



HOW DO RIVERS DIVIDE AMAZONIAN ANIMALS?

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YOUNG REVIEWERS:



HARMONY

AGE: 11



KAUSHIK

AGE: 8

Rivers can be difficult barriers for animals to cross, especially animals that cannot swim or fly. The Amazon region has many of the largest rivers in the world, which limits the movements of many animals that cannot cross them. Thus, some animal species occur on one side of a river but not on the other side. Isolation of animal species caused by rivers or other physical barriers can generate what are called centers of endemism, which are regions that have unique species not seen anywhere else. In this article, we will explain how rivers create barriers to animal movement and how centers of endemism can contribute to the fascinating biodiversity of the Amazon region.

BIODIVERSE

Having a high level of species of living organisms.

Figure 1

The Amazon River basin. **(A)** The rivers of the Amazon River basin are shown in blue on the map. **(B, C)** The Machado river is an Amazonian river over 300 meters wide, which is still considered a medium-sized river (Illustration and photographs: Larissa Goebel).

AMAZONIAN RIVERS ARE HUGE!

The Amazon forest is one of the most **biodiverse** places on the planet. Research has shown that a large percentage of all animal and plant species in the world are found in the Amazon, including over 7,500 butterfly species (over 40% of the total number of butterfly species worldwide), over 1,500 bird species (close to 15% of the number of bird species), and more than 11,200 tree species (over 15% of tree species) [1, 2]. Moreover, the Amazon forest is called a rainforest because a lot of rain falls throughout the year. All that rain, together with the region's flat plains and high Andes mountains where most major Amazonian rivers are born, contribute to the existence of 20 out of the 34 largest rivers in the tropics (in terms of the amount of water that flows through them) and four out of the 10 largest rivers in the world (Figure 1). Amazonian rivers can be thousands of kilometers long. For example, the Amazon River, the second-longest river in the world, extends for almost 7,000 km.

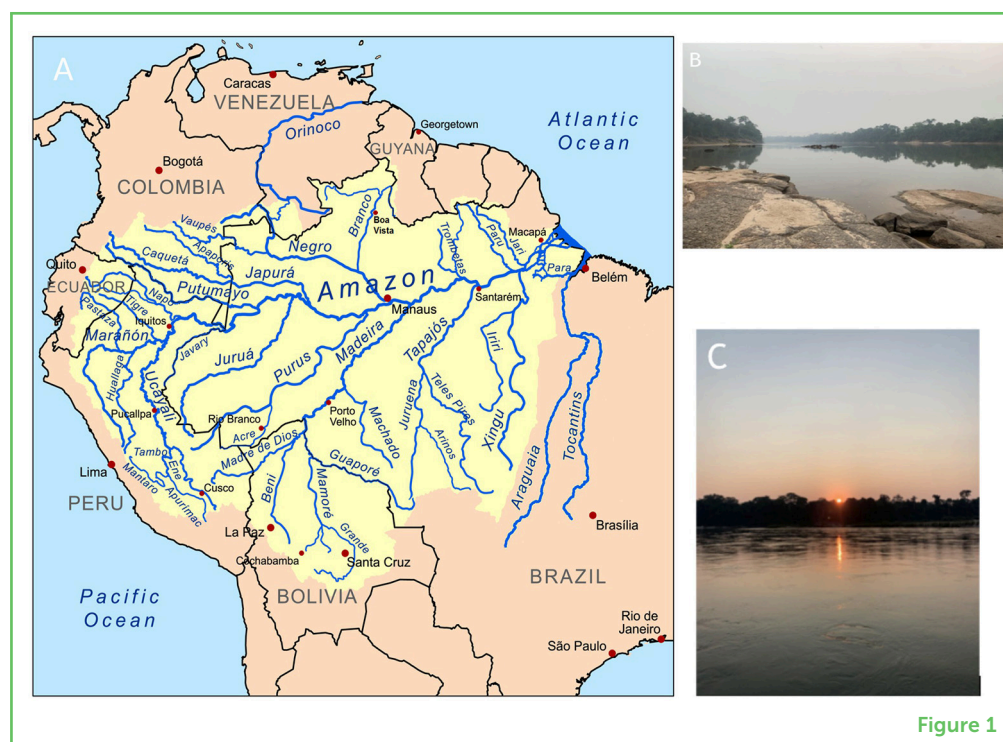


Figure 1

Furthermore, Amazonian rivers can be so wide that, in some parts, it is impossible to see the riverbank on the other side. This makes many rivers throughout the Amazon basin quite difficult or even impossible for some animals to cross, leading to what is called **endemism**. Endemism is a situation in which animals are found only in specific areas—nowhere else on Earth. In this article, we are going to talk about Amazonian rivers and learn how they influence the animals of this region.

