Results of the Archbold Expeditions. No. 29

By A. L. Rand and L. J. Brass

BULLETIN

OF

THE AMERICAN MUSEUM OF NATURAL HISTORY

Vol. LXXVII, Art. VII, pp. 341–380

New York

Issued November 29, 1940

Article VII.—RESULTS OF THE ARCHBOLD EXPEDITIONS. NO. 29

SUMMARY OF THE 1936–1937 NEW GUINEA EXPEDITION

By A. L. Rand and L. J. Brass

Plates XXI to XLII and 2 Maps

CONTENTS

	Page
Introduction	341
Organization and Equipment	342
Itinerary	345
Country as Seen from the Air	348
Routes and Collecting Localities	355
Summary of Types of Habitat	372
Notes on the Distribution of Birds	376
Results of the Expedition	378

INTRODUCTION

As the plans of the Archbold Expeditions for the biological exploration of New Guinea include projected field work that will take a number of years to complete, it is advisable to present a summary of each expedition as it is finished.

Not only will this provide a record of the expeditions and a reference to localities visited and types of country worked for the various specialists who will be studying our very diversified collections, but it will also be a contribution to the knowledge of little-known areas in New Guinea.

The previous New Guinea work of the Archbold Expeditions was carried out in 1933–1934, when a cross section of the southern slopes in the mountains of southeast New Guinea between Yule Island and Mt. Albert Edward was made, and two months were spent on the Oriomo River near the coast in south New Guinea.[1]

D'Albertis, the first man to ascend the Fly River, during his explorations of 1875–1877, made the only extensive natural history collections in this area.[2]

Sir William MacGregor, the second man to go up the Fly, in 1889–1890, went as far as the limestone barrier on the Palmer River.[3] He brought back a few specimens. Since then the Fly River has been frequently visited, but until 1927 no one had gone much farther inland than had MacGregor. In 1926–1928 the Northwest Patrol of the Papuan Government penetrated beyond the limestone barrier on the Palmer, discovered the source of the Fly River and crossed it and descended the Sepik River on the north of the island; a feat which earned for Mr. Karius, the leader of the expedition, the medal of the Royal Geographical Society.[4]

But these explorations had added little to the biological knowledge of the area, and the few scattered, fragmentary collections made, especially in the Netherlands portion of south New Guinea, helped to show that more work remained to be done.

The original plan of the 1936–1937 expedition included collecting at 2000-foot levels in the mountains at the headwaters of the Fly River up to 11,000 feet, in addition to an exploration of the lowlands of south New Guinea. But with the destruction of the plane on which we counted for transportation of food into the mountains, before we had started collecting there, our

[1] 1935, Summary of the 1933–1934 Expedition, Bull. Amer. Mus. Nat. Hist., LXVIII, pp. 527–579, maps and Pl. xxix–xlvi.

[2] 1925. Austen, Leo, Royal Austr. Hist. Soc. Jour. and Proc., XI, pp. 251–261, has demonstrated that D'Albertis ascended the Fly and Palmer rivers to about Thompson's Junction.

[3] 1890, Ann. Rep. Brit. New Guinea for 1889–1890, pp. 49–64, map.

[4] 1932, Champion, Ivan, Across New Guinea from the Fly to the Sepik, London.

work was restricted to the lowlands, where water transport was available. General collecting stations were established at Daru, on the Fly River from its mouth to about 600 miles upstream on the Palmer River, and later on the Wassi Kussa River to the west.

A small transport party penetrated into the mountains on the upper Palmer River, and established a camp near Mt. Mabiom. This was occupied but a short time before the loss of the plane forced the return of the party.

A side trip into the mountains back of Port Moresby after the main part of the expedition was finished was undertaken by Mr. Tate, mammalogist, for topotypical mammal material.

Mr. Richard Archbold, a mammalogist and an airplane pilot, who led and financed the expedition, planned a broad biological scope for the expedition as he had for the previous one. Mammals, birds and plants received most of our attention, but large collections were made of other animals both vertebrate and invertebrate. A considerable mass of data on habitats and habits of many animals also was secured.

The personnel of the expedition included:

RICHARD ARCHBOLD, leader, mammalogist and pilot

A. L. RAND, assistant leader and ornithologist, who also collected cold-blooded vertebrates

G. H. H. TATE, mammalogist, who also made extensive collections of invertebrates

L. J. BRASS, botanist

R. R. ROGERS, pilot

EWING JULSTEDT, radio operator

L. A. WILLIS, transport manager inland

M. J. HEALY, patrol officer, who, with 6 native police, was loaned to the expedition as escort by the Papuan Government.

As on our 1933–1934 expedition we found the government actively sympathetic with our intended researches. We met His Excellency Sir Hubert Murray, Lieutenant-Governor of Papua, in Sydney on our way to New Guinea and he assured us permission would be granted to enter the Fly River area and that permits would be issued for collecting. In Port Moresby Mr. W. H. Champion, acting Lieutenant-Governor during Sir Hubert's absence, graciously provided us with the necessary permits and, since we were going into an area not under government control, provided us with a police escort.

Mr. Ivan Champion, who in 1926–1928 was with Karius as second in command of the Northwest Patrol, and was preparing to lead an exploration patrol into the territory east of our region, accompanied us as guide on our first survey flights to the mountains.

Other government officials were obliging and helpful toward our work. Especially do we wish to express our appreciation of the aid and hospitality of Mr. R. A. Woodward, Resident Magistrate at Daru, and of his successor, Mr. Leo Austen.

To Mr. H. P. Beach of Daru we are indebted for much. His hospitality was unfailing, his time and his equipment were always at our disposal, he acted as our forwarding agent, and his knowledge of local conditions helped us over many obstacles.

ORGANIZATION AND EQUIPMENT

What makes New Guinea an extremely difficult country to penetrate is that local natives cannot be depended on to act as carriers, and local food supplies being equally uncertain, it is necessary for the traveler to secure carriers elsewhere and to take with him all the food required.

We had already experienced these difficulties in southeast New Guinea; and if we were to work successfully for a long period in the mountains at the headwaters of the Fly River, airplane transport of our supplies would greatly simplify our problem of provisioning camps.

Landing fields being impractical in the mountains at the headwaters of the Fly, it would be necessary to establish a base on the coast and for the collecting party to walk into the mountains and have supplies delivered at intervals by the plane in flight.

The ideal arrangement would be to make a series of reconnaissance flights from the coastal base over the area, choosing the most suitable localities for working and the best route for the collecting party to follow, then land the collecting party as far up the river as possible and have them, with the minimum number of carriers, make their way inland on foot. The collecting party was to have a two-way portable radio and keep in daily contact with the base camp, to advise their position and progress, and to request supplies, which would then be flown in and delivered. In practice the arrangements proved somewhat more complicated than that.

The airplane with which the Expedition was equipped was a Fairchild Amphibian with a 76-foot spread. It carried a crew of pilot, co-pilot and radio operator, and had seats for 6 passengers. When fueled for 700 miles the payload was 1500 pounds. The advantage of an amphibian plane was that it could land on the sea, the rivers and the lakes, and could also land at the few made airports in New Guinea. This gave us our transport, but there was still the question of the delivery of the supplies to be made to an inland collecting party. The first method we tried was one of a combined delivery and pick-up perfected by Mr. Lytle S. Adams and exhibited at the World's Fair in Chicago in 1935. In brief, the package to be delivered was trailed one hundred feet or so below the plane on the end of a cable. There was a heavy iron ball three inches in diameter just above the end of the cable, which had to do with the pick-up. The device arranged for the delivery and pick-up was a V-shaped affair of iron with a narrow slot at the end of the V, and leading wings of iron to guide the package to be delivered. The airplane flew low over this, guiding the package into the V, where it jammed and was released by breaking a copper wire which attached it to the iron ball, and the cable, with the iron ball, slid on through the slot in the opening of the V. Here the ball was engaged by a ring which was attached to the package to be picked up, and the package was whipped into the air.

At first it seemed that this might be the ideal solution; a method of delivering foodstuffs and picking up specimens so that a party traveling by land and serviced by plane could laugh at transportation troubles.

Extensive tests and experiments were conducted with this equipment in Georgia in 1935. There were several features against it; especially the bulk and weight of the iron V which was the essential part of the device. Wood could be used for the leading wings, but wood could not stand the battering of the packages and the iron ball, coming at sixty to eighty miles an hour. And to carry several hundred pounds of metal for this part of the apparatus would be little easier than carrying the food to be delivered. The labor and the equipment for constructing and installing the whole device were also considerable. Then, too, the packages to be delivered received a severe buffeting and the package to be sent out was picked up with a jerk, and frequently hit the ground several times at long intervals before it pulled steadily on the cable—treatment which would be bad for specimens. This could perhaps be avoided if the pick-up was on a knife-edge ridge; but would one always be available in New Guinea? Then, too, the plane had to come so low that in heavily forested country, with trees more than one hundred feet high, there might be trouble.

Though possible under favorable conditions, we decided this method was impracticable for us in New Guinea. We then turned to parachutes for delivery. We found that for mountain work at 10,000 feet a twenty-four-foot cargo parachute loaded with one hundred pounds of foodstuffs landed its load with about the same jar it would receive were it dropped from a height of eight feet. Most things can be packed to withstand this jar. We accepted this as the method of delivering breakable articles. Rice, the staple food of the carriers, did not need a parachute. It was made up in tightly packed forty-pound sacks (the proper load for a boy to carry) and these small bags were enclosed loosely in a large heavy sack such as is used for copra. When the rice hit the ground, the inner, tightly packed sack exploded but the

contents were kept together by the loose outer sack.

Still in hopes of a satisfactory method of pick-up, we tried fixing a large loop of rope between two high posts about sixty feet apart, and attaching the package to be picked up to this loop. The plane trailed a grappling hook one to two hundred feet below it, and was guided so that the hook engaged the rope and the package could be hauled up to the plane. This worked, and had the advantage of being simple, easily constructed and allowed the plane to keep farther off the ground. But after the initial jerk the package usually bounced several times on the ground, which, again, would be bad for specimens; and we also thought of what might happen if the grapple became entangled in the branches of a tree.

Finally, all idea of a pick-up by the moving plane was abandoned and we decided that specimens would have to be brought out by carriers to a point on the river where the plane could land to receive them.

Radio communication between the base camp and the inland party was important. There had to be a sending and receiving set for the base camp on the coast, a two-way set for the plane, and a two-way portable set for the inland party which could be moved by carriers. The commercial sets tried in the United States were found unsuitable for expedition use. Equipment for the plane was designed by Archbold and Julstedt, who built a 135-watt aircraft transmitter consisting of one RK-25 tube as an oscillator and two RK-20 tubes in push-pull suppressor grid modulated by one RK-25. The transmitter itself weighed twenty-five pounds and could be used with either voice or code. It gave a power of 135 watts on code and about 50 watts on voice. A simple regenerative type of receiver was used.

Three of each of these units were constructed, one set for the advance party, one for the plane and one for the base camp. But it was finally found that the motor-driven generator that was to be used inland could not supply the high voltage required for the transmitter.

For the inland party a combination transmitter and receiver, in one metal case, was secured from Amalgamated Wireless Ltd. of Australasia, and rebuilt by Mr. Ken Franks and Julstedt. The ten-watt transmitter consisted of two tubes, 42 oscillator and another 42 used as a modulator, thus giving both voice and code communication. The receiver was a simple regenerative set of the same type as used on the plane. The power unit used for the transmitter was a gasoline engine driven generator (to supply filament and plate power). The engine with the generator weighed about eighty pounds, the transmitter and receiver about fifty-five pounds, and batteries were necessary for the receiver, which, with odds and ends necessary, made another forty pounds or so.

The radio equipment for the inland party as it was finally used required five men to carry it.

The transmitter at the base station was the same as that in the plane, but for every-day reception we employed a National HRO receiver, for which we had four extra coils. This enabled us to cover the broadcasts and emergency long wave band. The power unit at Daru was a 1 1/2-kilowatt 110-volt Kohler plant, alternating current, which also supplied lights for the camp and current for a cooling unit used for photographic purposes. The radio schedules with the inland party were daily, usually at eight in the morning. Voice was generally used, but when atmospherics made voice transmission impossible, code was used. Daily schedules were kept with the commercial station VIG at Port Moresby, where Mr. Ken Franks gave us every aid possible.

The airplane was also equipped with an RCA direction finder, which was of little use in New Guinea owing to the lack of broadcasting stations.

Carriers of course were necessary for transporting equipment and some food between camps. We recruited for this purpose about 50 Gosiago boys from Fergusson Island, in the D'Entrecasteaux Group, and a few from East Cape. These eastern boys are reputed to be the best carriers in Papua and we certainly found them very satisfactory. We also had 4 carriers from the lower Bamu River.

As weight was an all-important consideration, collecting equipment was of the simplest kind practicable for the preparation and transportation of specimens. Boxes of stout 3-ply wood, 69 cm. long, 32 cm. wide and 27 cm. deep, painted, the lid covered with overlapping canvas and edges bound with metal, were used for packing skins of birds and mammals. Weighing only 10 1/2 pounds, a convenient shape for carrying, and strong enough to pack with foodstuffs, this type of box had proved very suitable on our 1933–1934 expedition and gave good service on this. Drying ovens operated on the principle of a heated water-jacket were used for the preparation of botanical material, and the dried specimens packed in painted canvas bags shaped to the form of the bundles and tied with rope, which when twitched tightly made them completely waterproof.

Each member of the party took three chosen Gosiago boys to assist in the collection and preparation of specimens. Some of these boys developed into quite good hunters and trappers, and all proved loyal and capable helpers.

ITINERARY

The following is a summary of the movements of the members of the expedition in relation to collecting activities.

Messrs. Brass, Rand and Tate arrived in Port Moresby by steamer from Australia on February 6. While initial arrangements were being finalized, and stores packed, Brass and Tate went to Rona[1] February 14–18 to collect plants and mammals. During this time 45 of the indentured laborers, ordered by radio some time before, arrived from Fergusson Island and East Cape. A boat was chartered to take the party and stores to Daru, where the base camp was to be established. This trip, directly across the Gulf of Papua, was prolonged by trouble with the ship's engines, and took from the 20th to the 24th of February.

Mr. Beach had ready at Daru the old quarters which we had occupied in 1934. After landing stores and equipment, preparations were made for the arrival of the plane, including the building of a ramp for beaching it. Some collecting was carried on locally.

The airplane had been shipped to Brisbane, where it was assembled. On March 9, with Archbold, Julstedt and Rogers on board, the plane was flown to Cairns. Bad weather delayed them a day there and on March 11 the flight to Daru was completed. Archbold and Rogers flew to Port Moresby and returned to Daru with Champion and Willis on March 18.

The arrangement of equipment kept us in Daru until March 23, when the first reconnaissance flight was made. Archbold and Rogers piloted; Brass, Champion, Rand and Tate went as observers. Food for two weeks, guns, cartridges, axes, mosquito nets, cooking utensils, etc., were carried for use in the event of a forced landing. The objective of this flight was the Dap Range, but finding the mountains under cloud, we landed on Lake Murray and remained there an hour and a half in the hope that the clouds would lift. Cloud conditions failing to improve, the flight was then continued low over the forests to the junction of the Black and Palmer rivers, thence down the Palmer and along the Fly for a few miles below Palmer Junction, and back to Daru. This flight satisfied us that the plane could land on the Fly River anywhere below Palmer Junction.

On March 24 the same party flew directly to the Devil's Race on the upper Strickland River, circled about over the upper Palmer and Fly Rivers and along the edge of the cloud-covered Dap Range, then across to the Ok Mart River on the return flight. On this flight Champion recognized parts of the mountain route and several camp sites of the Northwest Patrol, and places suitable for parachute grounds were observed by the pilots.

On March 25 a flight was made to Mt. Leonard Murray and the recently discovered Lake Marguerite.

Mechanical troubles then delayed further flights for a time. Collecting was

[1] For description of this country see 1935, Bull. Amer. Mus. Nat. Hist., LXVIII, pp. 548–550.

carried on locally, with an occasional trip to the mainland or out toward the reefs in the Torres Straits. Brass and Tate made collections at Mabadauan between April 13 and 26. Healy with his six native police, and the remainder of the eastern carriers, arrived by the "Papuan Chief" on March 21.

The "Maira," an auxiliary ketch 60 feet in length and drawing 5 1/2 feet when loaded, was chartered from Port Moresby to take the stores and carriers to the upper Fly River. With Brass and Tate, the police escort, 54 carriers and collecting boys, cooks, and full equipment and stores for four months, it left Daru on May 2.

On May 5 the airplane party with Healy, Rand and Willis as observers attempted to view the top of the Dap Range. Forced back by clouds, the vicinity of the Palmer Junction was reconnoitered and a landing made on a long straight stretch of river about 150 m. in width, some 8 km. below Palmer Junction.

This seemed satisfactory for a river landing and base, and it was decided that the inland base camp should be established at the head of this stretch. The party then returned to Daru. On May 7 the same party flew in toward the mountains, but clouds were dense, and after a vain wait on Lake Murray again returned to Daru.

On May 9 the flight was finally successful. After a reconnaissance of the Dap, including its highest point, Mt. Faim, the plane was flown down the Fly to meet the "Maira" just above the lagoon country of the middle river. Healy, Rand and Willis transhipped to the "Maira" and the plane returned to Daru.

The "Maira," with all the inland party on board, reached Palmer Junction on May 13. "Palmer Junction" Camp was established on the selected site and on May 16 the "Maira" left on the return trip to Daru. A few specimens had been secured on the way up the river.

In the next day or two the work of clearing and constructing camp was completed, tracks cut in the vicinity, and friendly contact made with the shy natives who appeared in increasing numbers from the surrounding forests.

The plane visited the inland camp for a final discussion of plans on May 18. It was decided that Willis and Healy should follow the route of the Northwest Patrol to Mt. Mabiom where the advance base was to be established. On the 19th Willis and Healy, with 4 police, 45 indentured carriers and about 30 local volunteers, left to cut a track into the mountains and establish a depot at Mt. Mabiom. The carriers would return to take in the collecting party, and radio, after food for two and one-half months had been laid down by the plane at Mt. Mabiom.

The plane contacted Healy and Willis when they reached a point 3 km. below the junction of the Black and Palmer rivers on June 1, and was able to land there. Three or four days' walk nearer the mountains, though only eleven minutes by air from Palmer Junction Camp, this place had obvious advantages as a river base. The collecting party and stores were therefore moved up by plane, in eight flights, on the fourth and fifth of June. Willis and Healy continued toward the mountains on the morning of the 5th.

The advance party found their way to a prearranged spot in a garden clearing on the west slope of Mt. Blücher, where the plane, flying in on a prearranged day (June 18), successfully delivered them rice without parachutes and other supplies with parachutes.

The advance party then crossed the Palmer to the base of Mt. Mabiom, where, at an altitude of 750 m. on the west side of the mountain, a place was cleared for the plane to drop supplies. This, within easy reach of our final objective, the Dap Range, was to be our main mountain depot where reserve food would be kept, and from which it might be necessary to carry supplies to at least some camps at higher elevations.

It was soon found that observations on mountain cloud conditions, as seen and reported to Daru from the river base, were of little use to the plane on its provisioning flights to Mt. Mabiom. Accordingly, when the plane succeeded in reaching the mountain camp on June 27, after vain attempts on the 24th and 25th, a note was dropped asking Willis to send out carriers for the

radio. Another cargo of foodstuffs was dropped at Mt. Mabiom on July 3, and a small radio receiver brought in to the river base.

