
Results of the Archbold Expeditions. No. 7
Summary of the 1933-1934 Papuan Expedition

BY RICHARD ARCHBOLD AND A. L. RAND

BULLETIN

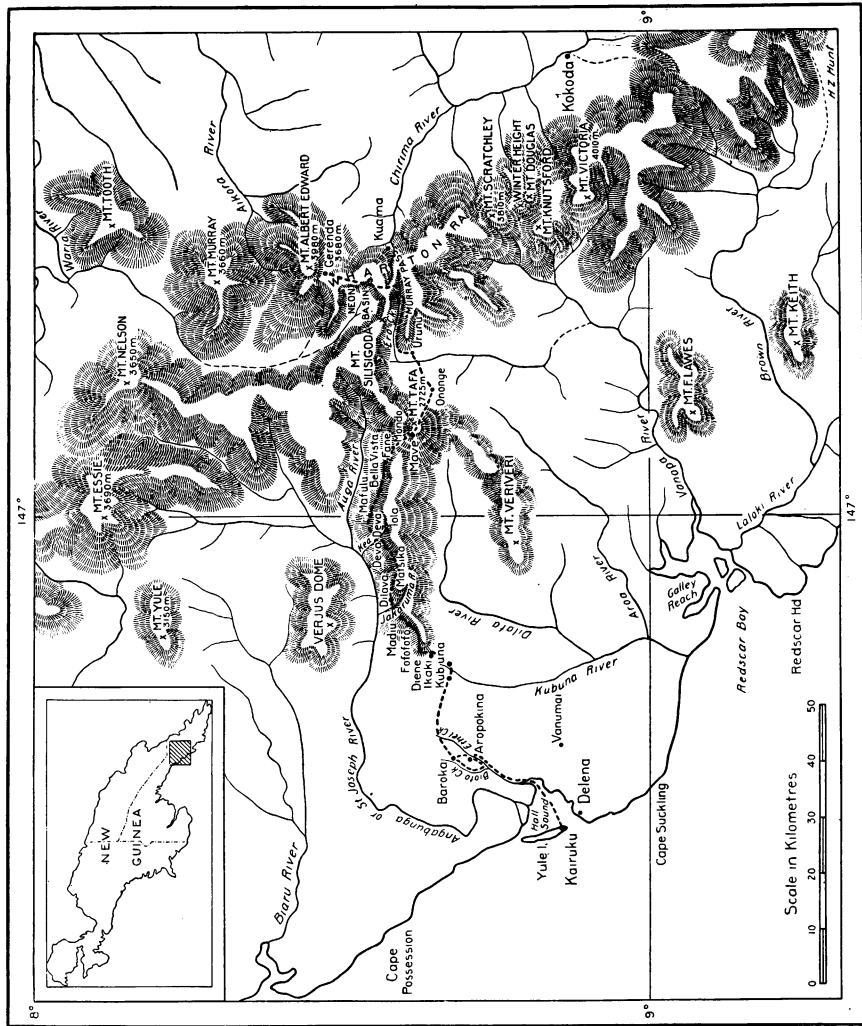
OF

THE AMERICAN MUSEUM OF NATURAL HISTORY

VOL. LXVIII, ART. VIII, pp. 527-579

New York

Issued November 8, 1935



Map showing the mountain area visited by the Expedition and the collecting localities. The route is marked by a broken line.

**Article VIII.—RESULTS OF THE ARCHBOLD
EXPEDITIONS. NO. 7**

SUMMARY OF THE 1933-1934 PAPUAN EXPEDITION

BY RICHARD ARCHBOLD AND A. L. RAND¹

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INTRODUCTION

New Guinea is largely a mountainous island. Though there are extensive lowlands in south New Guinea and large river valleys and a number of small, isolated mountain ranges in the northern part of the island, the characteristic topographical feature of New Guinea is the line of high mountains which extends throughout its length. These ranges reach their greatest heights in the snow-clad peaks of the Snow Mountains of Dutch New Guinea, Mt. Carstensz rising to 5000 meters.

These are the highest mountains in the Australasian area. In the islands to the north and northwest many peaks rise to over 3000 meters, but Mt. Kinabalu in North Borneo, with its summit about 4215 meters above sea level, is the highest.

The mountains in eastern New Guinea do not reach the altitudes of those of the Snow Mountains, but, nevertheless, some rise to the considerable height of 4000 meters.

In the mountains to the north of the Gulf of Papua, which are still being explored and mapped,² Mt. Wilhelm rises to 4300 meters. Going eastward, the peaks are lower: Mt. Otto, 3500 meters; Mt. Marien, 3200 meters; Mt. Zollen, 3000 meters.

¹ Photographs by the authors and L. J. Brass; the sections in the summary of the main types of habitat and altitudinal distribution in southeast New Guinea are by A. L. Rand.

² See Chinnery, 1934, Geogr. Jour., LXXXIV, pp. 398-412.

Then there is a comparatively low part of the range between the headwaters of the Wusi and Lakekamu Rivers, until to the eastward one comes to Mt. Lawson, 2900 meters; and then a group of high mountains; Mt. Chapman, 3500 meters; Mt. Essie, 3690 meters; Mt. Nelson, 3650 meters; and Mt. Murray, 3650 meters, amongst others, which lie close to the Wharton Range. This range contains the highest peaks in southeast New Guinea, Mt. Albert Edward and Mt. Victoria, both about 4000 meters in height. The central mountain chain continuing to the east, the Owen Stanley range, is lower. Mt. Obree rises to 3120 meters, Mt. Brown to 2420, Mt. Suckling to 3420, Mt. Dayman to 2836, Mt. Simpson to 3040, and Mt. Thompson to 1798 in the extreme southeast.¹

The richness of New Guinea's endemic fauna has long attracted the attention of naturalists. Each succeeding collection, producing novelties and extending the ranges of forms already known, has but emphasized the fact that there is still zoölogical exploration to be done in the island. Not only in defining ranges of known forms and discovering new ones, but also in finding out something about their habits and habitats concerning which, for many of the forms, practically nothing is known.

The exploration of some of the most zoölogically interesting areas in New Guinea in which little collecting had been done was the object of this expedition.

In the mountains of southeast New Guinea most of the known endemic forms from the high altitudes, especially the birds, were known only from the few specimens of each species collected by Giulianetti about forty years ago, when he was working under that wonderful naturalist-explorer-administrator, Sir William MacGregor.² Many of these specimens are in the Queensland Museum, Brisbane, and some of these forms have hitherto been rare or unrepresented in European and American collections.

South New Guinea was another area of interest. The collections of D'Albertis,³ made about sixty years ago on and near the Fly River, showed that this low country most closely approaching Australia had a somewhat different fauna than the rest of New Guinea; and here too was the only part of the island to which many Australian species extended. A few small collections made later in the Dutch Territory

¹ For a map of New Guinea see that of the East Indies, Geographical Section, General Staff, No. 3860, War Office (London), January, 1928; and for Papua see the map "Papua," compiled and drawn by Lands and Survey Branch, Works Department, Canberra (Australia), 1932; for the geology of Papua, see Stanley, *The Geology of Papua*, Government Printer, Melbourne, 1923.

² See 1888-1897, *Ann. Rep. Papua*; 1897, *Ibis*, pp. 371-392.

³ 1880, *New Guinea: What I saw and where I went*.

continued to yield novelties, but, until our work there, no systematic collecting had been done in the lowlands of south New Guinea since the time of D'Albertis.

The Wharton Range in central Papua, with Mt. Victoria on the southeast end and Mt. Albert Edward on the northwest, about 50 kilometers apart and both rising to about 4000 meters, with Murray Pass near the center, its lowest point about 3000 meters high, seemed the most accessible high mountain area. The country just west of the Fly River seemed to offer the best opportunities for collecting in south New Guinea. These were finally decided on for investigation by the expedition.

Mr. Richard Archbold, the leader and financier of the party, is a mammalogist, but the work was planned to have a broad biological aspect and extensive preparations were made to collect material in other fields, especially birds, other vertebrate animals and plants. A. L. Rand was the ornithologist of the party and also collected cold-blooded vertebrates; Mr. L. J. Brass was the botanist. After our arrival in New Guinea we secured the services of Mr. C. J. Adamson to aid us in the difficult work of transport in the mountain country.

We arrived in Port Moresby the end of February, 1933, and found the government actively sympathetic with our proposed researches. His Excellency, Sir Hubert Murray, Governor of Papua, through the Government Secretary, the Honorable Mr. W. H. Champion, very kindly allowed us a general permit for collecting birds and a special permit to collect two pairs of each kind of bird of paradise. This latter permit is issued rarely, and then only for scientific purposes; otherwise no white people are allowed to take or possess birds of paradise.

In order to facilitate our work we were very kindly provided with letters of introduction to the government officers in charge of the areas we were to visit. Everywhere we went in Papua we received the utmost hospitality and assistance, both official and unofficial.

The government officials were universally obliging and helpful and in particular do we wish to express our appreciation of the innumerable courtesies and aid given us by Captain W. H. H. Thompson, assistant resident magistrate of the Central Division at Kairuku, and Mr. S. G. Middleton, officer in charge of the Kambisi police camp at Mondo, also of the Central Division, and by Mr. R. A. Woodward, resident magistrate of the Western Division.

From the members of the Mission of the Sacred Heart, in whose territory we were working in the Central Division, we received an un-

failing welcome, and especially from Father Dubuy of Ononge we received the most delightful hospitality. Father Dubuy, who had twice visited the summit of Mt. Albert Edward, had a deep interest in our trip and its object, and by his influence and aid greatly facilitated the last stage of the mountain trip beyond Ononge. He also presented us with a few specimens of birds which we otherwise would not have secured.

Messrs. Burns, Philp and Company of Port Moresby acted as our forwarding and shipping agents, and they and their manager, Mr. W. D. Dupain, handled our affairs in a most satisfactory manner.

In the Western Division Dr. G. H. Vernon of Daru was our forwarding agent, and to him we are indebted for many favors in addition to the water transport which he supplied.

Mr. H. P. Beach, also of Daru, graciously allowed us the use of the Oriomo Oil Company buildings at Daru, Wuroi and Dogwa, of which he had charge, and also from his extensive knowledge of the near-by country gave us invaluable data as well as much other assistance.

The hearty cooperation of the fellow members of the party in the field made the present trip enjoyable as well as extremely successful. Mr. Brass, besides being a competent botanist and pleasant associate, was experienced in the ways of camp life and knew native customs. As well as collecting plant material, he often secured specimens of other groups, and helped especially with the collecting of fishes. Mr. C. J. Adamson's knowledge of the natives and the country stood us in good stead. For two seasons he had worked the Auga River below Mondo for gold; he knew the native customs and what the natives wanted for trade, and besides being experienced and capable in handling native labor, was a good companion whose aid contributed largely to the early success of the mountain trip.

In undertaking travel inland in New Guinea, transport is the greatest difficulty. In the mountainous parts of the island we visited, we were told that trails led in most directions between the villages, but that the local natives were often loath to divulge their whereabouts. The traveler was led by a rough circuitous route when the most direct was bad enough.

Probably the greatest drawback to travel is that local natives can not be depended on to carry; they may or may not do so, making indentured carriers necessary. And then one can not depend on local food. There may be an abundance of it, or, after an orgy of dancing and feasting such as delight these people, they may be short of food

themselves, much less have any to spare for a traveler's carriers. In the interior of New Guinea one can expect nothing from the country in the way of food or transport. Some may be forthcoming, but it is sporadic, and it may not be forthcoming at all. Any expedition that attempts to depend on them is courting disaster!

Thus food has to be carried. An indentured boy's ration is stipulated by the government as one and one-half pounds of rice (or its equivalent) per day, a pound of meat a week and a few incidentals, including tobacco. A boy carries forty pounds. Carrying rice, he has enough food for twenty-six days or could go thirteen days from his base, saving half the food for the return, but landing no cargo. If one boy carries food and one cargo there is enough for both to go about seven days and return. Of course the carriers take fewer days returning empty-handed, and sometimes a little native food is available, but relaying of supplies is necessary when working far inland and the above shows the difficulties involved. In New Guinea traveling is usually done in the morning and camp pitched before noon. This is to take advantage of the weather, for here the mornings are usually fine, and rains come on in the afternoon.

Mt. Albert Edward was chosen as our final objective, chiefly because a well-graded road for pack animals, made by the mission, extended from the coast to Ononge, nine days inland. Ononge was within a few days of Mt. Albert Edward. Father Dubuy had been to the summit of the mountain twice and several patrol officers had visited it. Mr. Middleton made a patrol to Mt. Albert Edward just before we went up and made a compass traverse and sketch map, of which he very kindly supplied us a copy. Mr. Middleton made what will probably stand as a record for some time on his descent from Mt. Albert Edward. He descended from the Mt. Albert Edward camp at Gerenda to Ononge in thirteen and one-half hours.

We had been fortunate in getting Mr. Adamson to undertake our transport. He had a homestead at Baroka, on the mainland opposite Yule Island, and only an hour away from water transport. This had been the headquarters of the government mule train which used to supply the Kambisi Police Camp with food before its gardens made it largely self-supporting, and here we made our headquarters.

Here Adamson had five mules and three horses and we bought two more horses from a near-by plantation. With these pack animals many of the worries of feeding a large number of carriers were avoided.

These pack animals would get us as far as Ononge, but indentured carriers were necessary for the final lap from Ononge to Mt. Albert Edward. Gossiago boys from the d'Entrecasteaux Islands are considered the best labor in the Territory of Papua, but the delay and expense involved in securing them made us decide to get boys from the Bamu River in the Western Division. Thus we would be independent of local natives, and if none volunteered we would be able to relay our goods from camp to camp. We ordered sixteen Bamu boys from a recruiter. They proved very satisfactory as carriers, being always willing and cheerful, but any more complicated task about camp was rather beyond them.

As no Malays or Orientals are admitted to this territory, personal boys and a cook were signed on from Hanuabada near Port Moresby. But the morale and stamina of these Hanuabada boys were not equal to the mountain trip. They were unable to stand the ordinary short stages of daily travel, and the first night at 1480 meters cried from fear and cold (in spite of having been issued two woolen shirts and two blankets apiece, as were all the boys that we kept at high altitudes).

They were replaced by boys from the Gulf Division (Orokolo, Moto Moto and Moviave) who had been signed on as carriers. Gulf boys are notorious for their uneven temper and being difficult to handle, but we found them very intelligent, if not always willing, and they had remarkable stamina. Although they lived in a tent for a month at 2840 meters and another at 3680 meters, during which time we experienced several periods of rather bad weather, we had only one short case of sickness amongst them.

