down through 20–50 cm. of moss and peat to the underlying yellow clay. On the crest, where the largest trees were about 20 m. high and 0.5 m. in diameter, stilt-roots tented with moss were a conspicuous feature. The trees developed dense richly branched crowns and had smallish, recurved, often emarginate glossy leaves. Even when the sun shone, the forest was dimly lighted.

Although relatively poor in species, the "mossy-forest" of this 900 m. ridge exhibited most of the characters of the formation at higher altitudes on this mountain complex and on the Snow Mts., and was essentially a forest of antarctic beech. Associated with the dominant *Nothofagus 13147* were the conifers *Podocarpus imbricatus* Bl., *P. 13519* and especially *Phyllocladus 13520, Metrosideros 13149,* and a few minor species such as *Rhodamnia 13524* and *Endriandra 13678.* Scattered *Agathis* and the palm *Gulubia 13099* protruded above the canopy. Subsidiary trees, chiefly *Astronia 13312* and *Tetractomia Lauterbachiana* Merr. & Perry, extended their tops into the branches of the canopy trees and did much to exclude light from the forest. Often absent except for a few small ferns and *Argostemma 13316,* an abundant woody and herbaceous undergrowth of chiefly **Pandanus leptocaulis* Merr. & Perry, 1.5–2 m. high, *Dianella 13317* and *Mapania 13097,* developed under the somewhat broken canopy on crests and steep slopes, where subscandent *Oleandra cuspidata* Baker, *Cyathea biformis* (Ros.) Copel. and small *Freycinetia* spp. massed themselves on both ground and tree-trunks. Climbing *Nepenthes 13669* with big green pitchers, **Freycinetia pleurantha* Merr. & Perry, and especially the bamboo *Schizostachyum 13327* ascended to the upper levels. Poor for this type of forest, the epiphytic flora consisted mainly of Hymenophyllaceae and small orchids.

The 850 m. Camp lay beyond this ridge in a mountain-locked valley

dominated on the other side by a 1600 m. crest on the range on which the higher camps of this series were situated. Swampy in parts, and drained by a considerable stream named Araucaria Creek for stands of *Araucaria 13108* that occurred on its lower course, the valley bottom broadened to approximately 0.5 km. above the camp. Below camp the mountains gradually closed in and the creek became a succession of rapids, pools, and small waterfalls. The character of the forests indicated for this valley a rainfall far greater than that of Bernhard Camp and the intervening slopes. Dull, showery weather, broken by only six fine days, prevailed during the occupation of the camp from March 6 to April 15. Early morning fogs were frequent, and daily mist clouds, nearly always descending to the same level on the slopes, capped both the 900 m. and 1600 m. ridges at about 9 a.m. Often the day would end with torrential rain and strong wind from thunderstorms between 4 and 7 o'clock, followed by a steady downpour lasting far into the night. Temperature[1]: maximum (27 days) 22.5–28, mean 25, minimum (27 days) 16.5–19, mean 18 degrees Centigrade.

Rain-forests filled the valley bottom and extended up the slopes to *Nothofagus*-forest on both sides. But on the south slope, between 870 m. and 950 m. altitude, some broad ridges, at best poorly drained and in parts swampy, carried a distinctive type of forest dominated by *Agathis 13171.* The trees rooted shallowly in a compacted grey sand covered with a thin layer of peaty plant remains and living moss. A stately tree, up to 45 m. high and 1.5 m. in diameter, the older specimens standing in a mound of rotting bark scales, the *Agathis* formed a very open stand above a thin subsidiary layer of slender *Metrosideros 13291, Quintinia 13703, Campnosperma 13338* (peculiar to this forest) and *Daphniphyllum 13705,* 15–20 m. high. **Ternstroemia Merrilliana* Kobuski was a characteristic small tree in the more open parts, where *Astronia 13292, Drimys 13704* and *Pandanus stenocarpus* Solms-Laub. (?) supplied a rather abundant woody undergrowth. The ferns *Taenitis blechnoides* (Willd.) Sw., *Dryopteris viscosa* (J. Sm.) O. Ktz. and *Macroglena meifolia* (Bory) Copel. typified the ground flora, and *Hanguana 13304,* found nowhere else, occurred throughout. Other characteristic elements were root-climbing *Freycinetia* spp., *Cyathea biformis* (Ros.) Copel. and *Aeschynanthus 13300,* massed about the lower tree-trunks, and *Leucostegia pallida* (Mett.) Copel., **Humata Archboldii* Copel. and red-flowered *Dichrotrichum 13302* as low epiphytes. High epiphytes, mostly associated with cushioned bryophytes, included *Hydnophytum* spp. and