ENDEMISM

Refers to a species found only in one area, not anywhere else on the planet. These species are called endemic species.

RIVERS CAN ISOLATE ANIMALS

During the 19th century, Alfred R. Wallace, a scientist known as the “father of biogeography”, showed that rivers are responsible for shaping the distribution of Amazonian animals [3]. Decades later, after much research, the idea that rivers are important barriers that prevent the movement of animals has even more scientific support [4]. Imagine that many species are separated by a wide river such that, on each riverbank, there are different combinations of animal species (Figures 2A–C). Since these species cannot cross the river to reach other areas, they are isolated in giant “land islands” (Figure 2C). Thus, each side of the river could have different animals distributed in one or a few areas. This distribution pattern is called **centers of endemism** [4]. So far, 11 centers of endemism are proposed to exist in the Amazon, based on the distribution of animal species influenced by nine main rivers: Branco, Negro, Solimões, Javari, Xingu, Madeira, Tocantins, Tapajós, and Amazonas (Figure 2D).

CENTERS OF ENDEMISM

Areas inhabited by species not found anywhere else on the planet.

Figure 2

Large rivers can influence the distribution of animal species. (A) In a habitat with no geographical barriers, various species can live together in the same area. (B, C) If a 300 meter-wide river emerges, some species on one side of the river will not be able to cross to the other side, limiting their distribution and creating centers of endemism. (D) Eleven centers of endemism have been found in the Amazon region due to rivers acting as barriers preventing animal distribution (Illustration: Larissa Goebel and Stephen Nash). Illustrations copyright 2013 Stephen D. Nash/IUCN SSC Primate Specialist Group. Used with permission.

ALLOPATRIC SPECIATION

The mechanism by which one species separates into two (or more) due to being separated by physical barriers.