Foodstuffs and trade goods were easily procured in Port Moresby, where the merchants were accustomed to outfitting prospecting parties going into the interior. Once off the coast, money was useless except about the mission stations. Payments were made in goods; knives, axes, red calico, salt, dry yellow ochre for face paint, beads and razor blades were in demand. We took our first lot of supplies with us, having later consignments sent to Yule Island by the regular coastal steamer. Adamson then brought them to Baroka and relayed them to our camps. On our first arrival at Yule Island our supplies and gear amounted to over five tons. It looked like an appalling task to transport this by mules and carriers into the mountains.

We intended to hurry on to our highest camp, collect there first and then work in the lower altitudes. We arrived at Yule Island on March 30, but it was not until June 14 that camp was established at Gerenda

on Mt. Albert Edward at an altitude of 3680 meters. On June 21 we first climbed to the top of this mountain. Gerenda was fifteen days actual travel from the coast, the rest of the time being taken up with waiting for carriers and one relay of supplies.

Our work in the Western Division was carried on near the coast and there was little trouble with transport. Mr. Woodward, Dr. Vernon and Mr. Beach, each at various times supplied us with water transport to Benituri, Wuroi and the mainland opposite Daru.

The camp farthest inland, Wuroi, was only 10 kilometers from water transport, and this was over a well-made road. A light spring cart was available and this we used to transport supplies, a few indentured laborers supplying the power.

Living conditions were very comfortable in this section, as Mr. Beach kindly allowed us the use of the Oriomo Oil Company buildings.

SUMMARY OF THE MAIN TYPES OF HABITAT

In traveling from sea level to the mountain tops in southeast New Guinea, we passed through several main plant associations which appeared to be correlated, in part at least, with altitudes.

The following is a summary of the conditions encountered between Yule Island and Mt. Albert Edward. Though the extent of the habitats varies in different places, this summary will serve as a broad outline for a typical cross-section of conditions in much of southeast New Guinea.¹

Opposite Yule Island, between Cape Possession to the west and the point at Delena to the east, are several types of beach formation. These vary from the mangrove swamp we found along the Ethel River to sand beach, with its accompanying groves of cocoanut palms, to low hills, covered with grass, savanna or low, dry-appearing forest coming directly out to the sea. On the coast and a certain distance inland is probably the most densely populated belt of country in New Guinea.

The lowlands opposite Yule Island are occupied in part by a fresh-water marsh of some extent and in part by the western end of an extensive savanna area. This savanna extends along the coast eastward to Rigo, about its eastern limit.

Along our route inland from Yule Island the savanna did not extend above 130 meters, but near Rona, inland from Port Moresby, the savanna extended upwards to at least 700 meters. Lane Poole² gives

¹ Lam, 1934, *Blumea*, I, pp. 116-124, has outlined the extent of the primary plant formations in New Guinea.

² 1925, "The Forest Resources of the Territories of Papua and New Guinea," Government Printer for the State of Victoria, Australia, p. 5.

instances of the savanna extending up to an altitude of about 1700 meters, to the lower edge of the subtropical zone.

Near Kubuna the continuous rain forest extends down to about 100 meters, with of course humid forest extending out into the savanna along the streams and in wet situations. Where the savanna extends higher onto the hills the rain forest of course is pushed back accordingly. Inland from Kubuna the rain forest extends up to about 800 meters, broken only by occasional small villages and their gardens. In this belt population is scanty. The abandoned gardens grow up to secondary brush and no grasslands are formed.

From about 800 to 2000 meters in the valleys of the Auga and the Vanapa Rivers, but not in that of the Chirima River, there are large areas of grassland and second growth, making extensive islands of open ground in the sea of forest. In the Auga and Vanapa valleys this belt is the most heavily populated area, but population is scanty in the Chirima valley. Apparently these mountain valley grasslands are formed by burning. That burning is necessary to maintain them is shown by the continual encroachment of shrubs and trees that goes on in these grasslands.

The old garden land at the upper edge of this belt, around 2000 meters, is replanted to the edible mountain pandanus, resulting in large, nearly pure stands of these plants. The recently described extensive grass areas in the Mt. Hagen section of northeast New Guinea¹ may be primary, but such is not the case in the areas we visited in the south-east.

Landslides are common on the steep mountain slopes and the original habitat of the open ground forms confined to the mountain valley grasslands may well have been the clear places left by the landslides. The forest continues around, and completely encloses and isolates these mountain valley grasslands. Here the mountain ranges begin to be well marked; the chaos of broken foothills is left behind.

The forest continues upwards, unbroken, until on top of the Wharton Range in Murray Pass alpine grassland appears at about 2800 meters. The top of the Wharton Range gradually increases in altitude going toward Mt. Albert Edward, with alpine grassland covering most of the top of the range. The edge of the continuous forest rises higher and higher as it approaches Mt. Albert Edward, corresponding to the lower edge of the grassland on top of the range, until on Mt.

¹ Chinnery, *loc. cit.*

Albert Edward trees occur at about 3800 meters. This probably approximates the original timber line.

Scattered trees and stumps in the lower alpine grassland indicate that along much of the Wharton Range the timber line was higher than it is now, and has been pushed down by the action of the fires set by the natives.

The highest native village, Kuama, is at about 2400 meters, but natives continually hunt over this high country and even while we were there they often attempted to burn the grass. The country was too wet, however, for their grass fires to spread. Conditions which are dry enough for extensive burning probably occur only once in several years.

To the northwest of the Wharton Range other mountains of similar height had even more extensive areas of grassland, while the southeastern end of the Wharton Range had much less grassland than its northwestern end.

Lane Poole (*loc. cit.*, pp. 68, 69) has stated his belief that all the high country in Papua, except very steep rocky slopes, was once completely wooded, the present grasslands being the results of native-set fires.

From our observations it seems that though the extent of the alpine grassland has been increased by the burning of the forest, alpine grassland is an old, primary condition on top of the Wharton Range. The original timber line probably was at about 3800 meters, determined perhaps as much by the paucity of the soil as by climatic conditions, and even at 3800 meters the forest probably did not present a solid front, but was broken by glades and seepage slopes which could not support forest, and such conditions carried the alpine grassland lower, even as we find it penetrating into the forest to-day.

ALTITUDINAL DISTRIBUTION OF BIRDS IN SOUTHEAST NEW GUINEA

In the mountains of New Guinea, as is usual in tropical mountains of sufficient height, as one goes from the coast to the summit of the highest peaks, one passes from the heat of the lowlands and encounters progressively cooler conditions in ascending the mountains, until at an altitude of about 4300 meters one reaches the line of perpetual snow. In southeast New Guinea frost occurs and ice forms during the night at 3680 meters, but the peaks are not high enough to be snow-capped.

The large area of these mountain masses, as compared with the extent of the lowlands, has resulted in the evolution of many forms

peculiar to the higher altitudes, and some of these are restricted to rather narrow vertical limits. A general survey of this distribution, correlating the data obtained from the study of both plants and animals, is contemplated. The collections are still in the process of being worked out, but from the preliminary studies, and those of the birds in particular, some conclusions already have been reached.

Though these conclusions are based largely on our own mountain work in a small area, this has the advantage of a personal knowledge of conditions. And a personal knowledge of the conditions under which the material was collected is of immense importance in understanding the perplexing problems of altitudinal distribution. Stresemann¹ has discussed the altitudinal distribution of birds in New Guinea, but he had little data on distribution above 2000 meters. The 1933-1934 Papuan Expedition's mountain work was planned to give an opportunity for intensive study of distribution at these higher altitudes, and we have been well repaid by the results.

Besides determining the zonal limits for the species of the higher altitudes we discovered cases of altitudinal differentiation in a number of species. Some of these conform to the Bergmann rule, that individuals from the higher altitudes are larger in size than individuals of the same species from the lower altitudes. Some cases of altitudinal variation show the influence of the principles of zonal distributions as outlined by Dr. F. M. Chapman² for South America; that is, there is a critical altitude at which there is a sudden change in the character of the species.

Stresemann (*loc. cit.*) writing in 1923 of the subspeciation of lowland birds, which alone is comparatively well known, says that spatial isolation is an important if not the only factor in the formation of races. But he also points out that by ascending the same valley one can find a change from one subspecies to another, as in *Pitohui kirhocephalus* and *Myiolestes megarhynchus*. Possibly these are altitudinal subspecies.

However, Sharpe,³ described *Lonchura scratchleyana*, which has proved to be the mountain representative of *L. caniceps* in southeast New Guinea, and DeVis⁴ described at least one honeyeater, *Ptiloprora perstriata*, which our work has shown to be a mountain representative of *P. guisei*. Ogilvie Grant described two mountain races of swifts of the genus *Collocalia*.⁵ Hartert considered that a number of species in

¹ 1923, Arch. f. Natur., LXXXIX, Heft 7, pp. 7-15.

² 1926, Bull. Amer. Mus. Nat. Hist., LV.

³ 1898, Bull. Brit. Ornith. Club, VII, p. 9.

⁴ 1896-97, Ann. Rep. Brit. New Guinea, p. 86.

⁵ 1914, Bull. Brit. Ornith. Club, XXXV, pp. 34, 35.

New Guinea had lowland and mountain subspecies. He held that *Peltops montanus* and *Syma megarhyncha* were but mountain races of *P. blainvillii* and *S. torotoro*, and possibly this view is correct.

Nevertheless, the question of altitudinal differentiation and of subspecies representing each other altitudinally has received very little attention in New Guinea, despite the great amount of ornithological interest that has centered about the island. Possibly the great amount of lateral differentiation that exists has obscured the fact that this altitudinal variation occurs. We found a number of additional examples of both grassland and forest birds which have become differentiated at different altitudes; in some cases, into very distinct subspecies; in others into slightly different forms, though the difference is too small to be used in separating the populations from different altitudes as subspecies. Probably when the other high mountains in New Guinea have been thoroughly explored, and the collections critically examined with this idea in mind, many more cases of altitudinal variation will be found.

Restriction to a certain type of habitat and consequent isolation may seem to play a part in the formation of races, of grassland species, as in *Synoicus ypsilophorus*. This quail has a lowland race, a larger race in the mountain valley grassland, and the largest race is found in the alpine grass. *Megalurus timoriensis*, showing slight modifications, at different altitudes has a similar distribution. *Lonchura caniceps caniceps* was collected only in the lowlands, *L. c. scratchleyana* only in the mountain valley grassland.

In the areas we visited these races were isolated from their nearest relatives, isolated in their grassland habitats by barriers of forest.

But that this isolation alone is responsible for their differences is not probable when we consider that from the alpine grassland one can look down into the grassland of the mountain valleys but a few kilometers away; that the distance between the latter and the lowland savanna is in places but little more; that the mountain valley grasslands are secondary in origin so that each one must have been colonized separately from another, while the grassland of another zone was not farther away. It seems that the isolation caused by the forest barriers between these grasslands of different zones is not alone responsible for the formation of these races. In the places where the grassland of the lowlands (as savanna) extends up to 1700 meters, so that the mountain valley grassland and the lowland grassland are continuous, it will be

interesting to compare the altitudinal distribution with that in areas where there is the barrier of forest.

Some species of savanna and grassland birds also show altitudinal distribution. *Anthus gutturalis* and *Lonchura monticola* are restricted to the alpine grasslands, though these birds have comparatively good powers of flight and are near enough to see the mountain valley grassland. *Lanius schach* and *Saxicola caprata* are confined to the mountain valley grasslands which they have colonized.

Lonchura grandis occurs both in the lowlands and in the mountain valley grassland, as does *Trichoglossus ornatus*, largely a savanna species. Evidently the barrier of forest has not been enough to prevent the upward spread of these last two. But the upward extent of the savannas determines to some extent the upward limits of some species. At Kubuna, where the savanna stopped at 100 meters, a number of savanna species, such as *Myiagra rubercola*, *Melithreptus lunatus*, *Colluricincla harmonica*, etc., did not go higher, but at Rona, where the savanna went to more than 450 meters, these birds were common. In this case the altitudinal distribution was correlated with the upward extent of a type of vegetation. However, some species, such as *Cisticola exilis*, and many which frequented the edge of savanna and the edge of the gallery forest, were restricted to the lowlands.

Salvadorina waigiuiensis found its optimum conditions on the alpine lakes in the grasslands above 3500 meters, but we also found it on a little forest-fringed pond on Mt. Tafa at 2400 meters. It has also been recorded on the Aroa River at about 900 meters, but is unknown from the many streams, ponds and swamps of the lowlands.

Pomareopsis bruijnii, a bird of the little, forested, mountain streams, is unknown above about 2000 meters, though the habitat continues upward.

Collocalia fuciphaga feeds over the alpine grassland and is also common down to the lowland savanna near the coast; *C. esculenta* is more of a forest bird, but is common at 3700 meters over the edge of the grassland, and was found feeding down to the savanna at Rona, 450 meters, though it was not found in the lowlands. There is no break in the ranges of these species, but the specimens of the latter from the higher altitudes differ from those of lower altitudes in their larger size.

Hirundo tahitica is said by the missionaries to appear in the mountain valleys only after mission houses are erected to give them nesting sites, thus depending on a man-made habitat, but I was told that these birds also appeared after the missionaries had taken over a native house

to be used by the mission, so that this supposed correlation requires confirmation.

In the continuous forests, where no breaks whatever occurred, we found several cases of species differing at different altitudes. In some cases these differences are slight, as those between the populations of *Pachycephala griseiceps* and *Myiolestes megarhynchus* at sea-level and the populations of these two birds at 1250 meters. It is worthy of note here that what may be an altitudinal race of the latter was separable in the Sepik area (Stresemann, *loc. cit.*).

The specimens of *Poecilodryas sigillata* from 2400 meters were somewhat smaller than those collected at 3680 meters, and the *Sericornis nouhuysi* populations from these two altitudes differed. In these two cases the birds from an intermediate altitude were intermediate in characters. But in other cases, as in that of *Melidectes belfordi*, in which the 2000 meter bird is definitely smaller than that at 3680 meters, and that of *Ptiloprora guisei*, in which the 3680 meter bird is distinctly differently colored as well as being larger than the 2000 meter bird, the birds from the intermediate altitudes, 2400 and 2800 meters, are not intermediate in character but definitely have the characters of the form from the lower altitude.