[1]Unless otherwise stated, meteorological readings were made 1 m. above the ground under a thatched roof in the various camp clearings.

the curious "ant-house" fern *Lecanopteris pumila* Bl. Like the *Nothofagus*-forest, from which many of its principal components were derived, the *Agathis*-forest, except for *Agathis* itself, was well mossed above as well as on the ground. It should probably be regarded as an edaphic subclimax of the rain-forest, which surrounded it on all sides, and in which, in this climatically wet valley, *Agathis* occurred in quantity.

Mossy to a degree seldom seen, and often retarded in their development by unfavourable soil conditions, the rain-forests presented other unusual features. One of these was the abundance of oaks (*Lithocarpus 13522, L. 13143, L. 13120*) and *Castanopsis 13521* on both the ridges and flat lands. Another oak (*L. 13466*) actually dominated the forest in swampy parts of the valley bottom, where the ground was broken by muddy pools, and scrambling bamboo combined with *Calamus* spp. and young *Pandanus* to form a prickly undergrowth difficult to penetrate. *Casuarina sumatrana? (13130)*, which, like *Agathis,* ranged up the slopes to 1200 m. and was not met with in any other locality, was conspicuous on steep ridges and sandy creekbanks.

The rain-forests attained their best expression on the deep sandy loam of river flats raised above the level of normal floods, where *Schizomeria 13117, No. 13309, Sloanea 13129, *Dysoxylum Randianum* Merr. & Perry, *Santiria 13111, Calophyllum 13122, Syzygium 13125, Hibiscus 13126, Cryptocarya 13127, Evodia Forbesii* Baker f., the oaks and *Castanopsis,* and some less important species formed the canopy layer of a well developed forest fully 30 m. in height. Most of the trees were conspicuously mossy. Mosses also covered exposed surface roots and rotting debris, while a thin layer of leaf litter lay on the ground. Young trees of the canopy species provided ill-defined second storey and substage layers enriched by the tall palms *Actinorhytis? 12966* and *Orania 13375.* High-climbing lianes, including *Calamus 13341* and several Apocynaceae, were well represented. There was a rich undergrowth, containing *Psychotria 13637, *Kibara elongata* A. C. Smith and *Codiaeum 13695* as small trees, *Licuala 13436* and *Linospadix? 13233* as palms, and an abundance of the tree-ferns *Cyathea geluensis* Ros. and exceedingly slender **C. gracillima* Copel., but chiefly characterized by herbaceous plants and ferns, such as *Procris* spp., *Elatostema* spp., *Tectaria cesatiana* (C. Chr.) Copel., *Dryopteris micans* Brause, **D. multiauriculata* Copel., *Selaginella velutina* Cesati, and at least a half-dozen species of *Begonia.* Epiphytes, both herbaceous and woody, were exceptionally abundant in association with climbing *Freycinetia angustissima* Ridl. and *Schizostachyum 13327* on the tree-trunks and on the undergrowth. Most important of these were the ferns *Arthropteris*

dolichopoda v. A. v. R., *Meringium gorgoneum* Copel., *Polypodium accedens* Bl., *P. albidosquamatum* Bl., *Goniophlebium subauriculatum* (Bl.) Presl, *Leucostegia pallida* (Mett.) Copel., *Nephrolepis Lauterbachii* Christ, **Asplenium paedigens* Copel., *A. cromwellianum* Ros., *Hymenolepis revoluta* Bl., *Lindsaya marginata* Brause and *Loxogramme subselliguea* (Baker) Alston, *Elatostematoides 13688, Ophiorrhiza 13059* and *Medinilla 13226.* In the tree-tops, which also carried a varied complement of epiphytes, *Polypodium enerve* Cav. and **Humata deltoides* Copel. grew half buried in moss, *Nepenthes 13232* with narrow green pitchers was common, and *Rhododendron* made its first appearance in the form of *R. 13067,* a shrub with showy reddish flowers, also found on open banks of the creek.

