THE IRWIN EXPEDITION ABOUT CERRO DE PASCO AND LAKE TITICACA

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In a recent number of "Science" Prof. C. H. Eigenman[1] gave a general outline of the Irwin Expedition of

[1] Science, August 1, 1919.

Indiana University to South America. The writer was a member of the party as a traveling fellow of the University of Illinois.[2] My chief activities were the collection of parasitic material, and the collection of the fishes of the Lake Titicaca basin.

All members of the party reached Lima, Peru, in August, 1918. As related by Prof. Eigenmann we followed up the course of the Rimac, and the upper portion of the Mantaro and its tributaries which center at Oroya.

As an introductory procedure I worked about Lake Junin in Central Peru and spent more than a month along the Huallaga from its sources near 14,000, feet down to 2000 feet.

After early September the writer proceeded independently of the others, first to Lake Junin and the Rio Huallaga, later to Lake Titicaca. Lake Junin (Chinchaycocha) is a shallow, mud-bottomed lake near Cerro de Pasco. It is surrounded by great areas of marsh and lies in the midst of an extensive peaty pampa at more than 13,500 feet elevation. It forms the source of the Rio Mantaro, one of the principal tributaries of the Ucayali, and this in turn one of the three chief Peruvian affluents of the Amazon. The inhabitants regard it as the true source of the Amazon an honor it shares with a score of high Andean rivers.

The pampa is a bleak area upon which virtually nothing grows except certain native sessile rosette-plants, representing a number of families, but principally composites. These constitute the pasturage of the few sheep and llamas that can be maintained. Everywhere in the Peruvian Andes there is a remarkable climatic difference between elevations of 12,000 and those of 13,500 feet. Though Lake Titicaca is five hundred miles farther from the equator than Junin, there, at 12,500 feet, an extensive agriculture is practised. Wheat, barley, and potatoes are rarely seen at elevations of 13,000 and the Junin pampa will produce none of them. At midday tempera-

[2] Special acknowledgement is due Pres. E. J. James, Dean David Kinley, and Prof. Henry B. Ward of that institution. It was only through their active interest and financial co-operation that the writer was enabled to be one of the party.

tures may be quite high. But nights are always cold, and the passing of a cloud over the face of the sun will cause the fisherman to assume his coat. In equal altitude at Cebollar, Chile, a diurnal temperature variation of 65° F. was encountered.

While the elevation is too great to allow more than a few land plants, there is still an abundance of aquatic vegetation. The lake bottom is deeply covered with mud and flocculent organic debris. Ceratophyllum, Potamogeton, and Philotria are abundant. The exposed roots of the shore plants at the water's edge are covered with great quantities of green fresh-water sponge, of which adequate collections were made.

The fish are of only two species, but very numerous in individuals. They are: the *bagre,* a Pygidium, catfish, which the inhabitants say ascends the rivers to spawn; and the *challhua,* an Orestias.

The fish are only slightly susceptible to dynamiting. It affected only those nearest the explosion. Most of these instead of rising to the surface as was expected sank into the ooze at the bottom and were lost. At first one is inclined to attribute this to the great elevation, and the decrease of about two-fifths of the atmospheric pressure. But the fishes here are apparently in as perfect adjustment to the existing hydrostatic pressure as at any other elevation, and ought therefore to respond in a similar way. It was disconcerting to cruise (in a motor launch kindly loaned by an American gun club at La Fundición) among the reedy embayments and lagoons, seeing vast numbers of fish in the clear water, unable to interest them in hook and line, unable to manipulate a seine, or to dynamite successfully, and the fish always out of reach of a dip net. The Peruvian came to the rescue. With a hardihood inherent in the dwellers of the bleak pampas he stepped into the water to his thighs, supporting his weight upon the rhizomes and roots of plants. Here he searched among stems for the fishes lurking there, and found them.

Very large frogs, Cyclorhamphus culeus Garman, were found fairly abundant in the lake and its tributaries.

They were much parasitized, especially with small Cestodes. The frogs are taken by the native *balseros* with a crude, three-tined gig, and are marketed at Junin. This species is not commonly used for food about Lake Titicaca, where it exists in great numbers.

The marshes and reedy islands surrounding Lake Junin harbor a multitude of birds, especially ducks, coots, and grebes. Seldom may one look out upon the lake without sighting the smoke of fires in the bulrushes employed by the Indians to reveal the nests of birds. The eggs are a highly prized addition to the scanty diet, though scorched by the fire or in a state of partial incubation.

Six weeks were spent upon the Huallaga river and some of its affluents. The highway from Cerro de Pasco to Huánuco follows the river from its origin, a group of springs below Cerro at 14,000 feet. Between Cerro and Huánuco, a distance of seventy miles, both river and road descend to an elevation of 6,000. In its upper course the river is mostly a series of rapids. No fish were encountered above Ambo, at an elevation of probably 7,500. They are said to occur at San Rafael during the lower stages of the river. This village has an elevation of 9,000 or more. At Huánuco several species of fish occur.