In these cases the zone of intergradation, if there is one, probably occupies a very limited area. The distance between the two camps, one at 3680 meters, the other at 2840 meters, could be covered on foot in a little over three hours. It is certainly not more than eighteen kilometers. No break whatever occurs in the continuity of the forest habitat along the sides of the range. Isolation of habitat does not exist. The range of these two mountain forms on Mt. Albert Edward is only a few square miles in area, but apparently DeVis described these same high altitude forms from the mountains to the southeast; probably they will be found on other peaks of sufficient height in southeast New Guinea. In contrast to this restricted distribution the smaller, lower representatives have a wide distribution in southeast New Guinea.

These seem to be cases in which the species, above a certain critical altitude, appear suddenly as a different form. Since these birds are obviously derived from lowland ancestors, there seems to have been a critical altitude above which they have changed, probably due to a climatic stimulus, the decreased temperature. This is in accord with Chapman's findings (*op. cit.*) in South America.

From these races which represent each other altitudinally it is logical to turn to a discussion of such altitudinal forms as those of *Syma*

and *Peltops* (see above). But when we come to the very similar *Neopsittacus pullicauda* and *N. musschenbroekii* we find that, while their altitudinal distribution is different, their vertical ranges overlap; *Erythrura papuana* is very similar to *E. trichroa*, but the altitudinal range of the former seems to be entirely within that of the latter. A host of other cases comes to mind of other genera with very different altitudinal representatives. The fact that forms are altitudinal representatives neither proves nor disproves their status as species or subspecies. If their ranges do not overlap and if intergrades are not known, the only criterion that can be used is that of degree of difference and it must be applied in these cases just as in cases of lateral distribution.

There are of course many cases in which the altitudinal ranges of generic representatives overlap or that of one is contained within that of another. The fact that there are a number of cases in New Guinea of altitudinal representatives showing varying degrees of difference, from those too slight to name to those marking very distinct species, as well as the fact that these changes may occur at a critical level, as we have shown in two cases, is a starting point for speculation on the origin of the endemic mountain fauna in New Guinea. That most of the endemic high mountain fauna was derived from lowland forms is evident and the effect of temperature, acting as a stimulus to change, may be the explanation of its origin.

Habitat preferences may affect some forest species, as they do some grassland species. The mangrove association is often pointed out as having species restricted to it, but in our work in south and southeast New Guinea, we found only two birds, *Myiagra ruficollis* and *Myzomela erythrocephala*, common in the mangrove formation and restricted to it. One species at least, *Megapodius reinwardt*, was restricted to the forest in the vicinity of the coast, rarely straggling inland to Kubuna.

Adaptability in feeding habits may limit the altitudinal ranges of some species. Flowering and fruiting trees are abundant to timber line, but of course they are quite different from the flowering and fruiting trees of the lowlands. The upward limit of some of the species of pigeons of the genus *Ptilinopus* may be limited by the upward extension of the abundantly fruiting large fig trees, but one species, *P. r. bellus*, is common at 2800 meters as well as at 1250 meters. Another fruit-eating pigeon, *Columba albertisii*, was found near sea-level, common at 2800 meters and it occurred even at 3680 meters, though most pigeons do not occur above 2000 meters. Macgregor's bird of paradise

(*Macgregoria*) appears to feed largely on the fruits of a taxad found only at the highest altitudes, and its distribution may perhaps be correlated with that of the taxad. Cassowaries, depending on large fruits of forest trees, are common at 2800 meters and their upward range may be limited by the lack of large fruits above this. Four species of *Myzomela* fed about the flowers of the *Albizzia* trees at Mafulu (1250 m.), but only one of them, *M. rosenbergi*, ranged above 1700 meters, and this was common in the forest to timber line. Adaptability to the food supply may be a factor in limiting the altitudinal range of species, but the limits of the food supply may in turn be limited by temperature.

If *Aepyodius arfakianus* does not range above 2400 meters because the temperature is too low for its eggs to hatch, there still remains the question as to why it does not range lower.

The effect of the progressively decreasing temperature, due to increased altitude, is probably the single most important factor in limiting the altitudinal distribution of bird life.

The limits of the zones we set off below are not sharp lines. Different species stop at different levels. Some stop suddenly on the mountainside; others, spreading upward and downward from their area of greatest abundance, gradually become scarcer before disappearing. The zonal limits represent the line drawn through the area of merging of two faunae. And also it must be kept in mind that local conditions will modify the altitudes of these limits. Different slopes and exposures may cause the limits to vary within a very short distance.

Lane-Poole,¹ in discussing the vertical distribution of forests in the Bismarck Mountains, points out that the mid-mountain forests (= forests of the subtropical zone) of the Mandated Territory come a great deal lower there than they do in the Territory of Papua.

Lane-Poole (*loc. cit.*) from a study of the flora of Papua has fixed on the following altitudinal limits for the different types of humid forest:

Lowland forests	0- 1000 feet
Foothill forests	1000- 5500 feet
Midmountain forests	5500- 7500 feet
Mossy forests	7500-11000 feet
Alpine forests ²	over 11000 feet

¹"The Forest Resources of the Territories of Papua and New Guinea," p. 63, Government Printer for the State of Victoria, Australia. 1925.
²The use of the term "forests" for the alpine grasslands requires explanation. Lane-Poole, *loc. cit.*, pp. 65-68, believes that practically all the alpine grassland in Papua has been forested and since denuded through fires set by man. He retains the term "forest" for this association.

Stresemann,¹ in discussing the altitudinal distribution of bird life in ex-German New Guinea gives names to various strata characterized by certain groups of birds as follows:

Lowlands

Lower mountain forest zone up to 6-700 meters

Middle mountain forest zone 800-1500 meters

Upper mountain forest zone above 1500-2000 meters

Later, pp. 11-15, in discussing the ranges of birds over New Guinea, he considers their distribution as falling into two groups:

1.—Forms of the lowlands and lower mountain slopes.

2.—Forms of the upper mountain zone.

From our collections and study it appears that the single biggest change in the character of the bird life occurs near 1700 meters. This corresponds with the line between Stresemann's lowlands and lower mountain slopes, and his upper mountain zone. It is also about the altitude at which Lane-Poole found the change from the foothill forest to the mid-mountain forest.

Though the lowland tropical avifauna below 1700 meters and the montane fauna above this limit are the most clearly distinct, and with little overlapping, the simple division of the avifauna into tropical and montane is not sufficient to bring out the character of altitudinal distribution within the montane fauna. Our work in the tropical zone did not provide us with data enough to determine altitudinal distribution within that zone, so we must depend on a comparison of our collections at 1250 meters and at 100 meters and the summary of distribution presented by Stresemann (*loc. cit.*).

In working out these altitudinal zones and comparing them with the zones recognized by Chapman in South America,² the correlation was so marked that it seemed advisable to use the zonal names employed there, substituting "alpine" for "paramo," however, for the highest zone.

TROPICAL ZONE, 0 TO 1500-2000 METERS.

In addition to the lowland and foothill forests of Lane-Poole this includes the savanna and probably the mountain valley grasslands. Subdivisions of this can be recognized as:

Lowlands to the base of the foothills

Lower tropical up to 600-800 meters

Upper tropical 600-800 up to 1700-2000 meters

¹ 1923, Arch. f. Natur., LXXXIV, Heft 7, pp. 8-10.

² *Op. cit.*

Our Kubuna camp, 100 meters, was in the lowlands; Baroka, 30 meters, and Rona, 450 meters, were largely savanna camps; Mafulu, 1250 meters, was in the upper tropical.

SUBTROPICAL ZONE, 1500–2000 METERS UP TO 2300.

The lower limit of this zone is indicated by the lower limits of the morning clouds. This zone is rather narrow in extent. It is composed of comparatively open forest containing the largest and finest trees in Papua. We collected in this zone at our camp on the east slope of Mt. Tafa, 2070 meters, and we collected downward into this zone from the 2400 meter camp on the west slope of Mt. Tafa.

TEMPERATE ZONE, 2300 METERS TO 3900 METERS.

This zone's lower limit was at the lower edge of the mossy forest, its upper limit at the tree line. The lower part below 2800 meters, was much richer in species than the upper part so that perhaps it is advisable to recognize a lower temperate zone, 2300–2900 meters; and an upper temperate zone, 2900–3900 meters.

Our 2400 meter camp on the west slope of Mt. Tafa was near the lower edge of the zone; the 2840 meter camp in Murray Pass was near the lower edge of the upper temperate, and from our Mt. Albert Edward camp at 3680 meters we collected in its upper edge.

ALPINE ZONE, 2800–3200 UPWARDS.

This is the alpine grassland of the top of the ranges. We collected in this from both the Murray Pass and Mt. Albert Edward camps.

RESULTS OF THE EXPEDITION

The collections consist largely of vertebrate animals and vascular plants, though the lower orders of plants are also represented.

The following is an approximate list of the number of specimens collected in each department:

Mammalogy	850 specimens
Ornithology	3200 “
Herpetology	530 “
Ichthyology	130 “
Botany	2500 numbers, composed of about 15,000 specimens.

The animal collections are deposited in the American Museum and the division of the scientific material is assigned as follows:

Mammalogy	G. H. H. Tate and Richard Archbold
Ornithology	E. W. Mayr and A. L. Rand
Herpetology	G. K. Noble and C. F. Kauffeld
Ichthyology	J. T. Nichols and H. C. Raven

The plant specimens have been presented to the New York Botanical Garden, and Dr. E. D. Merrill has undertaken to distribute the various groups to specialists for their reports on the material. The publication of the studies on the botanical material has not yet been arranged.

The study of the animal forms has been progressing steadily and it is hoped will soon be ready to go to press.

Much new data on the distribution, ecology and habits of the various forms have been recorded, the range of many species has been extended, and in the study of the collections there has proved to be a number of forms hitherto unknown to science.¹

The results of the present expedition show clearly that New Guinea still affords a fertile field for zoological exploration and it is with the assurance of a rich opportunity for further research that future expeditions may go into New Guinea.

ITINERARY

The following are the detailed accounts of our travels in New Guinea, the descriptions of the country passed over and our collection stations.

TRIP NUMBER ONE, FEBRUARY 28, 1933, TO DECEMBER 27, 1933

ROUTE.—Port Moresby to Rona and return. Then Port Moresby to Yule Island, inland to the top of Mt. Albert Edward, Wharton Range and return by the same route.

PERSONNEL.—C. J. Adamson, R. Archbold, L. J. Brass and A. L. Rand.

ITINERARY.—R. Archbold and A. L. Rand arrived in Port Moresby on February 28 on the ss "Lurline" of the Matson Line, and L. J. Brass arrived on March 2 by the Burns Philip and Company's ss "Macdui."

While waiting to make arrangements for the mountain trip, we went by motor lorry to Rona, collecting there until March 17. On March 18 we returned to Port Moresby. Here C. J. Adamson joined us, stores were procured, and on March 30 we went to Kairuku, Yule Island. A coastal boat makes this run regularly, but to suit our convenience we chartered a small power boat called the "H. & S." At Kairuku we met the Assistant Resident Magistrate, Captain Thompson, and the officer in charge of the Kambisi Police Camp at Mondo,

¹Two new fishes have already been described. 1934. *American Museum Novitates*, No. 755.

Mr. S. G. Middleton, the latter being down to the coast because of sickness.

Captain Thompson loaned us a large canoe in which we loaded our gear and supplies, amounting to over five tons. This we had towed across Hall Sound and up the Ethel Creek. On April 1 our first stores were landed at Aropokina, the mission landing, but on subsequent occasions supplies were brought to Bioto on Bioto Creek.

Both landing places were about an hour's walk away from Baroka, which was to be our base camp.

Baroka had been the headquarters of the government mule trail that used to supply Kambisi Police Camp and was not far from the road made by the members of the Mission of the Sacred Heart. This is a well-graded road over which supplies were taken by pack animals to the mission stations as far as Ononge and was to be our road into the mountains.

A few days were spent in getting our gear from Aropokina by mules and local carriers and in sorting equipment. The arrival of our indentured carriers was delayed and Brass went on to Diene by pack animal to collect plants, while Rand collected around Baroka until April 27.

On April 28 Adamson, Archbold and Rand, with mules and a few carriers indentured locally—for the carriers we had ordered had not arrived—started for Ononge, stopping at Kubuna, April 28; Diene, April 29; Madiu, April 30; Matsika, May 1; Deva Deva, May 2; Bella Vista, May 3; Mondo, May 4. Here we rested one day as guests of Mr. Middleton, then on to the mission rest-house on Mt. Tafa which was kindly placed at our disposal, and arrived at Ononge May 7. Here Father Dubuy, in charge of the mission station, made us warmly welcome and insisted that we stay a day with him.

The next day, May 9, we retraced our route two hours to Nimode, on the east slope of Mt. Tafa, where we made camp in the edge of the heavy forest. Adamson returned to the coast for carriers and supplies. Fortunately native food—chiefly sweet potatoes, pumpkins and sugar-cane—was common and a large supply was purchased from the natives. This saved our rice supply for the other camps.

Archbold and Rand collected at this camp until June 5. On this date Adamson arrived from the coast with mules and the overdue carriers; Brass having arrived in the meantime with one mule and local carriers.

We moved on to Ononge on June 6 where we again enjoyed the hospitality of the Ononge fathers. The graded track ended not far beyond Ononge so that mules had to be left here.

We were fortunate in securing about 40 local carriers here, and Adamson and Archbold went on with them to Urunu and then to Ero Creek at the foot of the Wharton Range where they established camp.

Brass and Rand followed a day later with the Bamu carriers, arriving at Urunu June 9, meeting Adamson on his way to the coast for more supplies, and reaching the Ero Creek camp on June 10. Here again we were supplied with native food.

The next day with the Bamu and a number of local carriers we took part of our gear to a camp in Murray Pass. The Bamu carriers returned to the foot of the range and after one day's rest carried the last of our gear to Murray Pass.

In the meantime Archbold and Brass, with the aid of Kuama carriers from the Chirima Valley on the other side of the range, had gone on to Gerenda, the camp site below Mt. Albert Edward. Fortune favored us in having these people carry. While we were at Ononge there was a Kuama man there whom Father Dubuy persuaded to act as our guide as far as Murray Pass and then to go on to his village and bring us carriers and food. The curiosity of these friendly people, who only occasionally had seen a white man and never collectors, was probably as strong an inducement in bringing them to us as were the knives and cloth we offered as payment for their services.

On June 14, Rand with the Bamu carriers went on toward Gerenda, the camp below Mt. Albert Edward, camping at a bark shelter above Kuama because of the exhausted condition of the carriers, due to the altitude. Archbold and Brass had also camped here the day before to avoid an icy rain storm.