Throughout the lower mountains of New Guinea, there occurs on the edges of streams a community of flood-resistant small trees, alike in the horizontal arrangement of their branches, and, as a rule, with narrow lanceolate leaves. The branches of these trees may form one or more layers with a spread equal to or exceeding their height, which averages 2–3 m. As represented at Araucaria Creek, the community consists of *Ficus 13222, F. 13228, Syzygium 13223,* the clump palm *Actinophloeus 13700* and massed growths of *Boerlagiodendron 13697,* the latter an attractive shrub with narrow-palmate leaves and purplish inflorescence. Equally widespread and characteristic is an associated herbaceous community, restricted to firm banks and flood-washed points of rock, of which *Dryopteris cesatiana* C. Chr., *Lindsaya crassipes* Ros., *Dryopteris mutabilis* Brause, **D. riparia* Copel., *Selaginella Kerstingii* Hieron., *Hemigraphis 13100,* and the grasses *Pogonatherum paniceum* (Lam.) Hack. and *Isachne micrantha* Merr. are the most important local species. *Impatiens 13066* produces striking displays of salmon-pink flowers on the gravel beds.

Good examples of rain-forest succession occurred on the flood banks of the creek. As pioneer on beaches of gravel and sand, *Saccharum spontaneum* L. formed brakes up to 8 m. high, in which climbing *Cissus* spp. and *Mikania cordata* (Burm. f.) B. L. Rob., the shrubs *Otanthera 13063* and *Clerodendron 13062,* and small trees *Pseudopipturus 13078, *Parasponia simulans* Merr. & Perry and *Breynia 13077* appeared as the first woody plants. The quick-growing small softwood trees *Saurauia 13265, S. 13394, Wendlandia 13284, Schuurmansia 12766, Dammaropsis Kingiana* Warb. with leaves 75 cm. long and 50 cm. broad, and the magnificent tree-fern *Cyathea contaminans* (Wall.) Copel. played a prominent part in succeeding stages, which culminated in a 25 m. stand of *Homalanthus 13268* and *Albizzia 13141.* Ground societies of *Nephro-*

lepis hirsutula (Forst.) Presl, *Dryopteris unita* (L.) O. Ktz., *Elatostema* spp. and the orchid *Spathoglottis 13080* were well developed in open parts of the young forest. *Macaranga,* one of the principal genera of rain-forest "second growth" trees, was represented by only one species, and that of minor importance.

1200 M. CAMP, 6 KM. SOUTHWEST OF BERNHARD CAMP

From this camp one looked up to the 1600 m. crest which has already received mention, and down into the valley of Araucaria Creek. The country sloped sharply in well defined spur ridges separated by ravines with sides so steep as to be somewhat unstable. Although 350 m. higher in the mountains, rainfall was probably not so great, and certainly there was less mist and fog than in the valley of Araucaria Creek. Temperatures, recorded for 12 days between February 11 and March 3: maximum 20.5–23, mean 22, minimum 15–16.5, mean 16 degrees Centigrade.

Here the oaks (*Lithocarpus 12521, L. 12569, L. 12589, L. 12598, L. 13102*) and *Castanopsis* appeared in their true character as the constituents of practically pure forests on the broader ridge crests. About 25 m. high, with slightly spurred greyish trunks sometimes surrounded by coppice shoots, the oaks grew well apart and formed a rather thin canopy. In spite of abundant illumination, subsidiary and substage trees were few. Slower to decay than those of most rain-forest species, the leaves of the canopy trees formed a rustling ground litter. The distinctly dry appearance of the forest was accentuated by the scarcely mesophytic aspect of the fern *Syngramma Hookeri* C. Chr., which characterized the sparse undergrowth, the fleshy small twiners *Dischidia 12863* and *Hoya 12845,* which found support on undergrowth and coppice shoots, and the common low epiphytes *Vittaria ensiformis* Sw., *V. elongata* Sw., *Oleandra Werneri* Ros. and *O. cuspidata* Baker. There were few high epiphytes, and usually only one canopy climber — *Dimorphanthera 12856.*

Oak-forest was, however, a rare development. The constituents ranged up and down the spurs in the prevailing rain-forest, showing preference for the crests, which, it might be mentioned, often were under mist when the ravines were clear of cloud. It was on the crests that *Agathis* reached the upper limit of its range at 1200 m.; *Phyllocladus 12523* and *Podocarpus imbricatus* Bl. descended to 1100 m. from the beech-forests and were common in places where beds of moss and surface roots covered the ground, and *Nothofagus 11963* assumed prominence at about 1400 m.

Exceptionally rich in tree species, woody and herbaceous under-