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Cannibalism in a semi-aquatic reptile from the Early Cretaceous of China

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Cannibalism or intraspecific predation is a particular form of feeding behavior that is far more common in lower vertebrates and invertebrates than in higher vertebrates such as reptiles, birds and mammals[1,2]. Evidence for cannibalism in vertebrate fossils, however, is generally rare, and the best examples were recently found in the Madagascan dinosaur *Majungatholus atopus*[3], and the Neanderthals[4]. Here we report the presence of cannibalism in a semi-aquatic reptile *Monjurosuchus splendens*[5,6] from the Lower Cretaceous of China (Fig. 1), as shown by an adult individual containing seven skulls of juveniles of the same species in its abdominal cavity, indicating that it is an active cannibal that preys on young members of its own kind. This discovery also represents the earliest known and most gruesome cannibalism ever recorded among the prehistoric vertebrates.

The fossil (IVPP V13761) was collected from the lacustrine Lower Cretaceous Yixian Formation at Jingangshan locality in Yixian, western Liaoning, Northeast China. The age of the deposit was dated as 121 Ma[7]. Associated with the fossil from the same locality are abundant fish *Lycoptera*, turtle *Manchurochelys*, lizard *Yabeinosaurus*, pterosaurs and birds[8], including the recently discovered and published pterosaur egg[9], the avian embryo[10] and the bird with leg feathers[11]. Although various fossils from this region have preserved stomach contents[12] indicating carnivorous behavior, none of them shows any evidence of cannibalism.

The ventrally preserved adult reptile is a nearly complete articulated individual, lacking only the rostral skull and the distal forelimbs and tail. The seven juvenile skulls are restricted to the abdominal region of the adult; they are ventrally overlapped by the gastralia, and dorsally by the thoracic ribs of the adult, which clearly indicates that they were eaten by the adult rather than occasionally preserved together. Among the seven juvenile skulls, the five anteriorly positioned skulls are nearly complete, but the two posterior ones are more or less disarticulated (Fig. 1(c)). It is also notable that most of the postcranial bones are not preserved with the juvenile skulls. However, the two most anteriorly positioned skulls appear to be in association with some faintly preserved cervicals and thoracic ribs.

The adult reptile clearly belongs to a choristodere by several apomorphies such as a dorsa-ventrally flattened skull, a flared posterior temporal region with a deeply incised posterior skull margin, thoracic ribs with expanded distal end, the ratio of femur to humerus length over 1.3, and fifth metatarsal with expanded proximal end but no plantar tubercles[6]. It can also be unambiguously referred to the species *M. splendens* by such diagnostic features as the presence of two or three rows of teeth on the upper jaw[5], the unfusion between the slender flask-like scapula and the oval coracoid, gastralia extremely slender with three or four rows to each body segment, and pedal phalangeal formula 2-3-4-4-3[6] (Fig. 1(a) and (b)).

The skulls of the seven juveniles are preserved either dorsally or ventrally. They all measure about 20 mm in length. The skull features of the seven individuals are indistinguishable in morphology from the skull of the adult and other specimens referable to *M. splendens*. More apomorphies of the species are recognizable in these skulls, including an extremely narrow frontal, a small supratemporal fenestra, a relatively large orbit, and antorbital and postorbital regions nearly equal in length[6]. Therefore, all the seven juvenile skulls in the adult belong to the same species: *M. splendens*.

rostral ends cranially directed with only one exception, which probably represent the original positions of the skulls after being eaten. The anteriorly positioned skulls are generally better preserved than the posterior ones, and the most anterior two even preserved some postcranial elements, which may reflect the variation of degree of digestion of the juveniles. Further, the absence of most of the postcranial elements of the juveniles precludes the possibility that the adult is a gravid female.

Evidence for cannibalism has rarely been preserved in fossil vertebrates. Cannibalism was inferred from biting marks on the bones of the dinosaur *M. atopus*[3] and the Neanderthal[4]. The other well-known example of a dinosaur cannibal in the Triassic *Coelophysis bauri*[13] is, however, now believed to be unsubstantiated[14]. The new fossil reptile provides yet another direct and unambiguous evidence for such feeding behavior in fossil vertebrates. It also represents the earliest known evidence for vertebrate cannibalism, which is about 50 Ma older than the Late Cretaceous dinosaur *M. atopus*[3].