The next day, June 15, it took only two hours to reach Gerenda, where Archbold and Brass had already established camp. The Bamu carriers were sent back to Ononge, where they would be able to buy native food, and they were to come in again on Adamson's return, to carry our equipment back to Murray Pass.

We stayed at Gerenda until July 12, twice visiting the summit of Mt. Albert Edward. The Kuama people visited us a number of times bringing much native food.

On Adamson's return with the Bamu carriers, we again secured the services of about 40 of the Kuama people as carriers, and returned to Murray Pass on July 13 where we set up camp on the north side of the valley on Mr. Middleton's old camp site.

The Bamu carriers were again sent down to Ononge, though local food was becoming scarce, and Adamson once again went to the coast. At Murray Pass we stayed until August 16. Again the Kuamas brought local food. At one time we had nearly a ton of it in the tent. This supply of native food made our continued stay on the Wharton Range possible. Without it our supply of rice for the boys would have been exhausted and our descent to Ononge imperative.

With the Bamus and about 45 Urunu carriers, we went down to Urunu on August 16, and on to Ononge on August 17. Once again we were on the graded road, and with pack animals transport was comparatively easy and certain.

After a few days' rest as guests of the mission, we finally established camp on the west slope of Mt. Tafa at 2400 meters, near the mission rest house, on August 21. We stayed here about 35 days, making one trip to Mave three hours to the west, September 6-8.

Adamson returning with mules, we went back to Mondo on September 26, Bella Vista on September 27 and made camp in the government rest house near Mafulu on September 28. Here we collected until November 20, visiting the Auga River below camp and the top of the ridge above, a range of about 1000 meters. Most of the Mafulu specimens, however, were secured within a few hundred meters of the altitude of camp; those obtained from markedly different altitudes were so labeled.

On November 20 we left Mafulu, went to Deva Deva November 21, and to Matsika November 22, where Rand stayed until November 24 in hopes of getting desirable mammals from the local people, Kuni, who are supposed to be good hunters.

On November 25 Rand went on to Kubuna, where Brass had camp already established in the government rest house, Archbold having gone on to the coast. At Kubuna we collected for twenty days.

On December 17 Brass and Rand went on to Baroka and met Archbold. Then, on the nineteenth we went to Yule Island where we packed part of our collections. On December 27 we took the rest to Port Moresby to pack there.

DESCRIPTION OF THE ROUTE.—(Note: collecting stations are described in the order they were first encountered rather than that in which we worked them, for we started at the highest camps and worked down).

PORT MORESBY.—This is the capital of the Territory of Papua, a town of about 350 whites. Built on the neck of a small peninsula it has good harbor and deep water close in shore, so that ships of more than 3000 tons can come alongside the wharf.

The shops are accustomed to outfit miners and prospectors, so provisions were easily obtained. The large group of native villages usually referred to collectively as Hanuabada was on the shore, three kilometers to the west and there were few small native villages to the east. The town with its white, red-roofed buildings and ornamental trees, some of which bore brilliant flowers, had a rather pleasing appearance from a distance. Low hills came out to the coast, and reefs and a few small islands are strewn through the near-by coastal waters. The hills are largely covered with rather low open savanna, with scattered areas of rain forest, especially in the little valleys and gullies.

Our arrival in Port Moresby at the end of February was near the end of a wet season during which we were told an unusual amount of rain had fallen. The rainfall at Port Moresby for the period from 1922 to 1931 has varied between 464 mm and 1465 mm per year, with between 55 and 111 rainy days a year. The average annual temperature has varied during the same period between 26 and 27 degrees C.

PORT MORESBY TO RONA.—Rona is about 40 kilometers by motor road inland. The road traversed undulating to hilly country as far as Sapphire Creek about 32 kilometers inland and not far above sea-level. Then the road climbed by a devious route to Rona above the Laloki River. The road was said to be passable the year round, but the last few kilometers needed constant repairs during the wet season because of frequent landslips and washouts. Several rubber plantations were situated inland beyond Rona. Provisions for them were taken in the next few kilometers by mule train and then transferred to motor lorries, which had been brought in over the trail now used only for mules. This was the start of the overland mail route to Buna *via* Kokoda. The police with carriers took eight to ten days for the trip, crossing the divide at an altitude of about 2500 meters.

From Port Moresby to Sapphire Creek the country was largely open savanna, mostly of low trees 4–7 meters high. Probably this had been originally somewhat higher, as the presence of a few larger trees, 12–

15 meters high, indicated; but the savanna trees had been cut for firewood for Port Moresby and for use in the copper mines that used to operate a short distance to the south. For the most part the trees were rather scattered, a few cycads occurred and dense grass covered the ground. Near the Twelve Mile were a few swampy areas, some with very tall grass 3-4 meters high; farther inland fringes of gallery forest appeared. From Sapphire Creek the mountains of the Astrolabe Range rose sharply ahead and the country changed from the smooth coastal area to the steep valley of the Laloki River.

The red, rough volcanic soil was studded with dark boulders, large and small. The same open savanna country, chiefly of broad leaf and small leaf gums, obtained. Here the trees had not been cut and formed a taller stand.

RONA, ALTITUDE 450 METERS.—Rona was a relay station for the plantations beyond. This was on the Laloki River on a spur opposite Rona Falls. There was a small establishment that catered to travelers and there were two government-owned rest houses and a dining-room and kitchen that could be rented by intending visitors. It was a beautiful place, with the falls, the deep valley, the cliffs and green rain forest contrasting with the lighter colored savanna. The climate was much cooler than at Port Moresby, making a pleasant change for the inhabitants on week-end visits.

Here one could look down into the steep valley of the Laloki and up at the sterile cliffs that formed the upper part of the slopes of the valley. Above the falls the valley was much less deep and fairly broad. The river was a beautiful, swift, broken stream studded with boulders, the stream averaging 50 meters wide here. On the southeast (*i.e.*, Rona) side, scattered areas of rain forest stretched along the cliffs and very steep slopes, interrupting the savanna, and were joined to the fringe of rain forest along the river by way of the gallery forest along the small creeks. On the far side the rain forest was of much greater extent, extending from the river to the base of the cliffs. We visited only the fragments of rain forest on the southeast side of the valley. This was a rather poor forest of trees about 30-40 meters high with a fairly clear forest floor and little undergrowth, but with much secondary growth and brush along the edges. Up the river valley for a few miles was much secondary rain forest; above that was the upper savanna where again only scattered areas of rain forest and gallery forest occurred. On top of the bluff, to the southeast, at an altitude of perhaps 700 meters, where the upper savanna covered most of the country,

there were also areas of rather open rain forest in the shallow valleys. The savanna about Rona was similar to that at Sapphire Creek but further up the river, in the upper savanna, there were taller, denser stands of trees and scattered casurinas, and thickets of low trees and shrubs were fairly common. Along the river the grass was very dense and tall. On top of the bluff to the southeast in the upper savanna the trees were also rather dense, but not very tall, with a different narrow leaf gum prevailing and with an occasional casurina. The grass was mostly short and scanty and in places the ground was nearly bare.

About Rona there was a small garden area and near the dwellings and in the paddocks were clumps of very tall rank herbaceous plants.

PORT MORESBY TO YULE ISLAND.—This was a distance of somewhat more than 95 kilometers. The coastal country was low and level with low hills some miles inland; these hills extended to the coast at Redscar Head and at Delena. Cocoonut plantations were common along this part of the coast and on the edge of the sand beach were often dense stands of pandanus. Some of the hills appeared savanna covered, others had a light, dry-appearing forest on them. Mist and haze usually prevented a clear view of the mountains inland, but one early morning at Yule Island we had a clear view of the mountains inland with Mt. Victoria looming up at the end of the Wharton Range.

YULE ISLAND.—Kairuku, the government station, is here, as is also the headquarters of the Mission of the Sacred Heart. Yule Island, about 5 kilometers off shore, was about 12 kilometers long by 3 kilometers wide. It was undulating to hilly, the hills reaching 100 to 150 meters above sea-level. In places were areas of rain forest, in others grass; some of the hills were covered with a low dry forest. Here and there along the coast were cocoonut groves.

YULE ISLAND TO BAROKA.—Baroka was a distance about 20 kilometers in a direct line but was much more by river. The coast between Delena and Cape Possession was all low and flat. Opposite Yule Island was a low point covered with sprawling mangroves. Entering the Ethel River to the east of that, we passed first through an area of this low mangrove, then through the higher type of mangrove and nipa palms until we came within a few miles of Bioto on Bioto Creek, where we found a dense tangled growth. From the river it appeared to consist of tall scattered forest trees, many vines, shrubs and tall grass; apparently this was all very swampy.

At Bioto the creek was about 20 meters wide but the water was deep. Back of the village was a shallow pond about 200 meters across, containing much aquatic vegetation, and in which we saw the natives seining for fish. Leaving Bioto, and passing a few banana gardens and cocoanut trees, the trail crossed a kilometer of swamp. The dense grass on each side of the trail was five meters or more tall and the trail itself was more than knee deep in mud and water when first we crossed it. In wet weather it was said to be impossible to use this trail, a detour to the north being necessary. Beyond the swamp were the hilly savanna and patches of rain forest about Baroka.

BAROKA, ALTITUDE 30 METERS.—Here Adamson's homestead was on the edge of the hilly savanna, overlooking the low flat country to the south and west. Near at hand was a broad flat marsh, looking as smooth and green as a meadow. But when I attempted to hunt in it, the vegetation proved more than head high and I sank waist deep between the tussocks of vegetation along the edge.

A small pond, where water birds were seen disporting, showed a kilometer out in the swamp. No collecting was done in this habitat. The country south to the coast was all flat, Yule Island appearing as a low ridge. Westward, beyond the marsh and the low forested country, was a line of low hills leading out from the mountains to Cape Possession. To the northwest, areas of rain forest with many palms, and secondary growth covered the low flat ground beyond the swamp. Beyond lay low hills largely forested but with a few areas of grass and savanna, then the valley of the St. Joseph River and beyond wooded hills rose to the nearer mountains. Mt. Davison was easily distinguished by its cleft summit. Mt. Yule rose conspicuously and some of the high mountains of the interior could be dimly seen. To the east the hilly savanna, with hills a few score of meters high, shut off any distant view. The savanna was similar to the Port Moresby and Rona savanna. It is in fact a continuation of it and is nearly the western end of the dry belt with its savanna.

The savanna was open park-like country. For the most part dense grass covered the ground with taller, denser grass in the valleys and scanty grass on the ridges. Along the edge of the swamp was a fringe of rain forest which extended into the savanna along the creeks. Farther inland the rain forest was found competing with the savanna trees on the ridges. The forest was a rather poor rain forest with a few big trees, but with a great deal of low vegetation, shrubs and scrambling woody plants. Usually it was possible to force a way through the

undergrowth, but many of the plants bore spines, making progress difficult. Lawyer cane, however, was not very common.

At Kairuku the annual rainfall for the period from 1922 to 1931 has varied between 508 mm and 1671 mm with the number of days of rainfall per year varying between 17 and 113. The average annual temperature for the same period varied between 26 degrees C. and 27.5 degrees C. This is the dry belt and conditions at Baroka are probably similar, though Kubuna must have much more rain.

BAROKA to KUBUNA.—For about 20 kilometers from Baroka the stony trail led over the hilly savanna and through areas of rain forest, both in gullies and on hills. The occasional stream beds contained no running water; here and there were still pools of clear water.

In an hour and a half the graded track of the mission was reached, and in another twenty minutes the road entered the rain forest. This forest continued to Kubuna, with a small break at Wynona, an area of grass and a cocoanut grove growing up to brush, where the government mule team had headquarters for a time.

KUBUNA, ALTITUDE 100 METERS.—Here we camped in the government rest house, across the Kubuna River from the mission station. The country was still low and comparatively level, with undulating to low hills. The Kubuna River, from 20–50 meters wide, flowed over strong ripples and through deep quiet pools. An hour and a half to the east was the Dilafa River, carrying perhaps three times as much water. Many small streams had cut sharp but not deep gullies through the forest. In December many of these gullies were dry. Sudden heavy rains evidently did fill them, and caused floods as shown by traces on the banks. The Kubuna River itself rose and fell more than three meters one night in December while we were there.

About the mission station a fairly large area had been cleared and was largely grown up to Guava bush. A grassy airplane landing field had been made by the government and along the river were many sweet potato and banana gardens, with many dead trees standing in them. Along the river were areas of second growth, evidently old garden land, with trees 3–9 meters high and the ground covered with grass.

Some of the small Kuni villages, however, were in little clearings in the heavy forest. We visited no sago swamps here, but there must be extensive ones, for we saw large stores of sago in one village on the Dilafa River.

The rain forest which covered most of the country was composed of many species of trees, the largest about 1 meter in diameter, rather

slender, and reaching 30 or 40 meters in height. The tallest trees were scattered and many lower trees and saplings filled in the spaces between them. Buttress and prop roots were not very plentiful. Palms of a few species were very common, some very tall, others very slender but 2 to 5 meters high; there were a few tree ferns and a forest cycad. Lianas and lawyer cane were common, some of the latter being very long. The longest canes are those which have been blown down from the trees, and which by growing up into the trees again greatly increase their length.

Saplings and lianas formed the middle spaces; shrubby undergrowth was not common and it was usually possible to walk about through the forest without much difficulty. In some places one could see the leaf-covered ground for fifty meters or more in all directions; in others a very low woody plant, not much more than 300 mm high, grew rather luxuriantly on the forest floor. Along some of the small streams in the forest were occasional clumps of a small bamboo.

The weather here was unsettled. We had some clear days and some afternoons and evenings with very heavy rains. The streams flooded badly and quickly returned to normal after the rains.

The morning temperatures, taken at about 7:00 A.M., were between 22 and 23 degrees C.; 32 degrees C. at 2:00 P.M. was the highest recorded.

KUBUNA TO MAFULU, ABOUT 85 KILOMETERS.—The first ten kilometers were a slow, steady climb to Ikaki, altitude 390 meters, along the mission road through the same type of forest. The road was passable for motor lorries this far and mission supplies were brought from Aropokina, the mission landing on the Ethel River, to Ikaki by lorry. This was the beginning of the foothill country and we looked onto Dilafa Valley and the rugged foothills beyond; then by a circuitous route the trail led to Diene (where we slept in the government rest house), altitude 480 meters, in a small clearing in the forest. Beyond Diene the trail descended a short distance, then made a long slow climb through a heavy forest. The tall rather slender trees had an open substage of slender saplings and the forest floor was rather bare of cover.