Tate, with the two-way radio equipment, left for the mountain camp on July 4. He had barely arrived there when, on July 10, he heard that the plane, which had been flown to Port Moresby and buoyed in the harbor, had overturned during a sudden midnight storm and sunk at its moorings.

The loss of the plane meant the immediate abandonment of our projected mountain work and preparations for a retreat down the river. First, the inland party had to withdraw to the river base. To enable this to be done without leaving behind some necessary equipment, a commercial airplane was chartered at Lae, and with Rogers as co-pilot, flown to Mt. Mabiom with a load of rice. This made retreat from the mountains easy. Healy and Tate arrived at the Black River camp on July 20, the carriers returned for Willis and he arrived there on the first of August.

Reserve foodstuffs at the river base were ample for the retreat down the river. Brass and Rand had picked up news of the loss of the plane on their small radio set and set about building rafts. Some difficulty was experienced in finding a sufficient quantity of large logs buoyant enough for the purpose. Each raft consisted of four logs 20 feet in length and 18 to 20 inches in diameter. The logs were stripped of bark, fastened together with cross pieces and decked over, the whole thing being held together with lashings of split rattan. Twelve rafts were thus constructed, and each equipped as a separate unit, with fireplace, firewood, tent or fly, cooking gear and food for three weeks.

While these activities were in progress Archbold and Julstedt started up the Fly in the "Maira" with supplies for further collecting work to be undertaken on navigable parts of the river. The "Maira" got no further than Alligator Island, in the lower river, where it was brought to anchor with a broken crankshaft. Through the courtesy of a party of prospectors of the Oroville Company, who were on their way up river to continue explorations for gold, Archbold was, after a few days, able to transfer his stores to their chartered vessel, the "Ronald S."

On August 4 the inland party left Black River Camp on the rafts, and on August 8 arrived at Oroville, the old camp of the gold prospectors, situated on the Fly about 30 miles (48 km.) above D'Albertis Junction.

On August 10 Archbold and Julstedt arrived at Oroville with the "Ronald S" and we departed downstream on August 13. On August 16 we reached Lake Daviumbu where Brass, Healy, Rand and Tate, with the police escort and a number of boys, made camp for collecting; while Archbold, Julstedt and Willis, with most of the carriers, went on to the coast. Archbold and Julstedt joined Rogers in Port Moresby and returned to the United States. The carriers were returned to their homes. Willis severed his connection with the expedition though he later independently collected some mammal specimens for Archbold near Port Moresby and on the Kemp Welch River.

On September 29 the "Ronald S" returned to Daviumbu and on October 1 Brass, Rand and Tate left for the next camp down the river. Healy and his police, being no longer necessary to us, were transferred to the gold mining concern for escort duties and flown back to Oroville by the company's plane.

On October 3 we established camp on the east bank of the Fly opposite Sturt Island and collected there until November 5, when we left for the mouth of the Fly by the auxiliary ketch "Goodwill," chartered for the purpose.

We reached Madiri the same day and spent the sixth to the eighth of November inspecting the east bank of the estuary of the Fly. Brass and Rand finally established camp at Gaima on November 8. Tate, suffering from ill health, returned on the "Goodwill" to Madiri and on a little cutter, the "Quest," to Daru, where medical attention was available.

On November 23 the "Goodwill" picked up Brass and Rand at Gaima and took them via Madiri to Daru. Here they

found Tate much improved in health. On December 1 they started on the "Goodwill" for Tarara, on the Wassi Kussa River, where they arrived via the Mai Kussa on December 3 and established camp.

The period December 13 to 21 was spent by Brass and Rand on a trip to Penzara, about 5 hours to the northwest of Tarara. Tate, exhausting the possibilities of mammal collecting by December 29, left for Daru by canoe on that date. At Buji, just east of the mouth of the Mai Kussa, Tate collected some birds and mammals. He then went on to Daru and thence to Port Moresby Collections were made by Tate at the following localities in the mountains behind Port Moresby:

Rona Falls	275 m.	Jan. 19–22
Itiki	450 m.	" 23–28
Sogeri	365 m.	Jan. 29–Feb. 9
		Feb. 22–Mar. 2
Baruari	510 m.	Feb 9, 12–22
Iawareri (bat caves)	210 m.	" 10–11
Trip Sogeri to Kagi:		
Sogeri	365 m.	Mar. 2, 18
Uberi	120 m.	" 3, 17
Ioribawa	790 m.	" 4, 5, 16
Naoro	675 m.	" 6, 15
Emoia	735 m.	" 7, 14
Kagi	1450 m.	" 8–12

On February 1 the government vessel "Vailala," bringing Mr. Austen from a patrol on the Morehead River, picked up Brass and Rand at Tarara and took them to Daru. There they packed their specimens, took them to Port Moresby February 16–23 and left New Guinea the first week in March.

COUNTRY AS SEEN FROM THE AIR

This section deals with the area covered by aerial reconnaissance, describes the methods used in recording observations, and includes notes on general topography and particular features.

Area Covered by Our Flights

Five of our six flights were made with the intention of surveying the Palmer River and the mountains about it and the other headwaters of the Fly River; so that in leaving Daru we flew northward more or less directly for these objectives, passing over the Oriomo, the Fly, the Aramia and Strickland rivers, and the neighborhood of Lake Murray. On several flights we were unable to reach the mountains, and on two flights cloud conditions were so bad that we went no farther than Lake Murray. Our return flights were usually over much the same route, though one was farther to the west, when we reached the coast just east of the Mai Kussa; and on the last flight when, searching for the "Maira," the plane followed down the Fly River from D'Albertis Junction nearly to the lower contact of the Fly River and the Dutch border. (The observers were left with the "Maira" and unfortunately no notes could be kept on the last part of this flight over previously unseen country.) One of the flights to the mountains was made directly to the Devil's Race on the Strickland, taking us over the little-known country east of the Strickland.

The one flight which did not have for its objective the headwaters of the Fly River was up the Turama to Mt. Leonard Murray, then eastward to the newly discovered Lake Marguerite.

These flights gave us opportunity to gather an impression of the general topography of the country, to sketch some of the geographical features and to see the extent of the various types of vegetation which cover the country.

Later we traveled 600 miles of the Fly River and Palmer River by boat and raft, giving us a closer view of part of the country, and our various camps along the shores of these rivers gave us an opportunity to make more detailed investigations at certain points.

Methods of Recording

Observations were recorded by a time and compass traverse. The exact time of being over each feature was noted. This was later translated into miles (the speed of the plane averaged just below 2 miles per minute) and was laid out along the course of the plane as plotted on a large scale map.

The manner in which observations were recorded and correlated for reference after

the flights is shown in the following transcription of notes made by Champion, Brass, Rand and Tate on March 25:

8.38	Along edge barrier. Leonard Murray few points off port bow (sketches by Rand, Brass, Tate. See also photographs taken later). River (Turama) still winding along under edge limestone (B). To right same hilly country without break but definite ridges beyond.
8.40	Swinging to N, course already 330.
8.41	Eight miles to right country drops away to river valley (R) (Kikori ?), Tate's sketch showing end of limestone and L. M. beyond it.
8.43	Over limestone. Plane altitude 1700 meters. Leonard Murray summit a ring of jagged peaks around a central crater opening SE (B). West peak of Leonard Murray 290 degr. Upper slopes of Leonard Murray mossy forest and scattered dwarf bushy trees and shrubs clinging to sheer gray walls of crater. (B).
8.45 1/2	Mt. Ialibu 50 degr. Still over limestone (T).
8.47 1/2	O'Mally Peaks 302 degr.
8.48	Many miles limestone plateau stretch to low range running parallel with main divide (B). Gardens, 5–6 houses (C).
8.52	Leonard Murray 357 degr. (ship).
8.52 1/2	Large River from NW (Kikori) (T).

General Topography

South New Guinea is essentially a low, flat country. On the coast between the Wassi Kussa and the Turama rivers the only noteworthy elevation is Mabadauan Hill, a mere knob of granite a few hundred feet high. Passing inland (northward) from the Wassi Kussa there is no definite hilly country until one passes the Elevala River. The country is all low and flat, or at most undulating low ridges. North of the Elevala the country soon becomes broken and hilly, and continues so to the foot of the limestone band just in front of the Mount Blücher and Sare Ranges. Though roughly hilly, these hills are low; none probably reaching much more than 250 meters altitude.

The very rough limestone band or "barrier," through which the Palmer cuts its deep gorge, is well developed between the Fly and the Palmer, reaching an altitude of perhaps 600 meters. East of the Palmer, however, it dwindles away and disappears in a few isolated hillocks halfway to the Strickland. The Devil's Race of the Strickland is in a gap separating Mt. Blücher Range itself from the Müller Range to the east.

Mt. Blücher Range and Sare Range, reaching about 1500 meters altitude, and probably of an older limestone, are steep-fronted ranges running east and west. On the north they join up, through a confusion of little ranges, with the Dap Range—a part of the central mountain mass. East of the Strickland the limestone "barrier" is again well developed, and, changing its direction, runs southeast to Mt. Leonard Murray. Many streams, some of considerable size, break through this to carry water from the country behind to the Strickland. From Mt. Leonard Murray the limestone "barrier," probably 500 to 600 meters high, very steep, even cliff-like on its western face, continues southeast, with no large streams breaking through it, to end in the Darai Hills.

Mt. Leonard Murray, rising to about 2400 m., is without doubt an extinct volcanic cone, and several small hills to the west of the Wawoi tributary of the Bamu are surely also volcanic cones. A small lake in these hills, near the river, seems to occupy an old crater. Except for the few hills near the Wawoi, and the hilly mass christened by us Kono Hills, the country bounded on the east and north by the limestone "barrier" is low, rising nowhere more than a hundred meters or so above sea level. At the Black River Junction, about 600 miles up the Fly and the Palmer, the elevation of the river is only about 100 m.

West of Mt. Leonard Murray there appears to be a low watershed running toward Everill Junction. The area north of this drains into the Strickland as mentioned above. But south of it very little of the water flows westward. No important streams enter the east bank of the Fly between Everill Junction and its mouth.

Some of the other physical features are perhaps best noted in connection with other aspects of the country, such as vegetation and population. Under the following headings are pertinent details concern-

ing the various areas seen, which amplify what detail has been plotted on the map.

MT. LEONARD MURRAY AND LAKE MARGUERITE.—Mt. Leonard Murray was of course seen from a distance many times, but the party visited it and the country to the east but once, on March 25. As well as giving Mr. Champion an opportunity to see the country over which he was to patrol, the party thought that the area might be attractive from a collecting standpoint. The lake was reported big enough for aircraft landing. It had been seen twice before; a distant view by Hides and O'Malley who discovered it while patrolling to the north in 1935, and by a government-chartered aircraft in 1936.

Our plane flew up the Turama and about 80 miles (128 km.) inland and 20 miles from Mt. Leonard Murray passed over the edge of the limestone "barrier." The country eastward was seen to be a very rough plateau, its surface covered with hillocks like haycocks, one to five hundred feet high, the hillocks with no definite arrangement, no series of ridges. Farther to the east the plateau dropped away to the valley of the Kikori River. The plateau was completely clothed with a light-colored forest. Along the face of the limestone barrier, which reached an altitude of about 600 meters, it dropped very sharply, with cliffs in places, to the level plain of the Turama.

We continued to a position about ten miles to the east of Mt. Leonard Murray, then set our course for where the lake should be, crossed the Kikori and were soon over the lake. After an examination of Lake Marguerite we completed our circuit of Mt. Leonard Murray and returned via the Bamu River to the coast.

Circling Mt. Leonard Murray we saw plainly that it was a single, isolated volcanic cone rising from the edge of the limestone barrier. The central crater had a break on the southerly side.

About 2400 meters high, it was completely forested, though the steepness of the upper slopes was such that vegetation appeared to have difficulty in maintaining a hold, and only scattered shrubs and dwarf bushy trees clung to the sheer gray walls of the crater.

The waters which fall on Mt. Leonard Murray help to swell several river systems: the Kikori to the east, which is already a big stream; the Bamu, which has its source on the south and southwest of the mountain; probably also the Turama, on the south; and lastly, on the north, west and southwest, are streams which appear to flow to the Strickland.

The country between Mt. Leonard Murray and the Kikori River is composed of long, heavily forested ridges radiating from Mt. Leonard Murray. On the lower ends of these ridges were a number of native gardens. Though the Kikori has a sloping valley here, farther down it appears to flow through gorges. The country between the Kikori and Lake Marguerite is of ridges, probably limestone, running north-northwest and south-southeast, with sometimes grassy swamp in the valleys. Lake Marguerite lies in a valley between two such ridges.

The lake is at least 4 km. wide by 16 long, appears deep, has a few islands in it, and is about 900 meters above sea level. The surrounding ridges rise to about fifteen to eighteen hundred meters altitude and carry a scattered population, as indicated by gardens seen in the forest. Generally the shores rise steeply on the southwest side of the lake. The opposite shores are lower and in places fringed with grass, and there is an extensive grass swamp at the upper end. Two small rivers flow into the upper end of the lake, but there was no evident outlet. On one of the islands in the lake Brass saw a village, so there must have been canoes. In addition to gardens on both shores of the lake, sago palms, another source of food, were observed in the vicinity.

To the east and north the immediate country was not much higher, but in the distance, 50 to 60 km. away, the peaks of the main range showed, and Champion pointed out Mt. Giluwer with its split top, Mt. Hagen and the O'Malley Peaks.

The old garden lands in this area were growing up to secondary forest, but to the northwest of the lake Champion and Adamson on their patrol found grassy valleys.

TURAMA RIVER.—The Turama, which

we followed upstream on March 25, is a sluggish, winding stream in flat country completely forested; the forest swampy and containing much sago on the lower part of the river. A very few villages and solitary houses were seen along its banks.

About 60 km. from the mouth of the river we had our first good view of the limestone barrier to the east. Some 30 km. farther on a large tributary joined the river on the east side; low hills appeared 12 km. to 15 km. west of the river, in country generally higher and less swampy. Where last seen, about 128 km. from the coast, it was flowing close under the edge of the limestone barrier and appeared to have its source on Mt. Leonard Murray.

Bamu River.—We saw parts of the Bamu on a number of flights, and on the return from the visit to Mt. Leonard Murray definitely established that its main affluents, the Awarra and the Wawoi, have their sources on that mountain. The Bamu proper was deep and quiet, but its upper portions appeared swift and turbulent. It flowed entirely through forested country though on its lower reaches there was much sago in the forest. Occasional longhouses were seen along the lower reaches of the Wawoi and between the Wawoi and the Awarra. A scattered agricultural population, living in small village communities, inhabited the hilly country near the head of the Wawoi.

Aramia River.—Though a tributary of the Bamu this river is very different from it in the great area of lagoon and marsh country through which it flows. The course of the Aramia is westwardly from the Bamu until it approaches within about 40 km. of the Fly. A belt of forest across the mouth of the Aramia separates its swamps from the Bamu River, but for the rest the more or less east-west course of the river is through an area of marsh and lagoons.

Near the western end of this swamp country the two main tributaries extend northward into an extensive forest area which is continuous with that of the Bamu and the forests which cover by far the greater part of the land surface of New Guinea.

The narrow strip between the lower Fly River and the swamps of the Aramia appeared to be a flat, poorly drained area covered with a mixture of tea-tree (*Melaleuca Leucadendron*) swamps, grass swamp, sago swamp, rain-forest and savanna. The country seen at close range on the east bank of the Fly River near its mouth was probably somewhat characteristic of this area.

The considerable population seen on the Aramia was living in longhouses on slight elevations of ground in the swamp area. Very few habitations and gardens were seen in the forests of the upper river.

Country East of the Strickland River.—This area was almost unknown. We crossed its southwest corner a number of times on our way to and from the mountains, but our one extended flight over it was when we flew directly from Daru to the Devil's Race on the upper Strickland on March 24.

In the southeast corner of this area, as shown by our many flights, the country is low and forested. Only within a few miles of the Strickland itself are there extensive swampy grass areas, tea-tree swamps and large sago swamps.

The Strickland itself, where we saw it on its lower reaches, was a river very different from the Fly. It was wide and twisting, but much more rapid than the Fly in similar latitude. Its course was frequently broken by islands, and there were many old cut-offs, some still filled with water, others growing up to light-colored trees, evidently a secondary or developmental forest formation.

But on the flight of March 24, after passing Mt. Leonard Murray on a course about 15 miles to the west of it, our route to the Devil's Race was over a rough, hilly limestone country broken by gorges and cliffs as well as flat valleys. Many streams, some of considerable size, flowed toward the Strickland.

In the southern portion of this area we found a very heavy longhouse population. Many gardens, generally circular in shape, were seen in the forests. In places the gardens touched one another, but usually a line of trees was left between them, giving the

impression from the air of honeycomb. Going northward the population became more scattered, but some population extended almost to the Devil's Race. Except for the gardens, and occasional exposed rock surfaces, this country was entirely forested. Where gardens had been abandoned they were growing up to secondary forest, and in the southern portion of this area there were considerable extents of this.

THE UPPER STRICKLAND.—Our only view of the upper Strickland was on March 24, when we entered its deep gorge at the Devil's Race and after passing the mouth of the Crystal River gorge, swung west over the saddle between the Dap and Mt. Blücher ranges to the headwaters of the Palmer. The Devil's Race, where the river breaks through the limestone, is a tremendous gash several thousand feet deep. Garden clearings and small villages of low houses thatched with *Pandanus* leaves were seen on the north slopes of Mt. Blücher Range, in the drainage basin of a small river flowing east to the Strickland. At altitudes of 1500 m. or more, tall hoop-pines (*Araucaria*) towered above the forest on the mountain spurs. *Pandanus* trees were conspicuous in what appeared to be low mossy forest on the Dap-Blücher saddle, and groves of these trees, probably one of the species commonly planted by the mountain peoples of New Guinea for their large oily seeds, were seen near the villages.

Our most interesting note concerns the Crystal Gorge. As may be seen from our map it joins the Strickland Valley from the northeast rather than the northwest, as is shown on earlier maps.

The southern part of the valley was steep, dark and wooded, with only a few garden clearings. But farther up it widened and the less steep slopes were grass covered. This was evidently the mid-mountain grassland country which occurs from about 1000 to 2000 meters in the mountains, where old garden lands grow up to grass rather than second growth forest, as at lower altitudes. The extent of this grassland would imply a heavy population in the upper valley of the Crystal.

FLY RIVER.—Our activities centered around the Fly. We flew over parts of it, traveled much of it by raft and boat, walked along it in part and established camps on its margins. The various observations made are given later, so that here it is only necessary to give a sketchy survey of the area for the sake of uniformity of treatment.

Our aerial observations of the river may be summarized as covering fairly completely only the eastern headwaters area as far down as the junction of the Elevala, and the lower river from the Fairfax group of islands to the mouth. One flight over the headwaters took in the country as far west as the Ok Mart and Alice rivers, while another followed the river down to its lower crossing of the 141st meridian.

The broad physical features of the river basin have already been described. From the mouth of its muddy, funnel-shaped estuary to Macrossan Island, a distance of about 520 miles (832 km.) as measured by the windings of the river, the Fly is a broad muddy stream flowing with a steady current of 2 1/2 to 8 km. an hour. Although the water is fresh enough to be drinkable almost to the mouth of the river, there is evidence of a tidal rise and fall as far as Ellangowan Island, approximately 320 km. from the coast. The following measurements of the river and calculations of its volume were made by MacGregor in 1890[1]:

[1] 1890, Ann Report British New Guinea, 1889-1890, Appendix I, pp. 57, 63.

