

JOURNAL

OF

The New York Botanical Garden

VOL. XXIII

August, 1922

No. 272

REPORT OF WORK ON THE MULFORD BIOLOGICAL EXPLORATION OF 1921-'22

My botanical collections on this journey began immediately after crossing the divide of Quime-Cruz, on the eastern cordillera of the Andes, at an altitude of about 15,500 feet. This pass is just east of the railroad between Antofogasta and La Paz.

Previous to this time, I had obtained by purchase in the markets of Arequipa and La Paz a few commercial products for our economic museum, and one of the members of the party had obtained a quantity of *Bystropogon mollis*, for distillation and the study of its volatile oil, which is very similar to oil of pennyroyal.

The journey from the railroad station of Eucalyptus through the above-named pass was made by automobile, through the courtesy of Messrs. Guggenheim Brothers of New York, who own a tin mine near Quime. On the slope beyond the pass, I found enough water supply in early July to maintain a scanty growth of alpine plants. My collections here included two cactuses, two caiophoras, a ribes in fruit, and several senecios. From this point to Quime, at an elevation of about ten or eleven thousand feet, there was a steadily increasing display of plants in flower, and of ferns, on the sides of the valley, which were well supplied with surface water and with small streams entering the Quime River. The term "Pongo" means a beginning or commencement, and refers to the origin of some important stream or the commencement of a route to some important place. Hence there are a number of places so named, and they are distinguished by the addition of such a phrase as "de Quime," to indicate the locality. For several leagues on the road to

Quime, the number of specimens in flower was very large and the display was showy. Yellow and white were the predominant colors of the flowers. There were but few trees, and these very small, but the mountain sides were abundantly clothed with shrubs, large herbs, and half-shrubby plants. Circumstances having compelled me to precede the other members of the party, and to travel rapidly, I was unable to make any examination of this interesting flora, except during a few days' stay at Pongo, at an elevation of about 11,500 feet, and at a camp below Quime. Very prominent features of the flora along this route were half-shrubby species of crimson flowered *Virgularia*, a number of species of *Fagelia*, several species of *Bystropogon*, and a tall, slender, very spiny, pink flowered *Barnadesia*. These plants together constituted a large part of the vegetation of the mountain side. There were many grasses and ferns, but most of them were found at a season when collections were not to be made. The sides of the cliffs were covered with bromeliads, the "florida moss" being very conspicuous. When the wind was blowing, the extensive masses of this plant made it appear almost as if the face of the cliff was in motion.

As I had not been able to carry my driers with me, and had only a few old newspapers, I could obtain only scraps of the more interesting plants, which I dried by artificial heat. Dr. White came later and made a small, but exceedingly interesting collection on this portion of the route.

At Pongo, three species of *Berberis*, several of *Baccharis* one or more *zanthoxylums*, and a very large, shrubby *Poecilochroma* were very prominent. There were but few herbaceous plants in bloom. I collected some forty species at this place, but the specimens are small, poorly dried and of little value except for identification.

Below Quime, the soil rapidly became drier and the vegetation sere. From this point to Canyamina, at about 3,000 feet, a journey of several days by mule travel, the road is a succession of steep ascents and descents over high mountain spurs, most of their summits above tree level and with most of the vegetation sere. At several points, however, there were ridges and slopes known as "rain belts," where, due to local conditions, rains were occasional or frequent in the dry season, and the soil was moist. Here we found many plants in bloom. Among the more

noticeable, were two species of blackberry, many senecios and liabums, a *Cosmibuena*, *Cinchona ledgeriana*, species of *Triplaris*, three fuchsias and a great variety of ferns. Shrubs in the Compositae and Rubiaceae, especially a number of senecios, were common, but could hardly be called abundant. An interesting feature of the landscape was a species of *Bombax*, absolutely devoid of leaves, and with short, thick, trunk-like branchlets, bearing its pure white flowers on the naked wood. The narrow petals and numerous, elongated stamens gave to these flowers the peculiar appearance of a mass of silken fibers. Near Canyamina, large cactuses of several species became common, and a great variety of orchids was encountered. Unfortunately but few of the latter were in bloom at this season (early July). One of the cactuses growing in this region forms a large tree and is perhaps the largest species of cactus in the world. One which we photographed and measured was about 55 feet in height, with a spread of crown 43 feet wide, and with a trunk, 7 feet 8 inches in circumference 3 feet above ground. Here also the forests were largely composed of Mimosaceous trees, which furnished the most important timber of this region. A few trees and shrubs in the Melastomaceae were here encountered.