Near Fofofoyo the forest had been cleared away from the trail and second growth and dense thickets of wild bananas had grown up. At Fofofoyo a large paddock, now largely grown up to weeds, had been cleared and here Brother John, who managed the mission pack train in the foothills, had his headquarters. Our carriers were new to their work and were not standing the travel well, so we camped under can-

was at Madiu, altitude 750 meters. This had been a government mule train paddock. It was three hours from Diene. Madiu was on a hill, and from it we obtained a beautiful view of the heavily wooded foothills. Fofofoto was the only clearing in sight. There was also a view down the Dilafa and the St. Joseph Rivers onto the Mekeo Plain.

The next day there was a climb to the divide on the south of the Jakaruma River, altitude 835 meters. Many ferns, tree ferns, club mosses and wild bananas grew along the trail. From the crest of the divide we looked across the wooded valley to the Delava Mission Station. The quick descent led to the Jakaruma River, altitude 150 meters, a small dashing mountain stream barely ten to fifteen meters wide. In flood it is said to be dangerous to attempt to ford mules across. Many beautiful clear mountain rills crossed the trail on this stretch.

Next we climbed to Delava, altitude 870 meters, through forest with occasional gardens on the very steep slopes along the trail. Delava was on the end of a spur overlooking the St. Joseph Valley with a beautiful view of the country. This was foothill country and was probably some of the roughest in Papua. All about were steep valleys a thousand meters or more deep with spurs running in every direction. Travel without the mission road would have been very difficult. The whole country was heavily wooded. Here and there scattered Kuni villages of four to eight houses and their gardens could be seen on the spurs. The old gardens have grown up to bushes again resulting in no grassland, but far inland on the headwaters of the St. Joseph there showed an area of grass characteristic of the upper valleys.

MATSIKA, ALTITUDE 980 METERS.—The government rest house was an hour and twenty minutes beyond Delava. The nearly level trail along the spur was through second growth brush and old gardens. From Matsika itself it was very difficult to get into any real forest. A certain amount of native food was forthcoming both on our way inland and when I stopped here on the way out. From Matsika the trail swung far back into a valley like a vast amphitheatre, then back along the other side and around the end of the spur, altitude 1180 meters, where the trail was cut into the hillside and many landslips of various ages had carried the trail far below.

Travel is precarious during the rainy season, a slip necessitating a day or two's delay in rebuilding the trail, and it sometimes happens that the soil, loosened from the underlying rock by the rains, is started

into action by the passing of a pack train and carries a pack animal down with it.

On the first trip inland most of our troubles were due to an inexperienced horse walking too near the edge of the trail and slipping over, fortunately never very far. But later in the season Adamson on several occasions found the trail swept away by a landslide, necessitating tedious, time-consuming trail-making.

The trail descended around several small valleys covered with heavy rain forest, dense, trailing bamboo fringing its edge, into the watershed of the Kea River, a tributary of the St. Joseph, and down to the Deva Deva government rest house, altitude 770 meters.

The country immediately about Deva Deva was second growth, probably old garden land, which would make it very unsuitable for a collecting camp, but the rough steep drainage basin of the Kea appeared to be largely wooded, with the exception of a few gardens and the scars of landslides old and new. There were apparently a number of villages in the vicinity and a small supply of native food was brought us here.

Leaving Deva Deva, for an hour the trail descended by a series of zigzags through second growth to the Kea River, altitude 430 meters. The Kea was considered larger than the Jakaruma and, though easily forded when we were there, is said to flood badly and hold up the mission transport.

An hour's climb by a zigzag route through heavy forest led up from the Kea. The trail continued to rise slowly around the ends of spurs, until rounding the last spur we came into the Auga Valley near Mafulu. Up to here the view, though sometimes magnificent, had always been limited by the forested foothills; sometimes for hours one could see little but the forest close about. But here the valley was wider and more open. There were extensive areas of grass as well as second growth, and one had a view of the distant mountains. There was the feeling of being definitely up in the mountains.

MAFULU, ALTITUDE 1250 METERS.—Camp was set up in the government rest house, 40 minutes by trail west of the Mafulu Mission Station. This also had been a stopping place for the government mule trail and had been aptly called Range View. This was situated just west of where the trail swung around the last spur above the St. Joseph River and enters the Auga Valley. It was in a grassy area and one could look over the near-by steep slopes with occasional small, comparatively flat areas and far up the Auga Valley to the

mountains beyond. The river was far below at an altitude of 580 meters and the spur above rose to about 1700 meters.

Many little mountain rills cascaded down the steep gullies. The Auga River, about 45 m. wide below Mafulu, was a rapid boulder-strewn stream with a few deep pools. It carried gold and for two dry seasons Adamson had carried on mining operations some distance above here, below Mondo.

Near camp there was an area of limestone outcrop with fissures and crevices from which sounded the gurgling of running water. There were also small caves, one with a very small entrance broadened into a chamber perhaps 6 meters wide and 12 meters high. A small gallery with a stream covering the floor led about eighty meters into the hill, the gallery just big enough to squeeze through. This ended just above a deep pool of water. Other smaller galleries, which were left unexplored, led off from it. Another smaller cave, with a stream bed forming the floor, was a simple small gallery which it was possible to follow about thirty meters underground. It was in this swifts, *Collocalia fusciphaga*, were nesting.

Above the trail there were only limited areas of grass and secondary brush extending into the forest edge. But below the trail areas of grass and second growth extended far down toward the river. Across the river conditions were the same, large grass and secondary brush areas on the lower half of the valley; this condition extended some distance up the valley.

These were the first large grass areas we had encountered since leaving the savanna of the coast. These grassy areas, on which the grass was often waist high and which intergraded with the low dense secondary brush mixed with heavy grass, were probably secondary.

There was a fairly large native population here. Gardens old and new were common. The grassland was probably formed by the continued clearing of second growth for gardens, a practice which was common.

It was true that certain birds were found only in these mountain grass and second growth areas, but there certainly always have been landslips which in time developed a shrubby vegetation and this may have been the original habitat of these forms that are now found in isolated areas of suitable habitat, separated from the next by miles of forested mountains. At Matsika in the second growth along the trail, *Malurus*, usually a bird of the grassland and its borders, was found, and the natives said that flocks of grass finches were sometimes seen

there. This shows that these forms can find their way to very small areas of grasslands.

Chiefly below the trail (*i.e.*, chiefly below 1300 m.) were areas of an open, light forest. The trees were 10–20 meters high with the foliage open enough to allow the sun to penetrate to the forest floor with its scanty grass and low ferns.

These areas of open habitat were completely surrounded by heavy rain forest. Above about 1500 meters the forest was continuous, except for occasional land slides. Shortly below Mafulu, the Auga Valley was completely wooded, as it was also above Mondo.

The rain forest was of tall, often rather slender, trees 30–40 meters high and .5–1 meter in diameter, interspersed with lower trees. Occasional hoop pines, *Araucaria*, singly or in small groups towered above the other forest trees to a height of 45 meters and more. Constrictor figs, having strangled their original supporting trees and now, supported by numerous prop roots, formed huge spreading trees and were not uncommon. Small trees, sapling and scrawny shrubs formed what was usually an open substage in the forest. There were a few low pandanus and palms; a few epiphytic ferns decked the tree trunks; lianas were occasionally plentiful and here and there was lawyer cane.

Low ground cover on the forest floor was usually rather scanty and composed of low plants and a few ferns. Buttress and prop roots were not very common. The ground was covered with dead leaves, or in places nearly bare, the soil of rock rubble showing. A little moss was found on exposed roots and dead wood. Some distance above camp, where oaks were common, large acorns littered the ground.

Usually it was possible to walk about through the forest easily in the few level spots and gentle slopes, but in most places the steepness of the slopes made travel difficult.

Along the forest trail where it had been cleared there was naturally a dense secondary growth with occasional thickets of tall herbaceous plants or wild bananas.

The mission had a sawmill run by water-power near Mafulu. When we were there it had been out of operation for some time. Formerly selected trees had been cut in the near-by forest and this had left a tangled brushy area of forest.

A considerable quantity of native food was brought to us here: sweet potatoes, sugar-cane, pumpkins and some bananas. Salt, paint, beads, red calico and knives were in demand for trade.

It was impossible to interest the Kuni natives from lower in the mountains to hunt birds for us. Previous parties there, especially live bird collectors, had paid so well for the few specimens of a few species they needed that the natives would not consider the small pay we could afford to offer.

Mafulu was down below the cloud belt, but the schedule held true of clear mornings and rainy afternoons. Morning rains and completely clear afternoons were the exceptions. At Mafulu the rains were heavier than we had experienced earlier in the mountains and they sometimes continued into the evenings. Thunderstorms were common. Apparently this was the beginning of the rainy season in the mountains.

Adamson had worked the Auga River below Mondo for gold during two consecutive dry seasons and had found a great difference in the rainfall of the two seasons. During one the rainfall was light and the water level in the river low so that operations were successful. During the other so much rain fell that the river rose high enough to make mining unprofitable.

During our stay at Mafulu the morning temperature was about 19 degrees C., the maximum recorded was 26.5 degrees at 2:00 P.M.

MAFULU-BELLA VISTA, ABOUT 11 KILOMETERS.—The graded track led on up to the Auga Valley, swinging back into tributary valleys and out onto the spurs; many little streams crossed the trail. This led largely through second growth, with scattered large trees (*Albizia*). Several very large gardens had been freshly cleared in this second growth and fenced with large bamboo. There were no villages on the trail, but there were numbers but a short distance from it. Bella Vista was nearly reached before grassy areas along the trail appeared again.

BELLA VISTA, 1450 METERS.—Most of the Auga Valley slopes were rather steep, but about Bella Vista, as on the spurs on which Mafulu, Fane and Mondo were located, there was a certain amount of level or gently sloping land. There was little forest about Bella Vista; the country was covered with dense matted grass with an open stand of low trees 6–9 meters high. Pigs had rooted up some areas that had grown up to a stand of goat weed, a favorite food of quail. There was a large village five minutes above the rest house, but it was falling into decay, the villagers moving out to their small garden villages.

There was a garden just east of Bella Vista along the trail. It had been made on cleared forest land. Many of the big trees had been killed by lopping the branches rather than cutting the tree. This saved trouble both in felling the tree and in disposing of the trunk.

This was on the edge of a forest patch along the trail, a forest not unlike that of Mafulu, but there seemed a slight difference in the bird life, some species being secured here that were not seen at Mafulu. The natives here were very friendly and brought us some food. Very little field work was done here, the natives bringing many specimens.

BELLA VISTA TO MT. TAFU, WEST SLOPE, ALTITUDE 2400 METERS, 40 KILOMETERS.—To Fane, a mission station, altitude 1300 m., and then to Mondo, the Kambisi Police Camp, altitude 1480 m., the trail swung back into valleys, largely second growth and patches of forest with many gardens and then out onto spurs with tree-fern-dotted grassland.

About Fane, where there was considerable gently sloping grassland, were several little ponds. About Mondo was considerable grassland and much second growth. Mondo was a beautiful station with a bright garden of gaily colored crotons and balsams, and with blooming roses. This had been the site of a large village, the huge burial trees, said to be haunted, still standing in the garden, but now there were only a few small villages scattered about.

The heavy forest started about an hour east along the trail, and the native population was left behind. First there was second growth and scattered groves of the edible pandanus, then groves in the forest, their light green color standing out sharply against the darker forest. The trail climbed more quickly around the deep valleys, all heavily forested. At about 2000 meters the forest began to change to a higher altitude type. The trees were somewhat lower, with some moss on them, with moss-grown roots and with much trailing bamboo.

After three hours of climbing, Mave, altitude 2200 m., was reached and the next three hours to Tafu rest house, altitude 2400 m., with the highest point in the road 2440 meters, was along a comparatively level track. Several landslides of considerable volume had cut away the trail, evidently not long before, but all had been repaired. This was all through heavy forest.

MT. TAFU, WEST SLOPE, ALTITUDE 2400 METERS.—Camp was situated about five minutes west of the mission rest house. It was in a saddle formed by a dip in a ridge coming down from Mt. Tafu, which rises to an altitude of 2725 meters about 2.5 kilometers to the east. The ridge continues on west, continuing the divide, which sends out spurs to the north on both sides of our camp site, so that we were at the head of a valley with fairly easy slopes at the head but quickly changing

into a large, steep, deep valley that swung east and continued east to the Vanapa River.

To the south of camp the land dropped very sharply several scores of meters to a stream a few meters across, one of the headwaters of the Dilafa River.

The whole country was rough and mountainous, with little level land or easy slopes. A short distance west of camp, where the road crossed the spur that goes north to form the divide between the Auga and the Vanapa Rivers, one looked east over a rough wooded valley to the broad valley of the Vanapa, where some of the grassland showed and also the dark Wharton Range beyond, with Mt. Victoria as the culminating point.

To the east, across the headwaters of the Auga, the country was very rough and mountainous and almost completely wooded, except for one or two small garden patches, and the tops of the highest mountains in the distance, probably over 2800 meters, where grassland showed; Mt. Albert Edward was visible from a little farther west.

Most of the longer ridges, which are sometimes level for some distance, have native trails along them. It would be possible to travel through this country on these trails—indeed, it was done before the mission road was built—but after following a comparatively easy ridge the trail usually plunges straight down into a deep valley and then up the other side, regardless of slope.

It was from three to four hours to the nearest grassland and two hours to the nearest garden clearing. About the rest house and camp site was a small clearing with a little grass, cropped short by the pack animals, but the clearing was largely brush and bamboo. The road had the trees cleared back from 10–20 meters on each side, grown up to shrubs and a heavy tangle of bamboo; raspberry bushes were common, and when fruiting, attracted certain birds.

In some places were landslips; some fresh, others grown up to shrubs, grass and herbaceous things. Streams were naturally small on the divide; an unusual feature of Mt. Tafa, however, was the presence of two little lakes or ponds on its northwest face, one slightly above and one below the level of camp, and about 300 meters apart. An old landslip had evidently left these pockets, which have filled with water and now form the lakes, each about 80 meters long and 40 meters wide, rather closely enclosed by forest but with a little grass and shrubs along the shores; a water plant was common in them. The upper lake was said to be haunted and shunned by local natives.

The forest which covered practically all this country was of two main types, a ridge type of forest with trees 15–20 meters tall was usually rather mossy and without much bamboo, and a lower forest with trees 20–30 meters tall, sometimes with moss on the larger limbs but little on the ground, and much trailing bamboo. On the northern slope, our camp was about at the altitude where these two forests meet; but in the south, that is, the shady slope, the ridge forest goes much lower. But crossing the stream at the bottom one finds the lower type of forest on the sunny slope of the next ridge, showing the effect of different exposures to the sun. Though this was little more than eight degrees from the equator, the difference between sunny and shady slopes existed. Though prevailing winds (the shady side being the windward side) may have some effect, we saw the effect of shade on Mt. Albert Edward in June, when ice persisted much later in the day on the southern, shady side. Close study of these two habitats would probably show some difference in bird life; the most evident to us was the crested starling (*Paramythia*), which occurred only in the higher mossy forest.

