

Ancestral branches

The divergence among capuchin monkeys, as old as that between humans and chimpanzees, is reflected in their ecology and behavior

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Capuchin monkeys inhabit Central America, the entire Amazon Region, the cerrado savannas, the caatinga scrublands and the Atlantic rainforest, extending all the way to Argentina.

Within this territorial range, the monkeys vary greatly in their shape, color, size, food preferences and behavior. Capuchins are outstanding primates exhibiting complex social systems and a rare skill – the ability to use tools. Despite the large variation between species, until recently, experts classified the gracile capuchins, also known as caiararas, and the capuchin monkeys as belonging to the same genus, *Cebus*. Most of these monkeys were scientifically registered as *Cebus apella*. In the past 10 years, however, the classification of these primates has undergone a revolution based on the findings of Brazilian and foreign researchers. Prior to this revision, “Their taxonomy was still based on the work of naturalists” according to the Brazilian primatologist Jean-Philippe Boubli, but “the molecular technology era is allowing a full reorganization.” Boubli, a researcher at the Wildlife Conservation Society, and his American colleague Jessica Lynch Alfaro from the University of California, Los Angeles organized a symposium on these

monkeys at a conference held in Japan in 2010. The meeting and the contributions of the gathered researchers resulted in a special issue of the *American Journal of Primatology*, published in April of this year.

While studying the behavior of these monkeys in Caratinga in Minas Gerais state, Jessica noticed differences compared to these species in other locations, but no evolutionary context was available in which to assess the origin of these dissimilarities. “We didn’t know how long the groups had been separated or anything about the relationship between them,” she says. Today, the animals she studied are classified as *Sapajus nigritus*, which is different from their prior designation in terms of both the genus and species names. In 2001, the initial push for change came from a suggestion made by José de Sousa e Silva Junior in his doctoral dissertation at the Federal University of Rio de Janeiro. He advocated two subgenera: *Cebus* for the more delicate capuchins ranging northwards from the Amazon region, and *Sapajus* for the robust capuchin monkeys, often characterized by a tuft on the head, distributed southwards from the Amazon. “It was courageous of him to propose a division,” says Boubli, “but now we can go beyond this.”



PHOTOS: EDUARDO CESAR

Having remained unseen for centuries, the blond capuchin monkeys were rediscovered a few years ago



It is only now, a decade later, that the sub-division has been expanded further through the work of Jessica, Boublil and their colleagues, published in February in the *Journal of Biogeography*. *Cebus* and *Sapajus* have been proven to be sufficiently different to be considered distinct genera through extensive genetic analyses carried out primarily in Jessica's laboratory as well as Izeni Farias' facilities at the Federal University of Amazonas (Ufam). The distinction was confirmed, despite a similarity in size: the two types of monkeys both weigh just over 2 kilograms. More specifically, their study showed that the two lineages separated more than 6 million years ago. This is the same amount of time that was required for chimpanzees and humans to develop from a common ancestor. This change in the classification of these monkeys has been accepted by most primatologists and was published in April in the *Lista anotada dos mamíferos do Brasil* by Conservation International; however, opinions on this topic are not unanimous, as is customary in scientific circles. In his recently published comment on the *American Journal of Primatology* website, Alfred Rosenberger from Brooklyn College in New York claimed that acceptance of the division within capuchin monkeys was hasty and somewhat unnecessary. Although he does not criticize its genetic foundations, he argues that an exaggerated division can create rare species, raising more funds for conservation, even if it is not justified from a scientific point of view. This argument is situated more at the philosophical level, rooted on the fluidity of the species concept, which lacks defined boundaries.