At Canyamina, a stop of several days was made, after our collecting outfit had arrived, and rather large collections were made, in spite of the fact that the dry season was still in force. Fruiting specimens largely predominated over those in flower. We were interested here in finding an abundance of the genuine matico plant (*Piper angustifolium* R. & P.) and a photograph of a large shrub of this species was obtained, probably the only illustration of it in existence. The bark of a tree called "vilca," apparently a *Piptadenia*, finds an important use in hastening the fermentation of cane juice, for the making of alcohol, which is the important industry at Canyamina.

Ferns grew in great abundance and in fair variety, and meibomias made a dense growth along the streams.

The most striking character of this entire journey from Pongo to Canyamina is the restriction of habitation, owing to the absence of grounds level enough for cultivation. At every point where the canyon opens out into a valley with sloping sides, notwithstanding that these slopes are exceedingly steep, a town or village has been located and every yard of land level

enough for tilling is utilized for crop production. It is a most interesting sight to view the side of a large mountain dotted with cultivated plots, varying in size from a few thousand square feet to many acres, with their outlines very carefully marked by walls, in order that there shall be no danger of the owner losing any portion of his tillable land. Some of these plots are at long distances from the homes of their owners and are so elevated that the latter must climb from one to three thousand feet above their cabins in order to work them.

Canyamina itself is at the head of a long and broad valley affording tens of thousands of acres of rich, tillable land. Hundreds of acres are here planted with sugar cane. Although this cane is not of good quality, the fact is due, not to any defect in the soil or climate, but to the fact that the same plants have been yielding cane for long periods, some of them as much as forty years.

At this point I made a most interesting observation, and one which throws a good deal of light on plant conditions in the Andes. I found a patch of bananas that was gradually slipping, along with the adjacent soil, into the small river at the bottom of the valley. I was assured by the gentleman in charge of the plantation, a thoroughly intelligent and highly educated French engineer, that within ten years this banana patch had been located high up on the hills and distant several hundred yards horizontally from its present position. Its displacement has been perfectly gradual, so much so that the life of the plants themselves has not been interfered with.

From Canyamina, a day's journey by muleback brought us to the junction of the rivers La Paz and Meguilla, which form the Bopi River. Near here, on the edge of a vast rocky playa, is located Espia. There are no houses here, it being merely a locality, bearing this name because of its importance as a junction of the route from La Paz, via Chulimani, to Canyamina and Cochabamba, and the down-river route on the Bopi to the eastern Andean region. This region is interesting because of the great extent of its cactus flora. It is not an arid region, although very dry during the dry season. Its cactuses are peculiar. One of them is the very large one to which allusion has already been made, and which is very abundant. Another one is either a form of the former, or a very closely related species.

Since there were no blossoms or fruits, I could not decide this point. Another is tall, very slender, and perfectly erect, with the exception of (sometimes) erect, slender branches growing close to the main trunk. It is often thirty or forty feet high, and has many shallow grooves and ridges. There were no flowers or fruits, and I could not even guess at its identity. A very peculiar *Opuntia* grows here. It is perfectly erect and very straight, and bears branches only at the top, these forming a small and compact crown. It grows in the dense forest and as its crown is pushed upward, it loses the branches below, which leave scars. Eventually it may become thirty or forty feet high. I have photographs of all these species. One or more species of *Epiphyllum* are abundant, and here and there is a *Rhipsalis* which festoons the large trees in the river bottom very densely. The stems hang vertically and sometimes attain a length of ten feet. Also a *Pereskia* with pink flowers often lines the roadsides, its stems very long and slender and partially reclining.

Except for a narrow fringe along the stream, the vegetation in this locality was absolutely sere at the time of our stay there, and most of the trees were bare of leaves. Some of the ferns and some other small herbaceous plants possess the peculiarity of curling up tightly during the dry weather and opening out again when the rains occur. Climbing over rotten logs and rocks and tree trunks there was an abundance of exceedingly thick leaved, fleshy polypodiums and peperomias. The former possess fronds of two forms on the same plant, one ovate and cordate, the other lanceolate. We were informed that within a few leagues there were high, elevated regions where the vegetation was always fresh and fertile, but circumstances prevented me from reaching them.

In spite of these unfavorable conditions, we secured a rather large collection before leaving Espia, which I am inclined to think will be unusually interesting.