The seven juveniles in the abdominal cavity of the adult *M. splendens* are of nearly the same size, indicating that they might have come from one single nest, and the clutch size of *M. splendens* is no less than seven. However, it is unclear whether this reptile preys on its own offspring or someone else's. It is unusual that only skulls and little of the postcranial bones of the seven juveniles were pre-

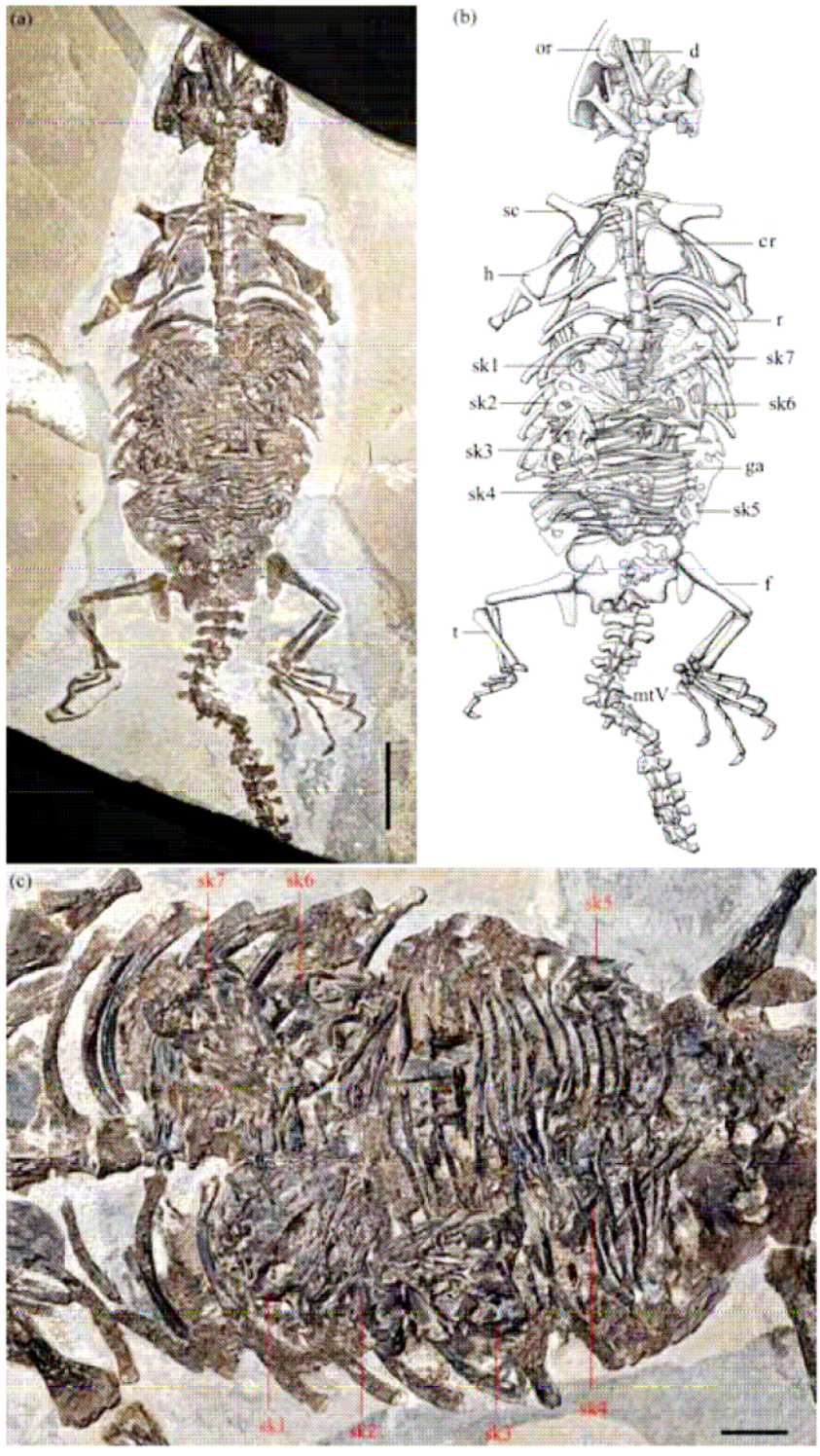

Fig. 1. Cannibalism in *Monjurosuchus splendens* from the Early Cretaceous of Liaoning, China (IVPP V13761). Fossil (a) and drawing (b). Scale bar, 3 cm. (c) Close up photo of the adult *M. splendens*'s abdomen showing seven juvenile skulls inside its body cavity. Scale bar, 1 cm. cr, coracoid; d, dentary; f, femur; ga, gastralia; h, humerus; mtV, metatarsal V; or, orbit; r, thoracic rib; sc, scapula; sk1—7, juvenile skulls 1—7; t, tibia.

served in the adult. It might be possible that the predator had killed all the young individuals in the clutch before it started to eat their heads first as in many living predators.

It is noteworthy that all the juvenile skulls have their

It is generally believed that animals resort to cannibalism due to ecological pressure for survival[1,2]. Conceivably, the frequent volcanic eruptions in the Early Cretaceous of Liaoning could have temporarily disrupted the environment[8] and caused the shortage of food. The seven skulls in the abdominal cavity of the cannibal represent not only a clutch of newly hatched victims but also the last meal of the predator before itself died of a natural disaster.

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