1. *Sapajus libidinosus* climbs a wall in the Capivara mountain range

2. The white-headed capuchins, inhabitants of Central America

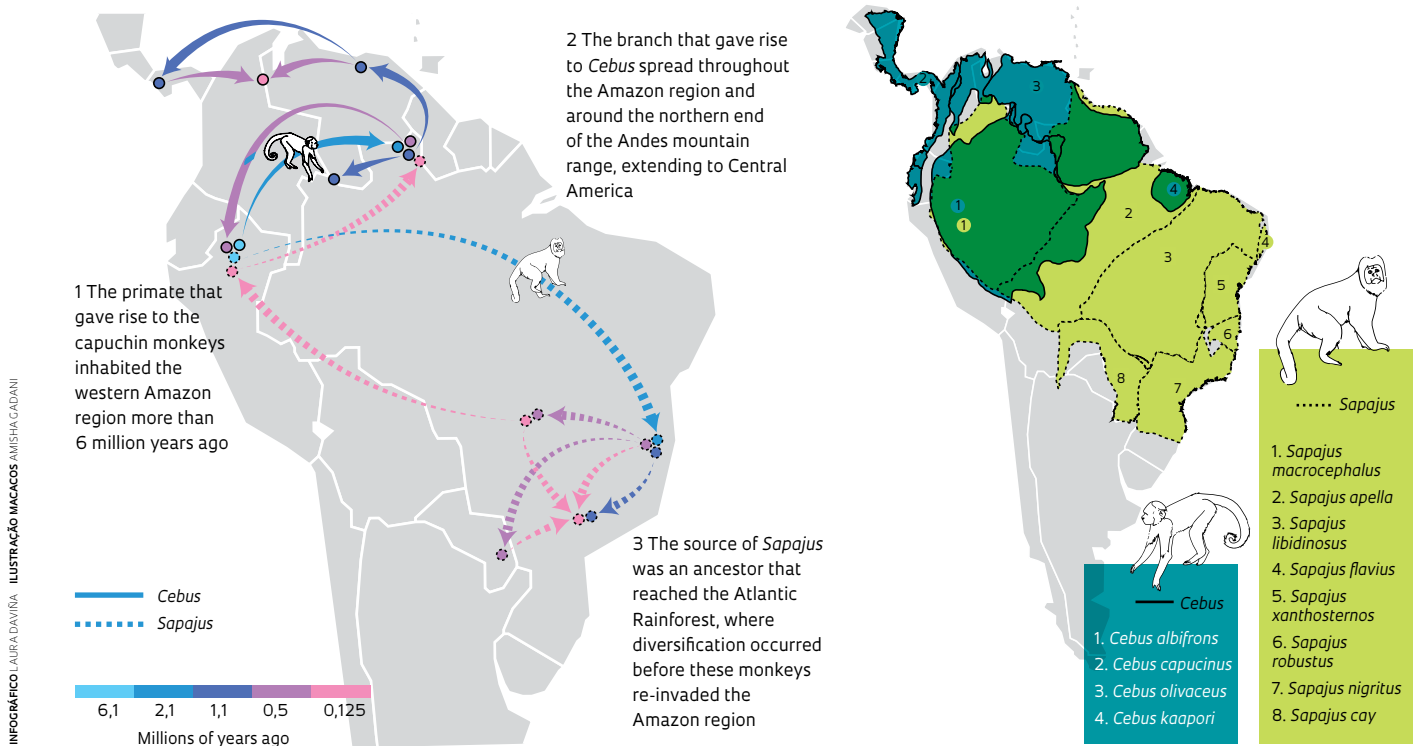
Jessica is convinced that her conclusions are correct. Using genetic sequencing and techniques that make it possible to estimate the ramifications of genealogy trees for these primates as well as accounting for the primates' current distribution, her group put forth a proposal regarding the evolutionary trajectories of these animals. This hypothesis indicates that the formation of the Amazon River was responsible for creating a north-south divide and isolating the primates living along its waters, thus creating a genealogical branch that gave rise to *Cebus* and *Sapajus*. It is unclear what subsequently took place during the following 4 million years. It was only approximately 2 million years ago that the group that gave rise to the more robust monkeys spread throughout the Atlantic rainforest, without leaving descendants in the Amazon. Their distribution along the entire coast of Brazil was rapid and coincided with species diversification. Approximately 700 thousand years ago, the expansion in the south reached Argentina, near Iguassu Falls, and turned north, where the cerrado savannas in central Brazil are found. Subsequently, approximately 400 thousand years ago, the robust capuchins returned to the Amazon, where they met their more gracile relatives who, in turn, spread throughout the northern region around the Andes, reaching Costa Rica in Central America.

This relatively recent reinvasion of the Amazon region by capuchin monkeys explains the low species diversity in the area as well as the competition between the two genera that had

Genetic data show that the robust capuchin monkeys and caiarara monkeys are sufficiently different to be considered distinct species

Evolutionary pathways

Genetic analyses have enabled scientists to retrace the trajectory during *Cebus* and *Sapajus* evolution over the course of millions of years (left) and to understand how the diversity that is only now being revealed arose. On the right, the proposed distribution of the genera today, showing some overlap in the Amazon region.