Our next stop was at Huachi, just below the junction of the Bopi and Cochabamba Rivers, which together form the Beni. This journey, of about 4 days, was made by callapo, consisting of two rafts of ochroma wood lashed side by side. It is one of the most difficult and perilous raft journeys in South America, large amounts of property, and occasionally lives, being lost in the rapids. One of our own callapos was there smashed, and consid-

erable valuable property was lost, all of the remainder being water soaked and more or less damaged.

The Bopi River runs through high mountains, mostly difficult of ascent. The bad rapids begin when one is about two-thirds of the way from Espia to Huachi. The current is exceedingly swift and the river bed is filled with huge rocks, which make the entire journey decidedly dangerous. The men who navigate the rafts are Indians, called balseros, and they are wonderfully strong and skillful in this work. At several points, it is necessary to make portages by land. The worst dangers occur at a point (Rapids of San Fernando) where the river is hemmed in by precipitous cliffs, so there is no possibility of making a portage and one has to shoot the rapids and dodge the rocks. It is here that most of the accidents occur and where we suffered disaster. Some of the cliffs along the river are of such height and appearance as to be exceedingly impressive. I think it impossible for any intelligent man to pass through these canyons without being quieted and subdued in spirit. These cliffs are covered with the most interesting plants, huge bromeliads being the most conspicuous.

It is a matter of the deepest regret with me that we could not stop by the way and make collections on these steep mountain sides. The cost of our journey here amounted to about one hundred dollars a day, and the men's food supply was very limited, so that we could not afford to tarry, and our collections had to be confined to the immediate shores of the river. I can imagine no more profitable way of spending a season than for a party to go properly equipped for depending upon themselves and collecting systematically in this region.

The conditions of vegetation along this river vary greatly at different points and this variation is of the greatest interest. A day's journey below Espia, the sere hillsides give place to moist slopes covered with luxuriant vegetation, including an abundance of flowering trees and shrubs. Farther down, other similar sudden alternations between arid and moist conditions were encountered. Most of the trees of the arid belt were deciduous and of course leafless at this season. Every possible opportunity was utilized for making collections in these two classes of regions; but these collections cannot be characteristic, because they had to be made near the stream, where the full effects of the aridity did not manifest themselves. It is to be noted that even in the

localities which were verdant, the percentage of plants in flower was not large. All things considered, therefore, I should say that our collections represented not more than five percent of the species that were within sight as we traveled.

At Huachi, we were obliged to remain for ten days, while awaiting the rafts by which alone we could pursue our journey. Here, the beginning of the rainy season was bringing many plants into bloom, and we managed to keep our driers almost fully occupied. It was rather notable that each day brought new plants into bloom in the localities visited the day before. That is to say, the blooming season of the species comes on with great suddenness. Not only did we collect the plants of the immediate vicinity of the little settlement, but we made rather extensive and important excursions from this base. Dr. White was most energetic and persevering in these side trips, which were made with great difficulty and subject to considerable hardship. Perhaps the most notable piece of work performed at this place was the investigation of the sources of Coto and Para-Coto bark. These are important medicinal barks, the botanical origin of which has been entirely unknown, except that they were evidently members of the Lauraceae. For many years past, practically all of our supplies of these barks have been wholly spurious. It was our object to determine not only the species that yielded them, but the causes of this defect in our supplies. Dr. White carried out these investigations, as I was unable to travel by land. He found a number of species of trees, very similar and very closely related, the barks of which have been collected under these names. He collected bark and herbarium specimens from identical trees. One of them proved to be the genuine Coto and another the genuine Para-Coto. The species yielding the spurious bark were found to be closely similar to those yielding the genuine ones, so that it appears almost certain that the incorrect collections have been due to accidental errors on the part of collectors. I believe that the result of Dr. White's work will be to establish the possibility of securing perfect supplies of these barks in future.

While Dr. White was making these land journeys, over steep mountains and through difficult jungles, exposed both by night and day to very inclement weather, I arranged a return trip up the river, on an economical basis, and spent about two weeks in collecting the flora of the lower Bopi. I had intended to go much

farther up than I did, and anticipated great results from the excursion, but in this was greatly disappointed. One of my companions was attacked with a severe remittent fever, immediately after which he developed a large abscess in his arm pit. His condition was rather serious and threatening, so that we were obliged to encamp and give him suitable conditions for safety. At this particular time I suffered a severe attack of neuritis and was almost completely incapacitated. Nevertheless, I did, with much discomfort, keep my driers working almost to full capacity and obtained many interesting species.