Everill Junction:	Fly	Strickland
Average depth	14 yards	10.8 yards
Width	302 "	420 "
Current per hour	1.5 miles	3.3 miles
Gallons in 24 hours	45,000,000,000	106,000,000,000

Palmer Junction:	Fly	Palmer
Average depth	2 2/3 fathoms	3 fathoms
Width	130 yards	120 yards
Current per hour	3 miles	2 1/2 miles
Gallons in 24 hours	14,760,000,000	12,770,000,000

Some idea of the flat character of the country below the foothills of the central mountain range may be gained from the fact that, on a voyage up the river, if we except MacGregor's Conical Sandhill, a half-eroded hillock of soft sandstone about 3 km. below the Fairfax group of islands, no elevation that could be called a hill is seen for a distance of about 650 km. from the river mouth, where, on the west bank, a ridge 2 or 3 km. in length rises some 50 m. above the level of the plain.

This flatness of the land, and the often swampy nature of the banks, were of course remarked upon by the early explorers; and on the basis of their accounts, corroborated by the reports of later visitors who traveled the river by boat, it has been generally believed that by far the greater part of the lowland course of the river is through a country of uninhabitable swamps. That this is a somewhat exaggerated conception will be seen from our observations.

The country behind the north bank, from the coast to the vicinity of the Fairfax Group, is described elsewhere. On the south side the country is generally low and covered with swampy forests, sago swamp and rain-forest for a distance of 2 to 8 km. out from the banks. Beyond this are low savanna ridges which carry, in parts, considerable bodies of forest. In broad terms it may be said that the banks of the lower river are forested as far as Cassowary Island.

About Cassowary Island the vegetation of the banks becomes more open and the river begins to assume a different character. A few miles above Ellangowan Island its appearance is almost entirely changed. Still a broad stream flowing with a strong current, it cuts a tortuous, shifting course through largely inundated plains covered with reeds, swamp-forests of various types and expanses of floating grass. The wild sugar-cane *Saccharum arundinaceum* fringes the banks in continuous tall brakes. Numerous old cut-offs of the river provide stretches of open water, while set off from the banks, especially above Everill Junction, are series of large lagoons. Rain-forest persists, however, on strips and patches of elevated ground, and particularly on the western side are rather extensive areas of low-tree savanna. Aerial observations, confined to distant views from the east, seem to confirm the impression gained from a boat, namely, that rain-forests cover the country at no great distance from the eastern bank. Behind the cane grass the forests fringe the river for much of the distance up to Everill Junction.

Near the lower contact of the river with the Dutch boundary forest-clad hills begin to appear, and with the gradual rise of the land toward the foothills, the swamps of the "middle river" give way to continuous rain-forest.

Our flights over the headwaters of the river gave more impressions of steep slopes, rugged mountains, cliffs, waterfalls and the immensity of this country than they yielded geographical data. The Dap Range, rising to about 3300 m. in Mt. Faim, the source of the Palmer as well as tributaries of the Fly proper, had already been chosen as the goal of the collecting party. And, having the maps of the Northwest Patrol, published by Karius and Champion, our time was chiefly occupied in checking these and in an examination of the country for collecting localities and sites suitable for parachute delivery grounds.

The limestone barrier which rises from the lowlands, and the fronting ranges of Sare and Mt. Blücher, have been mentioned. The garden clearings and villages of a small population were observed on the south slopes of Mt. Sare. In the upper valley of the Palmer, between the fronting ranges and the Dap Range, there is also a small population, increasing toward the west. A heavier population occurs in the valley of the Bol River (a tributary of the Fly), where limited areas of mid-mountain grassland were seen on the lower slopes of the Dap.

Indications of altitudinal differentiation were observed in the forests of the mountains. Low, very mossy forest covers the summits of the Sare, Mt. Blücher and Dap ranges. Dark foliaged coniferous trees (probably *Podocarpus* or *Libocedrus*) were abundant on the higher parts of the Dap. On the summit of Mt. Faim were patches of

alpine grassland and a number of small ponds.

Ok Mart River.—Mr. Champion was interested in seeing the Ok Mart to judge the density of the population, always of prime importance to government officers. Officers patrolling on foot years before had estimated the population at two thousand people; and in 1935 the Oroville Gold Company, after flying over the area, had increased this estimate to ten thousand.

While population is not dense on the Ok Mart, certainly there are many people there. Little circular gardens and square, squat houses set up on posts are common in the forest. On comparing the evidences of habitation with those at Palmer Junction, where few gardens and villages were seen from the air but as many as 106 men appeared in our camp at one time, it would seem that the population on the Ok Mart is certainly more than twice the original estimate of two thousand.

Lake Murray.—Lake Murray is a vast lagoon, greatly indented, half filled with islands, and comparatively shallow in relation to its extent. It occupies an irregular depression in a country of low ridges. At least two small rivers enter it from the north. In the direction of the Strickland, to which it is connected by a deep creek, is a mixture of forest, open marsh and swamp vegetation. To the east, west and north are forests, and the islands in the lake are also forested. A marginal fringe of floating grass, widening to fill small bays, extends along the entire length of the shores and also encircles the islands.

Situated on islands in the lake are several villages of a canoe people who seem to subsist mainly on sago and fish, while far to the north, in the forests drained by the feeder streams of the lake, lives a scattered population that grows at least a part of its food supply in unfenced gardens.

Oriomo River.[1]—The Oriomo is, for the most part, edged with forest. To the east mixed savanna and forest extend toward the Fly; to the west the savanna has some forest patches in it, and is probably continuous with that of the Wassi Kussa. To the north, forest patches become more plentiful on an east-west rise which appears to be the divide between the Oriomo and waters flowing northward to the Fly.

Mai Kussa and Wassi Kussa Rivers.—The waterways here are narrowly fringed with forest, and there are large areas of flat, low, brownish savanna which extend far to the north and are evidently more or less continuous with the savannas of the mid-Fly.

Coast from Wassi Kussa to the Fly River.—The only elevations on this flat, monotonous coast are the granite outcrops of Mabadauan, rising but 200 feet above the level of the coastal plain.

A sloping beach of mud is broken here and there by stretches of sand, as at Old Mawatta, just east of the Binaturi River, and at Mabadauan. A narrow line of sprawling mangroves usually fringes the sea, behind which is a band of forest consisting of taller mangroves or a transition of mangrove forest to rain-forest. Frequently a line of grass and sedge swamps, with or without open water, runs parallel with the coast behind the forest fringe, and another band of forest may occur between the swamps and the savannas, which appear a mile or two from the beach. Sometimes the seaward edge of the savanna changes to grassy swamp miles in extent and fringed with mangroves.

This succession of course varies somewhat and tends to be upset at the mouth of the rivers, but it was found in a goodly number of places.

Coast from the Fly River to the Turama River.—This coast is apparently of mud, or a muddy silt deposited by the rivers. The fringing mangroves, only a few hundred meters in width at most, are succeeded by forests of tall swamp-inhabiting trees perhaps tolerant to brackish water, freshwater sago swamps, rain-forest containing abundant sago or sago growing in reeds. Tea-tree swamp-forests and open grass marshes are frequent between the Fly and the Bamu. In a very few places are areas of dry-land forest, well away from the sea, or on the banks of streams.

[1] For a description of collecting stations at Wuroi and Dogwa on the Oriomo see 1935, Bull. Amer. Mus. Nat. Hist., LXVIII, pp. 576–579.

ROUTES AND COLLECTING LOCALITIES

In addition to the data gained from water and land travel, we have endeavored, where possible, to correlate observations made on the airplane flights.

The localities are not listed in the order in which they were visited, but in a geographical sequence; first the Mai Kussa and Wassi Kussa rivers; then the localities from the mouth of the Fly River inland.

Mai Kussa and Wassi Kussa rivers
Tarara Camp
Penzara Camp
Mabadauan
Mouth of the Fly River
Gaima Camp
Gaima to Sturt Island
East bank of Fly River opposite Sturt Island (Sturt Island Camp)
Sturt Island to Lake Daviumbu
Lake Daviumbu Camp
Lake Daviumbu to 30 miles above D'Albertis Junction
Oroville Camp
Fly River from Oroville to Palmer Junction
Camp 5 miles below Palmer Junction (Palmer Junction Camp)
The Palmer River below Black River Junction
Camp 2 miles below the junction of the Black and Palmer rivers (Black River Camp)
The upper Palmer River and Mt. Mabiom Camp

MAI KUSSA RIVER AND WASSI KUSSA RIVER.—These rivers are in reality two arms of the sea which enclose Strachan Island. Entering the Mai Kussa, the country at the mouth of the river is all mangrove, but very soon it becomes somewhat higher, with low red banks or flat exposures of gray limestone showing along the river in places, and occasional low ridges on both the island and the mainland. The country appears covered with a light rain-forest, mixed with savanna. Twenty to twenty-five kilometers up the river the banks flatten out and from there around the north of Strachan Island there is a wider mangrove fringe, nipa palms (*Nipa fruticans*) begin to occur in some abundance, and more meandering creeks appear.

The land about the Wassi Kussa, near its mouth, is low, and there appears to be flat grass country, sparsely dotted with savanna trees; some of it may be swampy. About Tarara Creek, a tributary of the Wassi Kussa, the country is somewhat higher, and more savanna shows on the banks.

The climate of this area is semi-arid, i.e., characterized by marked periodicity in the rains. Very little rain falls during the season of the southeast trade winds, which blow with varying strength from about May to November. Of an estimated annual rainfall of 60–70 inches probably more than seventy-five per cent is received during the five months December to April, the season of the northwest monsoons.

TARARA, WASSI KUSSA RIVER.—December 7, 1936, to January 31, 1937. Camp was made in the old village of Tarara, on a point of land dividing Tarara Creek into two nearly equal streams. Along the creek the banks sometimes rose to a height of 20–30 feet. Both branches of the creek were tidal for a distance of several kilometers above Tarara, and narrowly edged with mangrove and nipa.

Though elevated above the flood level of the river, for a considerable distance behind Tarara village the country is very flat, with scarcely perceptible ridges. The streams are seasonal. When we arrived early in December fresh water was to be found only in a few small holes in a dry stream bed about a mile from the village. Farther up both branches of the creek, and in the direction of the coast, are areas of low ridges. In several places in the ridges south of the right-hand branch are chains of permanent waterholes about 50 m. in width, and also small swamps filled with sedges. Exposures of limestone, which evidently underlies the entire area at no great depth, occur in some of the streams.

Savannas of various types constitute by far the greater part of the vegetation cover. Rain-forest occurs chiefly as fringing strips along the creeks and seasonal streams and in isolated patches on some of the ridges. It may, in places, spread back from the stream a distance of one or two hundred meters, but is nowhere of great extent. Only one small sago swamp was found in the area. Small patches of tea-tree (*Melaleuca Leucadendron* var.) swamp-forest were more common; the straight white trunks of the trees sometimes covered with a robust climbing fern (*Stenochlaena* sp.) with shining, pinnate leaves.

The best of the rain-forest is poor and light. Some of it could only be described as dense brush. The better developed stands consist of scattered large trees 25 to 30 meters high which, with many lower, more slender trees, give a closed canopy. Slender, sapling-like trees form a rather abundant substage; lianes are not common; there is little rattan,[1] and the ground is covered with dead leaves. It is easy to walk about in this forest and one can see a considerable distance near the ground. Areas such as this are, however, of very limited extent. Savanna trees such as *Acacia crassicarpa, Tristania suaveolens* and *Tristania longivalvis* intrude into the forest; and where the forest is more open, lighter and drier, there is much undergrowth of a dense, springy euphorbiaceous shrub through which it is possible to force a way only with difficulty. In places this undergrowth is invading the taller and denser savanna-forest, though fire is to some extent keeping the movement in check. The thorny shrub *Alyxia ruscifolia* and a small clump bamboo (*Dendrocalamus latifolius*) also form troublesome undergrowth in the lighter forest, where, strangely enough, thick moss cushions of a vivid green occur on the ground.

The savannas exhibit, in accordance with soil conditions, considerable diversity in character, and, within the limits of a somewhat meagre flora, corresponding differences in composition. Very slight differences in elevation, through their influence on soil drainage in the wet season, suffice to bring about marked changes in the character of both soil and vegetation. Striking features of all types of savanna are the termite mounds, grey in color on the flats and reddish on the ridges. Varieties of *Melaleuca Leucadendron*, mostly with gray or whitish papery bark, but differing in habitat requirements and general appearance, provide much of the tree stocking throughout.

Extensive ridgy areas are covered with 20–25 m. high savanna-forests of one or two kinds of these "tea-trees" and *Tristania suaveolens*, with species of *Eucalyptus*, *Acacia*, etc., intermixed. The trees form a more or less complete, though thin, high canopy, under which is a dense ground cover of grasses, 1.5–2 m. high when in flower in the wet season. As mentioned above, the savanna-forests of the drier soils are often invaded by undergrowth shrubs from adjoining rain-forest.

There are also extensive, poorly drained areas of open tea-tree savanna, with trees 4–6 m. high, and a 40–60 cm. ground cover dominated by sedges (*Schoenus* and *Rhynchospora*). Under somewhat similar conditions, and in association with the same type of ground cover, another species of tea-tree (*M. symphyocarpa*) grows to a height of 8–10 m. in nearly pure stands, and forms a sparse canopy overhead. There is very little grass country without trees, but here and there low sedge-covered almost treeless flats, usually long and narrow, extend through the savannas. Bright flowering herbs, and especially sun dews (*Drosera*) and shrubby pitcher plants (*Nepenthes mirabilis*), are common on the sour tea-tree flats and areas of open grass.

In these savannas we found many of the less known savanna birds, such as *Choriotis australis, Ninox novaeseelandiae, Sauromarptis tyro, Gymnorhinus tibicen, Entomyzon cyanotis, Philemon citreogularis* and *P. corniculatus*.

In a few places near Tarara, and more commonly farther inland in the direction of Penzara, the savannas are interrupted by belts of low scrub, composed of a thin-stemmed shrub with very small leaves; probably a species of *Agonis*. These scrubs, which vary from about 1 m. to more than 2 m. in height, are waterless in the dry season. They appear to hold no peculiar birds or mammals.

The lack of water on the savannas, with often only the salt water of the rivers available during the dry season, may be a factor in the distribution of some forms of animal life. This may be the reason that wallabies were very common across the creek from Tarara where small swamps and lagoons provide permanent water, while on the Tarara side where the only water, in small holes, probably dried up during the southeast season, wallabies were seldom seen.

[1] Climbing palms of the genera *Calamus* and *Korthalsia*.

Mr. Claude Champion, who has patrolled much of this area, says that in the dry season water is a problem, the village waterholes providing an almost undrinkable fluid.

It was quite different in the rainy season. In January the flat savanna, with poor drainage, became soft and boggy, and was covered at times with an inch or so to a foot of standing water. Snipe were found feeding in the more open parts, frogs hopped across one's path and fishes swam through the grass and in the little streams which flowed along what had been dry, hard trail.

The population was very scattered here, but finally considerable numbers of natives came to visit us. Their help in hunting and securing specimens was negligible, but they brought in quantities of native food. Yams, the important food crop, are stored for use during the year. Manioc is also a common article of diet, and a certain amount of sago is eaten. Many bananas were brought for sale, considerable numbers of pineapples and papaws, and a few sweet potatoes, mangoes and coconuts.

Fish lines and fish hooks were very good trade; knives and calico were prized, and tobacco, matches and mirrors also attracted some demand.

After the turn of the season, in the latter part of December, much rain fell, often in the form of thunderstorms. We experienced a few days of steady, soaking downpour, but as a rule much of the day, usually the morning, was fine, and the afternoon showery. Sudden squalls of wind and rain were common in the afternoon in January. During the latter part of our stay the river became quite fresh from flood waters.

Temperatures (C.) at Tarara, December 7–January 31:

December	Min. 11	readings	22°–23.5°: average 23°
	Max. 14	"	31°–35.5°: average 33.5°
January	Min. 18	"	22.5°–26°: average 23.5°
	Max. 18	"	29.5°–36°: average 33°

PENZARA.—Between the Morehead and Wassi Kussa rivers: December 13–21, 1936. Almost entirely savanna, the country was more hilly here than at Tarara, the gradual slopes reaching an altitude of perhaps a score of meters. In broad aspect similar in most respects to those of the more elevated ridges of Tarara, the savannas carried an abundance of the shrubby *Agonis*. In places the *Agonis* formed an undergrowth in savanna-forest, in others it appeared in the characteristic pure scrubs, with very few trees rising above it. The scrubs had been killed back by fire over considerable areas and were springing up afresh.

The grass for the most part had been burned and was beginning to grow again after early rains. In places on the higher ground, however, the unburned grass cover was short and sparse.

Along the small waterways which ran through the savannas, and in which water from recent rains was beginning to accumulate, were narrow interrupted lines of rain-forest trees. Occasional very small patches of rain-forest also occurred on the savanna ridges.

A mile or more from Penzara, in a depression in a valley completely flooded in the wet season, was a waterhole a few hundred meters long and 20–30 m. wide. Along the edges of this waterhole were a few bits of marsh, and above and below it, in the bottom of the valley, were areas of low dense forest of some extent. In places this forest was almost a pure stand of a briefly deciduous species of *Barringtonia*, the trees 4–5 m. high, and heavily draped with the climbing fern *Stenochlaena*. Epiphytes, including ferns, mosses and orchids, were very common. There was little undergrowth, the leaf-covered ground again indicating the flooding which occurs.

MABADAUAN.—April 14–24, 1936. This is the only locality in which granite is known to occur in south New Guinea. There are several outcrops in the vicinity. One is on a low promontory 6 km. up the coast; some form rocky islets off shore; while others rise above the coastal plain as a cluster of small hills and knolls just south of the mouth of the Pahoturi River.

Mabadauan hill, about 60 m. high, is the largest of the granite outcrops. The lower slopes of the hill are strewn with great

rounded boulders, and are park-like with clumps of low bushy trees (*Terminalia, Sterculia, Mimusops*). A dry type of rain-forest containing many candlenut trees (*Aleurites moluccana*) covers the upper slopes. This forest has no doubt been reduced in area by the native population. Other patches and belts of rain-forest, none of them very extensive, occur on the moist flats of the river and of creeks, and at intervals on the savannas. A narrow strip of poorly drained forest, interrupted to some extent by tea-tree swamp-forest, also runs parallel with the coast.

The prevailing savanna-forests cover a gently undulating country and on the whole are better drained than those of Tarara. Here *Eucalyptus terminalis* (bloodwood) and *Acacia crassicarpa* (?), growing to a height of 18–20 m., are the principal trees, and *Themeda triandra* (kangaroo grass) generally dominants in a thick ground cover rather less than 1 m. high. Low flats covered with a more open savanna vegetation of low tea-trees and *Grevillea glauca* also occur. Small areas of tea-tree swamp-forest are not uncommon. In one place we found a grassy swamp in which grew a quantity of low sago palms. Very large pinnacled termite nests, which may exceed 3 m. in height, are a characteristic feature of the Mabadauan savannas.

With the exception of short stretches of rocky shore and some sandy coves associated with the granite, the coast is mangrove fringed. There is, however, usually a narrow beach of sand, with open low mangroves growing on rather firm flats of mixed sand and mud on the seaward side, and sometimes taller mangroves merging into swampy rain-forest in the rear. Behind the beach are extensive planted groves of coconuts. Here, at Daru, and along the intervening coast, quantities of water-rounded pumice have been cast up on the beaches and in mangrove swamps, above the level reached by ordinary high tides.

The village of Mabadauan, with a population of about 600, is well known for the progressive and independent spirit of its people. Most of the younger men find employment as crew-boys with the Thursday Island pearling fleet. The older men employ their time in making canoes, fishing, and to a certain extent in assisting the women in the production of food crops such as yams, sweet potatoes, taro, maize and bananas. Other activities include voyages to the lower Fly and Bamu rivers for sago to augment the food supply, and for canoe logs. There is an old established trade in finished sailing canoes of the double outrigger type to the islands of the Torres Straits.