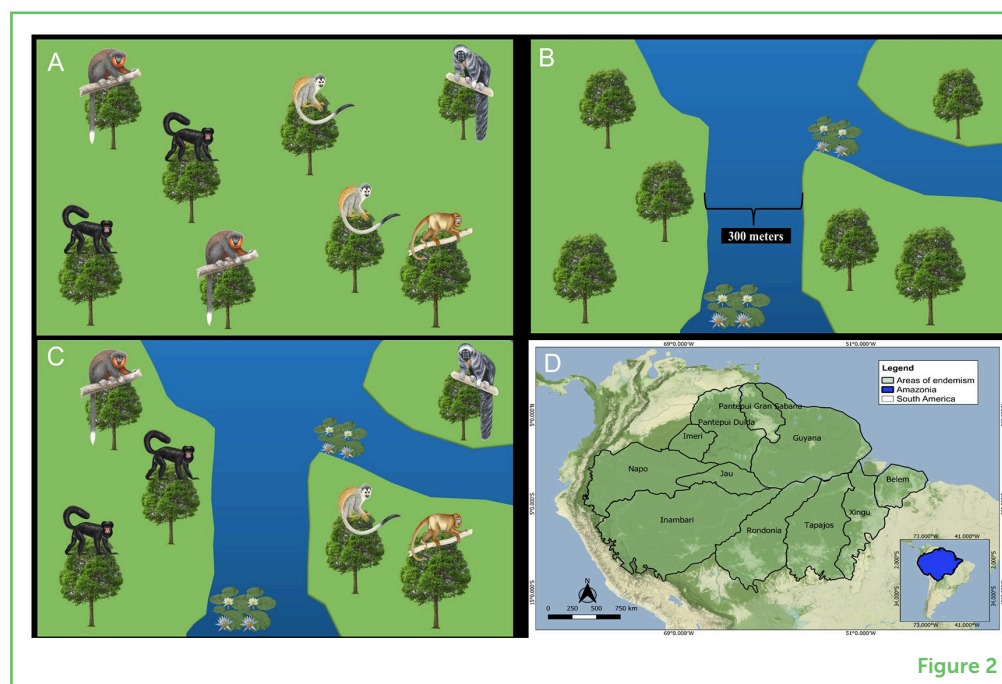


Figure 2

But how did these species end up in their isolated locations on either side of the river? Maybe they got there thousands of years ago, before the rivers were in their current locations, or when the rivers were not so broad. Amazonian rivers do change a lot over time. Also, when one species of animals becomes divided—with some animals trapped on one side of the river and some on the other side—each group will begin to accumulate differences over time. Over many thousands of years, what was once one species can become two or more different species. This process is called **allopatric speciation**, and it can help to explain the high levels of animal biodiversity seen in the Amazon.

Trumpeter birds, which got their name due to the trumpet-like threat call of the males, are a good example. These birds are endemic to the Amazon forest and there are eight currently recognized species. Two groups of species were separated north and south of the Amazon River between 2.7 and 2.0 million years ago. Evidence shows that the emergence of certain Amazonian rivers, such as the Madeira and the Tapajó rivers, have isolated some birds on each side of the river, leading to the development of new species across time.

HOW DO RIVERS FORM BARRIERS?

Not all animals like water or can swim well. While some animals, such as otters and caimans, are good swimmers that spend much of their lives in the water (Figure 3), other animals, such as primates and toads, are not adapted for the water—even though they can swim for a little while, they cannot go very far and may even drown if forced to swim long distances. That is why large rivers can be important barriers to their movement [5].

Figure 3

Amazonian animals differ in their ability to cross rivers. Some are aquatic (adapted to life in water) and can cross easily. **(A)** The king vulture can easily fly across rivers. **(B)** The neotropical cormorant, which can fly or swim across rivers, is a semi-aquatic bird. **(C)** The neotropical otter is also a semi-aquatic animal. **(D)** The spectacled caiman can also swim across rivers. All pictures were taken at Machado river, Rondonia, Brazil.



Figure 3

What about birds, bats, or even bees? You might think that these animals can fly across rivers for sure. Well, some species might be able to, but it is not that simple for all of them. Many Amazonian birds fly within the forest, below the trees but not above them. Animals adapted to these conditions do not take chances flying in open areas, such as deforested regions or across large rivers, because they are more exposed to predators. However, many birds and bats *are* known to

fly long distances and even to migrate across continents—so it would seem that those species can easily cross the distances created by Amazonian rivers. It took scientists a few decades of research on the distribution of Amazonian birds and bats to show that most rivers are not important barriers for these animals [6, 7].

ANIMAL DISTRIBUTIONS CHANGE OVER TIME

The Amazon region did not always look the way it does now, and it continues to change. Rivers can change depending on geologic formations, climate, and vegetation. For species that cannot swim or fly, when a new river appears it may divide and isolate some groups of animals but not others, as we have already explained. On the other hand, when old rivers dry out and disappear, formerly separated animal groups can come into contact. These processes drive evolution and animals' distributions patterns, and scientists are still working to understand which events are most important for Amazonian animals. Unfortunately, human activities are speeding up changes in the environment. Climate change and habitat loss are very serious threats to the Amazon region. Thus, scientific knowledge is crucial for understanding how current and future environmental changes will affect native animals and how we can better protect them.

FUTURE RESEARCH

The Amazon is one of the least explored parts of our planet, and many areas have still not been reached by scientists. This means that more research is needed on Amazonian animals, because lack of knowledge can hinder our ability to fully understand which factors affect their distribution and evolution. This is especially true for elusive groups of species, such as bats, which are not easily researched due to their nocturnal habits and other challenges associated with studying them. Moreover, many new species of animals are still being described every year, which were previously unknown to science, and that can change our current understanding of the distribution of Amazonian animals.

Even though rivers are now known to be barriers for some types of animals, our understanding about the role of rivers and other environmental factors shaping the distribution of Amazonian animals is still far from complete! The full picture of the role of rivers as barriers to Amazonian animals may still change over time, and we always need new scientists and explorers to help us. Will you be one of them?