INFOGRÁFICO: LAURA DAVINHA. ILUSTRAÇÃO: MACACOS ANÍSHIA GADANI

6,2
 million years
 is how long
Cebus and
Sapajus have
 evolved
 separately

been separated for millions of years. “*Sapajus* are able to use a wider range of resources, such as breaking tougher fruit,” explains Jessica. This means that when they coexist with their cousins from the north, which is common in the western Amazon region for *C. albifrons* and *S. macrocephalus*, the density of the more delicate monkeys is reduced. Boubli examined the genetic diversity of the *Cebus* genus more thoroughly in an article published in a special issue of the *American Journal of Primatology*, in which he showed that these animals, which have not been thoroughly studied, harbor an enormous diversity. Izeni Farias, who was responsible for the genetic analyses, was not surprised. “The distribution is very broad. One would expect a broad variety”. A geneticist, she is head of a project within the program National Biodiversity Research System (Sisbiota), which aims to sample the genetic diversity of Amazonian vertebrates.

Boubli, who is experienced in Amazon jungle walks, sees this genetic analysis as a starting point that will indicate the need for further studies, noting that “The interfluves of rivers such as the Jaú, the Purus and others separate populations that may have been isolated long enough to become species”. One example he observed regarding this phenomenon involved monkeys

from the two sides of the Negro River, which have been separated for a million years according to genetic data. “At first glance, they look the same. But are they different species?”

TO THE NAKED EYE

Given the three-dimensional expanse of the Amazon region, merely collecting material for genetic analyses is difficult. Furthermore, ecological and behavioral studies are much more complicated, which is why we are almost entirely ignorant about the animals that live there. Most observational studies take place in easy-access areas, where monkeys are already acclimated to the presence of humans. In Brazil, this means that there have been many more studies performed on *Sapajus* than on *Cebus*. And there is much variation among *Sapajus* species.

In an article published in the *American Journal of Primatology*, a group led by Patricia Izar from the Institute of Psychology at the University of São Paulo (IP-USP) showed that this variation partially depends on the environment. The team compared *S. nigritus* from Carlos Botelho State Park in São Paulo with *S. libidinosus* from the Boa Vista farm in the municipality of Gilbués in Piauí. The ecological differences that were observed in these species are striking: the species from the



Atlantic rainforest spends most of its time in the crowns of the trees, whereas the other species, from the caatinga scrublands, spends more time on the ground amid less dense vegetation.

Perhaps because of their naturally more open habitat, the northeastern monkeys were less comfortable with the presence of the researchers and often made warning cries as if faced with predators. This increased perception of risk in their surroundings may be the reason that the social groups found in this region were more cohesive than those in the São Paulo forest. The availability of food, which, surprisingly, was lower in the woods, also affects group structure. In Carlos Botelho, the monkeys often disperse in search of a good meal. However, caatinga palm trees produce an assortment of nutrient-rich coconuts, which demand a certain amount of expertise on the part of those who seek to eat them due to the requirement of tool use. This behavior is commonly seen among *Sapajus* but has never been observed in *Cebus*.

As noted by Tiago Falótico from IP-USP, “There are very few records of tool use among tree monkeys”. In his doctoral work, which was completed in 2011 under the guidance of Eduardo Ottoni, Falótico showed that in addition to the ecological aspect, this behavior is also influenced by group culture. “The monkeys in the Serra da Capivara National Park have much more varied tools than those in Gilbués,” he says, referring to the two sites in Piauí. In Gilbués, the piassava and two types of coconuts (catulé and catuli) can be quite large and difficult to break. However, the bearded capuchin, *Sapajus libidinosus*, is not discouraged from exploiting these food sources, as it employs stones as large as 3 kilograms (nearly its own weight), lifting and knocking this tool on a coconut supported on a flat stone. “The females sometimes even have to jump up and use the additional force from the descent to break the coconuts,” he observes.