Collecting was continued seventy miles below Huánuco —as far as the Cayumba rapids, at 1,800 or 2,000 feet. These constitute an effective barrier to the tropical fishes of the lower course of the Huallaga. Not more than six species occur above the rapids. A native river man was able to enumerate and describe thirty-six species occurring from Cayumba to Tingo Maria, the ensuing forty miles. A crab was found for some distance above the falls, as well as below.

On the ridge of Punta de Esperanza, altitude 9,000 feet, and thirty miles northeast of Huánuco, the trail abruptly enters the tropical forest, which from this point onward entirely envelops the mountains. On the forested east slope the rainy season was well under way, in sharp-

est contrast with the barren west slope and ranges back of it.

Comparatively few of the mountain slopes have been cleared and placed under cultivation (chiefly to coca.) At San Juan, one of the estates of Dr. Augusto Durand, the writer was hospitably sheltered for ten days while engaged in collecting the parasites of tropical birds.

After certain delays due to transportation and to fever, work was begun in southern Peru in mid-November. The ensuing four months were devoted to the Titicaca-Poopó basin of Peru and Bolivia, and to northern Chile.

A few small fishes, Orestias, were obtained at Crucero Alto, on the Pacific-Titicaca divide above Arequipa, at an elevation of 14,650 feet. A narrow pampa forms an easy gradation here between the two slopes. The fish were collected from a network of sluggish ditches beside the railroad, and partially filled with ice and melting snow. In the Titicaca basin collecting was done at Lagunillas and Saracocha, lakes at about 13,500 feet, and in the Rio de Lampa at Maravillas and Juliaca. Similarly collecting was carried up the Rio de Pucará to Tirapata and La Raya, the latter on the Titicaca-Vilcanota divide at 14,150 feet. No fish occur in the swift water of the upper R. de Pucará, nor in the little sacred lake at La Raya. But *suches* (Pygidium rivulatum) were taken just over the divide, both in Lago Verde at equal altitude with La Raya, one kilometer north of the latter, and at Aguas Calientes in the upper river Vilcanota. The latter is a stream of the Urubamba-Ucayli-Amazon system.

For want of riding animals four trips were taken on foot, aggregating 200 miles, in order to reach some of the rivers and lakes of the Titicaca-Poopó basin. The first trip was from Puno to Yunguyo, paralleling the west shore of Titicaca. Collections were obtained at Puno, Chucuito, and Yunguyo from the lake itself, from the rivers of Ilave and Juli, and from the wet meadows of the pampa at Acora, Ilave, etc.

The second trip extended from the port of Moho, at the northeast corner of the lake, northwestward to Tirapata.

Collections were made in Lake Titicaca at Moho and Vilque Chico; in the meadow ponds of Huancané; the R. de Huacané, Lake Arapa, R. de Chúpa, R. de Azángaro, and R. Porque. Laguna Salinas is too saline for fishes. In fact nothing living was found in it except certain phyllopod crustacea, Artemia salina (reported for the first time from the continent, though found in all other continents). These were very abundant, and in all stages of development simultaneously. Flamingoes were feeding constantly in the lake.

Lake Umayo, five leagues inland from Puno, is very rich in several species of Orestias. It abounds also in freshwater sponges, which form masses covering the roots of aquatic plants and exposed bowlders to a depth of one-fourth inch or more. Thanks to the hospitality and cooperation of Sr. Francisco P. Valcarcel I was able to obtain excellent collections there, and to visit the ruins of Silustani and Atunorco.

On the Bolivian side of Lake Titicaca fishes were obtained at Puerta Acosta and Guaqui. The Rio de Tiahuanácu was fished near the ruined "House of the Sun" at Tiahuanácu, and the Rio Colorado near Viacha.

La Paz marks the upper limit to which Atlantic drainage has invaded the pampas of the Titicaca-Poopó basin. Unfortunately the only fish obtained here turned out to have been introduced artificially from the Pacific slope near Mollendo. It is doubtful whether native fish ever reach this elevation, 12,000 feet, in the River Chuquiapo. The current is very rapid and the water polluted with sewage

Near Calacoto the Rio de Calacoto, R. de Corocoro, and R. Desaguadero were fished. The last is the outlet of Lake Titicaca into Lake Poopó. Since it is retarded here in a narrow gorge, there is great seasonal variation in the level of the lake above—as much as five feet between extremes.

Other tributaries of Lake Poopó visited were: R. de Eucaliptus, R. de Poopó, R. de Pazna, R. de Challapata, all to the east; southward, Rio Mulato and Rio Grande de Lipez.

Lake Poopó at 12,000 feet elevation in the Bolivian highlands, is nearly unapproachable, hence there is a total lack of native facilities, and it was possible to do shallow water fishing only. The lake shores are extremely flat. The fluctuations in level carry the shore line back and forth more than a mile from season to season. The writer was able to wade more than a mile out into the lake at its lower level before reaching water that was above the knees. In addition to the seasonal fluctuations there are changes in level of shorter periods, apparently almost diurnal. They are probably due to the wind rather than to the existence of a *seiche*. Though more than fifty miles long, and half as wide, the lake has a maximum known depth of but thirteen feet.

