



Press Release

Pterosaurs and birds developed flight-ready brains in different ways

University of Tübingen-led international research team investigates brain evolution in flying reptiles in the age of the dinosaurs

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It has long been known that pterosaurs and birds acquired their ability to fly independently of each other. A new study has now revealed that there are no major similarities between the brains of pterosaurs, which lived around 215 million to 66 million years ago, and those of today's birds; however, there are similarities with the brains of bird ancestors – certain species of dinosaurs that were unable to fly or had limited flying ability. In addition, pterosaurs had comparatively small brains in relation to their body mass. This finding challenges the long-held scientific assumption that a large brain, similar to that of birds, is a prerequisite for the ability to fly. The study by an international team of specialists was led by Dr. Mario Bronzati from the Department of Geosciences at the University of Tübingen and was published in the journal *Current Biology*.

The ability to fly developed only three times among vertebrates: in bats, birds, and the extinct pterosaurs. "The basic structure of the brain of today's birds is clearly recognizable as a legacy of non-flying dinosaur relatives," says Professor Lawrence Witmer of Ohio University, USA, one of the study's authors. "The brain structures of pterosaurs, on the other hand, seemed to have appeared out of nowhere." More than 215 million years ago, these animals were the first to be able to fly actively, long before the earliest birds appeared. "It is only in recent years that we have found evidence of close relatives of pterosaurs, called lagerpetids: small, bipedal animals that probably lived in trees," reports Bronzati. The lagerpetid fossils known to date have helped researchers to understand the changes in the physique of pterosaurs. "We were interested in the changes in their brain anatomy associated with the development of flight," Bronzati says.

Many different skull types investigated

In its new study, the research team examined the skulls of a wide range of reptiles: from extinct land-dwelling reptiles such as pterosaurs and

dinosaurs to modern crocodiles and birds. Using computer tomography scans, the researchers measured the internal cavities in the skulls to reconstruct the shape, structure, and size of the brains in three dimensions. Among the skulls examined was the most complete known fossilized skull of a lagerpetid of the species *Ixalerpeton pelesinensis*, which was found in southern Brazil and believed to have lived around 233 million years ago.

The reconstruction revealed that lagerpetids, the closest relatives of pterosaurs, still had very primitive reptilian brains, similar to those of the earliest dinosaurs that lived at the same time. "However, they had already developed better eyesight. The lobes of their brain responsible for the visual system, known as the optic tectum, were enlarged and arranged laterally, as in pterosaurs and the ancestors of birds," says Bronzati. "This adaptation enabled the lagerpetids to navigate better in a tree-covered environment, and it probably helped the pterosaurs later on in the development of flight." Overall, the anatomy of the brain in pterosaurs and the dinosaur ancestors of birds is similar, reports one of the study's authors, Professor Akinobu Watanabe of New York University, based on comparative analyses. "In today's birds, however, it looks different."

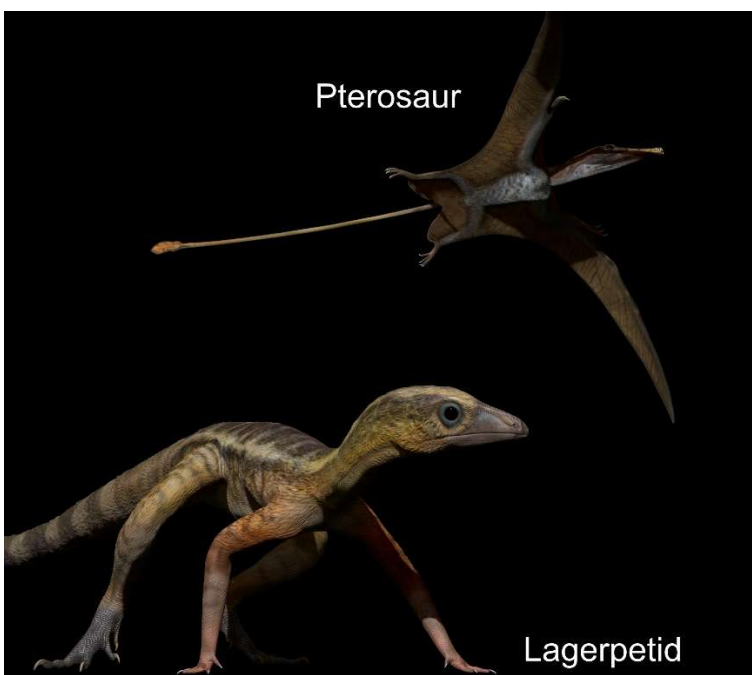
Rapid evolution

On an evolutionary timescale, the anatomy of the pterosaur brain must have developed very quickly as flying ability evolved, says Bronzati. "This happened at least 50 million years earlier than flying ability developed in the lineage from dinosaurs to birds." This is astonishing, he says, because flying is a physiologically demanding way of getting around. "Pterosaurs had much smaller brains than birds, which proves that you don't need a large brain to fly," adds another of the study's authors, Professor Matteo Fabbri of Johns Hopkins University, USA. A special feature of the pterosaur brain is an enlarged flocculus, a structure of the cerebellum that is involved in processing sensory information. This information came from the membrane-covered wings and helped the animals to keep their eyes fixed on their target while flying. "In today's birds, on the other hand, the cerebrum is particularly enlarged, which suggests that they have more pronounced cognitive abilities, such as a complex social life, higher skills, and intelligence," says Fabbri.

