RESEARCH HIGHLIGHTS

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A tale of a 'middle' tail

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Zhongornis refers to a 'middle' or 'intermediate' bird because its tail was claimed to be transitional between primitive birds with a long bony tail (such as *Archaeopteryx* and *Jeholornis*) and those with a short tail ending in a fused tip called the pygostyle (such as *Confuciusornis*) [1]. This finding is significant, as it appeared to fill a 'gap' at a critical stage in the early evolution of birds.

However, after a detailed restudy, O'Connor and Sullivan [2] suggest that this juvenile bird from the Early Cretaceous Jehol fauna of China actually possesses 20, rather than 14, tail vertebrae; further, this tail is very similar to those of *Epidexipteryx* (a scansoriopterygid) and *Caudipteryx* (an oviraptorosaur) among the theropods. Based on this and other features, the authors reinterpret *Zhongornis* as the sister taxon of scansoriopterygids, and further suggest that this clade (*Zhongornis* + Scansoriopterygidae) is the sister group of Oviraptorosauria.

Surprisingly, despite the discovery of so many beautifully preserved feathered dinosaurs in China, the relationships among them, especially those close to the origin of birds, are still intriguing. This intrigue applies to Oviraptorosauria, the 'egg thief lizards', and Scansoriopterygidae, a recently recognized rare arboreal clade. Consider this: you have four tails, one each from an oviraptorosaur dinosaur, a dromaeosaur dinosaur, a primitive bird (*Archaeopteryx*), and a true bird (*Confuciusornis*). Like many others, you may have immediately seen (1) a long bony tail similar in dromaeosaurs and primitive birds, (2) a very short tail with a pygostyle unique in true birds, and (3) a reduced tail, an intermediate condition seen in oviraptorosaurs. However, most recent cladistic analyses reveal Oviraptorosauria as the sister group of Paraves, which includes dromaeosaurs and birds [3]. This forces us to interpret the tail similarities between oviraptorosaurs and birds as having evolved convergently. The robust and flexible oviraptorosaur tails, together with their broad tail-feather fans, were uniquely adapted to serve as dynamic intraspecific display structures [4]. However, the origin of oviraptorosaurs remains a mystery, with no Jurassic record. O'Connor and Sullivan's study indicates that oviraptorosaurs' cousins (scansoriopterygids) once lived in the Jurassic trees in the north-eastern China, and their differences might result from adaptation to contrasting ecological niches.

Will taking *Zhongornis*'s tail out of the 'middle' bird tail allow us to eventually discover the real 'middle' creature someday? Perhaps not! A recent genetic and evolutionary development study shows that a single genetic mutation could have occurred in paravian dinosaurs, which both truncated its tail and fused its distal caudal vertebrae into a pygostyle [5]. Moreover, this potential mutation has pleiotropic effects also leading to fusions in more anterior vertebrae, ribs, and even digits. These fusions have been observed in mice and modern birds, as well as in *Confuciusornis* and more advanced birds, but not in *Jeholornis* and *Archaeopteryx* [5]. The co-occurrence of *Confuciusornis* and *Jeholornis* about 125 million years ago also supports this sudden appearance of short-tailed birds. Therefore, the search for the fantastical middle bird may prove to be futile.

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