At times during our stay considerable quantities of water lay on the savannas after heavy rains from the northwest. Pools and swamps provided breeding places for swarms of Anopheline mosquitoes, which infested the village after nightfall. But the trade wind, heralding the approach of the long dry season, had already commenced to blow from the southeast.

Mouth of the Fly River.—The banks at the mouth of the Fly River are low and appear for the most part subject to inundation at the highest tides. This appears to be true as far up the river as Gaima on the east bank, where the banks rise sharply 20–30 feet above high water, and Madiri on the west bank, where the land rises slowly from the river, though even here the coconut plantations fringing the river are flooded by high tides.

Parama Head, on the west side of the estuary, is apparently entirely mangrove covered, and there is much mangrove on the islands opposite. Just above Totoresi is an area of what appears to be grass swamp fringing the river. Going toward Madiri at first there is considerable mangrove and nipa, then forest to the river's edge. There are three large villages, with coconuts, grassy areas and some second growth about them, perhaps not flooded by the tide.

At Madiri itself there is only a very narrow fringe of sprawling mangrove on the muddy shore, and behind that a line of tall firefly mangrove (*Sonneratia acida*).

The east bank was examined more closely, from Asaramirubi Creek to Gaima. The charts give this as a shore lined with mangroves and nipa, but actually there is little of either; where they occur it is as a narrow, broken line on the muddy beach.

We landed at several places in search of a suitable camp site.

At Asaramirubi Creek we found the only sand beach seen at the mouth of the Fly. The creek itself was 100 yards or so wide at low tide, with flat, sandy shores. Just downstream was the village of Segara, consisting of a curved longhouse and an incomplete government rest house. Its site, too, was composed of fine sand, and may have been just above the highest tides (the houses were of course built on piles). There was a small, deeply trenched banana garden near the village; and a large coconut grove along the edge of the creek, in which were the remains of an old longhouse. Apparently the coconut grove and the old village site were flooded by spring tides.

Walking inland we entered a stand of low, thorny shrubbery, so dense that it was impossible to move about in it except along the muddy trail. The trail ended, after a couple of hundred yards, in a big muddy creek. All the land showed evidence of tidal flooding.

Along the river beach there were banana gardens and a poor, low forest, little if at all above tidal influence.

From Asaramirubi Creek to Urio the "Goodwill" skirted the shore. The country continued low and flat. Scattered along the shore were several villages consisting of single longhouses with coconut groves and perhaps some land above tide level. But for the most part the country was low and apparently flooded, with tea-tree swamps or low trees mixed with sago palms coming down to the river's edge.

Urio was a village of the customary longhouse on piles with a few hundred yards of grass, apparently above high water, along the shore upstream, where a camp could have been made.

The party walked inland for a mile or so over a well-used trail that ran nearly straight north. Just back of the village was an area of second growth forest, then a ridge raised a few feet above the surrounding swamps. The ridge carried a poor low rain-forest, but for the rest the country was covered with sago swamp, or tall cane grass swamp with a scattering of low tea-tree. A mile or so inland the ridge ended in an apparently extensive flooded plain of cane grass 2–4 m. tall, which in the distance was thinly grown with tea-trees. The mud and water on the trail had by this time become so deep that it was necessary to skirt the edges of the deepest holes or cross them on submerged trestles of sticks which served as bridges.

From Urio to Waribodoro and thence to the vicinity of Gaima, the country continued much the same. A landing was made at the village of Waribodoro, which again consisted of one immense longhouse on posts, built on ground washed by the tides. The shore was flat and muddy and the entire river frontage appeared to be subjected to tidal inundation. Following trails of sticks and tree trunks laid on the mud and bridging the innumerable creeks and ditches, the party proceeded a mile or so inland to find the country mostly covered with low second growth trees and sago palms, alternating with deeply trenched banana gardens. Here and there were small patches of low, wet forest, with the climbing fern *Stenochlaena* decking the trunks and in places tall coarse sedges on the ground.

Gaima Camp.—East bank of Fly River 72 km. from its mouth: November 8–28, 1936.

A grove of coconuts on a strip of savanna grassland extending to the river bank between two bodies of rain-forest, marks the position of the former village of Gaima, and near this our camp was established. Close at hand were a few rough shelters used by natives when making sago. About 2 km. downstream was a large banana garden, and at 6 km. the village of Kauiapu.

At Gaima the river water was quite fresh, though brown and muddy. The only other water obtainable at a convenient distance was the tea-colored fluid from sago swamps. Coconuts being plentiful, we drank coconut milk almost exclusively.

Here the country rose 6 to 10 m. above the river, then in a quarter to half a mile gradually sloped back to swamp. In front of Gaima itself was a 5-m. sharp bank of red and gray soil, the foot of which was washed by the tides. Fronting this high bank was a flat sloping beach, sandy in

places, but mostly of mud, with here and there loose boulders of a lateritic rock. The beach was littered with driftwood; some of it very big logs. Covering most of the beach were low formations of upright sedges and dense low shrubberies of *Derris trifoliata*, with which occurred a sprinkling of stunted mangrove trees. Several small islets of coarse sandstone, exposed at half-tide, lay just off shore.

Other high banks occurred along the river. There was frequently an abrupt rise of 1 m. or more to dry land behind the beach. Usually the outer beach was muddy and irregularly fringed with mangroves and a little nipa, while the inner beach was often sandy and open. In places where sago swamps touched upon the river there was little beach at all. Beds of a black peaty material (almost lignite), apparently laid down in sago swamp and later exposed by erosion of the banks, frequently stretched across the beaches.

The dry land positions carry either rain-forest or savanna in about equal proportions. The line of demarcation is not always well marked; especially where tall savanna-forest develops a canopy too dense for the vigorous growth of grasses and is being invaded by marginal undergrowth species and later trees from adjoining rain-forest.

The rain-forest is of a rather dry type with some very tall rough-barked trees and many lower ones giving an irregular canopy. Woody undergrowth is quite dense; frequently with many low palms and *Pandanus*. Lianes and rattan (*Calamus*) are common enough to be a hindrance to progress through the forest. Scattered over the leaf-covered ground are small tufts of hardy ferns.

The difficulty in penetrating the forest increases with the entrance of thorny sago palms as the land dips into poorly drained depressions. In the deeper hollows rain-forest trees give place to pure stands of sago, with 10-m. leaves and short, thick trunks. A person rash enough to attempt a crossing on the rotting fronds that litter the surface of a sago swamp is apt soon to find himself floundering at least knee to waist deep in foul-smelling mud and water.

The savanna in places is composed of open stands of large tea-trees 25 m. or more in height, with a tall dense stand of grass on the ground. Many cavities in the trunks and branches of these trees provide nesting sites for parrots. In other places the savanna changes into tall thick stands of tea-tree and *Tristania* with diminished grass cover, or to grasslands with a few scattered low trees. Frequent long, narrow, swampy depressions or watercourses, in which the water is quite deep, are more or less choked up with sago and a tall sedge (*Scleria oryzoides*).

The extensive sedge swamps which have been mentioned as occurring a little distance inland, appeared to be in a series running parallel with the river and 1 to 2 km. wide. Beyond them were rain-forest and sago swamp. At Gaima, the swamps were filled with *Scleria oryzoides*, and too deep for wading. But inland from Kauiapu, where they were shallower and partly dry, parts had been burned. There it was possible to walk over much of their area, sinking ankle deep in mud, and skirting small, deep waterholes about which cormorants and herons were common and where the natives fished.

The local natives are, of course, semi-civilized, and many are recruited for plantation work. They brought us bananas, coconuts, papaws, a few sweet potatoes, a dark mud fish from the swamps, and two sorts of crayfish—one from the swamps, the other from the river. Tobacco was the universal payment.

The first seven days at this camp were hot and bright, usually with a southeast wind. Later, the heat became oppressive and there was a good deal of thunder and lightning in late afternoon and evening. During the second week we had four days of rain; one heavy downpour lasting most of a night and morning.

Temperatures (C.): Minimum (11 records) 20.75–25.5, average 23.5. Maximum (8 records) 26–34.5, average 31.8.

Gaima to Sturt Island.—Until about 15 miles below Sturt Island the banks maintained their flat character. The river was wide and forested to the water's edge. In the upper part of this stretch much

driftwood lay stranded on the shores, as though tide and wind combined here to force ashore the floating timber which a little further upstream goes up and down on the tide.

About 25 km. below Sturt Island we passed a bluff 12–15 m. high overlooking the river. Its summit was occupied by a clearing, growing up to secondary forest. In this clearing was a large longhouse, old and falling into disrepair and apparently long deserted. It appeared similar to a house seen near Sturt Island Camp.

EAST BANK OF FLY RIVER OPPOSITE STURT ISLAND (STURT ISLAND CAMP).—October 4 to November 4, 1936.

Camp was situated in a grove of bamboos on the top of a red bluff, about 12 m. high, overlooking the river. Here the river had about 4 m. of tide; about 4 hours of up-flow and 8 hours of ebb. The water was perfectly fresh, though heavily charged with sediment. At slack water, as the tide began to ebb, a certain amount of heavy brown oil floated on the surface.

At certain times a pronounced tidal bore occurred in this stretch of river; a wall of water perhaps 2 m. in height, which passed up the channel to the west of Sturt Island. At night it made an impressive noise as it rushed up the river; commencing as a faint murmur, swelling to a roar as it passed on the far side of the island, and dying away up stream.

Sturt Island, and the two above it, the only ones visited, are all flat islands of silt and completely flooded by high tides. They carry dense forests of very tall trees with many aerial roots, in which the ground is bare and often muddy. Woody undergrowth is scanty and open, but in places a low *Pandanus* forms a 6–8 m. substage layer over considerable areas that are frequently flooded. On higher ground a slender betel-nut palm (*Areca macrocalyx*) constitutes an almost pure substage. Lianes and rattan drape the trees and form impenetrable low tangles in open places and on the banks of the river.

Bordering the river in many places are muddy tidal terraces with tall forests dominated by a mangrove (*Bruguiera*), and a nutmeg with a highly developed system of aerial roots. Along the river itself are mud banks exposed at low tide, some with a few low mangroves (*Sonneratia acida*), others covered with dense bodies of a *Pandanus* peculiar to such situations. Sometimes tall palms lean out over the water, or form small groves in a forest edge heavily hung with a red-flowering "D'Albertis Creeper" (*Mucuna Kratkei*) and densely fringed with *Calamus*.

The general terrain is of irregular lateritic ridges, among which are enclosed flat basins, for the most part swampy, and connected with the river by sometimes almost imperceptible watercourses which empty into muddy tidal creeks. In places the ridges rise sharply from the river. At 3 to 5 km. inland, which was as far as we explored, the ridges attain an elevation of 80 m. With the exception of the wetter flats, where transitions from rain-forest to swamp-forests of tea-tree and sago and eventually open reed swamps occur, the whole area is covered with rain-forest.

Though more luxuriant than those of Gaima, the rain-forests of the ridges are still of a dry type in which epiphytes are few and herbaceous undergrowth extremely scanty .Rough-barked species of *Syzygium* figure conspicuously in a scattered stand of larger trees which give, with smaller subsidiary trees, an irregular canopy. An open undergrowth of slender trees, containing numerous small fan palms and hardy pandans, merges into a plentiful though ill-defined substage layer of taller, sapling-like species. A thin covering of dry, slowly rotting dead leaves lies on the ground. Looping lianes are numerous, but *Calamus* poorly represented. Freedom of movement and the ability to see some distance through this type of forest made ground birds easy to secure.

On the drier ridges, where the forests are more open on top and very large deciduous trees such as candlenut and *Bombax malabathricum* form much of the stocking, a slender bamboo, growing in clumps and falling over one clump upon another, forms a very dense, vaulted undergrowth which makes progress, even with a bush knife, a matter of difficulty. In other parts the ground is slippery with the loose

dry leaves of a large clump bamboo with upright soft culms 6–8 cm. in diameter, which supplies an open high substage. Sometimes, on the crests of ridges, the forest carries a thin ground cover of the slender sedge *Scleria lithosperma*.

The *Bombax* is especially interesting in that cavities in trunk and branches furnish nesting sites for parrots and sleeping places for bats. Hollow trees of other species in which, in addition to bats, several rodents and marsupials make their homes, are unusually plentiful in the forests of this locality.

The rain-forest of the flats and river flood plains differs in having a denser, more uniform canopy high overhead, a thin second story (just the reverse of much of the ridge forest), and an undergrowth of woody plants, quite dense in places. The ground is damp, scantily leaf covered or nearly bare. In swampy places, where the red-flowered *Erythrina fusca* is the dominant tree, there are many small palms, clumps or small areas of low *Pandanus*, and usually a plentiful undergrowth of a 2–3-m. broad-leaved sedge (*Thoracostachyum pandanophyllum*) and tall herbaceous plants.

Open muddy areas, evidently series of pools in wetter weather, and a few pools with shrubs growing in them, were present on the inland flats. And on the edge of the rain-forest proper, extending in scattered order into flooded glades in tea-tree forest and also the reed swamps, were broad-leaved low "second growth" trees: another original habitat of the secondary growths which take possession of disturbed areas in primary forest, and rather productive for birds.

Tea-tree swamp-forests covered considerable areas. The tall slender trees, closely spaced, averaged 30 m. in height and only 20–25 cm. in diameter at the base. The climbing fern *Stenochlaena* covered the lower 20 m. or so of the trunks, while nearer the ground were seen the many roots and stems of the fern. The trees stood on little mounds. There was no canopy, the slender tops of the trees being open, but the density of the stand and the climbing fern kept out much light even when the sun was high. On the ground was nothing but a thick covering of dead leaves, here and there a few stems of ferns which had fallen, or prostrate tree trunks. The whole was evidently flooded in the wet season, and even when we were there pools of water stood on the ground and one sank through the dense layer of dead leaves into water beneath. This strange, eerie forest, with a sameness of trees all about, and similar vistas leading off in every direction, had an appearance more in keeping with a uniform coniferous forest of the north. It was a poor habitat for birds, though in it was found the rare kingfisher, *Halcyon nigrocyanea*.

Flooded glades in the habitat just described provided stations for the tall sedge characteristic of the swampy rain-forest and reeds from the open swamps. The latter (*Phragmites Karka*) covered rather large areas in dense stands 4 m. high, dotted with scattered trees draped with *Stenochlaena* and surrounded by belts of sago swamp as well as tea-trees.

Dense sago swamps occupied some of the wettest of the flats, covered deep with standing water.

On one of the ridges running inland from the river was an old native canoe road leading to a large communal house. About the house was considerable old garden land growing up to second growth trees and with a few small patches of weed grasses. The track continued inland, and from several bundles of *Agonis* twigs found about the house (probably gathered for brooms) it seemed possible that it led to savanna or grass country in the direction of the Aramia River. No natives were seen during our stay, nor had they visited the house for months. However, the canoe road was in fair order, and the house still habitable.

The owners of the house were said by the government to be Gogadara people from the Aramia River who cross to the Fly each season for the fishing; but it is interesting to note that three old canoes lying at the landing on the river were of the type used on the lower Fly, not the Gogadara canoes of the swamps. Letters painted in white on the posts of the house, including a list of the vowels A, E, I, O, U, indicated that the departed occupants,

whoever they were, had been in close contact with Europeans.

Many species of birds were nesting during our visit. Flocking of small birds was a very pronounced feature of the bird life. With the shrinking of the pools in the flat forest, several species came regularly to the few that were left to drink and bathe.

Though unpleasantly hot at times, the weather was usually fine and bright, with a medium to light wind from the southeast. The few showers we had made a considerable difference in the amount of water standing in the swamps and on the forested flats. Judging by the character of the vegetation and the prominence of deciduous trees in parts of the forest, the climate was rather dry and the rains were seasonal.

Temperatures (C.): Minimum (17 records) 20–24, average 22. Maximum (18 records) 30–33.5, average 32.5.

Sturt Island to Lake Daviumbu.—As far as Cassowary Island the river banks remained forested, though the forest was lower and less luxuriant than at Sturt Island. Several high banks covered with good tall forest came out to the river, and on three of these were large, well-established villages.

Just below Cassowary Island, where we went ashore to investigate a big roost of fruit bats, water was running off the flat country fringing the river, as though the tide had just fallen, and the vegetation was in part of fire-fly mangroves.

Shortly above this, to about 15 miles below Ellangowan Island, there was for the most part a fair stand of quite tall rain-forest, but in places high cane grass (*Saccharum arundinaceum*) fringed the river and extended back to swamp-forests of a slender *Adina* sp., tea-tree, etc., or vistas of reeds and sedges opened into the forest.

Above this, to about 15 miles beyond Ellangowan Island, the country appeared to be covered mostly with swamp-forests, and a poor, low, waterlogged type of rain-forest. Cane grass fringed the river in many places.

From there to about 12 miles below Everrill Junction rain-forest edging the river became less common in a country of reed swamps, grass marshes of *Echinochloa stagnina* and wild rice (*Oryza sativa*), swamp-forests and savanna. In a few places were low red banks which usually dropped away into the swamps.

Above this, to the vicinity of Lake Daviumbu, the country was low, flat and wet. Rain-forest near the river was restricted to clumps or narrow fringes along the stream back of its margins of tall cane grass. In places the level reed plains and swampy tea-tree country, sometimes broken by small lagoons, spread out for miles. Here and there scattered tall fan palms (*Livistona crustacea*) gave a picturesque touch to the landscape. Some of the low country appeared to be covered with dry savanna of tall grass and low shrubby trees. Apparently much of the country was swampy, with bits of islands covered with a poor rain-forest, savanna or planted groves of tall bamboo. Distant lines of dark forest perhaps indicated the presence of ridges on both sides of the river.

Lake Daviumbu Camp.—August 16–October 1, 1936.

Situated by a grove of large bamboos, where the forest gave way to tall savanna on a point of land between the lake and a lagoon about 3 km. from the Fly itself, this was the most attractive of all our camps and the most pleasant to work.

This is a country of partly drowned dry lateritic ridges, extensive lakes and lagoons, marshes and waterways. Very irregular in outline, the ridges attain a maximum elevation of about 30 m.

Lake Daviumbu is perhaps 6 km. long and 4 km. in greatest width. Its shores are deeply indented, and to the west it leads away in a series of lagoons and waterways that extend for miles. Islands of various sizes break the surface of the lake. There are at least two entrances from the river. Boats of 40–50 tons can enter by one of these channels. Part of the area separating the lake from the river is deep marsh, and Lake Daviumbu appears to be only the southeastern end of a long chain of lagoons running parallel to the Fly. Probably a considerable quantity of the water flowing down the river passes through these fringing lagoons and associated swamps.

Possibly, too, the river once flowed through them and has since changed its course.

With the aid of the natives, who transported us in their canoes, we were able to work over a radius of about 10 km. from camp. We collected in rain-forest, savanna, open grassland, marshes and swamps of several sorts—all of considerable extent in this locality—and the lagoons.