The literature is flatly contradictory as to the salinity of the water of Lake Poopó. It is in fact quite salt and non-potable. However the writer and attendant were able to subsist four days upon strong tea made with it. So far as observed the salt has no effect upon the fish fauna. The Rio de Juli in Peru is considerably more saline, yet is inhabited by the same fish as the adjacent freshwater creeks. Even Lake Titicaca is slightly salt, at least locally. This is not evident to the taste in most places. Some rivers of the altiplane are extremely saline and have no fish. Such are those about Urora, Bolivia, which thus resemble Laguna Salinas mentioned above. Other rivers vary seasonally in salt content. R. de Lampa in the rainy season has no taste of salt. But Mr. F. H. Grundy reports that at Maravillas during the dry season the Indians scrape salt off the rocks of its bed. Lake Poopó is probably less salt than it would be did its surplus not overflow annually into the Salar of Coipasa. Here, at Laguna Salinas, and elsewhere salt is recovered on a commercial scale by leaching it out of salty earth.

In the Rio de Poopó occurs a spring of superheated steam and water. This water mingles with and is gradually tempered by the water of the river. Small *suches* were observed in water of considerably more than 100° F. The same phenomenon occurs at Aguas Calientes in southern Peru.

At the same altitude as the Titicaca-Poopó altiplane the socalled Lake Ascotan is hemmed off by a ring of extinct volcanoes (only Ollagüe being active.) It is about twenty-five miles in extent and lies just within the border of Chile. It consists for the greater part of muddy deposits of lime salts. Numerous pools and sluggish streams appear throughout, and drain away by seepage. At the bases of the volcanoes along the eastward margin are many warm and cold springs. These are only slightly brackish. Small Orestias are everywhere abundant here, though there is no communication with the outside. Great quantities of aquatic plants of the same species as those found in other lakes occur. Facilities and help in fishing were kindly provided by Mr. E. W. Lycett, manager of the Borax Consolidated Company's calcining works.

Between Ascotan and the coast at Antofagasta lie vast volcanic areas and the nitrate belt. Only one river which might support fish occurs—the Loa. But at Calama (elevation 7,000 feet) it was found to be totally devod of them. This is reported to be due to a water fall twenty-five kilometers downstream, below which coastal forms exist.

No new genera of fish were obtained in the Titicaca-Poopó drainage system. Only two genera, Orestias and Pygidium, occur. There is probably sufficient material collected for adjusting the very unsatisfactory status of the species.

It is hoped that the parasites of the fishes may, through their affinities, throw some additional light upon the origin of the fauna of the land-locked Titicaca-Poopó system. With one exception few parasites were obtained from the many hundreds of fish dissected. The one exception was a minute, active trematode resident in the cranical cavity of nearly every Orestias examined, but not occurring in Pygidium. It is found not only in Titicaca itself but in all the tributary lakes and streams.

In the lakes of the altiplane the great quantity of bird life in the broad plant zone of the littoral is noteworthy. There are many coots, cormorants, grebes, ducks, flamingoes, ibises, lapwings, and gulls. The writer estimated that there were not fewer than 10,000 wading birds per

mile of the shore at the southern end of Lake Poopó According to F. M. Chapman they are principally winter residents. Many birds were found to be parasizited by tapeworms and Acanthocephali.

The lack of game fishes is much lamented both by the people of the country and by the English and American residents of the altiplane—principally employes of the mining companies. They regard the clear, cold, swift Mantaro and other rivers as well suited to trout production. Mr. A. S. Kalenborn of Oroya, and others, have made an effort, so far unsuccessfully, to procure from this country trout eggs or young.

In spite of the inferior quality of the native fish, the fishing industry is of considerable importance in Lake Titicaca. The chief Peruvian and Bolivian ports, Puno and Guaqui respectively, are noteworthy as fish markets. Many fish are shipped from these ports to La Paz and Arequipa. The Rio Ramiz and its tributaries at the north and the Desaguadero at the south are fished for *suches*. *Suches* are also taken in the lake, and when properly prepared are better than the Orestias. But they are much less plentiful and more expensive, especially when twelve to fifteen inches in length. *Hispes* (an Orestias) are taken when about three inches in length and dried entire. In this state they are marketed at great distances—even at Cuzco and beyond—and are much prized by the lower classes.

The smaller Orestias, *hispe* and *carache*, sometimes occur in remarkable concentration, especially in the meadow ponds of the pampas. Frequently scores of them may be dipped up with a single swoop of the dipnet. Even a roadside sheep-washing pool, without outlet and very muddy, contained a multitude of isolated, pallid *carachitos*. In the same pools occur also vast numbers of small Dytiscid beetles. As a result of this concentration no fish was found which did not have the fins more or less abbreviated.