The ridge type of forest, with trees 15–20 meters high, sometimes even less, has an open substage of small slender trees and slender shrubs. The forest floor was often covered with a layer of moss, though often there were many dead leaves on the ground; moss of course covered the fallen logs and there was some on the tree trunks. Lianas were not common. The ground was fairly clear of underbrush, but occasionally there were scattered stands of herbaceous plants a meter or so high.

The lower forest was a rather open stand of trees 20–30 meters high with a pronounced second story of lower trees, sometimes no more than 6 meters high, making it difficult to see to the tree tops. Some of the trees had clumps of moss on the limbs, slender saplings formed the middle spaces, lianas were fairly common, but bamboo flourished. The stems rose from the ground and so allowed one to pass through, but overhead 3 to 8 meters up the bamboo stems ran riot, forming dense mats, so that one walked as though under a roof. In these places the forest floor was covered with the dead leaves of the bamboo. In many places where the bamboo was less dense was a ground cover .5–1 meter high of shrubby *Elatostema*, making it difficult to see ground birds.

In a few places were dense thickets of herbaceous plants 3 to 5 meters high. Where the large trees were widely spaced, the bamboo mat was close to the ground, making travel very difficult. Occasional

pandanus trees occurred all through the forest. There was also a slender palm and some lawyer cane.

Going east along the trail, descending but little, one comes to another type of forest of much larger trees, somewhat taller, up to 40 meters in height and with very large trunks up to 2 meters and more in diameter. This was very similar to some of the forest at our camp on the east slope of Mt. Tafa, altitude 2070 meters. This camp at 2400 meters appeared to be at a critical altitude in the distribution of some species, with notable difference between this and the next Mt. Tafa camp at 2070 meters.

Plants were not flowering profusely, but there were always a few trees in bloom, attracting honey-eaters of four or five species, and parrots of four species and occasional other species, but fruiting trees attracted more species; aside from this there was little congregation or flocking of birds, which appeared scattered through the forest and fairly common. Many species were breeding or about to breed, but some individuals of the same species showed no indication of breeding. Some full-grown young were seen (warblers) but in September a more or less general breeding season was apparently approaching.

Here as appears usual in New Guinea the mornings were clear and the afternoons were usually rainy rather than misty; thunder storms were first noted on August 21. Cloud conditions did not appear to be the same on Mt. Tafa as on the Wharton Range, which we could see across the valley. Mist banked up on the south side of Mt. Tafa in the mornings, and only occasionally did it envelop our camp on the north side of the mountain and then it was usually in the afternoon. This possibly varies seasonally, as on our way through in May the afternoon mist closed in very dense.

It was warmer here than in Murray Pass, but the temperature was as low as 7 degrees some mornings.

MT. TAFa, WEST SLOPE, ALT. 2400 METERS TO MT. TAFa, EAST SLOPE, 2070 METERS, ABOUT 9 KILOMETERS.—The two hours travel between these camps was by the well-graded trail through heavy forest along the north slope of Mt. Tafa.

MT. TAFa, EAST SLOPE, ALTITUDE 2070 METERS.—The country was rough with steep slopes of several hundred meters and more. Streams were numerous but small and there were no swampy areas. The forest from 2000 to 2200 meters was of trees surprisingly large for this altitude, indeed it was one of the best forests we saw in New Guinea. There were large trees, 35–45 meters tall, with clear trunks, some with scaly

grey bark and trunks up to 2 meters in diameter, with of course many smaller trees between. A few pines and oaks occurred. Low trees and shrubs occupied the middle spaces; tree ferns were few; the edible pandanus was common. Liana were not very common, but the root climber *Freydenetia* with its orange flowers was fairly common as were epiphytes, including mosses and orchids.

On the ridges the undergrowth was fairly open and largely of slender woody plants and a little bamboo, the ground being covered with dead leaves and moss on the roots and stumps. In damper localities and about clearings were often dense tangles of herbaceous plants, bamboo and shrubs.

As one climbed to the top of the near-by spur, altitude 2300 meters, leading to Mt. Tafa, the trees became lower, mosses plentiful, giving a characteristic appearance to the forest, clothing ground, roots and trunks. Here was the only place we found real "moss forest" condition with prop roots covered with moss giving a springy carpet. The lower flowering trees were conspicuous; beautiful pink flowering trees about which parrots and honey-eaters fed. A pink epiphytic rhododendron was common and an occasional yellow-flowered rhododendron shrub. Orchids were conspicuous, and in this forest Brass collected more than twenty species in three days.

At lower altitudes, about 2000 meters, many areas had been cleared by cutting and burning to make native gardens. Sweet potatoes, yams, corn, sugar-cane and pumpkins were planted. Later when the soil had become impoverished it was planted to a pandanus with edible fruit.

When viewing the forest from an elevation the lighter green of the pandanus stood out sharply against the darker forest. The amount of pandanus was surprising. Toward Ononge the trail was wooded for one and one-half hours, and much of this was lined with pandanus groves. About them the undergrowth was very dense. Along the trail in the cleared spaces were ornamental plants set out by the natives.

From a garden clearing near camp a village on a spur with much second growth about it showed across a valley to the north. In the valley of the Upper Vanapa about Urunu there showed a well-grassed area of considerable extent.

The Wharton Range appeared heavily wooded from about 2000 meters to its summit. On its lower edge were recent clearings for gardens, and several times clouds of smoke were seen rising from farther

up the valley, out of sight, evidently from the burning of other clearings.

In a gap in the top of the range, Murray Pass, there showed a grassy area. Along the top of the range pine trees stood out in silhouette. Beyond rose the dark peaks of Mt. Albert Edward, with extensive areas of brownish grass.

A large number of trees and shrubs were in flower or fruit, attracting many birds. Flocking was not very conspicuous, birds being fairly common and scattered through the forest, though certain sunny spurs were favorite places in the mornings for birds, apparently attracted by the warmth and food, and not traveling as a flock. A few species of birds were breeding, but it did not seem to be a general breeding season.

At this camp mist shut in only occasionally, but in the early morning looking across at the Wharton Range we could see the stratum of clouds extending along its flanks from about 1800 to 2700 meters. Later in the day this belt of clouds lifted until its lower limit was at about 2700 meters, and sometimes in the afternoons a clear view of the mountains was obtained.

The first few days at this camp we had fine sunshiny mornings and rainy afternoons. Then we had a series of fine days, though the humidity was high. The last few days we again had rain in the afternoon.

MT. Tafa, EAST SLOPE, ALTITUDE 2070 METERS, TO MURRAY PASS, ALTITUDE 2840 METERS, 57 KILOMETERS.—For an hour and a half eastward the trail led through pandanus groves and forest that had been cut into, resulting in very tangled undergrowth. The last half hour to Ononge was over open grass country to the mission. It was amazing to find the group of white-painted, sheet-iron roofed buildings with cattle and fowl about, like a European hamlet, this far in the hills. It is a tribute to the industry of the fathers, especially Father Dubuy, who has been here twenty years.

This was in the Upper Vanapa Valley, a broad open valley with extensive areas of grass which far exceeded the areas of second growth. This grass extended far up the valley, but Father Dubuy said it was separated from the savanna of the coast by forest, this being another isolated area of grassland.

Groves of the edible pandanus were very common along the forest edge. Groves of forest trees, especially clumps of pines, were common, and of course areas of second growth were growing up, but much of the country was covered with grass knee to waist high. Little swampy areas were common, some with very short grass. Other little gullies

had tall grass, 3–5 meters high. The population was very large in this valley and extensive gardens were common.

A graded trail led down to the Vanapa Valley through grass and second growth. Father Dubuy had in mind to build a bridge over the stream which would enable pack animals to go on to Urunu and even beyond. A graded trail was under construction on the east side of the valley, but not being completed we climbed over a rough native trail for some time before reaching it.

From here past Urunu and to the camp on Ero Creek at the foot of the range, altitude 1690 meters, was the same type of grass country. Then came the steep slippery climb through old gardens and second growth, past a new garden and then into the forest to Murray Pass.

First the tall open forest had little undergrowth; climbing steeply over the trail used by Middleton we came in to a somewhat lower forest with some moss near 2400 meters, and at about 2600 meters came into a narrow belt of forest with very dense tangled bamboo undergrowth. Above this we entered the forest in which we collected from our Murray Pass camp, and at about the same altitude the trail followed along the side of the slope through more open forest, emerging shortly into the open country, where we camped.

MURRAY PASS, ALTITUDE 2840 METERS.—Our collecting station was established on the site of Mr. Middleton's camp on the north side of the pass in a hollow in the grassland, twenty minutes from and across the Ero Valley from the old camp site on the edge of the forest where we first stopped.

The Ero Creek, in a narrow deep valley, was a rapid mountain stream 2–4 meters across. To the north, wooded slopes rose to Silisigoda, about 3000 meters high. Across the valley to the south the wooded slopes were about as high.

The pass itself was grass, dotted with tree ferns and about 2 kilometers wide here at its western end. Going to the east the narrow steep valley soon widened into a sort of basin, several kilometers across, with grass and tree ferns, and placid meandering streams and tributaries, but there were still many steep sharp ridges. Farther east were patches of timber; a waterfall showed; and above was apparently another flatter area of grass with few tree ferns, probably the top of the pass.

From near camp we could see some of the grassland of the upper Vanapa Valley, a few villages, trails that looked well traveled, pandanus groves on the edge of the forests that cover the low divide between the

Vanapa and the Auga, and the police station at Mondo. To the left was Mt. Tafa, appearing to be part of a small range running east and west, extending westward to above Mafulu. On the north side of the pass the open ground, covered with grass and dotted with tree ferns, was often densely covered with tussocks of tall grass; in places shorter and harsh, stiff ferns predominate with a small low woody plant.

These large areas of open country probably had been secondarily caused by fires, but this north side of the pass evidently had not been burned for some time. On the south side of the pass, however, many of the ridges had been swept clean of ground vegetation, the ground being nearly bare or covered with a little green herbaceous growth. The tree fern trunks were deeply scarred with burns. Dead shrubs were common. There was no accumulation of dead grass where the tussocks of grass were springing up afresh, and on the lower edge of the forest the fire had run into the timber, forming a fringe of dead trees in places 60 meters wide. On the south side there was no such fringe. Fires were apparently not annual. The natives with us tried to fire the grass, but it would not burn. Evidently especially favorable conditions were necessary. Again there was no transition from grassland to forest. Freshly fire-killed timber joined directly with the grassland.

Several types of forest could be reached from our camp. South across the pass was a forest of rather widely spaced trees 12–20 meters high with trunks 1–1.5 meter in diameter with considerable moss on them and with a very dense bamboo undergrowth 2–5 meters high through which travel necessitated cutting a trail. But farther east the bamboo became much scarcer; in places there was none; in other places there was herbaceous ground cover; in still others only a few shrubs and saplings, with the ground somewhat mossy. Here it was easy to walk about, though the country was rather rough.

In the little valleys were open glades, some with many rather tall shrubs often dead from fire, as well as grass. Some were swampy with moss and grass. Mammal trails, made perhaps by wallabies, were very common.

On the north side of the pass the forest was more broken up by open ground, except on Silisigoda, which Brass visited and found to have a very dense undergrowth of bamboo. The other forests to the north of camp were varied from dense bamboo and lush herbaceous undergrowth to open forest with scarce slender shrubs; on the ground were

some moss and ferns. Orchids and ferns were fairly common, a few lianas were found, and pandanus was not common.

To the east of camp, back along the trail, the forest resembled somewhat that of lower altitudes. The trees were taller, in places a larger bamboo was common, sending its stems up 6-9 meters and far enough apart so that with care one could walk through them. Nothing but leaves from the bamboo covered the ground. In places there was no bamboo, but many slender shrubs, or a shrubby *Elatostema* .60-.80 cm. high that made an ideal cover for ground birds.

Occasionally mixed flocks of small birds were encountered but not commonly. Parrots and honey-eaters, and some other species, of course, gathered about fruit and flowering trees. There were signs of breeding activity amongst a few individuals of a few species, but there was no general breeding season.

The Kuama people brought us much native food which enabled us to prolong our stay here. This country was apparently often crossed by natives and hunted over by them. Bark shelters and trails were found in the forest as well as two main trails, one on Silisigoda from the Upper Vanapa and one to the south from Kailape to Kuama, besides the trail we were on.

While on Mt. Albert Edward we could look down toward Murray Pass, and in the morning as the clouds rose they piled against the east side of the range like water against a dam, until they were high enough to flow through the pass like a stream; then they rose to envelop Mt. Albert Edward. While at Murray Pass we found there was often a little mist early, when the clouds first rose, but this usually cleared and we had fine mornings, and occasionally clear afternoons, but it was more usual to have rain and mists in the afternoon.

At the high camps there was a tendency for the evenings to be clear. In addition to the mist driving through the pass, we experienced more heavy rains here than we had on Mt. Albert Edward.

Winds were also more frequent in Murray Pass. During one period of four days we had very bad weather with continuous heavy winds driving down rain and mist. One day the morning temperature at seven o'clock was six degrees C., the noon temperature nine degrees C., and the evening temperature (6:55 P.M.) six degrees C. The usual morning temperature, taken between six and seven o'clock, was about seven degrees C., and the noon temperature was usually between fifteen degrees C. and twenty degrees C.

Due to the frequent winds and rains the weather at this camp made living and working conditions more uncomfortable than on Mt. Albert Edward.

Though this was presumably the middle of the dry season the natives were unable to burn the grass, despite frequent attempts. Extensive grass fires do occur, but apparently only every few years. There is probably variation in the seasons.¹

MURRAY PASS TO MT. ALBERT EDWARD, ALTITUDE 3680 METERS, 18 KILOMETERS.—The well-traveled track led eastward through the pass for a ways, then turned north over easy slopes, over open grass and tree fern country, through and past clumps of forest, across swampy places and sodden meadows with very low vegetation to the Neon Basin.