The rain-forests clothed the ridges on the side of the lake farthest away from the river. Their extent was difficult to estimate. Somewhat similar in character to the ridge forests of Sturt Island Camp, and containing many of the same trees (*Calophyllum, Elaeocarpus, Flindersia,* numerous *Syzygium* species), they differed in having scattered very large, rough-boled trees, 30–35 m. high, whose crowns rose incompletely above the true canopy layer. Lianes such as *Entada, Mussaenda, Uncaria* species, *Gnetum latifolium* and *Calamus Hollrungii* occurred in abundance. Often the tall feather palm *Cyrtostachys microcarpa* raised its crown above the canopy level, while the slender *Areca macrocalyx* and *Hydriastele Beccariana* occurred in plenty in the lower layers of the forest. Other striking and more abundant constituents of the taller undergrowth and lower substage were *Pandanus Danckelmannianus, P. Krauelianus* and especially *P. leiophyllus.* There were few epiphytes. The ground was usually dead-leaf covered, dry and rustly for the most part while we were there, or nearly bare. Sometimes a few small ferns grew on the ground; and where the shade was dense, mosses covered the fallen logs.

In many parts of the forest undergrowth was scanty, of slender woody plants, and a few tall zingiberaceous herbs. Under these conditions it was easy to move about and see some distance through the forest, especially along the ground, and to secure such ground-inhabiting birds as the blue ground babbler (*Eupetes caerulescens*), brown ground babbler (*Drymodes*), little babbling thrushes (*Crateroscelis murina*), pittas (*Pitta*) and the brush hens *Megapodius* and *Talegallus.*

Where openings in the canopy allowed a good deal of sunlight to reach the ground, and in little glades (both the results of disturbance), there was a thin ground stratum of short grass (*Oplismenus undulatifolius*) and sedges (*Hypolytrum compactum, Scleria* spp.) characteristic of such places in dry types of rain-forest. Often a dense woody undergrowth and crowded stands of *Pandanus* hindered the view, or areas of a slender bamboo (*Schizostachyum* sp.), growing in clumps, rendered passage difficult. Frequently, however, the weak stems of the bamboo, arched and massed overhead, formed a shower-proof roof 3–4 m. from the ground, so that one walked freely in the gloom beneath.

In some of the narrow valleys in the forest were lines of sago swamp, of no great width, but sometimes of considerable length.

Where rain-forest meets savanna the transition is usually abrupt. But where the slope to the water's edge is gradual, so that periodical fluctuations in the level of the lake flood a strip of shore up to 100 m. in width, there is a curious mixture of a few rain-forest and many savanna trees. This gives a distinctive open forest of straight trees 20 m. high dominated by *Tristania suaveolens,* with thin canopy, little undergrowth, and leaf-covered ground; frequently with a few tea-trees and a low, hydrophytic *Barringtonia* fringing the water.

The savanna vegetation is somewhat diversified in character, although savanna-forest is a rare development except in sheltered and therefore relatively moist (but well-drained) situations adjacent to rain-forest.

Open savannas consisting of mixed, upright tuft grasses 1–1.5 m. high, and low, usually gray-appearing trees, cover extensive areas of dry ridges. On this type of savanna occur all the true savanna trees found at Lake Daviumbu, the most important being *Banksia dentata, Grevillea glauca, Melaleuca Leucadendron* var. *sanguinea, Tristania suaveolens, T. longivalvis* and *Parinarium nonda,* growing to a height of 4 to 8 m. *Melastoma polyanthum* is the characteristic shrub, and perennial semi-woody legumes such as *Tephrosia* sp., *Desmodium* spp. and twining *Vigna vex-*

illata figure conspicuously in the thick grass cover.

Still more extensive tracts of sour low ridges and flat plains carry an impoverished flora of which the chief features are a scattering of gnarled and twisted *Banksia* and *Grevillea*, 3–5 m. high, rising above a matted grass cover of *Ischaemum arundinaceum*. Pitcher plants (*Nepenthes mirabilis*) are plentiful. On hummocked flats innumerable white heads of an *Eriocaulon* protrude above the grass, and a grassland *Pandanus* (*P. Solms—Laubachii*) and scattered fan palms (*Livistona crustacea*), both present on dry savanna, tend to replace other trees. Sometimes there are areas with nothing but the tangled grass, a few herbs, and patches of fern (*Gleichenia* sp.) and *Lycopodium*.

At a place called Kakati, about 8 km. to the northwest of camp, we found a small area of sweet, short grass country, with many wallaby and pig trails running through it, and numerous small herbs in bloom. Here, also, was a rather extensive area of wet, tussocky, treeless grassland, some of which had been burned. Water standing between the tussocks made walking difficult, but the ground was generally firm underfoot. We found no birds peculiar to the Kakati area, although there were rails which were heard calling in the grass but not secured.

The savanna and the grassland habitats were poor in birds and conditions were often unsatisfactory for hunting. During our stay, however, some of the tangled grass areas were burned by native hunters, and a marked change occurred in their bird life. Small birds became very noticeable, and, if not actually more common, seemed so from being forced into the small unburned areas of grass. Also, many species such as shore birds, herons, ibis and hawks were attracted to the freshly burned areas to feed. It is interesting that the privilege of burning the grasslands, and taking the wallabies and bandicoots thus secured, belongs to certain groups of people.

At least a narrow fringe of floating grass (*Echinochloa stagnina*) runs along most of the lake shore. Where breaks in this occur, usually on points, the natives have regular canoe landings where one finds clumps of large bamboos, with stems 15–18 cm. in diameter, which seem to have been planted. In some of the bays, especially those surrounded by rain-forest, are swamps of tall tea-trees with undergrowth of reeds up to 4 m. high. When we were there these swamps were too deep to explore on foot and the vegetation too dense for a boat. But evidently they dry out at times, for we saw areas from which the reeds had been burned.

Where savanna borders directly on the lake or lagoons the grasses of the dry ground extend to the edge of the floating grass fringe. But irrespective of the bordering vegetation, whether savanna or rain-forest, almost everywhere along solid shores is at least a scattered fringe of low *Barringtonia* trees. These shapely little trees stand in or out of the water in accordance with the level of fluctuation, and are crowded with epiphytes such as fleshy "ant-houses" (*Myrmecodia*, *Hydnophytum*, *Dischidia*), hardy ferns and orchids.

Little of the lake is more than 2 fathoms deep and still less of it quite clear of floating lily pads. Bladderworts and hydrocharids occur in great abundance as submerged aquatics in some of the shallower bays. These are the vanguards of the aquatic and semi-aquatic communities which succeed one another in the gradual process of filling lagoons and marshes with vegetation and, presumably, converting them to dry land.

A good example of one type of this succession could be seen in a lagoon at the back of our camp, where, with the shallowing of the water, the lily pads became sprinkled with islets of floating grass on which a man could walk, yet so lightly attached to the bottom that they could be pulled about by hand. These islands increased in number until one came to the floating grass mat of *Echinochloa* and wild rice (*Oryza sativa*) which covered wide marginal areas of the lagoon, with clumps of reeds, afloat on the grass, sticking up here and there. The natives had regular canoe trails through such lagoons, from which the vegetation was more or less kept clear, but frequently they would push directly over

the more yielding grass mats in any desired direction.

The marshes along the southern channel connecting the lake with the river were typical of large areas of open plain inundated to a depth of 1 to 1 1/2 m. The floating grass mat, firmly anchored to the bottom and rising about a meter above the surface, was broken here and there by beautiful stands of lotus lilies pushing their broad leaves and enormous pink flowers a meter above the open water. Lining the channel on submerged silt banks, beginning near its inner end as dense clumps and later forming extensive stands, were tall reeds with a height of 4–5 m. Here also, standing afloat on the edge of the deep marsh, were clumps of the sword-leaved, sisal-like plant, *Hanguana malayana.*

Breadfruit trees, bamboos in clumps and groves, and many coconuts grew on some of the islands in the lake. On one was a village consisting of two long communal houses. Most of them had been cultivated and carried secondary forest in various stages of development. The smaller islands consisted of nothing but a few shrubby Barringtonias standing in shallow water, often well out in the lake.

During our stay the lake fluctuated considerably. At its lowest some of the swamp waterways could not be navigated by the larger canoes, and there was a pronounced increase in herons, especially *Egretta intermedia.* We were told by the natives that some of the big grass marshes then deep in water become nearly dry when the lake is low. When the water falls low enough to expose muddy or solid shores, as it probably does, a great increase might be expected in the number of wading birds.

Though somewhat apprehensive of their neighbors, the natives were extremely friendly. They are essentially a canoe people, living on sago and fish which they catch in little funnel-shaped traps made of *Calamus* tendrils. They brought a little food and did some hunting for us, but their chief service was in taking us about in their slender dugouts, which are so well adapted to pushing through swamps. A few of the men had been to Daru as prisoners or court witnesses and it was surprising how many spoke fairly good Motu. Knives, cloth and tobacco were the most useful articles in trade.

We found the climate pleasant and invigorating, with occasional days of rain or hard showers, but for the most part fine and with a cooling breeze from the southeast.

Temperatures (C.): August 31–September 29.
Minimum (29 readings) 21.5–24.5, average 23.
Maximum (29 readings) 28–31.75, average 29.75.

LAKE DAVIUMBU TO 30 MILES ABOVE D'ALBERTIS JUNCTION.—Between Lake Daviumbu and the lowest village in Dutch territory is the big marsh and lagoon country of the middle Fly, of which our impressions are all from the river.

As far as Wam Lagoon (or Lake Herbert Hoover) the country visible from the river is usually grass swamp, or flooded reed plains with open stands of tea-trees. Occasional clumps or lines of rain-forest fringe the bank, and some low ridges, covered with savanna or rain-forest, appear well back from the river.

Wam Lagoon, marsh fringed in savanna ridges, was separated from the river by such a narrow strip of floating grass that at first we thought we could enter it for an inspection, with the idea of making camp, but this was not possible.

Above Wam Lagoon the country continues with swamps and lagoons, more frequent rain-forest and occasional low hills by the river which would do for camp sites. At the lowest Dutch village the last of the marshes is seen. Here, however, fresh tea-tree bark seen in possession of the natives may be taken as evidence of the presence of tea-tree swamps.

From this village to Oroville much of the land is low and little above flood level, with occasional hills of 30 m. or so rising gradually or in sharp red banks. Most of the hills are on the right bank, and it is on such hills that three more big villages are established in Dutch territory. Solitary square houses, built high above the ground on tree stumps and long props, appear on

both banks as one approaches D'Albertis Junction—the junction of the Alice with the Fly.

The river is intermittently fringed with tall cane grass, dense shrubberies of woody "second growth" species, and sometimes herbaceous swamp growths. The prevailing rain-forest is tall and fairly luxuriant on the higher ground but on the low, sodden parts open and vine draped. Especially on the lower part of this stretch, old cut-offs, showing where the river had changed its course, and now in the process of being filled with marsh and swamp vegetation, were common.

Oroville Camp, 30 Miles above D'Albertis Junction.—August 8–13, 1936. This had been the base camp of a party of gold prospectors. A clearing of several acres had been carved out of heavy rain-forest on high ground overlooking the river and gardens of sweet potatoes, maize and other food crops planted round the camp. Across the river, on a point of low-lying ground, was an airplane runway. In the nine months which had passed since the abandonment of the camp and our voyage up river on the "Maira" both airdrome and camp clearing had grown up to a grassy brush of second growth forest in which the vigorous young trees had attained a height of 2–4 m. A rampant vine (*Ipomoea* sp.) climbed over the buildings, on which the sago leaf thatch was already rotting, and smothered the newer garden areas. After our retreat from Black River Camp in August we tied up our rafts here and occupied the camp for a few days while awaiting the arrival of the relief vessel, which also brought the returning prospectors.

At Oroville the river is still deep and slow flowing, exposing muddy shores when the water is low. On the camp side, the right-hand or north side of the river, hills rise sharply to 30–60 m. and extend inland as far as we explored—a distance of about 3 km. High red banks, on which are numerous Begonias and tree-ferns, face the river. Across the river the country is flat and waterlogged, the tall forest overgrown with lianes and encumbered with rattan and pandans in the undergrowth.

Evidences of an increased though still rather low or perhaps periodical rainfall are apparent in the forests of the ridges. As at Lake Daviumbu and also Sturt Island and Gaima Camp, species of *Syzygium* are important in the canopy layer. Here these rough-barked trees attain a great size and actually dominate, reaching a height of well over 30 m. and forming a uniform high canopy. Underneath is a very open stand of low substage trees and high woody undergrowth characterized by the palms *Hydriastele Beccariana, Orania Archboldiana, Licuala concinna* (a small fan palm) and *Pandanus* sp. Most abundant in a sparse herbaceous layer is a small, stiff *Selaginella*. The ground is almost entirely leaf-covered. Mosses and a few small ferns grow on exposed roots and rotting logs, and extend a little way up the tree trunks. But mosses, epiphytes and also lianes are by no means conspicuous elements of the forest.

A considerable number of natives gathered here from both the Alice and the Fly (two different tribes) and did some hunting for us, receiving chiefly beads and tobacco in payment. These people had, of course, had previous contact with the miners, and many spoke a little Motu.

Fly River from Oroville to Palmer Junction.—As far as Macrossan Island the river is broad, deep and smooth-flowing. The country continues flat along the banks, with occasional bits of elevated ground and red bluffs a few meters high. On high banks the forest is tall and luxuriant, but where the ground is low and sodden it is often of ill-grown trees scattered in a mass of lower woody vegetation. On stable banks rising gradually from the water the forest face is heavily draped with climbing plants and choked with tangled *Calamus*. On eroding banks it is sharp-cut and new from the trees continuously being undermined and falling into the stream. The fringing "second growth" shrubberies continue at intervals, but cane grass and reeds disappear from the banks.

At Macrossan Island we had our first difficulty with navigation on the "Maira." The water was high and the "Maira" drew but 5 feet, but in the center of the right-hand channel around the island we stuck

for a moment on a sandbar before bumping across.

Near Macrossan Island the country becomes hilly. The current is swifter. At the sharp bend at the 528-mile mark on the river a whirlpool caused needless anxiety. Just above that was an extensive gravel bar in the center of the stream. This was hidden from us on the "Maira" by the high water, but we remembered seeing it from the airplane. By keeping close to the bank we went around it, and on to Palmer Junction, without getting less than 1 1/2 fathoms of water. We could have gone some distance up the Palmer, but as the camp was to be at the 528-mile mark we turned back at the junction.

The appearance of the river of course changes tremendously with the height of the water, which may vary in level 5 m. or more. At the time of our reconnaissance flights gravel bars were exposed everywhere along this stretch of river. From the "Maira," and when rafting, hardly a bit of gravel was to be seen.

CAMP 5 MILES BELOW PALMER JUNCTION (PALMER JUNCTION CAMP).—May 13–June 5, 1936. Here the Fly flowed through ridges rising to a height of 50–70 m. above the river and about 80–100 m. above sea level. The ridges were steep and with narrow crests, the bottoms with small streams, muddy or containing gravel and sand, flowing in V-shaped valleys. The soil of the ridges was a reddish clay containing rounded or angular pebbles of quartz. The country rock exposed in streams appeared to be a soft, silty sandstone. In one of the streams Tate found beds of lignite. Recent gravel beds were being re-cut by the river in a few places. Only here and there were small flats along the river, muddy, and subject to periodical flooding.

A clearing was made and camp established on the point of a ridge about 100 m. back from the river, at an elevation of 80 m. Upstream the river had a number of sharp bends and gravel bars were exposed at low water. Below was the comparatively straight deep stretch on which the plane landed. At low water, steep muddy banks showed along much of the river.

The whole country lies under very tall forest, a magnificent mixed rain-forest overtopped by numerous lofty palms (*Gulubia costata* and *Cyrtostachys microcarpa*). The lower layers of the forest are rich in species but as a rule not well defined as strata. In the more open parts, especially in gullies, broad-leaved woody plants and herbs such as *Saurauia*, *Cyrtandra*, *Begonia*, *Elatostema*, Zingiberaceae, Marantaceae and Araceae, together with ferns, grow in abundance.

The forests are further characterized by a wealth of epiphytes—ferns, orchids and other flowering plants, mosses and liverworts—in the lower layers as well as the canopy. Large lianes show a decrease in abundance as compared with the dry forests of the middle and lower river, but a very noticeable increase in species of *Calamus* and *Freycinetia*. Other striking and common elements are palms, both feather- and fan-leaved, *Pandanus* spp. and a *Cycas*. Plentiful almost everywhere on surface roots, undergrowth and the lower parts of the trees, on some parts of the ridges the shade-loving mosses and liverworts of the forest interior form a thick covering on the ground.

It was usually possible to move about freely in the ridge forests. But on river flats a gregarious *Pandanus* and two species of *Calamus* peculiar to the flood plains and liberally armed with thorns and prickles, often so obstructed the forest that even track cutting was a matter of considerable labor.

While a number of the flood plain and riverbank species of plants extend far down the river, few of the ridge species were observed to occur below Oroville and not many were found at that camp. On the other hand the forests of this locality, of the riverside as well as the ridges, are in general similar in appearance and floristics to those of Black River Camp (described below).

Though few houses and gardens were seen from the air, there appeared to be a fairly large population scattered through the forests in this locality. Fifty or so natives camped near us much of the time and once we had more than 100 of them in

camp—all men. They seemed to eat a good deal of sago and planted in unfenced gardens chiefly sweet potatoes, some bananas of poor quality, and a little taro and sugar-cane. Old gardens were growing up to secondary forest.

The weather was usually dull during the early morning, sometimes with fine rain; clearing in the forenoon and with sunshine and clouds alternating during the middle of the day. By mid-afternoon it would cloud up again and, especially toward dark, often rain in hard showers. Thunder was sometimes heard to the north in the evenings. Frequently in the mornings and evenings clouds came down so that fog enveloped the tree tops, shutting in the camp and giving the atmosphere one usually associates with camps located at higher altitudes.

In flood when we arrived, the river fell about 5 m. in the next few days and fluctuated violently during our stay. This was apparently the result of rains in the mountains rather than due to local conditions.

The recorded temperatures varied little:

Minimum (12 readings) 23–24.25, average 23.5.
Maximum (12 readings) 28–31.5, average 26.5.

PALMER RIVER BELOW THE BLACK RIVER JUNCTION.—There was one bad rapid a couple of miles below the Black River Camp, which endangered the rafts when we came down the river, but for the rest the river was deep and fairly smooth flowing. Under conditions of high water, as we saw it, the sharp bends contained some small whirlpools, and there were places to be avoided where the force of the current dashed the water against eroding banks.

Most of this country was hilly, with irregular low hills 30 to 60 m. high, some of them rising sharply from near the water's edge. In places the river was enclosed by hills on each side. Where the current ate into these hills small landslips had exposed sharp-cut red banks.

The country was entirely forested, with much rattan along the banks. Some of the old red banks were covered with pale green *Selaginella* and *Lycopodium;* occasional flat flood points and islets carried growths of shrubs; and there were a few native gardens, new or growing up to secondary forest, along the river.

From D'Albertis' description of the country where his boat lay, it certainly appears that he succeeded in reaching some point above Palmer Junction, as Austen[1] has postulated.

CAMP 2 MILES BELOW THE JUNCTION OF THE BLACK AND PALMER RIVERS (BLACK RIVER CAMP).—June 5–August 4, 1936.

Camp was placed on the east bank, some 6 m. above the river at low water, and 100 m. above sea level. Under the bank in front of camp was a limestone outcrop and just above it a deep pool in which was a cluster of partly submerged limestone rocks. At the lower end of the camp clearing a small creek entered the long, quiet stretch of river which served as a landing place for the plane. Opposite and below camp on the far side of the river, here 70–80 m. wide, stretched a long beach of white limestone pebbles.

Close above camp we found, running nearly north and south, the track cut by the Northwest Patrol. It had become a native road and showed signs of considerable use since the patrol party had been there in 1927.

This was the first place on the river from which we viewed the mountains. On clear days we could see the scarped face of Mt. Blücher, only 30–35 km. distant, and from a tree ladder the view included Sare Range, the Dap, and behind them all the Victor Emanuel Range.