It may be remarked that this is one of the richest game countries that I have ever encountered. There were many deer, wild hogs of two species, tapirs and cornejos, besides a great abundance and variety of large, edible birds, there known as *pabas*, meaning turkeys.

Much of our time while on the lower Bopi was devoted to studying the economic elements of the flora and the studies of our collections in this department will doubtless form the subject of a number of special papers.

A very interesting observation made here was in connection with the burning of the cane brakes or bamboo jungles along the river bottom. It has been learned by the natives that after these bamboo thickets are burned away, ochroma trees spring up in considerable abundance. This being the wood from which their rafts are made, it is of the greatest importance to them, and they seek this means of promoting its production. On the first occasion when we observed this burning going on, I was startled by the loud and incessant explosions which resulted. The sounds were like those of the firing of heavy muskets or small cannons and were very noticeable at a distance of two or three miles. Investigation showed that this was due to the explosion of the bamboos, the hollow joints of which contain water. This water being vaporized by the heat, thousands of explosions resulted, producing the impression of an active and continuous bombardment.

The Beni, below Huachi, being free from impediments, we travelled with callapos comprised of three rafts, and were less hurried in our movements than on the upper river. This portion of the route I had traveled in 1886, but under conditions that precluded collecting until after the Andes had been passed. On the present occasion, we were still faced by adverse seasonal

conditions, almost all of the plants being in the transitional state between fruiting and flowering. Six days' journey carried us through the last half of the Andes and landed us at Rurren-abaque, just at the base of the last foothill. On my previous journey, there was nothing at this point except a house or two in a clearing of the deep jungle. Now there was a good sized town here, with many outlying plantations and haciendas. A few years ago the place was twice as large, as to population and business, as at present, the loss of the rubber industry being chiefly responsible for its decline.

Here we established our headquarters and maintained them until the end of the year, making many important excursions to other localities. Here again Dr. White was exceptionally active. He returned up the river and ascended side streams and climbed mountains, with the special object of securing orchids, of which, however, comparatively few were obtained, as they were not yet in flower. He will undoubtedly write an account of his work in this region, which must prove of exceptional interest and importance. He also visited Tumupasa and Ixiamas and made important collections, being accompanied by Mr. Martin Cardenas, the botanical student sent by the Minister of Instruction of Bolivia to secure instruction in field work.

During this period, my lameness had so increased that it was very painful for me to get about and my ability to work was quite limited; nevertheless large collections were made and the specimens were shipped home. The specimens were very carefully wrapped in double thicknesses of heavy waterproof paper taken with us especially for this purpose and the bundles were securely packed in boxes which we had also taken with us for this purpose, in the form of shooks. It was supposed that they must arrive in good condition, and they would have done so under ordinary circumstances. As it turned out, however, in their long journey to the ocean steamer for New York, during which they were subjected to various changes of transportation, they must have been transported under full exposure to the tropical rain, or else they must have been transported in such a way that the boxes stood in water. On opening them in New York, it was evident that the packages had been watersoaked for weeks. Everything was done to dry them out and save them, but they had suffered a great deal of damage.

The flora of the region under discussion is so diverse that little can be done in the way of generalization of its elements, yet there are certain features that should be reported here. At this season (December) fruiting specimens were largely in the ascendancy, so that our collections are in general complementary to those which I obtained in 1886 and to those of Mr. Williams, collected in the same general region while on the Conway Expedition.

This region excels all others known to me in the number of its native edible fruits. Many of these are of good quality and some of them are of real excellence, and well worthy of cultivation and improvement. A large collection of these was obtained and preserved in formaldehyde for our Economic Museum. Since they could only be preserved in glass jars, of which our supply was limited, duplicates could be collected in only very sparing amounts, but we have enough to furnish a good collection to Dr. Oakes Ames and a fair collection to the Brooklyn Botanic Garden.

Many of the plants collected about Rurenabaque are used medicinally by the natives. While few if any of them are likely to prove of sufficient medicinal value to be of practical importance to the materia medica, knowledge of them is not devoid of scientific interest. At least four species of *Guarea* were there found which had yielded commercial supplies of a valuable medicinal bark. Rurrenabaque is the river port by which access is given to the town of Reyes, eight leagues in the interior. At the time of my former visit, there were two such ports, the one below Rurenabaque being at one angle of an almost equilateral triangle with Rurrenabaque and the town of Reyes, at the other two angles. In the meantime, the river has so changed its course as to leave the lower port, Salinas, miles away from the present channel of the river.