This basin was a surprising natural phenomenon. It was a flat, grass-covered area about 7 kilometers across; meandering streams crossed it, lined in places with low trees and shrubs. The whole, except for a narrow exit, was surrounded by low ridges. Fires had burned the trees from the lower slopes, now grass-covered and dotted with tree ferns. The ridge on the south side was Silisigoda, on top of which was a trail from the Upper Vanapa, used by those people when they came here on hunting excursions for cuscus and wallabies. One of their lodges was on the southeast corner above the Neon Basin, and others showed on the south side. Our trail lay north along the narrow crest which was here the top of the range, separating the Chirima River, whose waters flow into the Yodda, and the Neon, whose waters flow into the Waria, both flowing to the north coast.

The waters of the swampy depression before the Neon were the last of the waters flowing to the south coast. Though there was a continual, gradual rise to Mt. Albert Edward the water flowed off each side of the range and then swung around north. The divide between the northern and southern watersheds went west along Silisigoda.

The trail led on along the narrow crest, through low bush and grass areas, swampy in places. After a short descent and a long gradual climb over grassy slopes we came to areas of timber and brush, on over a grassy valley with little streams, an open grassy hill with scattered clumps of flat-topped pine trees. Here the open ground was pitted with strange holes .5–1 meter across and about .3 meter deep, filled with water from the recent rains. Then on past a swampy depression which the abundance of a grey lichen gave the appearance of a salt pan. The trunks of the low tree ferns along its edge had been deeply marked by

¹ See also the discussion of this by Lane-Poole, *loc. cit.*

fire. The route lay over a grassy ridge and then up a rather steep slope. This country had been forested comparatively recently. There was much standing dead timber blackened by fire and it was now growing up to grass and shrubs. The forest on each side appeared largely of pine.

The carriers had been doing well, though traveling slowly, but here the altitude began to tell on them. They had to rest five to ten minutes every fifty to a hundred meters. Fortunately camp was not far ahead, across a broad flat marshy area with a small stream and more of the strange water-filled holes. Here for the first time boulders of schist were common on the surface. Here we camped, and the next day went on over grassy swamps and hills, across clear little streams, past patches of low timber and the first little lake to Gerenda.

MT. ALBERT EDWARD, ALTITUDE 3680 METERS.—Here the country was a series of plateaus and low gentle hills. Most of it was open grass country, in places dotted with tree ferns as trees dot an open savanna. The dense forests of the slopes extended onto it only as tongues and clumps of trees. Travel was easy and the cool air invigorating. Our camp, called Gerenda by the natives, was only one and one half hours from the top of Mt. Albert Edward.

To the west was the undulating open grass country; to the east, the steep wooded slope to the Chirima River. From a hill near camp we had a good view of the surrounding country. Here the tree fern country of the 2800–3000 meter level was poorly represented. The ridges were clothed with sparse, short grass, with taller, dense, grass in tussocks in the valleys and along the little streams.

Swamps, ponds and alpine lakes of all sizes up to a few hundred meters across were common, even on to Mt. Albert Edward itself at 3776 meters. Schist, with many white quartz veins, was close to the surface and outcropped in many places, making small bluffs and cliffs to the north and along the plateau edge. Due to the scanty layer of soil in places, there were many seepage slopes where the ground was always sodden. Small, bright flowers were common, some closely pressed to the soil. Others, like daisies and buttercups, grew amongst the grass.

Scattered trees, dead stubs, rotting logs and clumps of timber in the grassland indicated a former greater extent of forest. These dead trees, charred and blackened, suggested that the grass fires, set by native hunting parties, had accomplished this. Judging by the upward extent of the forest on Mt. Albert Edward, the timber line had

originally been in the neighborhood of 2800 meters. But on the seepage slopes and rocky outcrops at much lower altitudes there has certainly never been forest under conditions such as exist to-day. This would have given glades and opening of alpine conditions breaking up the continuity of the forest, and was probably the condition of the alpine grassland on the Wharton Range before it had been disturbed by the fires of the natives.

The forest on the steep slope to the Chirima had little shrubby growth except along its edge. Exposed schist and tumbled boulders formed little gullies and small caves. Moss occurred on the twisted trunks and carpeted the ground, but it is in no sense a moss forest. An orange, epiphytic orchid lent a pleasing touch of color. The trees, though with twisted irregular trunks and bizarre shapes, were 9-18 meters high and did not approach a dwarf vegetation, the trees at tree line being definitely trees. Some of the trees had flat tops, as though shorn by the wind.

In places the rocks form small caves and little cliffs, excellent hiding places for mammals. Between series of little cliffs were sometimes unforested shelves, giving grass and moss-covered glades.

To the northwest, one and one half hours away, rose Mt. Albert Edward, a mass of schist with the rock exposed in many places, rising to 3980 meters. Father Dubuy, who had visited it twice, had erected a cross on the central peak. This mountain mass was a series of low peaks enclosing a small basin about 3 kilometers across. This was the headwaters of the Aikora River, flowing away to the north.

The ascent was easy, largely a scramble over grassy slopes and sloping rocks. On top of the central peak, Father Dubuy's cross was still standing, and in the cairn at its base was a tin box and a quinine bottle containing papers left by earlier parties.

From the west slope flowed the tributaries of the Waria River and from the southeast slopes the Chirima River, which joined the Yodda. To the northwest across deep valleys were other small grass-covered plateaus. Eastward across the plateau country, Mt. Yule, the most distinctive of Papuan peaks with its flat top, showed above the intervening mass of high rugged country.

In clear weather from the summit of Mt. Albert Edward it is possible to see the coast to the southeast, but low-lying clouds always obscured this from our view. To the south the Wharton Range continued over undulating country and low hills. Near Mt. Albert Edward it

was about 5 kilometers across. It narrowed to a sharp ridge between the Chirima Valley and the Neon Basin.

Beyond this, the range top broadened again to a few kilometers, continuing down the Murray Pass. Then the country rose rather more rugged, and more wooded to Mt. Scratchley, a sharper peak than Albert Edward and with timber apparently extending higher. Patrol Officer Smith in his report of a patrol to Mt. Victoria, farther south-east on the range, recorded dense trailing bamboo at 11,000 feet.

To the east and southeast we looked down the dark, steep, wooded valley of the Chirima River, 1500–1800 meters below. Population was scanty, and though there were garden clearings, there were no grass-land areas like those in the wide open valley of the Upper Vanapa River on the west side of the range. Kuama Village in this valley, about 2400 meters, was said to be the highest village in Papua. It was in a commanding position on the crest of a spur from the Wharton Range and could be seen from afar.

Beyond, to the east, more mountain peaks showed in the distance, possibly Mt. Brown, Clarence and Suckling. A low mountain range to the east was possibly the Hydrographer Mountains, and north of them the islands of the D'Entrecasteaux Group could sometimes be seen. From the summit of Mt. Albert Edward, the whole north coast is in view in fine weather, but we were never fortunate enough to get more than a glimpse of rough wooded country through the swirling clouds to the north.

The country about Mt. Albert Edward was hunted over by the natives from the valleys below. The Kuama people said it was the hunting grounds of the Goilala people to the west. We never saw them. Fresh tracks and freshly burned grass areas showed that they had been in the vicinity during our stay, but they were probably too shy to come into our camp.

No bark lodges were built here, the bark being unsuitable, and the only roofing material we found available to fill in the ends of our flies was brush and the tussocks of grass, both very poor for the purpose.

The Kuama people brought us much native food from their villages, demanding of course trade as payment.

Looking down from this camp in the early mornings there were always clouds in the 1800–2700 meter belt, so that only occasionally could we catch a glimpse of the coast, though the tops of distant mountain ranges stood out clearly. We had but two or three completely fine days on the mountain itself. Usually the mornings were clear

until nine or ten o'clock, rarely later, then the clouds rose, coming up the Chirima Valley from the southeast. The afternoons were usually misty and drizzling. Wind and heavy rains were experienced only once, when we had very bad weather for a day and a night, with driving wind and rain. During our stay the whole country was too wet for the grass to burn extensively, as it evidently had at times. The natives set a few grass fires, but they soon died out.

On the warmest cloudy nights the temperature fell within a few degrees of freezing; on every clear night there was frost, and ice formed over the little pools. On Mt. Albert Edward itself in shady places we found ice still present at 11:00 A.M. One dull cloudy day the noon temperature did not rise above 11 degrees C.

Father Dubuy has been stationed for twenty years at the Ononge mission station, and he gave us some general information about the mountain weather. According to Father Dubuy the dry and wet seasons are much like those on the coast. In the dry season, which is the better for travel in the higher altitudes, little rain falls, but clouds continually shroud the mountains and a clear view of the coast can rarely be obtained. In the rainy season, though heavy rains occur in the afternoons, there are few clouds in the morning and a clear view of the coast can be obtained. Father Dubuy had visited Mt. Albert Edward during a wet season and had a beautiful series of photographs showing the panorama from the summit.

TRIP NUMBER TWO, JANUARY 3 TO MARCH 20, 1934

ROUTE.—Port Moresby to Daru; Daru to Benituri and return; Daru to Dogwa and return; then back to Port Moresby.

PERSONNEL.—R. Archbold, L. J. Brass and A. L. Rand.

ITINERARY.—We left Port Moresby on January 3 by the coastal boat SS. "Papuan Chief." Various stops were made along the coast, including Kikori on the Kikori River. On January 8 we arrived at Daru, having passed fairly close to Bramble Cay that morning shortly after dawn. A few days were spent in Daru making arrangements, and then a prospecting trip was made up the Benituri River and up the Oriomo River to Wuroi and Dogwa from January 12 to 15. Wuroi on the Oriomo River was chosen as our first collecting camp, and on January 16 Mr. Woodward kindly took our party there on the government power boat "Vailala." At Wuroi we collected for about twenty-five days.

Quantities of native food, chiefly bananas, pineapples and paw-paws, were brought to us by the local natives. Tobacco was almost a standard currency for trade here. Dogwa had been an oil company's camp and Wuroi had been the boat landing. Thanks to Mr. H. P. Beach, of Daru, who was in charge, we were allowed the use of the buildings at both camps. An excellent road connected Wuroi and Dogwa, and by loading our gear in a spring cart the eight indentured Bamu carriers whom we had retained were able to drag our gear to Dogwa on February 12 and 13. At Dogwa we collected until February 27. February 28 until March 4 was occupied in moving back to Daru. Here, while waiting for the "Papuan Chief" we visited the mainland opposite Daru on March 10. On March 15 we left Daru for Port Moresby, arriving there on March 20. We passed close by Bramble Cay on the afternoon of March 15 and on March 16 stopped at the Delta Saw Mills up the river above Port Romilly, where a few birds were collected.

DESCRIPTION OF THE ROUTE AND COLLECTING LOCALITIES

PORT MORESBY TO DARU.—The distance is about 560 kilometers. On the coastal boat "Papuan Chief" we stopped at many stations and plantations along the coast for mail and cargo. The trip as far as Yule Island has already been mentioned. Passing westward we rounded Cape Possession where a low line of hills reach the coast. Some of them were forest clad, others were grass or savanna covered. This is near the western end of the dry belt of savanna country, for westward extends the low wet country of the Gulf Division; the beaches are of dark-colored sand. Many pandanus line the beach, and in the cocoanut groves behind are many villages. The swampy river mouths are fringed with nipa palms. Cape Cupulo marks the abrupt end of another line of hills running south to the sea. It is difficult to land on all this coast, especially in southeast season, because of the heavy surf along the beach and over the bars at the mouths of the rivers.

West of Orokolo we entered the Delta Division, differing as greatly in the type of country as in the people. Here the very low swampy coast is covered with mangroves for miles inland; through them is an amazing network of connecting waterways, so that the Delta Division can be crossed by boat without going into the open sea. On our return trip we went up to Delta Saw Mills, above Port Romilly. The country is very flat until far inland, where the Albert Mountains rise. The

sound at Port Romilly is several kilometers wide. At first all was mangrove, then we entered the dense nipa palm belt; some of the leaves of these trunkless palms were more than 9 meters long. Large waterways opened off in every direction; about 12 to 15 kilometers inland we began to find forest, a tall luxuriant forest heavily draped with vines, some of them probably of the D'Albertis creeper, which, when in bloom, displays festoons of brilliant flowers amongst the trees; palms and pandanus were common and tree ferns grew into the water's edge, their bases flooded by the tide. Little groves of cocoanuts appeared; the villages amongst them were built on piles so that the tide ran under the houses. Here and there were little gardens under a half dozen dead trees which had been killed by cutting a ring of bark from the base of the tree. A few banana and betel-nut trees and a little sugar-cane were grown. At the sawmills we walked a kilometer or two along a trail into the bush. Sago palms and forest trees grew in a mixed stand. This flat country was very wet and muddy, with stagnant pools and streams everywhere; the tall trees were festooned with vines; palms were very common and lawyer cane everywhere reached out to seize one.

On the westward trip we also went up to Kikori. Near the mouth of the Kikori River were exposed mud bars on which many terns and a few pelicans were resting. The river has many islets and channels as well as waterways opening off them. Not until nearly at Kikori are the first low hills encountered. Between them and the sea the country was all flat and forested; first mangrove covered, then dense stands of nipa palms and mangrove, and then sago palms lined the banks along the edge of the tall rich-looking forest.

On our eastward trip we passed close by Bramble Cay; it is about 65 kilometers from Daru. Bramble Cay is a very small, sandy islet raised but little above sea-level. A beacon has been erected to make it more conspicuous to passing ships; to the westward are a few low dark rocky ledges, little more than reefs. Many terns, a few frigate birds and some brown boobies were seen here.

DARU.—The island of Daru was about 8 kilometers long by three kilometers wide, very flat and rising but little above sea-level. The government station at Daru, with its mango trees, crotons, palms and well-kept lawns, was beautifully kept. The island was largely covered with tea-tree savanna. The widely spaced trees were 25 to 30 meters high; a low pandanus 3 to 6 meters high was common in places. The grass had not been burned for years and was very tall and dense,

matted with the dead grass of previous seasons. The island was more or less fringed with mangrove swamp, probably with a width of more than one kilometer in places. The low spreading type of mangrove fringed the shore. Back of that was the tall, higher type, with trees 12 to 15 meters high and having straight, clean trunks. A few large boled trees with trunks about 2 meters in diameter were scattered through them. In the areas of high mangroves the soil was soft and bare, but one could skip about on the prop roots and move about by treading lightly on the mounds of mud thrown up by crabs. Just inside the mangroves there were, in places, small areas of open rain forest and some large clumps of a bamboo. On the south side of the island a flat-bedded shale came to the surface, giving a steep shore, but on the north the low tide exposed a wide muddy beach, frequented by many shore birds. In front of the government station an area of mangroves had been cleared, and here at high tide shore birds came to rest on the stumps and logs. Few natives live on the island, but the white inhabitants have large gardens.