Using a collapsible boat, we examined the river for a distance of about 8 km. upstream. Above camp the river shallows and divides round a series of little islands and is lined with gravel and sand beaches, first on one side then the other. Above the junction of the Black River pools are fewer, there are more swift riffles, much dead timber is lodged in the stream, gravel bars and silt beds are higher and more extensive, and the country becomes flatter in general. In places the banks of the river are sharp-cut by erosion, which brings the tall forest trees crashing into the stream. This

[1] *Loc. cit.*

erosion is cutting into and exposing flat-bedded deposits of gravel and silt, of comparatively recent origin.

When the river changed in character at Macrossan Island a new set of flood-resistant plants, peculiar to hill streams and occurring, apparently, throughout New Guinea and the Malaysian region, made their appearance. Growing on flood-swept sandy or gravelly banks, rocky points and open beaches, at Black River Camp they are a conspicuous feature of the river vegetation. This community consists of small, tough trees such as *Syzygium, Neonauclea* and *Ficus* species with wide-spreading horizontal branches and usually narrow, pointed leaves; with which are associated, especially on rocky banks, massed growths of Elatostemas, a few small ferns and often species of *Selaginella* and small-leaved shrubs.

Besides the riverside plants mentioned above, tangled growths of *Calamus* line the muddier banks; and the wild sugar-cane (*Saccharum arundinaceum*) reappears on the higher gravel and sand bars, where it forms extensive dense thickets. The high-climbing D'Albertis Creeper (*Mucuna*), of which one or more species occur on the riverbanks down to the sea, came into full bloom at the end of July, its great festoons and garlands of flowers colored a soft, beautiful red.

The country fringing the river was generally flat and little above flood level. Indeed when the river flooded some of the forest was inundated and the small streams backed far up into the lower ridges. Beyond this the country rose in steep ridges which reached an altitude of 250 m. about 5 km. out from the river. The soil of the ridges was like that of Palmer River Camp, but generally more sandy and containing more quartz pebbles. The deeper creeks cut down to limestone and occasional sinkholes were found in the forest. Quantities of marine fossils were to be seen in the limestone pebbles which comprised the bulk of the gravel bars.

In general similar to those of Palmer River Camp the forests presented the same variations in type on flood plains and ridges. They were, however, as a rule less open underneath: the more abundant subsidiary trees and woody undergrowth limiting the view but offering no great obstacle to progress except in wet depressions, where young *Calamus*, small species of *Pandanus* and palms and large forest sedges necessitated the cutting of tracks. Here and there in wet places were a few sago palms.

The sago of the upper Fly and Strickland was said by Karius to be of very poor quality. This probably means that a large quantity of pith is necessary for extracting a small quantity of starch; as the prepared sago brought us by the local natives was pronounced quite as good as the coastal product by the few sago-eating boys we had from the southwest coast.

A peculiar swamp forest, composed largely of one species of tree (*Campnosperma* ?), was found on the broad crest of a ridge about 2 km. inland. Tall and slender, the dominant trees reached a height of 30 m., their abundant kneed pneumatophores recalling those of some mangroves. Shallow pools of water lay here and there, and through the open canopy much light reached the saturated, mossy and leaf-covered ground. The sedge *Thoracostachyum bancanum*, 50 cm. high, was plentiful on the ground; a thrify *Pandanus* grew to a height of 5 m. in a scattering of sapling-like undergrowth. Scrambling pitcher plants were common, while in parts a large semi-scandent fern, more abundant in the surrounding rain-forest, massed itself about the lower tree trunks.

On less flat ridges the trees rooted shallowly in a thin layer of sandy gray soil overlying a more or less impervious substratum of brownish clay or conglomeritic material, and though tall and well grown, the forest was very mossy. Mosses and liverworts often formed mounds at the base of trees and combined with surface rootlets to make a soft mat on the ground. As at Palmer Junction Camp, many aspects of the ridge forests were suggestive of higher altitude conditions; and familiar mountain plants and also some mountain birds were found at these low elevations.

During our stay certain sapotaceous trees came into bloom through the forests, their flowers lasting but a few days, and

during these times lories such as *Trichoglossus*, *Chalcopsitta* and *Eos* were found commonly about them. At other times these birds were unprocurable, being seen only in long straggling lines passing high overhead.

The rain-forest "secondary formation" of quick-growing small trees was well represented in this locality, the chief components being species of *Macaranga*, *Ficus* and *Homalanthus*. When forest is cleared by humans or otherwise disturbed, regeneration, or rather the early stages of it, is by means of such second growth (sub-seral) species. From the air a few gardens were seen scattered in the forests. Along the river were a number of garden clearings, old and new; many of them on flats where extra high floods had deposited fertile silt. One old garden, growing up to secondary forest, and with a house in its center, was found on a ridge 5 km. out from camp. But the changing course of the river gave disturbed conditions, such as newly deposited soil and eroding banks, which provided for the second growth plants original habitats of considerable area in the aggregate.

Not only many plants, but a few birds, not climax forest species such as *Rhipidura leucophrys*, *Edolisoma tenuirostre* and *Todopsis cyanocephala* were found only in the second growth.

This area appeared to be sparsely populated. A number of natives visited our camp, coming even from the Tully River, and for a time 15 to 20 camped in shelters they erected across the river. They brought in a little food—bananas, sweet potatoes, taro and sago—and shot a few birds, but they did not seem particularly anxious for trade except for large knives and axes. Several pigs were brought, for which hand axes were paid, but after an attempted raid on our store, presumably for steel tools, we saw few natives until we prepared to leave, when numbers of them gathered to rifle the deserted camp.

Pigs whose cropped ears denoted native ownership were common in the forest and appeared to live largely on the sweet potatoes in the gardens. Possibly the gardens were planted partly for the purpose of keeping the pigs about, for none of them were fenced.

The weather here was similar to that of Palmer Junction Camp: with much rain, only a very few hours of sunshine on the average each day, and in the evening frequent lightning with thunder growling away to the north. The mornings were usually dull and misty, frequently with wisps of cloud resting in the tree tops, and often with light showers about 8 A.M. Most heavy rain fell in the late afternoon or evening, when on several occasions we had severe thunderstorms accompanied by strong wind.

The mountains about the headwaters of the Palmer were as a rule hidden by clouds until late afternoon, when frequently they became clear for an hour or two, to be obscured again toward nightfall. But we found that clouds obscuring our view of the mountains were a poor indication of cloud conditions in the mountains themselves. On one occasion the plane started from this camp for the advance camp at Mt. Mabiom while the mountains were completely hidden, to find that the clouds did not extend quite to the mountains and that the upper Palmer valley was clear.

Temperatures (C.):
June: Minimum (17 readings) 22.5–24, average 23.5.
Maximum (17 readings) 27.5–30.5, average 29.5.
July: Minimum (20 readings) 21.5–24.75, average 23.25.
Maximum (24 readings) 25.75–31.5, average 29.

THE UPPER PALMER RIVER AND MT. MABIOM CAMP.[1]—After a track had been opened up the advance camp and parachute field at Mt. Mabiom could be reached from Black River Camp in 6 1/2 days. The return journey took 5 days. The difficulties of the route may be judged from the fact that the distance, indirectly as the track ran, was approximately 40 miles, or 64 km.

First the trail followed the east bank of the Palmer, to the junction of the Black River. Unlike the Palmer, the Black was

[1] Compiled from information supplied by Tate and Willis.

found to be narrow and deep near its mouth and had to be crossed by ferry rafts. From the Black the route continued up the east side of the Palmer over ridges and mucky wet flats, and passing one small village, encountered the beginning of the rough limestone at the 610-mile Bend (the highest point reached by MacGregor in 1890). From the 610-mile Bend the track turned east along the Palmer and east and northeast along the bank of the Len River tributary for a distance of about 15 km. Crossing the Len to the south slopes of Mt. Blücher it swung west and northwest, then north round the steep western end of Mt. Blücher at an elevation of 500 m., and down to the Palmer at the upper end of its deep gorge.

The Palmer (here called the Luap) was crossed at the mouth of the Narin tributary. Thence the trail climbed through numerous old gardens on the south slope of Mt. Mabiom to a village at 500 m. and passed round the south side of the mountain to the camp.

Situated at a place called Kori-sala at an altitude of 780 m. on the west slope of Mt. Mabiom, the camp was surrounded by high forest somewhat mossy in character. As the slope was rather steep, and flying difficult, from past experience it was considered necessary to cut a clearing measuring 350 m. on the slope by 120 m. in width to ensure the safe delivery of parachutes.

Among the few mammals and birds taken at this camp, several were of species not found at the lowland collecting stations.

The natives of the Mt. Mabiom area, called Unkia, differed from those of our two upper base camps (A-win) in physiognomy, customs and dress. Of very friendly disposition, they lived in small villages of several family houses of rectangular shape, with grass-thatched roof and split timber walls, raised about a meter from the ground. The villages were surrounded by close plantings of tall *Cordyline* with leaves of various colors. The subsistence crop of the Unkia was taro. They also cultivated bananas, sugar-cane and several kinds of *Hibiscus* (perhaps forms of *H. esculentus*) as green vegetables, but apparently no sweet potatoes. Salt was valued above all else in trade for food. In accordance with established custom in Papua, axes or long knives were paid for pigs.

SUMMARY OF TYPES OF HABITAT

It may be advisable briefly to outline the main types of habitat and their extent in the area under review. From our view of them from the airplane and our investigations on land, it is possible to distinguish:

Mangrove and Strand Communities
Rain-forest
Secondary Rain-forest
Freshwater Swamp-forest
Open Swamps and Marshes[1]
Savanna
Mid-mountain Grassland
Alpine Grassland
Mountain Forest

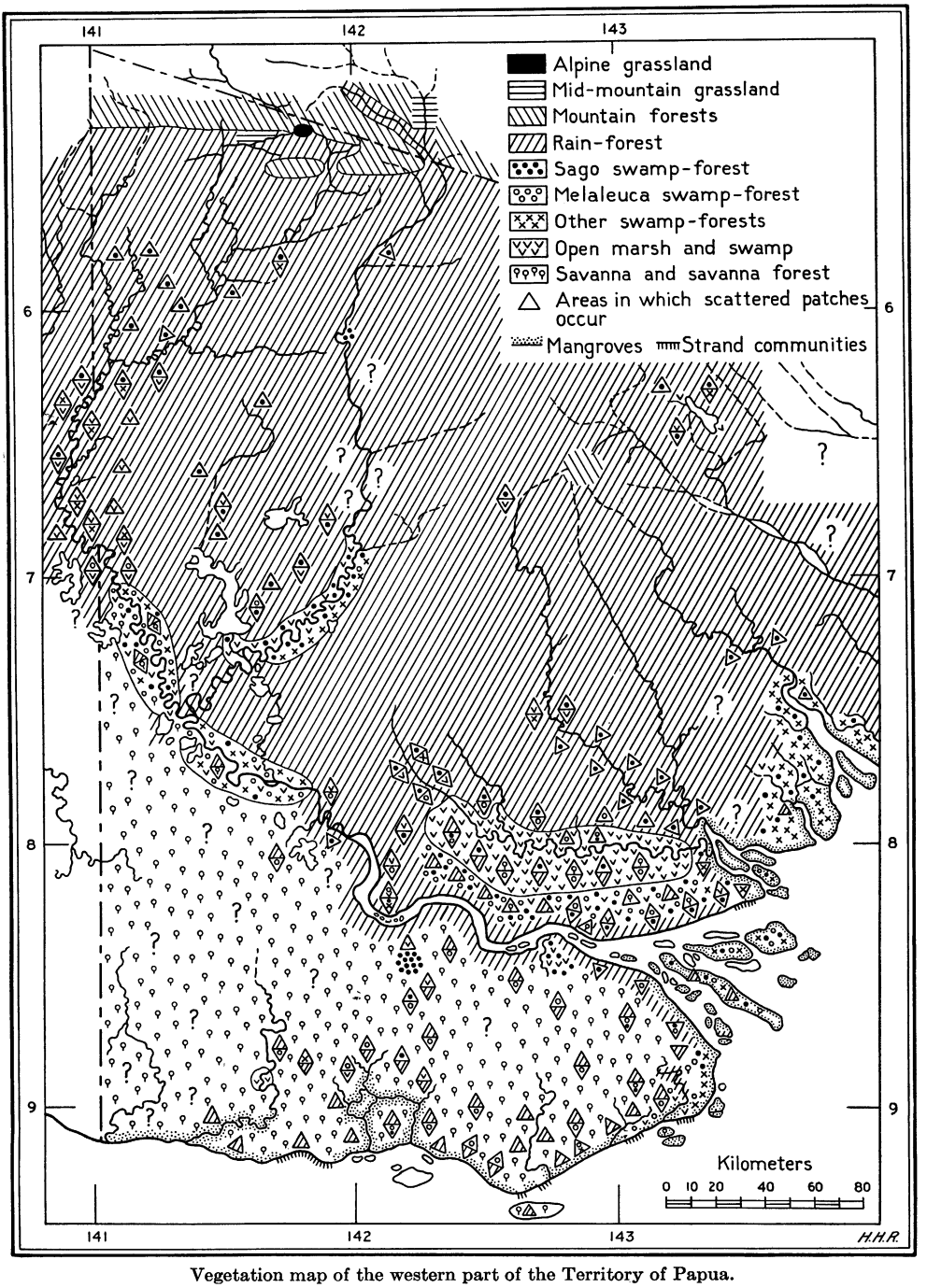
MANGROVE AND STRAND COMMUNITIES.—Mangrove forests fringe most of the coast and extend as a narrow margin some distance up the rivers, but seem seldom to exceed a few hundred meters in width. This limited development is no doubt due to the low saline content of the waters of the coastal swamps and the muddy estuaries of the big rivers. The principal trees are species of *Bruguiera, Rhizophora, Avicennia, Sonneratia* and *Excoecaria*, with which the Nipa palm occurs within the rivers.

Strand communities occupying sandy beaches above tide level, and here characterized by *Calophyllum inophyllum* as a large tree, *Pandanus tectorius*, trailing *Ipomoea pes-caprae* and the sand-binding grass *Ischaemum muticum*, occur in a few places on the coast, especially west of the Fly.

The principal plants of these littoral communities enjoy a wide range of distribution in the Malaysian region and on the northern coasts of Australia, and some species are pan-tropical.

RAIN-FOREST.—Tropical rain-forest cov-

[1] Swamps are distinguished here as areas of shallow standing water of seasonal or periodic duration; marshes as permanent bodies of standing water, usually shallow, and without trees. This distinction is not always possible, e.g., in sago swamps inundation may be permanent or periodic.



Vegetation map of the western part of the Territory of Papua.

ers the lowlands and lower mountains of the upper Fly and Strickland without conspicuous breaks, and, with the exception of coastal strips of swamp-forest, the entire area drained by the Turama and Bamu rivers. Its southern boundary skirts the north of the Aramia swamps and passes on to the Fly. On the west it is broken by extensive swamps on the lower Strickland, and as a continuous body it appears not to cross the Fly below the 7th parallel.

North of this line there are no conspicuous breaks; south of the line, particularly along streams, are also considerable rain-forests, but there they are much interrupted by swamp-forests, open swamps and marshes, and savanna.

The floristic affinities of the New Guinea rain-forests are emphatically Malaysian and Asiatic. They contain also Polynesian, and to a lesser extent, Australian elements.

SECONDARY RAIN-FOREST.—Wherever disturbance occurs in rain-forest, whether by "natural" causes such as erosion and landslips, the decay and fall of larger trees or damage by wind, or by the operations of man, the first stages of revegetation are by means of numerous, wide-ranging, soft-wooded trees and other plants which rarely if ever occur in primary closed forest. These forms may also be found on the open margins of forest bordering on savannas or open water, and within the forest in places where conditions of soil or slope inhibit the development of the climax.

Though changing their position constantly, the second growth plants are always present in any rain-forest area. To survive, the species must be of rapid growth, prolific, and provided with efficient agencies of dispersal. Man, with his propensity for disturbing climax conditions, destroying forest and allowing it to grow up again, provides only a greater area for these second growth forms.

In the area under review the forests are in general little disturbed by man. The population is in most parts thinly scattered. Large concentrations of population occur only in the coastal and near-coastal regions and a few localities in the foothills and mountains of the remote interior. The larger coastal populations subsist chiefly on sago, which is obtained with little disturbance to the forests. Only in the mountains north of Mt. Leonard Murray, the upper valleys of the Palmer and Fly, and on the Ok Mart River, where the numerous populations live, apparently, chiefly by agriculture, were large areas of second growth forest observed.

FRESHWATER SWAMP-FOREST.—Numerous areas of *Melaleuca Leucadendron* swamp-forest occur outside the boundaries of the great rain-forests, i.e., in the lower rainfall areas. Small patches of this type of swamp-forest were seen at Lake Murray and in the vicinity of the Fly River as far north as the middle of the "Dutch Bend." *Melaleuca Leucadendron* ranges through New Guinea to western Malaysia. The *Melaleuca* swamp-forest may be regarded as successional to both savanna and rain-forest.

Probably of greater area than any other type of swamp-forest are the sago swamps, which attain an extensive development on the lowlands and extend into the mountains. Sago swamps were observed at an elevation of about 900 m. in the valleys of the Lake Marguerite area and above 700 m. in the valley of the upper Palmer. They always occur in association with rain-forest, of which they represent a stage of succession. The swamp sago palms (*Metroxylon* including *Coelococcus*) range from Siam through eastern Malaysia to Fiji and Samoa, but are not known to occur in Australia.

Other types of swamp-forest, all of which appear successional to rain-forest, occur on the lowlands. Extensive areas of perhaps a brackish-water swamp-forest, apparently of a species of *Camptostemon*,[1] occur behind the mangroves on the Turama-Bamu coast. An *Adina* and a species of Anacardiaceae each form large swamp-forests on the Fly River and lower Strickland, one patch of the latter being found in the rain-forest high up the Palmer River.

OPEN SWAMPS AND MARSHES.—These are a striking feature of South New Guinea. In our territory they occupy several areas,

[1] Determination of the botanical collections is not yet complete.

more or less separate, of which the most important are listed below:

(a) The line of grass and sedge swamp just inside the coast line.
(b) The isolated area of big open swamps, marshes and lagoons of the Aramia River.
(c) The big swamp, marsh and lagoon area of the middle Fly.
(d) The Lake Murray area has many lagoons but the country is almost completely forested, with open swamp and marsh only along the margins of the water. The same is true of the country about the Fly River where it forms the boundary between Netherlands New Guinea and the Territory of Papua.

There is said to be much grass swamp on the Bensbach River; but this area was not visited.

The principal plants of the open swamps and marshes are *Echinochloa stagnina* and *Oryza* spp. (tropical Asia through Malaysia to Australia), *Phragmites Karka* (tropical Asia to New Guinea) and *Saccharum arundinaceum* (warm temperate Asia through Malaysia to New Guinea) as grasses, and the sedge *Scleria oryzoides*.

SAVANNA.—This habitat, representing an extension to New Guinea of the tropical "open forest" climax of Australia, contains some of the most distinctive elements of the flora and fauna of South New Guinea.

The greatest extents of unbroken savanna and savanna-forest that we examined were about the Wassi Kussa and Mai Kussa rivers, where rain-forest was practically limited to narrow fringes along the infrequent streams. This savanna is surely more or less continuous with that of the middle Fly (Lake Daviumbu, etc.) where it is much interrupted by rain-forest and swamp; and with the savanna of the Oriomo River, where this habitat is well developed. The same great body of savanna extends far westward into Netherlands New Guinea. It also extends east of the Fly into the big swamp country of the Aramia, though only as scattered patches mixed with areas of rain-forest and swamp.

