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An Evolutionary Study Of Caecilians

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Opinion Article

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ABOUT THE STUDY

Caecilians are a group of limbless, vermiform (worm-shaped) or serpentine (snake-shaped) amphibians. They mostly live hidden in soil or in streambeds, and this cryptic lifestyle renders caecilians among the least familiar amphibians. Modern caecilians live in the tropics of South and Central America, Africa, and southern Asia. Caecilians feed on small subterranean creatures such as earthworms. The body is cylindrical and often darkly coloured, and the skull is bullet-shaped and strongly built. Caecilian heads have several unique adaptations, including fused cranial and jaw bones, a two-part system of jaw muscles, and a chemosensory tentacle in front of the eye. The skin is slimy and bears ring like markings or grooves, which may contain tiny scales. The study of caecilian evolution is complicated by their poor fossil record and specialized anatomy. Genetic evidence and some anatomical details (such as pedicellate teeth) support the idea that frogs, salamanders, and caecilians (collectively known as lissamphibians) are each other's' closest relatives. Frogs and salamanders show many similarities to dissorophoids, a group of extinct amphibians in the order Temnospondyli. Caecilians are more controversial; many studies extend dissorophoid ancestry to caecilians. Some studies have instead argued that caecilians descend from extinct lepospondyl or stereospondyl amphibians, contradicting evidence for lissamphibian monophyly (common ancestry). Rare fossils of early gymnophionans such as Eocaecilia and Funcusvermis have helped to test the various conflicting hypotheses for the relationships between caecilians and other living and extinct amphibians.

Little is known of the evolutionary history of the caecilians, which have left a very sparse fossil record. The first fossil, a vertebra dated to the Paleocene, was not discovered until 1972. Other vertebrae, which have characteristic features unique to modern species, were later found in Paleocene and Late Cretaceous (Cenomanian) sediments. Prior to 2023, the earliest fossil attributed to a stem-caecilian (an amphibian closer to caecilians than to frogs or

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salamanders but not a member of the extant caecilian lineage) comes from the Jurassic period. This primitive genus, Eocaecilia, had small limbs and well-developed eyes. In their 2008 description of the Early Permian amphibian Gerobatrachus, Anderson and co-authors suggested that caecilians arose from the Lepospondyl group of ancestral tetrapods, and may be more closely related to amniotes than to frogs and salamanders, which arose from Temnospondyl ancestors. Numerous groups of lepospondyls evolved reduced limbs, elongated bodies, and burrowing behaviors, and morphological studies on Permian and Carboniferous lepospondyls have placed the early caecilian (Eocaecilia) among these groups. Divergent origins of caecilians and other extant amphibians may help explain the slight discrepancy between fossil dates for the origins of modern Amphibia, which suggest Permian origins, and the earlier dates, in the Carboniferous, predicted by some molecular clock studies of DNA sequences. Most morphological and molecular studies of extant amphibians, however, support monophyly for caecilians, frogs, and salamanders, and the most recent molecular study based on multi-locus data suggest a Late Carboniferous–Early Permian origin of extant amphibians. Chinlestegophis, a stereospondyl temnospondyl from the Late Triassic Chinle Formation of Colorado, was proposed to be a stem-caecilian in a 2017 paper by Pardo and co-authors. If confirmed, this would bolster the proposed pre-Triassic origin of Lissamphibia suggested by molecular clocks. It would fill a gap in the fossil record of early caecilians and suggest that stereospondyls as a whole qualify as stem-group caecilians. However, affinities between Chinlestegophis and gymnophionans have been disputed along several lines of evidence. A 2020 study questioned the choice of characters supporting the relationship and a 2019 reanalysis of the original data matrix found that other equally parsimonious positions were supported for the placement of Chinlestegophis and gymnophionans among tetrapods.

A 2023 paper by Kligman and co-authors described Funcusvermis, another amphibian from the Chinle Formation of Arizona. Funcusvermis was strongly supported as a stem group caecilian based on traits of its numerous skull and jaw fragments, the largest sample of caecilian fossils known. The paper discussed the various hypotheses for caecilian origins: the polyphyly hypothesis (caecilians as lepospondyls, and other lissamphibians as temnospondyls), the lepospondyl hypothesis (lissamphibians as lepospondyls), and the newer hypothesis supported by Chinlestegophis, where caecilians and other lissamphibians had separate origins within temnospondyls. Nevertheless, all of these ideas were refuted, and the most strongly supported hypothesis combined lissamphibians into a monophyletic group of dissorophoid temnospondyls closely related to Gerobatrachus.