A female orchid bee (*Exaerete smaragdina*) on a pickerelweed flower (*Pontederia cordata*) in Cosmópolis, São Paulo

THE LONG HISTORY OF BEES

Pollinating insects are estimated to have appeared 120 million years ago on the Western Gondwana supercontinent, formed by what is currently South America and Africa

Sarah Schmidt

Approximately 120 million years ago, at the beginning of the Cretaceous period, groups of dinosaurs walked the earth when the first bees first appeared in what is currently South America and Africa and then connected as part of the Gondwana supercontinent. "The common ancestor of the bees probably appeared in the driest climate that this region had. To this day, the majority of the over 20,000 catalogued species prefer drier areas, where they are more diversified," explained biologist Eduardo Almeida from the Ribeirão Preto campus of the University of São Paulo (USP), while preparing to present the results about the evolution of bees at a workshop in the city of Portal, Arizona, USA, in mid-August.

Alongside German colleague Silas Bossert from Washington State University, Eduardo Almeida led the study published in August in the journal *Current Biology*, which added more details to the picture outlined in previous studies using DNA sequence analysis of different parts of the genome of 216 bee species from all seven families and 28 subfamilies known today. The samples were collected from all continents except Antarctica (the only continent uninhabited by the bees), thanks to the data and specimens in research museums—Almeida is the curator of the Prof. J. M. F. Camargo entomological collection, which houses hundreds of thousands of bees.

Almeida compared genetic estimates of age and geographic distribution data of these species with information from 220 fossils and the locations where they were collected. This information enabled the group to trace the family tree (phylogeny) of the bees, estimating the evolutionary kinship relationships between the major lineages and the ages of the evolutionary events. The result was a timeline that shows where and when the first species would have appeared and how the groups divided, diversified

colors, shapes, behaviors, and modes of organization, and spread across the planet over time, following the rearrangement of the continents.

According to the results of the group from Ribeirão Preto, from the moment that the common ancestor of the bees emerged approximately 124 million years ago, a continuous process of diversification was influenced by the configuration of the continents at the time, the rise and fall of the sea level and the climate changes that took place during the different geological periods.

"The separation of the supercontinent led to a change in the configuration of how the bees were spread across the world," says Almeida. The data suggest that, of the seven extant families, only Melittidae did not exist approximately 100 million years ago in the region that today corresponds to South America.

This may be why the bees resisted the falling asteroid, deemed responsible for the mass extinction of the dinosaurs in the Gulf of Mexico approximately 60 million years ago. "They were already spread across the planet, in a distribution close to the current one," Almeida states. He noted that from this period on, some tropical environments began to expand to more elevated latitudes, which enabled the groups that lived in the tropical and subtropical regions in the Southern Hemisphere to advance toward North America, Europe, Asia, and North Africa.

Groups of bees probably reached Australia between 70 and 35 million years ago, with the first originating in South America and following a route crossing Antarctica, which connected the two continents to the south and had a milder climate than today. Later, bees that were already on the Asian continent would have also colonized Australia. They likely arrived in present-day India approximately 50 million years ago, after the territory—which had broken from Gondwana prior to the origin of bees—collided with the Asian continent and met the local fauna.

The appearance of the ancestral bee is unknown: Would it have been large or small? Did it live in organized societies in hives, or was it solitary? Almeida provides a guess: It was probably solitary since 85% of the species today have this habit, with their members living in individual burrows in the ground. Almeida has also been investigating a means of reconstructing the ancestral morphology of these insects.

The notion that the bees appeared in the western part of Gondwana, which included South America and Africa, is not new. It was proposed by the US entomologist Charles Michener (1918–2015) in 1979 in an article published in the journal *Annals of the Missouri Botanical Garden*.

Michener, Almeida's academic "grandfather," is a reference in the study of the evolution of bees, and he spent a year in Brazil in 1956, working with the Brazilian entomologist Jesus Santiago Moure (1912–2010), known as Father Moure, at the UFPR in Curitiba. "Forty years later, the advance in genetic and computational analysis, besides the discovery of many bee fossils, allowed us to bring more evidence and new data for his hypothesis," observes the researcher from Ribeirão Preto.

Biologist Vera Lucia Imperatriz Fonseca, from the São Paulo campus of USP, who did not participate in the study, observes that this is the broadest phylogenetic study of bees ever made. "In the past we used to study the bees in our backyard. Today, we can study the bees of the world," she says, stressing the importance of preserving and expanding the country's collection of insects, including bees, for this type of research to be expanded.

"The association between bees and flowers over the millions of years is another point that the work helps to think about," says biologist Guilherme Cunha Ribeiro of the Federal University of ABC (UFABC), who also did not participate in the study. In an article published in 2022 in the journal *Cretaceous Research*, Ribeiro and colleagues described a new species of extinct wasp in the Crabronidae family, the fossil of which was in the Crato Formation in Nova Olinda, Ceará. Its age is estimated to be between 125 million and 115 million years.

"We argued that, if the Crabronidae family, considered by some studies as a sister of the bees, already existed in this time period, then the bees would have also existed," says Ribeiro. As fossils of bees have not been found, despite the great abundance of insects collected, he suggests that one of the explanations could be that they diversified further south on Gondwana.

Almeida explains that, at some point, carnivorous wasps became vegetarians, changing to feeding on pollen, after which the bees appeared. He states that "They became dependent on flowers and the main group responsible for pollination." For this reason, one conclusion of his work is that the rich biodiversity of South American plants is related to the fact that this is the continent where bees have existed the longest. They took millions of years to establish themselves, adapt, and diversify. "If climate change radically transforms environments, we don't know if they will be able to adapt," he warns. ■

A male of the Centris varia species on a guanhuma flower (*Cordia superba*) in Capão da Canoa, Rio Grande do Sul

PHOTOS ADRIANA TIBA E JULIO PUPIM

The research projects and scientific articles consulted for this report are listed in the online version.