View from the November 2022 expedition camp: the highest peak, at an altitude of 2,362 meters, is Mount Imeri, located in the northern Brazilian state of Amazonas, close to the border with Venezuela

FIRST EXPEDITION TO THE IMERI MOUNTAINS

Researchers have identified animals and plants isolated by altitude, which may help explain the relationships between species from high areas in northern South America

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It is difficult to reach the Imeri Mountains, which are located in the northern Amazonas near Brazil's border with Venezuela. At altitudes of up to 2,450 meters (m), the mountainous environment features bromeliad fields, rocky cliffs, and trees surrounded by fog. The area does not seem to have ever been visited by people and is probably home to many unknown animal and plant species. A team of researchers—12 from Brazil, one from Spain, and one from France (*see below*)—spent 11 days there in November 2022 on a scientific expedition carried out together with the Brazilian Army.

The biologists collected hundreds of specimens, some that appeared to represent species that have never been described, and gathered information that they hope will provide greater insight into the relationships between animals and plants in this and other high-altitude regions of Brazil.

"In almost 40 years of field research, I have never found such a large proportion of probable new species," says Miguel Trefaut Rodrigues, a zoologist from the University of São Paulo (USP) and leader of the expedition. In his laboratory,

a week after returning from the trip, he showed *Pesquisa FAPESP* dozens of glass jars containing lizards and frogs. Two lizards are similar to specimens of the genus *Riomlama* collected during a 2017 expedition he led to Pico da Neblina, 90 kilometers (km) to the southeast.

The Imeri Mountains and Pico da Neblina were part of a large plateau formed of sandstone rocks that occupied much of the so-called Guiana Shield before the formation of the Andes. Erosion of these rocks over millions of years helped form the soil in the surrounding lowland forests, leaving many animal and plant species stranded on the peaks of flattened or table-top mountains known as tepuis, such as Neblina, and isolated mountain ranges. Taran Grant, a zoologist from USP, collected a species of tree frog of the genus *Myersiohyla* from Imeri and observed similarities with species of the genus *Hyloscirtus*, which live in mountainous environments in the Colombian Andes, more than a thousand kilometers away.

The lizards were captured in traps or by hand during the day, while at night, they were usually found asleep between rocks or in trees. The frogs, meanwhile, were all caught at night. Grant and his team followed the nocturnal vocalizations of frogs to find them on stream and river banks. "We found four frogs and a caecilian—a type of amphibian—that could be new species," says Grant.

INHOSPITABLE ENVIRONMENT

Few species have adapted to the nutrient-poor, rocky soil and average daily temperature variations of 20 degrees Celsius (°C) at the top of the Imeri Mountains. The diversity there is therefore much lower than that in the neighboring lowland forests. Many of the species that exist in the region are endemic, meaning they are isolated species that can only be found there.

"We found few species for most of the families of collected plants, indicating that these lineages have not diversified much in the mountains or they gave rise to species that are now already extinct," says USP botanist Lúcia Lohmann, who specializes in vines of the Bignoniaceae family. "However, these mountains seem to have been the birthplace of many botanical groups." According to Lohmann, it is possible that various angiosperm families (plants that bear flowers or fruits) first emerged there before later spreading to the Atlantic Forest and lower areas of the Amazon, where they diversified greatly.

One example is *Brocchinia hechtioides*, a bromeliad that grows in wetland areas of the Imeri Mountains, identified by Rafaela Forzza of the Rio de Janeiro Botanical Garden, one of the expedition's participants. "It is a carnivorous bromeliad that has only been recorded twice in the country," she says. "Although we only found one

In the field (*from top*): Ana Paula Carmignotto, from UFSCar, goes to check traps for small mammals; Rafaela Forzza (*white sweatshirt*) and Lucia Lohmann (*blue shirt*), helped by Corporal Marcio Junior da Silva Garcia, descend ropes toward sampling sites; José Mario Ghellere looks for reptiles and amphibians during the night

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species of the genus *Brocchinia*, it is abundant in the highlands of these mountains and it is one of the oldest lineages of Bromeliaceae, a particularly diverse family of plants in the Atlantic Forest." The 1,200 samples of 220 plant species collected by the team will be distributed among specialists from Brazil and other countries, who will collaborate to identify the material.

"Because small mammals arrived in South America later than other animals and plants on the geologic time scale, they were probably the last groups of animals to remain isolated in the mountain range and specialize there," says the zoologist Alexandre Reis Percequillo of USP's Luiz de Queiroz College of Agriculture (ESALQ). Ana Paula Carmignotto, a biologist from the Federal University of São Carlos (UFSCar), collected a marsupial, three rodent species, and three bat species, which preliminary assessments suggest are similar to species found in Pico da Neblina.