While some trees of the savannas and savanna-forests represent species common in the open vegetation of dry areas in Malaysia and tropical Australia and are probably derived from monsoon-forest, the dominants (if they can be called dominants in a grassland habitat) are Australian, viz., *Melaleuca* spp., *Tristania* spp., *Eucalyptus* spp., *Banksia*, etc. The principal grasses, also chiefly Australian, are *Themeda triandra* (Africa to China and Australia), *Ischaemum arundinaceum* (Australia), *Manisuris rottboellioides* (Australia), *Imperata arundinacea* (warm regions of Eastern Hemisphere) and *Germainia capitata* (S. E. Asia). Like the grasses with which they are associated the herbs and shrubs are often of wider distribution than the principal trees, but most of them may be regarded as Australian elements.

Another large body of savanna and savanna-forest occurs in the dry area of eastern Papua between Cape Possession and the Kemp Welch River. The eastern savannas occupy a well-drained hilly terrain climatically drier than the Western Division area. Species of *Eucalyptus*, with only a slight admixture of other trees, provide the tree stocking, while *Themeda australis* and *T. triandra* are the dominant grasses.

MID-MOUNTAIN GRASSLAND.—This habitat, occurring only in the mountains (about 1000 to over 2000 m.) as a result of intensive cultivation after deforestation, would naturally be absent from most of the area under consideration. The only examples seen were in the Crystal Valley on the upper Strickland and in the Bol Valley.

ALPINE GRASSLAND.—Small patches of grassland on top of Mt. Faim (3300 m.), less than one square mile in total area, should probably be considered as alpine.

MOUNTAIN FORESTS.—Mountain mossy-forests were distinguished from the air at elevations above 1500 m. on the Central Range and the Dap, and also Mt. Leonard Murray. On Mt. Faim numerous conifers were seen in a low forest perhaps sub-alpine. And from the presence of oaks (*Quercus*) at our Black River and Palmer River camps, the usual development of Fagaceae forests might be expected to occur on the mountain slopes between the upper limits of the rain-forests and lower limits of the mossy-forests.

A diagrammatic representation of the limits and area of the various types of habi-

tat is given on the accompanying map. Data concerning the coast to the west of the Wassi Kussa, and also the Morehead River, are taken from the descriptions of MacGregor.[1] For the rest, the map is based on the observations of the expedition. While not claimed to be exact in detail, it is conjectural only to the extent shown by marks of interrogation.

In so far as they concern our area, Lam's[2] vegetation map of New Guinea and Bohrer's[3] more recent one of the Territory of Papua, both compiled from literature, are perhaps more in general agreement with the present map than with each other.

The breadfruit tree (*Artocarpus communis* Forst.), which Lam ranks as a characteristic feature of the freshwater swamps of New Guinea, cannot be considered as such in our area. Though of common occurrence on flooded river banks and in second growth rain-forest, the breadfruit tree can always be taken as an indication of the presence of human population. Records of its occurrence in undisturbed climax forest should be accepted with reserve. There is good reason to believe that in New Guinea the breadfruit tree is dispersed chiefly by man, and that it is not indigenous to the island.

NOTES ON THE DISTRIBUTION OF BIRDS

Though the collections have been only partly worked out, it is of interest to indicate some of the problems of distribution involved.

The consideration of the habitat distribution of birds in south New Guinea is important because of the extensive area covered by the diverse habitats existing there, greater than elsewhere in New Guinea, and the bearing this has on the zoo-geographical question of the relation between Australia and New Guinea. The zoo-geographical difference is more of habitat than of anything else. The savannas are so predominantly Australian that in the later, more detailed work on this subject probably it will be necessary to include the savannas of south New Guinea in the Australian subregion, while the rain-forests of northeast Australia may have to be considered part of the Papuan sub-region. Not only is this true of the birds, but, as has been pointed out in the previous section on plants, the savannas represent an extension to New Guinea of the tropical open forest climax of Australia.

With each succeeding expedition to New Guinea more and more birds are discovered in south New Guinea which occur elsewhere only in Australia, and most of these are savanna species.

Some of these will be mentioned in the brief discussion of the main habitats.

MANGROVE AND STRAND COMMUNITIES.—The sand beaches and mud flats of the coast hold for the most part widespread species, many of them migrant shore birds. The strand communities hold but few birds which intrude from the forest or savanna, or which flourish under disturbed conditions.

The mangrove community is in general like the strand community in respect to its birds. In south New Guinea we have found two species, *Myiagra ruficollis* and *Myzomela erythrocephala*, restricted to the mangroves and common there. Both of these are Australian species. Most of the many forms recorded in the literature as being restricted to mangroves we have found more commonly in other habitats.

RAIN-FOREST.—This contains the true Papuan avifauna, such as one finds, with minor modifications, in the lowlands of all New Guinea. This will be treated in a detailed report at a later time.

One species endemic to south New Guinea is a rain-forest species (*Pitohui incertus*), and another restricted to south New Guinea and Aru Island (*Tanysiptera hydrocharis*) is also a rain-forest species.

The rain-forest species common to south New Guinea only and Australia are few: *Ptilinopus regina* and *Pitta versicolor* are

[1] 1890, Ann. Report British New Guinea, 1889–1890, Appendix I.
[2] 1934, Blumea, I, pp. 116, 117.
[3] 1939, Papua, Physische Landeskunde von British-Neuguinea. Albrecht Beck, Frankfurt-Süd.

examples. The race *Chalcites malayanus russatus* also has such a distribution.[1]

FRESHWATER SWAMP-FORESTS.—This habitat is characterized by having an impoverished forest avifauna. The standing water that occurs there may attract certain kingfishers which also frequent the river margins (as *Halcyon nigrocyanea, Alcyone pusilla* and *azurea*).

SECONDARY RAIN-FOREST.—The existence of areas of secondary rain-forest growth in this region practically untouched by man was especially interesting because it gives a good clue to the original habitat of birds of the second growth.

Chapin[2] mentions the existence of birds peculiar to second growth areas in both Africa and South America. In temperate climates conditions have been so long disturbed that the existence of non-forest-loving species in an area that was originally forested has become accepted without question.

In the virgin forest of the Fly River there were always small areas of second growth with some non-forest birds. When and if man's activities clear this land and more extensive disturbed conditions come into existence, these birds will greatly increase in numbers. But the species have been there all the time, living a precarious existence in the shifting bits of habitat suitable for them and perhaps developing independent races. This is applicable to the mid-mountain grasslands of New Guinea as well. With this in mind we do not need to postulate that the lalang fields of north New Guinea have had a long existence, as Mayr[3] has done. Van Steenis[4] has already commented on this from a botanist's viewpoint.

Some examples of such birds follow:

Caprimulgus macrurus is not a forest bird in south New Guinea. Neither is it a savanna bird. The edges of the forest and bush are its habitat. On the upper Fly River but a single occurrence was noted; a bird flushed from the edge of the tall cane grass on an alluvial point in a bend of the river. At Sturt Island this species was common and nesting, wherever the bamboos were plentiful enough to cause breaks in the forest.

Todopsis cyanocephala finds its favorite habitat in the dense shrubbery bordering clearings, also venturing into the undergrowth in the forest. On the upper Fly it was found only in the dense shrubbery growing under disturbed conditions along the streams. On the middle Fly the shrubbery bordering marshes was an optimum habitat.

Edolisoma tenuirostre is a bird of the savanna and forest edge, yet we took one specimen on the upper Fly, at Black River, in the second growth on an old gravel bar.

Rhipidura leucophrys is a bird of open habitats, edges of mangroves, gardens, towns and villages, and even out into the savannas and marshes. It never goes into the forest. Open spaces for flycatching are its main requirement. On the upper Fly River it was fairly common along the river margins, living in the shrubbery, hunting over the river and nesting on exposed sticks projecting from the water.

As would be expected these species have a wide distribution in New Guinea, and except for *Todopsis cyanocephala*, range widely outside of New Guinea.

OPEN SWAMP AND MARSH.—The extensive grass marshes provide a striking aspect of the avifauna.

Three endemic south New Guinea birds are restricted to the marshes or their grassy margins, *Lonchura stygia, L. nevermanni* and *Megalurus albolimbatus;* and another, *Lonchura leucosticta*, includes the edges of the marshes in its habitat.

Some of the marsh species are Australian, reaching New Guinea only in this southern part, as *Grus rubicunda* and *Anseranas semipalmata;* most of them are of more widespread distribution as *Xenorhynchus asiaticus, Ixobrychus minutus, Irediparra gallinacea, Dendrocygna guttata, Phalacrocorax melanoleucus, Anhinga rufa* and *Acrocephalus arundinaceus.*

SAVANNA.—This habitat is typically Australian in character. Almost all of the birds which frequent the savanna of south New Guinea are also found in Australia.

[1] 1935, Stresemann and Paludan, Mitt. Zool. Mus. Berlin, p. 454.
[2] 1932, Bull. Amer. Mus. Nat. Hist., p. 210.
[3] 1930, Nov. Zool., p. 25.
[4] 1935, Bull. Jard. Bot. Buitenzorg, (Ser. 3) XIII, p. 369.

With some of the true savanna birds the northern extremity of their range is in south New Guinea, such as *Choriotis australis, Uroaetus audax, Geopelia humeralis, Aprosmictus erythropterus, Ninox novaeseelandiae, Pomatorhinus temporalis, Gymnorhina tibicen, Entomyzon cyanotis, Lichmera indistincta, Philemon citreogularis, P. corniculatus* and *Neochmia evangelinae.*

Other savanna birds from Australia have extended their range to the savannas of southeast as well as south New Guinea, such as *Dacelo leachi* and *Melithreptus lunatus.*

Others have extended their range farther into the secondary grasslands of the northeast and northern part of the island, as *Chlamydera cerviniventris, Microeca flavigaster, Myiagra rubecula* and *Colluricincla harmonica.*

Some savanna species have a more extended distribution in savanna or secondary grassland, as *Synoicus ypsilophorus, Excalfactoria chinensis, Cisticola exilis* and *Megalurus timoriensis.*

Some New Guinea species are as much at home in the forest trees as in the savanna trees, such as *Cacatus galerita, Probosciger aterrimus* and *Podargus papuensis,* which also occur in Australia.

Mid-mountain Grassland, Alpine Grassland, Mountain Forest.—These were seen only from a distance and this avifauna can only be a matter of conjecture. The small extent of these grass areas implies that the first two are of small importance.

Some other aspects of bird distribution may be mentioned.

Descent of Mountain Birds to the Lowlands.—As with plants, a number of birds which over most of New Guinea occur only in the mountains, as *Clytoceyx rex* and *Diphyllodes magnificus,* come to near sea level on the upper Fly River. The prevalence of mist and cloud conditions, lowering the light intensity, may have an effect in producing the conditions recalling cloud-shrouded mountain forest.

However, this will not apply to *Myzomela nigrita* and *Ailuroedus melanotis* which reach the Wassi Kussa River, where relatively dry bright conditions prevail much of the year.

Subspecies in This Area.—It is useless to attempt a discussion of race formations in this area before the taxonomy work is complete, but it may be worth while to mention a few points which have already appeared.

There is frequently a different subspecies on the upper and lower Fly River, both of which may be localized, endemic races. In other cases the race of the lower Fly River may be the same as the Cape York bird or as the Aru Island bird, or southeast New Guinea or south Snow Mountains, while the upper Fly River bird may be an eastern, a western or a more widespread subspecies.

The Fly River itself does not form a boundary between many, if any, subspecies, but as a glance at the vegetation map shows, the course of the middle and lower Fly is near the north and east edge of the dry type of vegetation, and the Fly River may in some species reinforce the ecological boundary.

Migration.—In studying the birds of New Guinea the possibility of some species being migratory must be considered. Migration from the Palaearctic is fairly well known, but the movements of many Australian nesting birds which pass the Austral winter in New Guinea, some of them reaching only south New Guinea, are less well known. Where the same or closely related species occur in both Australia and New Guinea, the specimens must be carefully studied with the possibility of migration in mind and the literature on Australian migration reviewed.

RESULTS OF THE EXPEDITION

Emphasis was placed on the collecting of mammals, birds and vascular plants, though cold-blooded vertebrates, invertebrate animals and representatives of the lower orders of plants were secured as opportunity offered.

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

Mammalogy	1857	specimens
Ornithology	3633	"
Herpetology	239	"
Ichthyology	100	"
Entomology	2000	"
Botany	2600	numbers

The animal collections are deposited in The American Museum of Natural History, and the persons reponsible for the working up or distribution of the collections are as follows:

Mammalogy	G. H. H. Tate and Richard Archbold
Ornithology	A. L. Rand
Herpetology	C. M. Bogert
Ichthyology	J. T. Nichols
Entomology	Frank E. Lutz

The plant materials are deposited in the Arnold Arboretum and Dr. E. D. Merrill has undertaken the work on certain groups and the distribution of other groups to various specialists.

Part of the results have already been published, and the work is being continued as rapidly as possible.

Many data on ecology and habits have been recorded, ranges have been extended and forms new to science discovered during the expedition.

The results of the expedition have been extremely gratifying, and form material for one of the most complete faunal and floral surveys made in New Guinea.

Publications based on the expedition which have already appeared are as follows (list compiled Jan. 1, 1940):

GENERAL

1937. ARCHBOLD, RICHARD, AND RAND, A. L.
With Plane and Radio in Stone Age New Guinea. Natural History, XL, No. 3, pp. 566–576.

1940. ARCHBOLD, RICHARD, AND RAND, A. L.
New Guinea Expedition, Robert M. McBride Co., New York. (A popular account of the expedition.)

ECOLOGICAL

1938. BRASS, L. J.
Notes on the Vegetation of the Fly and Wassi Kussa Rivers. Journal Arnold Arboretum, XIX, pp. 174–190.

MAMMALS

1937. RAND, A. L.
Results of the Archbold Expeditions, No. 17. Some Original Observations on the Habits of *Dactylopsila trivirgata* Gray. American Museum Novitates, No. 957.

1938. TATE, G. H. H., AND ARCHBOLD, RICHARD
Results of the Archbold Expeditions, No. 18. Two New Muridae from the Western Division of Papua. American Museum Novitates, No. 982.

1939. TATE, G. H. H., AND ARCHBOLD, RICHARD
Results of the Archbold Expeditions, No. 23. A Revision of the Genus *Emballonura* (Chiroptera). American Museum Novitates, No. 1035.

BIRDS

1938. RAND, A. L.
Results of the Archbold Expeditions, No. 19. On Some Non-Passerine New Guinea Birds. American Museum Novitates, No. 990.

1938. RAND, A. L.
Results of the Archbold Expeditions, No. 20. On Some Passerine New Guinea Birds. American Museum Novitates, No. 991.

1938. RAND, A. L.
Results of the Archbold Expeditions, No. 21. On Some New Guinea Birds. American Museum Novitates, No. 992.

1938. RAND, A. L.
Results of the Archbold Expeditions, No. 22. On the Breeding Habits of Some Birds of Paradise in the Wild. American Museum Novitates, No. 993.

FISHES

1937. NICHOLS, J. T.
Results of the Archbold Expeditions, No. 15. A New Fish of the Genus *Bostrychus* from New Guinea. American Museum Novitates, No. 922.

PLANTS

Papers published in the Journal of the Arnold Arboretum.

1939. DIELS, L.
Botanical Results of the Archbold Expeditions. New Guinea Records of Annonaceae and Menispermaceae. XX, No. 1, pp. 73, 74.

1939. PENNELL, FRANCIS W.
Botanical Results of the Archbold Expeditions. New and Noteworthy Papuan Scrophulariaceae. II. XX, No. 1, pp. 75–84.

1939. MERRILL, E. D., AND PERRY, L. M.
On the Brass Collections of Pandanaceae from New Guinea. With two plates. XX, No. 2, pp. 139–186.

1939. BURRET, MAX
Palmae Gesammelt in Neu Guinea von L. Brass. XX, No. 2, pp. 187–212.

1939. UITTIEN, H.
New Cyperaceae from New Guinea. XX, No. 2, pp. 213–215.

1939. CHASE, AGNES
Papuan Grasses Collected by L. J. Brass. II. XX, No. 3, pp. 304–316.

1939. EXELL, A. W.
Combretaceae of the 1936 Archbold Expedition (Fly River, British New Guinea). XX, No. 3, pp. 317–320.

1939. HARMS, H.
Enumeration of the Araliaceae Collected by L. J. Brass in New Guinea. XX, No. 3, pp. 321–323.

1939. MERRILL, E. D., AND PERRY, L. M.
Plantae Papuanae Archboldianae. I. XX, No. 3, pp. 324–345.

1939. MATTFELD, JOHANNES
Botanical Results of the Richard Archbold Expeditions. Einige Neue Cunoniaceen aus Neuguinea. XX, No. 4, pp. 432–436.

PLATES XXI TO XLII

PLATE XXI

Fig. 1. The expedition airplane moored at camp on Fly River 5 miles below Palmer Junction.
Fig. 2. Nipa palm and mangrove fringe of the Wassi Kussa River at Tarara.

1

2

PLATE XXII

Fig. 1. Nipa palm from a mainland river, stranded on Daru Island.
Fig. 2. Mangrove forest of *Rhizophora conjugata* and *R. mucronata* at mouth of the Pahoturi River.

1

2

PLATE XXIII

Fig. 1. Permanent waterhole at Penzara, showing fringing rain-forest and beds of sedges and floating grass.

Fig. 2. An early stage of wet season flooding in a *Barringtonia* swamp-forest at Penzara.

1

2

PLATE XXIV

Aerial view of the Oriomo River near Wuroi, showing strips of rain-forest bordering the river and tributary creeks and the character of the prevailing savanna and savanna-forest.

PLATE XXV

Fig. 1. An advanced stage in the transition of savanna-forest to rain-forest, frequent on the higher ridges at Tarara, Wassi Kussa River.

Fig. 2. Typical tall savanna-forest of *Tristania suaveolens*, *Melaleuca Leucadendron* var. and *Melaleuca* sp., on a ridge of deep red soil at Tarara, Wassi Kussa River.

1

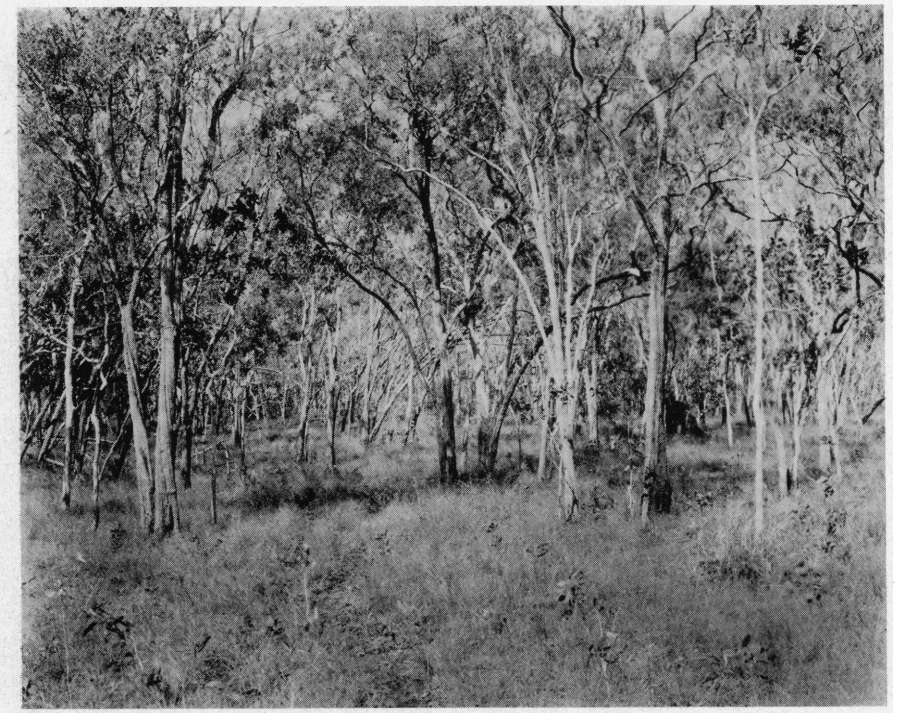
2

PLATE XXVI

Fig. 1. A patch of open *Eucalyptus* (*E. terminalis* and *E. clavigera*) savanna-forest, Tarara, Wassi Kussa River.