But that’s where the creativity ends at Gilbués. Meanwhile, the groups in the Capivara range, where coconuts are not available, open cashew



nuts with stones and use the same type of tools to dig in the sandy soil in search of roots and spiders that live in underground nests. Furthermore, they are also skilled in making and using sticks to obtain honey from hives and ferret bumblebees and other insects from hollow tree trunks. Additionally, they employ long poles to drive out lizards from cracks in reddish stone walls that rise 50 meters above the ground. “The differences in behavior between groups of the same species in similar environments indicate that some traditions may be transmitted through social conditioning,” explains Falótico. Another interesting application of tools can be observed only among females in the mountains of Capivara. They throw rocks at males to get their attention during the few days during which they are in heat.

The blond capuchin monkey (*S. Flavius*), which was studied in Rio Grande do Norte by Renata Ferreira and Ricardo Emidio from the Federal University of Rio Grande do Norte, is another apt user of tools. Only a few studies have been performed with this species, as until recently, the only evidence of it was found in an eighteenth century painting which no one knew if it actually represented an existing animal.

ALTERNATIVE SKILLS

Even though they do not use tools on a daily basis, the forest capuchin monkeys do exhibit manual skills, which was shown by the team led by primatologist Júlio César Bicca-Marques from the Catholic University of Rio Grande do Sul (PUCRS) through experiments in *Sapajus nigritus* in which bananas were placed in acrylic boxes on a platform on a private property in Porto Alegre. This experiment, which was devised by anthropologist Paul Garber from the University of Illinois, a co-author of the article, yielded similar results to those obtained by the American researcher in *Cebus capucinus* in Costa Ri-

1. The juveniles learn through close observation
2. A male uses a stick to collect honey from the tree

“The behavior differences between the groups indicate that some of their traditions may be passed on through learning,” according to Falótico

In the scrublands of Piauí, the monkeys use stones as heavy as themselves to crack nuts



ca. In a first version of the challenge, the monkeys were required to pull a stick to knock down a banana to reaching range. The two males in the group learned the trick easily. However, when the experiment was altered and the rod had to be pushed instead, they were not successful. The researcher from Rio Grande do Sul believes that this failure was not due to a lack of problem-solving abilities. “The association is very easy, but they seem to need more time to let go of the previous learning,” he explains. In future studies, this investigator intends to begin the tests with the second version of the experiment to prove his hypothesis.

Another very different type of tool use involves the rubbing various products, such as fruit or insects, on its own fur. Until recently, this practice was observed more commonly among *Cebus* than *Sapajus*. “As this behavior is observed only sporadically among the *Sapajus*, almost no one had enough data to publish,” says Jessica Lynch Alfaro, who aggregated the information gathered by various researchers in a review.

Overall, the study showed that *Cebus* are more likely than their cousins to rub almost anything they find on their fur, though they seem to prefer plant material, such as citrus fruits and leaves. This behavior is not as common among *Sapajus*, which, particularly in the Atlantic rainforest, restrict this activity to insects. The choice of rubbing material is influenced by whatever is available in the environment; however, there is an essential difference between the two genera. “In Manu National Park in Peru, the *Sapajus* don’t smear themselves, but the *Cebus* do,” explains Jessica.

In a study conducted in Tietê Ecological Park in São Paulo and published in 2007, Tiago Falótico and his colleague Michele Verderane showed that the Atlantic rainforest capuchin monkeys show a strong preference for ants. Especially in the dry season, when there are more ticks, these primates take handfuls of ants and rub their body with them thoroughly. “The ants release formic acid, which acts as a repellent for ticks,” says the researcher from USP. He and Michele have demonstrated this effect by smearing the substance on a finger, inserting it into a bottle of ticks and counting the amount of time and the distance over which the parasites walked on the finger. Falótico observed the same behavior in Piauí, where the monkeys also rub millipedes on themselves, which act as a source of benzoquinone and a mosquito repellent.

Jessica gathered other observations that allowed her to map the rubbing behavior performed by capuchin monkeys, showing that the procedure is not limited to a cosmetic preference but has practical and even medical utility. Some of the *Cebus albifrons* that live in the middle of a village in the equatorial Amazon region exhibit a curious form of such behaviors, as they often steal laundry soap to bathe.

There are many new findings in the capuchin monkey kingdom, but the experts are far from satisfied. In Jessica’s and Boubli’s eyes, they have merely revealed the tip of the iceberg, which is an indication of how much remains to be discovered. In the Amazon region, where the behavior and ecology of these monkeys are practically unknown, genetic information indicates that there may be species that have yet to be described. “I hope that the new populations and species we discover help make decisions about conservation,” says Jessica. ■

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