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YOUNG REVIEWERS



HARMONY, AGE: 11

My name is Harmony and I live with one bunny, shelves of books, and hundreds of birds and squirrels to share my backyard with. My dream is to be a marine biologist and an ornithologist. Some of my hobbies are bird photography, hiking, reading, writing, and booping my bunny. I have published two books *Blizzard in a Rainforest* and *Bubble up from a Kelp Forest* to give people a window into the secret and sometimes very unfair lives of animals.



KAUSHIK, AGE: 8

I like drawing and painting very much. I gift my paintings to my friends. I like to play with my friends. I am also interested in athletics. I also enjoy traveling to wildlife parks and jungle safari.

AUTHORS



HERNANI F. M. OLIVEIRA

Hernani F. M. Oliveira was born in the eastern portion of the Amazon forest. He is the father of Lorelei (7 years old) and is naturally curious about the natural world. He has explored many places on the planet (islands, mountains, rainforests, savannas) and hopes his daughter will be able to join him someday on his expeditions and adventures. *oliveiradebioh@gmail.com



MARCELLA G. SANTOS

Marcella G. Santos is a Brazilian biologist who loves to use DNA evidence to study how species originate and change through time. Although she does most of her work from the lab, she also enjoys being out in the wild collecting reptiles, amphibians, and fishes in South America. Her son Nicolas (six) is very curious and asks many questions about nature and the universe.



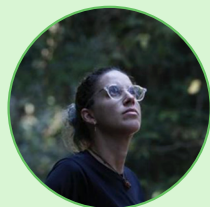
RENAN J. BOSQUE

Renan Janke Bosque works with coral snakes (one of the deadliest snakes in the world). He was born in Rio de Janeiro, one of the biggest cities in Brazil, but has spent most of his career studying reptiles and amphibians in various parts of Brazil. He loves to explore the outdoors and go on adventures with his 6-year-old son Nicolas.



LARISSA G. A. GOEBEL

Larissa was born in the state of Rondonia, which is located in the Brazilian Amazon. She is a Ph.D. student researching the impact of forest fragmentation on medium and large Amazonian mammals. She is inspired and motivated by her connection with the Amazon forest. She also shares her passion about the forest with her younger siblings aged 16, 10, and 6.



GABRIELA R. LONGO

Gabriela Rodrigues Longo is a Brazilian environmental educator, born in São Paulo, but considers herself a traveler, an inhabitant of a home without walls. She is a teacher and seeks, in the classroom or outside, to understand and teach about the potential of an education focused on the conservation of Brazilian biodiversity.



DAIANA C. SILVA

Daiana is a biologist and postdoctoral researcher in ecology and conservation, and she is interested in mammal ecology, biogeography, and conservation, with an emphasis on bats. Her 5-year-old daughter Eloah is very curious and loves insects and sea creatures.



PRISCILLA L. ZANGRANDI

Priscilla is a biologist and has studied populations of wild small mammals such as mice and opossums in Brazilian forests for years. She has had a love of and curiosity about nature and animals since she was a small kid, and now she shares the same passion with her 6-year-old nephew Matheus. She is not working directly with animals anymore, but she currently works on sustainability, hoping to make a positive change in the world.



GUARINO R. COLLI

Guarino is a herpetologist (scientists studying amphibians and reptiles) mainly interested in the evolution, biogeography, and conservation of the amphibians and reptiles of neotropical savannas. He is the curator of the herpetological collection of the University of Brasília and has trained many of the leading herpetologists in Brazil. Guarino enjoys traveling and conducting fieldwork in remote areas of Brazil, always driving a 1988 Toyota Landcruiser.



FABRICIUS M. C. B. DOMINGOS

Fabricius is an evolutionary biologist, interested in the processes that generate biodiversity. He considers himself a better lecturer than scientist, and he is always exploring cutting-edge teaching strategies. He and his wife, Marina, have taken their 6-year-old daughter, Flora, to do fieldwork in the depths of the Amazon, Atlantic Forest, and Cerrado, and are now doing the same with Aurora (2 years old). Fabricius is also a heavy metal aficionado and has been introducing Flora and Aurora to the magic world of music since the day they were born.