One afternoon was spent in visiting a marsh on the mainland opposite Daru in search of water birds. The sand beach was very shelving, so that the motor boat was left about two hundred meters out and we waded ashore. Inland for a short distance was the coastal fringe of cocoanuts; then a narrow fringe of tall trees with the water knee deep about their bases, then a short distance along a trail knee deep in water through a swamp grown up to brush and tall dense grass; and then, perhaps three hundred meters from the beach, was a marshy lagoon, parallel to the coast and forty to sixty meters wide. The water was nowhere more than waist deep, dense beds of tall reed-like plants were common and there was considerable floating vegetation. Water birds of a few species were common. Inland the country was heavily forested.

BINATURI RIVER.—This was on the mainland about 19 kilometers west of Daru. The river was about seventy-five meters wide at the mouth. We ascended it about 13 kilometers until farther progress in the auxiliary cutter became difficult because of the overhanging trees. This country was all flat, and mangroves extended as far up the river as we went. Inland, a short distance from the river mouth there was a large native village which had extensive, well-fenced, banana and taro gardens. All this country was very flat and wet, the taro was planted in beds and the gardens drained with ditches. There was a small amount of gallery forest along the small streams, but the characteristic

feature of the vegetation was the tea-tree country with tall, scattered tea-trees and tall grass; the ground was flooded so that we splashed along the trail knee deep in water much of the time. A few small ponds were encountered and in places were low thickets of brush.

DARU-WUROI, 72 KILOMETERS.—This country was all flat as far as the eye could see; from the deck of the "Papuan Chief" no hills showed. The mouth of the Oriomo River, opposite Daru, was several hundred meters wide. Wuroi was about 65 kilometers up stream where the river was about fifty meters wide and had a rise and fall of 3 meters of tide, but the water was not brackish. Ascending the river, after the first 8 kilometers of mangrove swamps fringing the river we encountered dense areas of nipa palms and then sago. Above 15 kilometers from the coast the shores are largely forested, though mangroves occur sparingly as far as Wuroi.

WUROI.—This had been the landing place for the oil-drilling company at Dogwa. The wharf and a large store were still standing and we camped in the latter. There were a few beds of aquatic plants along the river edge, and low tide left muddy banks exposed. In places the banks rose sharply 6 meters or so, in others it sloped up gradually. Within a few kilometers of camp were two small lagoons opening from the river, but these presented no peculiar features. The country back from the river was all low, with low flat ridges and little valleys. Small streams were very numerous, often with small deep pools connected by trickles of water. These streams were usually fringed with humid forest, but occasionally they ran through savanna where they were choked with tall grass. Here and there in hollows on the savanna ridges were shallow pools; clear of vegetation, with clear-cut edges and the bottoms lined with dead leaves; others more or less completely filled with a tall coarse grass or sedge. After rain there was of course standing water in every hollow.

The rain forest fringed the river and most of the small creeks; in places there were considerable areas of it. The general appearance of this forest varied considerably. In places the larger trees were 30 to 40 meters high, but these large trees were scattered; slender lower trees formed a substage and there were many saplings. In other places the slender trees reached no more than 12 to 16 meters in height. There was sometimes no ground cover and the ground was littered with dead leaves. Lianas were fairly common, but there were few buttress and prop roots. In places the sapling stand was open, so that one could walk about through the forest easily, with only an occasional low pan-

danus or palm to impede one's progress. But in places these latter were very plentiful, making walking slow and noisy, and in some places where these were mixed with low shrubs, lianas and lawyer cane, progress was almost impossible without the aid of a scrub knife. Tall palms were only occasionally encountered here, though some distance down the river they formed a conspicuous element of the river bank forest, towering far above the rest of the trees; tall slender pandanus sending down long prop roots were fairly common. Passing from this rain forest toward the savanna one entered a definitely lighter type of forest, with more light coming down to the forest floor. The trees and saplings were more widely spaced, in places there was a little grass in the glades, in some of which a trailing bracken formed masses. In this light forest a tea-tree was fairly common, a tree that occurred commonly on the savanna and was perhaps characteristic of it.

Here and there on the edge of the forest were areas of low dense brush of shrubs and small trees, often with masses of trailing bracken and thorny raspberry bushes. This occasionally made a transition from the forest to the savanna, but in most places the transition was abrupt, the grassy savanna abutting directly on the rain forest.

The savanna at Wuroi had two main aspects. The one that was the most common was an open stand of tall tea-trees reaching perhaps 30 meters in height. The ground was grass-covered, in places dense and shoulder high, in others much shorter but unless recently burned it was dense. Sometimes there were numbers of scattered low trees 5 to 8 meters high; this occasionally was dense enough to form what might be called a substage; sometimes open thickets of tall shrubs were encountered. A few trees were shrubby to the base and bore dark green leaves, in contrast to the prevailing grey green of most of the savanna trees.

Another type of savanna was found on some of the ridges. The trees were low, short and scanty, and often there were many low shrubs. One area near Wuroi that was covered with grass and low herbaceous plants was probably an old garden site. The forest-fringed streams of course interrupted the savanna, and occasionally there were isolated clumps of forest trees out in the savanna.

WUROI-DOGWA.—This was over 9 kilometers of good road through the savanna.

DOGWA, ALTITUDE FORTY METERS.—This was about on the divide between the Oriomo River and the streams that flow toward the Binaturi River. The country changed here. To the east toward Wuroi were

little valleys and ridges with their numerous creeks, but to the west this country was flatter, more open; low ridges and flat valleys with easy slopes were more common. Being on a divide in such low country the ridges ran in every direction and the streams were numerous and small; here and there limestone outcropped. After heavy rains the whole country was flooded and the flat valleys were under water.

The savanna to the east of camp was similar to that at Wuroi. The scattered tea-trees were 20 to 30 meters high, often interspersed with many low trees 3 to 8 meters high. In places there was nothing but a dense stand of these low trees, where the twisted trunks and abundant epiphytic plants gave a striking appearance. In places there was short scanty grass on the ridges, in others, dense grass knee high and in others, especially in the valleys, there were stands of tall, dense grass, more than head high, through which it was very difficult to force a way. Low palms and pandanus were scattered sparingly through this country. A few small, shallow, clear-cut ponds occurred on these savanna ridges, often with a clump of tall tea-trees but no marsh vegetation about them. These little pools undoubtedly became completely dry in the dry season. Some of the creeks here were in very sharp little gullies, sometimes as much as 4 meters deep, they had cut into the valley bottom. Most of the humid forest here was only a scanty gallery forest growing in these gullies. In places, however, the streams were fringed with savanna and sometimes these streams were little more than a series of deep pools joined by a trickle of water flowing through the dense grass which fringed these pools.

This fringing gallery forest with its dark green leaves, however, was not a conspicuous feature of the landscape because of the ridges which characterized the country and the denseness of the savanna trees. This was very different from the country to the east, where the lower, flatter ridges and flat valleys had easy slopes and low vegetation, so that the fringes of gallery forest and clumps of rain forest on the ridges stood out conspicuously, and from a distance gave the impression of large stands of rain forest.

On the tops of the ridges were strange depressions filled with water, giving ponds sometimes fifty or one hundred meters across or sinkholes with water disappearing away underground through the limestone caves. These were often surrounded with rain forest and brush, and in both these and in other small patches of rain forest many cocoanut palms occurred. Along one little stream that was mostly swamp and grass-fringed were clumps of a large bamboo. There was little tall

savanna to the west of Dogwa. The flat valleys were covered with tall dense grass and scattered low trees or were covered with extensive stands of pandanus. The ridges are also grass-covered, some dotted with low trees, some with stands of pandanus. The clear stands of pandanus that might be called pandanus forests were a striking feature. Stands of those trees 6 to 10 meters high extended over some of the valleys in which the ground was very wet, often with water standing at the grass roots and with little pools and depressions filled with water. The same sort of pandanus stands also extended onto the ridges, where the soil was dry and where burning of the grass was practiced by natives. On some of these the grass was very short. In places there were few trees and the ridges were mostly covered with very short grass. The natives burned the grass, in much of this country giving areas with very short, scanty grass and low herbaceous plants.

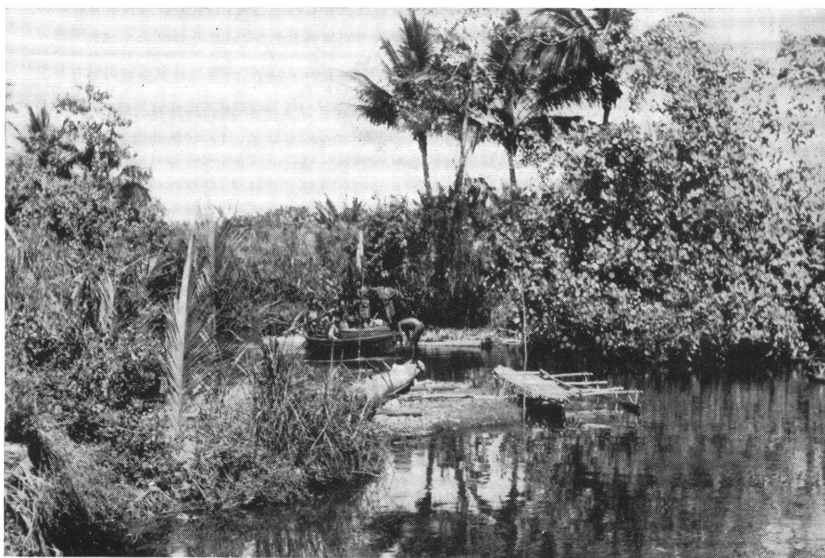
In some valleys were a few ponds and lagoons of various sizes up to 150 meters across. These contained much aquatic vegetation, some having wide fringes of tall reeds extending well out toward the center of the pools.

PLATE XXIX

- Fig. 1. The upper gum-tree savanna above Rona at 700 meters.
Fig. 2. Bioto Creek at the village of Bioto.



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PLATE XXX

- Fig. 1. The swamp at Baroka with Mt. Yule in the background at the left.
Fig. 2. Second growth forest at Mafulu.



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PLATE XXXI

Fig. 1. Interior of the forest at Diene.

Fig. 2. A typical mountain stream at Mafulu.



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PLATE XXXII

Fig. 1. Interior of the forest at Mafulu.

Fig. 2. The Auga Valley near Mafulu.



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PLATE XXXIII

- Fig. 1. Dense substage of saplings and a scanty ground cover of *Elatostemma*
in the forest on Mt. Tafa, altitude 2400 meters.
- Fig. 2. The trail through the forest on Mt. Tafa at 2400 meters.



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PLATE XXXIV

- Fig. 1. Dense bamboo undergrowth in the forest at 2400 meters, Mt. Tafa.
Fig. 2. Camp on the west slope of Mt. Tafa at 2400 meters.



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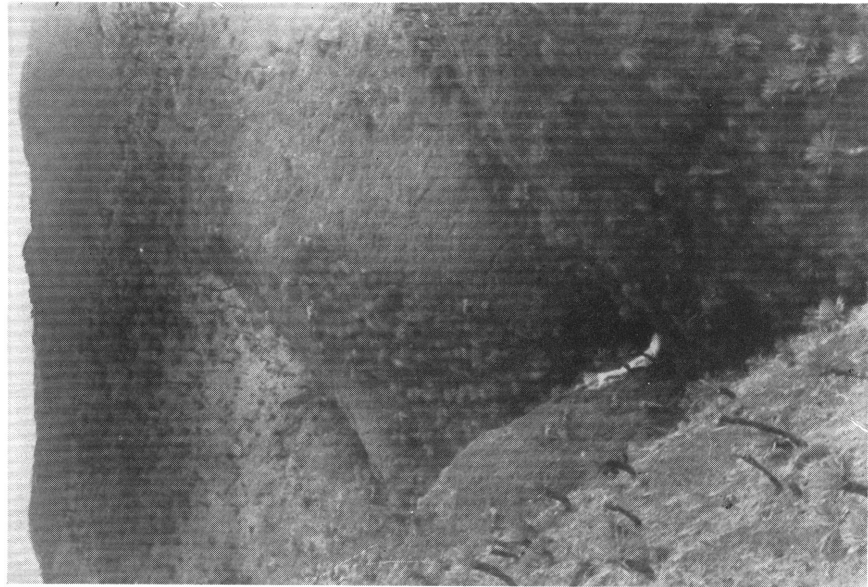
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PLATE XXXV

- Fig. 1. A grove of the edible pandanus at 2000 meters on the east slope of Mt. Tafa.
- Fig. 2. The Ero Creek in Murray Pass, near our 2860 meter camp.



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PLATE XXXVI

- Fig. 1. Grassy slopes of the Vanapa Valley above Ononge.
Fig. 2. The tree fern country in Murray Pass.



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PLATE XXXVII

- Fig. 1. Tree fern country, Murray Pass, from which the grass had been burned the previous year.
- Fig. 2. Forest with open undergrowth, Murray Pass.



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PLATE XXXVIII

- Fig. 1. The Neon Basin from its southeast corner.
Fig. 2. The northeast peak of Mt. Albert Edward, viewed from the southeast peak.



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PLATE XXXIX

- Fig. 1. The plateau country on top of the Wharton Range, near our 3680 meter camp. Mt. Yule is in the background.
- Fig. 2. The short grass plateau at 3600 meters on the Wharton Range, with Mt. Albert Edward in the background.



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PLATE XL

Fig. 1. Looking south along the Wharton Range from near Gerenda.

Fig. 2. Gerenda; our camp at 3680 meters.



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PLATE XLI

- Fig. 1. A marsh-filled lake at about 3600 meters on the Wharton Range, near
Mt. Albert Edward.
- Fig. 2. The edge of the forest near Gerenda.



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PLATE XLII

- Fig. 1. The exterior of the forest at 3700 meters on the Wharton Range, near
Mt. Albert Edward.
- Fig. 2. A forest glade near Gerenda at about 3650 meters.



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PLATE XLIII

The interior of the forest at 3650 meters near Gerenda.



PLATE XLIV

- Fig. 1. One of the headwaters of the Chirima River on Mt. Albert Edward, at about 3650 meters.
- Fig. 2. Heavy forest about the Oriomo River at Wuroi.



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PLATE XLV

Fig. 1. Tall tea-tree savanna near Wuroi.

Fig. 2. A stand of low trees forming a substage in the tea-tree savanna, near Wuroi.



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PLATE XLVI

Fig. 1. Low gallery forest at Dogwa.

Fig. 2. The very open savanna at Dogwa.



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