In planning for this journey of exploration, great hopes had been entertained of the results of a journey to the little known Lake Rogagua, located in the pampas to the northeast of Reyes. I had hoped to settle the much discussed question as to whether the waters of this lake drain into the Beni or into the Mamore, and I had expected to make very extensive collections about its shores and on the road between it and Reyes. My disappointment was inexpressible on finding that the season had not advanced beyond the point of getting the early spring vegetation well started, with only the very earliest of spring flowers in evidence. A careful examination of the young plants showed that our col-

lections in flower did not represent more than one in twenty of what could be secured in the course of an entire season. The conditions relatively were about what would be encountered in the vicinity of New York in the middle of April. We were also disappointed to find that the outlet of the lake would not be capable of navigation before late February or March so that we were obliged to cut short our stay and return to Rurrenabaque with a very small botanical harvest.

The flora of this region possesses features of great phytographical interest, of which enough was learned to entitle the subject to treatment in a separate communication.

Before we could reach the Beni again, my health had become so poor, and my capacity for action so limited, that I feared becoming an encumbrance to the rest of the party and I determined to descend the river as rapidly as possible, and endeavor to secure improvement at the English Hospital of Candelaria, at the eastern terminus of the Maderia & Mamore Railroad and at the foot of the lowest of the falls of the Madeira. I therefore bade adieu to my companions and dropped down the river on a raft until I encountered the little Bolivian Government launch Beni, which carried me to the town of Riberalta near the uppermost of the falls.

Before leaving Rurrenabaque, careful arrangements were made for the continuation of the field work of the party. While at Canyamina, I had granted the request of the Bolivian Minister of Instruction, to permit two government students to accompany us and secure training in field work. Of these, Mr. Martin Cardenas specialized in botany and Mr. Lopez in entomology. Both had proved themselves assiduous students and industrious collectors. It was now arranged that Mr. Cardenas should continue collecting under the direction of Dr. White. While Dr. White himself made side trips, Mr. Cardenas was to collect the flora about Rurrenabaque, which was now rapidly coming into flower.

While at Riberalta, I engaged a small launch and a crew for a month's voyaging by the other members of the party when they should arrive there, enabling them to work along the Beni and the streams entering it. In this way, our botanical collecting was continued for a considerable time after my departure.

At Candelaria, I was informed that my condition would not justify returning to the party or engaging in any farther field

work after their arrival at that point. I therefore decided to return to New York after making all possible arrangements for the comfort and success of the party on their way down the river.

On my way down the Madeira, I was much impressed with the extent of the industry of Brazil-nut collecting. Many stops were made by our small steamer, by night as well as by day, for shipping hundreds of tons of these nuts which largely constituted our cargo. The nuts were stored in buildings and cribs along the river bank, from which they were either carried on board in bags and baskets, or shoveled directly out of canoes and barges, moored alongside of our vessel. They were dumped for measurement into a standard barrel kept for the purpose and then thrown into the hold.

H. H. RUSBY

SOME EDIBLE CUP-FUNGI.

The fungi have been used as articles of food since ancient times. Not only are their food values known to man but some of the lower animals are almost entirely dependent upon certain species which form their staple articles of diet and are apparently as essential to their existence as the potato is to the people of Ireland. This is especially true of the leaf-cutting ant, by far the most destructive insect in certain parts of the tropics. Living in great underground houses these ants scour the country often for miles, in search of suitable trees. Having located the object of their search they ascend the trunk of the tree, cutting off portions of the leaves many times their own size. These are carried down the tree and back to the nest over well beaten paths prepared for this purpose, the work often continuing until the tree is entirely defoliated.

Within the nest the leaves are cut into small bits which are gathered into little heaps and serve as the substratum for the growth of a certain species of fungus, the mycelium of which produces enlarged growths, the part of the fungus which is eaten by the ants. It is claimed that these enlargements are abnormal and are brought about by some unknown cultural process. This and several other species of ants have thus not only discovered the food value of the fungi, but have become expert mushroom growers.



Rusby, Henry Hurd. 1922. "Report of work on the Mulford Biological Exploration of 1921-'22." *Journal of the New York Botanical Garden* 23(272), 101–112.

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