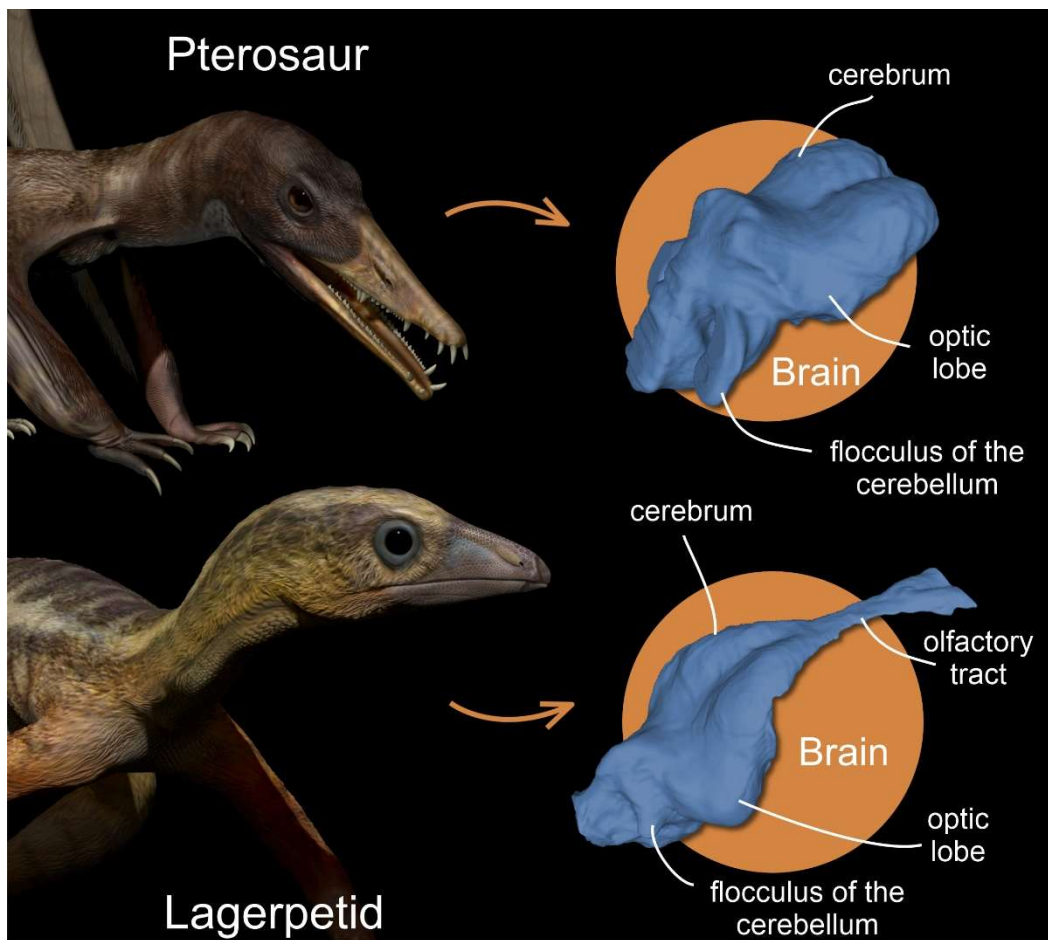
"Finds from southern Brazil provide impressive insights into the origins of large animal groups such as dinosaurs and pterosaurs. Each new fossil discovery brings us closer to understanding what their early relatives looked like – knowledge that was hardly imaginable just a few years ago," explains another of the study's authors, Dr. Rodrigo T. Müller from the Universidade Federal de Santa Maria in Brazil. "Paleontological research continues to provide fascinating insights into the power of evolution. Our researchers have built up comprehensive expertise in this field," said Professor Dr. h.c. (Dōshisha) Karla Pollmann, President of the University of Tübingen.



Reconstruction of a late Triassic landscape approximately 215 million years ago: a lagerpetid, a close relative of the pterosaurs, sits on a rock and watches the pterosaurs flying above it. Illustration: Matheus Fernandes



Artist's impression of a pterosaur (top) and a lagerpetid (bottom) from the late Triassic period approximately 215 million years ago. Illustration: Matheus Fernandes



Artist's impression of a pterosaur (top) and a lagerpetid (bottom) from the late Triassic period approximately 215 million years ago: The images on the right show 3D reconstructions of their brains, created with the help of computer tomography scans. Illustrations: Matheus Fernandes, Rodrigo T. Müller, Mario Bronzati

Publication:

Mario Bronzati, Akinobu Watanabe, Roger B. J. Benson, Rodrigo T. Müller, Lawrence M. Witmer, Martín D. Ezcurra, Felipe C. Montefeltro, M. Belén von Baczko, Bhart-Anjan S. Bhullar, Julia B. Desojo, Fabien Knoll, Max C. Langer, Stephan Lautenschlager, Michelle R. Stocker, Alan H. Turner, Ingmar Werneburg, Sterling J. Nesbitt, Matteo Fabbri: Neuroanatomical convergence between pterosaurs and non-avian paravians in the evolution of flight. *Current Biology*, <https://doi.org/10.1016/j.cub.2025.10.086>

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