In addition to collecting plants and animals, some of the researchers on the expedition also carried out experiments. Agustin Guerrero, a zoologist from USP, placed reptiles and amphibians in a box connected to a heat source and slowly increased the temperature until the animals left the box. The results indicated which locations would be too hot for these species to survive.

"Imeri reptiles and amphibians have a low tolerance for high temperatures. They all left the box at less than 34 °C," noted Guerrero. "They would be in danger if their habitats reached that temperature."

Before the expedition, the scientists practiced boarding and disembarking the helicopter by rope, in case an emergency should occur—which fortunately did not happen. A group of 22 military personnel accompanied the team, transporting the biologists and their equipment on eight helicopter trips.

The expedition landed in an area of very wet ground at an altitude of 1,900 m. The helicopter that had carried the team had to land lightly on the ground to avoid sinking into the mud. The military team had tried in vain to find a way of accessing the area by land, but not even the Yanomami indigenous people—who are originally from the region—knew how to reach the top of the mountains due to the steep terrain.

On the first day at the camp, the group cleared three trails, each approximately 1 km long and some so steep that they could only be traversed with the aid of a rope. Three scientists injured their ribs, eyes, and shoulders and had to be treated by Army medical staff. Water from the incessant rainfall and mud washed into their tents. But their lives were a little easier when the sun came out.


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Once collected, animals, such as rodents (*top*), plants, and blood samples are prepared and boxed to be examined in detail in the laboratory

PHOTOS 1 TO 5 HERTON ESCOBAR/USP IMAGENS **6** ANDRÉ DIB/DIVULGAÇÃO **INFOGRAPHIC** ALEXANDRE AFFONSO/PESQUISA FAPESP MAGAZINE

On top of the Amazon

Near Pico da Neblina and inside Yanomami land, the Imeri Mountains were previously unexplored

SOURCE JORNAL DA USP

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An army helicopter transported scientists and equipment to the top of the mountain range; the team of researchers and soldiers who participated in the expedition (*above*)

PATHOGENS

General Sinclair Mayer, head of the Campinas branch of the Brazilian Defense, Industry, and Innovation Academy System (SISDIA), an agency run by the Army's Department of Science and Technology that helped organize the expedition, highlighted the importance of exploring new areas of Brazilian territory through such expeditions. At a meeting held at USP's Institute for Advanced Studies (IEA) on December 16, he highlighted the studies on pathogens carried out by USP parasitologist Bruno Fermino, who collected blood samples from amphibians, lizards, birds, mammals, and bloodsucking insects and claims to have found new protozoan species of the genus *Trypanosoma*.

These protozoa have existed for over 100 million years. They may have once infected dinosaurs, and they now live in all classes of vertebrates, from fish to mammals. "Species collected at Pico da Neblina and other areas in Venezuela may be related to this one, with shared ancestors millions of years ago," says Fermino. In humans, *T. cruzi* causes Chagas disease, and *T. brucei* causes sleeping sickness.

COLLABORATION

"The expedition would not have been possible without the Army. Everyone was very careful about our safety and very interested in what we were doing," acknowledges Rodrigues. Paulo Muzy, a physicist from the IEA, said during the December meeting that the partnership between USP and the Army began in 2015, with a view to enabling the trip to Pico da Neblina. Luís Fábio Silveira, a biologist from the USP Museum of Zoology who specializes in birds, spoke highly of the partnership: "The military were very helpful, they even came out at night to help us descend a cliff by rope to collect samples." Silveira collected 56 specimens of birds that he believes are exclusive to the region. Most are small with brown feathers and live in an area with few food resources.

The next goal for Rodrigues, 69, is to visit the Tulu Tuloi Mountains, which are also in the state of Amazonas, approximately 200 km northeast of Imeri. "There is another set of mountains there, isolated from Imeri by the valley of the Padauari River, which represents another natural evolutionary experiment," he says. "Since populations of the same species can change and give rise to new species when isolated, we wonder if there might be another group of endemic species related to those in Imeri." ■

Project

Comparative phylogeography, phylogeny, paleoclimate modeling, and taxonomy of neotropical reptiles and amphibians (no. 11/50146-6); **Grant Mechanism** Biota Program; **Principal Investigator** Miguel Trefaut Rodrigues; **Investment** R$6,183,134.96.