Fig. 2. Low savanna-forest of *Melaleuca symphyocarpa* and *M. Leucadendron* var. on a poorly drained flat, Tarara, Wassi Kussa River.

1

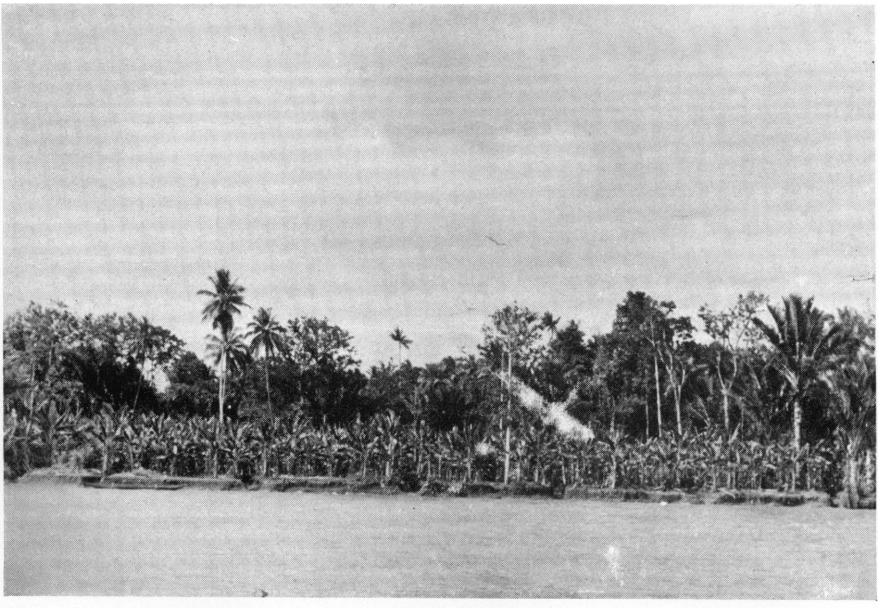


2

PLATE XXVII

Fig. 1. Native banana plantation, with coconut and breadfruit trees, on west bank of the Fly River estuary.

Fig. 2. Low tide view of firefly mangroves (*Sonneratia acida*) and lignite beds, Gaima, lower Fly River. Daumori Island in distance.



1

2

PLATE XXVIII

Fig. 1. Outer edge of a sago (*Metroxylon Rumphii* var. *flyriverense*) swamp, inland from Waribodoro village, lower Fly River.

Fig. 2. Bamboo substage of dry, open rain-forest, camp opposite Sturt Island, lower Fly River.

1

2

PLATE XXIX

Fig. 1. Dry season aspect of *Melaleuca Leucadendron* var. swamp-forest, camp opposite Sturt Island, lower Fly River. Trunks of trees covered with a climbing fern (*Stenochlaena* sp.).

Fig. 2. A freshwater tidal terrace carrying tall forest of nutmeg-mangrove (*Myristica* sp.) and *Bruguiera sexangula*, camp opposite Sturt Island, lower Fly River. The large liane is *Entada phaseoloides*.

1

2

PLATE XXX

Dry season aspect of *Erythrina fusca* swamp-forest with tall sedge (*Thoracostachyum pandanophyllum*) and *Pandanus* sp. undergrowth and the climbing fern *Stenochlaena* sp., camp opposite Sturt Island, lower Fly River.

Plate XXXI

Fig. 1. Riverbank facies of flood-plain rain-forest on Sturt Island, lower Fly River, with a group of *Gulubia costata* (palm), and, on the mudbank, firefly mangroves (*Sonneratia acida*).

Fig. 2. Freshly exposed face of ridge rain-forest, Fly River 5 miles below Palmer Junction.

1

2

PLATE XXXII

Fig. 1. Recently burnt over *Banksia dentata* savanna, Lake Daviumbu, middle Fly River.
Fig. 2. Native hunters burning very open savanna, Lake Daviumbu, middle Fly River.

1

2

Plate XXXIII

Fig. 1. Low scrub of *Agonis* sp. ? containing *Melaleuca Leucadendron* var. (2) and *Banksia dentata* as scattered low trees, and the tall sedge *Gahnia tetragonocarpa;* Tarara, Wassi Kussa River.

Fig. 2. Edge of an extensive, deep marsh bordering on a lagoon, Lake Daviumbu, middle Fly River. The marsh vegetation consists of the floating grass *Echinochloa stagnina*, lotus lilies (*Nelumbium nelumbo*) and *Limnanthemum indicum*.

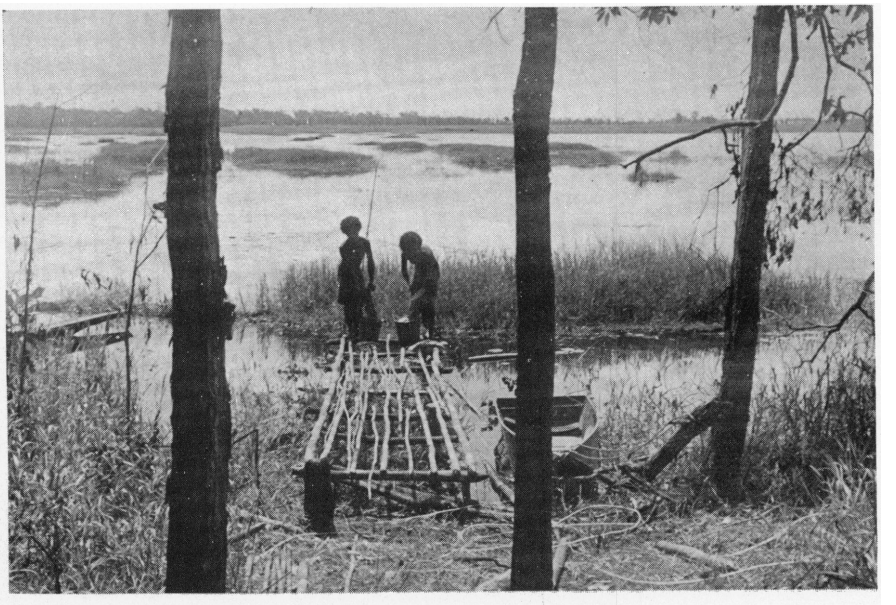
1

2

PLATE XXXIV

Fig. 1. View over a shallow lagoon containing floating islands of sedges, chiefly *Lepironia mucronata:* Lake Daviumbu, middle Fly River.

Fig. 2. Beds of floating grass (*Echinochloa stagnina*) and reeds (*Phragmites Karka*) at the southern entrance to Lake Daviumbu, middle Fly River.



1

2

PLATE XXXV

Fig. 1. Tea-tree (*Melaleuca Leucadendron* var.) swamp-forest with characteristic sedge undergrowth of *Scleria* sp., Lake Daviumbu, middle Fly River.

Fig. 2. Canoe lane through a sedge swamp of *Scleria oryzoides* carrying stunted tea-trees (*Melaleuca Leucadendron* var.), Lake Daviumbu, middle Fly River.

1

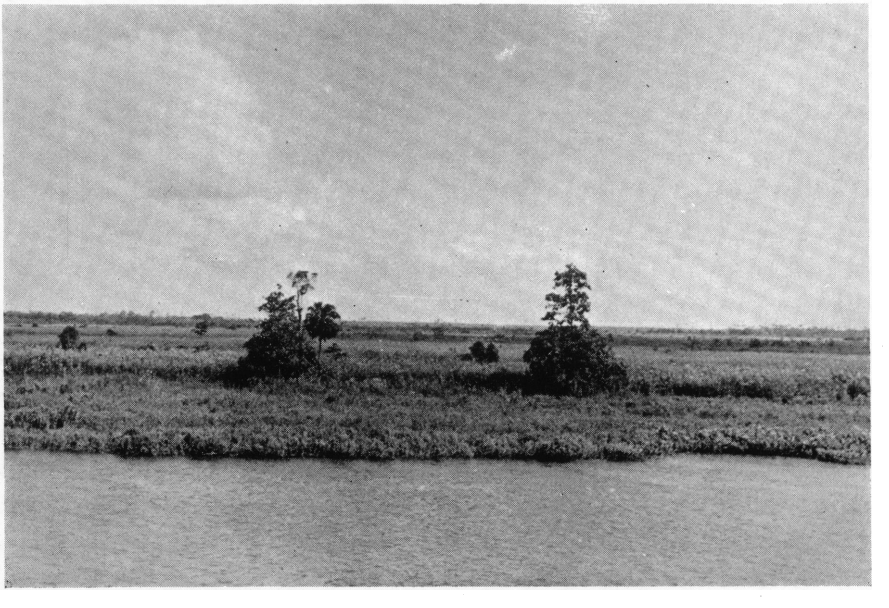
2

PLATE XXXVI

Fig. 1. Low *Barringtonia* trees fringing a large lagoon, at a period of high water; Lake Daviumbu, middle Fly River.

Fig. 2. View over grass marshes and reed swamps, near Lake Daviumbu, middle Fly River.

1

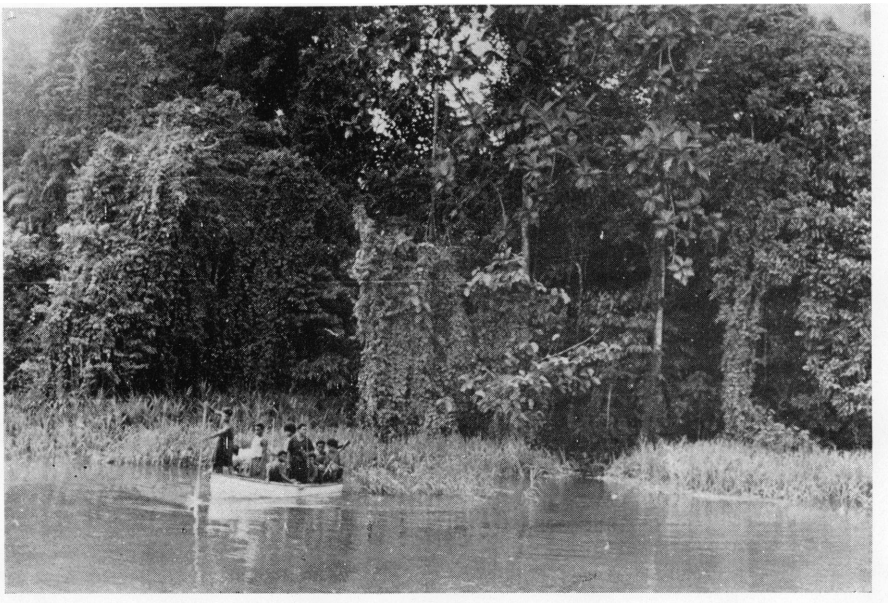


2

PLATE XXXVII

Fig. 1. Outer edge of a fringing strip of rain-forest containing breadfruit trees (*Artocarpus communis*) and bordered with floating grass (*Echinochloa stagnina*), middle Fly River.

Fig. 2. Wild sugar-cane (*Saccharum arundinaceum*) and rain-forest "second growth" trees on bank of the middle Fly River.



1

2

PLATE XXXVIII

Fig. 1. Fly River at Oroville Camp, showing a corner of the old airdrome on left, and, behind the camp, typical tall rain-forest of the ridges.

Fig. 2. The Palmer River, 2 miles below Black River Junction, showing beds of limestone gravel and the horizontally branched low *Ficus* trees characteristic of the upper river.

1

2

PLATE XXXIX

Fig. 1. Expedition camp on the Palmer River, 2 miles below Black River Junction.
Fig. 2. Open, mossy rain-forest of the ridges, with undergrowth of *Freycinetia* sp. and young palms; Palmer River, 2 miles below Black River Junction.

1

2

PLATE XL

Fig. 1. Interior of swamp-forest, showing the kneed pneumatophores of the dominant tree (*Campnosperma* ? sp.); Palmer River, 2 miles below Black River Junction.

Fig. 2. Old and new rain-forest second growths, following disturbance by native cultivation on an island in the Palmer River, 2 miles below Black River Junction.

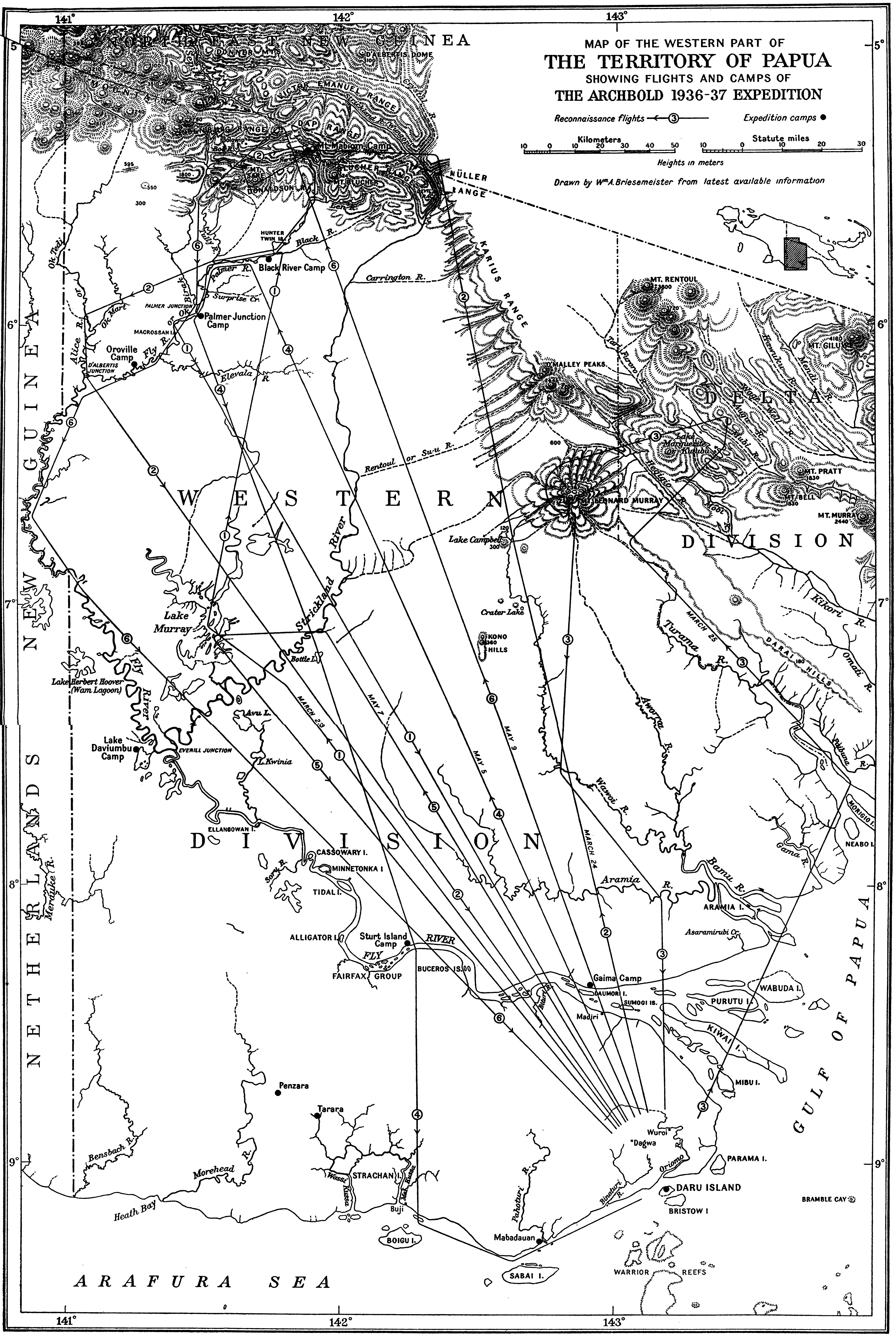
1

2

PLATE XLI

Aerial view of Lake Marguerite, showing the narrow fringe of floating grass on parts of the shores, and in foreground, a swampy parallel valley carrying sago palms.

PLATE XLII
Aerial view of the mossy-forested summit of Mt. Leonard Murray.


MAP OF THE WESTERN PART OF
THE TERRITORY OF PAPUA
SHOWING FLIGHTS AND CAMPS OF
THE ARCHBOLD 1936-37 EXPEDITION
Reconnaissance flights
Expedition camps
Kilometers
10 0 10 20 30 40 50
Statute miles
10 0 10 20 30
Heights in meters
Drawn by Wm A. Briesemeister from latest available information
141°
142°
143°
5°
6°
7°
8°
9°
NORTH EAST NEW GUINEA
D'ALBERTIS DOME
VICTOR EMANUEL RANGE
DAP RANGE
Mt. Mabiom Camp
BLUCHER RANGE
MT. BLUCHER
MT. DONALDSON
MÜLLER RANGE
HUNTER TWIN IS.
Black R.
Black River Camp
Palmer R.
Carrington R.
KARIUS RANGE
Surprise Cr.
PALMER JUNCTION
Palmer Junction Camp
MACROSSAN I.
Ok Tedi
Alice R.
Oroville Camp
D'ALBERTIS JUNCTION
Fly R.
Elevala R.
O'MALLEY PEAKS
MT. RENTOUL
MT. GILUWE
DELTA
Lake Marguerite or Kutubu
MT. PRATT
MT. BELL
MT. MURRAY
Rentoul or Su-u R.
WESTERN
MT. LEONARD MURRAY
DIVISION
Lake Campbell
Strickland River
Crater Lake
KONO HILLS
Lake Murray
Bottle L.
Kikori R.
Turama R.
MARCH 25
DARAI HILLS
Omati R.
Lake Herbert Hoover (Wam Lagoon)
Fly River
Avu L.
MARCH 23
MAY 7
MAY 9
MAY 5
MARCH 24
Aworra R.
Lake Daviumbu Camp
EVERILL JUNCTION
L. Kwinia
Wawoi R.
Purari R.
MORIGIO I.
NEABO I.
Gama R.
ELLANGOWAN I.
DIVISION
CASSOWARY I.
MINNETONKA I.
TIDAL I.
Aramia R.
Bamu R.
ARAMIA I.
Asaramirubi Cr.
NETHERLANDS NEW GUINEA
Merauke R.
ALLIGATOR I.
Sturt Island Camp
FLY RIVER
FAIRFAX GROUP
BUCEROS IS.
Gaima Camp
DAUMORI I.
SUMOGI IS.
Madiri
WABUDA I.
PURUTU I.
KIWAI I.
MIBU I.
GULF OF PAPUA
Penzara
Tarara
Wuroi
Dagwa
Bensbach R.
Morehead R.
STRACHAN I.
Wassi Kussa
Mai Kussa
Pahoturi R.
Binaturi R.
Oriomo R.
PARAMA I.
DARU ISLAND
BRISTOW I.
BRAMBLE CAY
Heath Bay
Buji
BOIGU I.
Mabadauan
SABAI I.
WARRIOR REEFS
ARAFURA SEA