

Additional Evidence

LETTERS TO NATURE

occurred. Recent studies²⁰ of the ¹⁴Mn-⁵³Cr system (half-life, 3.7 Myr) indicate that the Cr isotope composition of the Earth and Moon are similar but distinct from less radiogenic than characteristic compositions. Manganese is more volatile than Cr (ref. 22), so the radiogenic Cr isotope composition of the Earth can be explained if the Earth accreted from volatile depleted material with low Mn/Cr. However, core formation, being late, had no effect on Cr or W isotope compositions. □

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A nesting dinosaur

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A SPECIALLY fossil specimen that suggests the presence of an avian type of nesting behaviour in ornithomimid, a clade of non-avian maniraptoran theropods, is reported here. The substantial evidence indicating that birds are a type of theropod dinosaur has led to copious discussion concerning the origin and possible presence of advanced avian reproductive behaviour in non-avian dinosaurs. Although the inference of behaviour from fossils is problematic, some remarkable discoveries, such as the incontrovertible evidence of dinosaur nests¹, and more controversial claims made on the basis of dinosaur nesting grounds² and parental morphology³, hint at the occurrence of advanced reproductive behaviour in a variety of non-avian dinosaurs. But there is no direct fossil evidence implying advanced parental systems such as those found in modern birds. The closest association between preserved parents and nests occur in ornithomimid dinosaurs from Late Cretaceous deposits of the Gobi Desert⁴. The specimen described here is the first preserved well enough to determine its precise relationship with the nest. It is a large ornithomimid positioned over a nest of ornithomimid eggs in the same posture taken by many living birds when brooding. This provides the strongest evidence yet for the presence of avian brooding behaviour in non-avian dinosaurs.

Other *Ornithomimid* discoveries have been found associated with nests⁵, including the first discovery of *Ornithomimid* at the Flaming Cliffs in 1927⁶, and it has been suggested previously that perhaps these individuals were defending or incubating their nests⁷. At the time of the original discovery in 1923, the eggs were thought to belong to *Protoceratops andrewsi*, the most common dinosaur in those deposits. This led to the erroneous suggestion that *Ornithomimid* had been scavenging the eggs. The recent discovery of an ornithomimid embryo⁸ within the type of egg associated with

the *Ornithomimid philocoryps* holotype suggests instead that this individual's proximity to the nest was related to parental care rather than to predation.

The specimen (IGM 100-979) (Fig. 1) was collected at Ukhiaa Tolgoi, a Late Cretaceous fossil locality in South Central Mongolia⁹, during the 1983 segment of the Mongolian Academy of Sciences/American Museum of Natural History, of Paleontological Project. To preserve spatial relationships definitively the entire specimen was collected in a single large block. No eggs were exposed on the surface, indicating that the entire nest as preserved was collected.

At Ukhiaa Tolgoi, remains of ornithomimids are the most common theropod dinosaurs encountered, rivalled only by *Tyrannosaurus* as the most common dinosaur discovered at this locality⁹. Like most specimens from Ukhiaa Tolgoi, the specimen shows no evidence of transportation after death, and is preserved in a facies hyperbosted to be deposited by large sandstorms. The specimen is of a large individual, although it is not outside the range of Ukhiaa Tolgoi ornithomimids. The skull, vertebrae, tail and dorsal pelvic bones, and proximal parts of both hindlimbs are missing, yet the majority of the remaining elements including the gastralia and ribs are preserved (Fig. 1).

The maniraptoran affinity of this specimen is shown by the presence of a semilunate carpal that is firmly secured to metacarpals I and II. The clavicles are fused forming a stout furcula, a feature typical of ornithomimids¹⁰. IGM 100-979 has a forward-pointing pubis and metasternal III is not fused proximally by II and IV; digit three in the hand is gracile as is typical of many maniraptorans. Differences in manual proportions have been used to differentiate ornithomimid taxa¹¹. In *Ornithomimid* and *Carcharias*, digits II and III are subequal in length and longer than digit I, whereas all three digits are nearly equal in length in *Agouti*. Furthermore, the digit of *Ornithomimid* are longer and stouter than in other ornithomimids and the tarsus scarcely displays large, laterally compressed, recurved claws, with commonly three flexor tubercles as expressed in IGM 100-979. The specimen displays several pathologies, including a right ilium that was broken and healed during life.

IGM 100-979 is the best preserved and most complete ornithomimid specimen of any yet found on a nest, and offers the first evidence of the precise position of the skeleton to the nest (Fig. 2). Both hindlimbs are tightly folded (Fig. 1c), with the feet and the lower legs nearly parallel to one another. The feet lay antip and adjacent to eggs on the inner perimeter of the circle defined

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