

Dinosaurs and Their Youth

Letters from:

Mark A. Norell and James M. Clark
Nicholas R. Geist and Terry D. Jones

In their report "Juvenile skeletal structure and the reproductive habits of dinosaurs" (3 May, p. 712), Nicholas R. Geist and Terry D. Jones conclude that juvenile dinosaurs were precocial (mobile and relatively independent) at hatching. This conclusion is not novel, but is expected because both crocodiles and ratite birds (the basal sistergroup to all other living birds) are precocial at hatching. Precociality is a primitive characteristic of Archosauria, as can be determined by its phylogenetic distribution within the group (1).

Geist and Jones state that the pelvic girdle of *Oviraptor* was well ossified as an embryo and that "the discovery [by us (2)] of eggs in close association with an adult *Oviraptor* has been interpreted as evidence of birdlike parental behaviour, including perhaps endothermy and incubation of eggs by adults." This misrepresents statements in our original paper. In our paper about the brooding theropod (3), we defined brooding behaviour as "the behaviour of sitting on nests." In living birds, this behaviour is associated with thermoregulatory incubation; however, we explicitly caution that "[a]lthough strongly suggestive, this does *not* imply that brooding behaviour and endothermy are necessarily correlated" (*italics added*) (3, p. 776).

As pointed out by Geist and Jones, nest attending and brooding (which they left undefined) is widespread among tetrapods. They cite one example where "female crocodiles (*Crocodilus niloticus*) often rest their lower *throat* or *thorax* directly on the nest for the duration of the 90-day incubation period" (*italics added*). Birds (both precocial and altricial) sit in the middle of their nests, curl their legs up under themselves, and the eggs are manipulated into a neat pattern around the body. These behaviours are not found in crocodiles. Birds are living dinosaurs. *Oviraptor* is closely related to birds (4). *Oviraptor* fossils have been found not just in "close association" with nests, but in actual brooding positions over neatly arranged nests, identical to the pattern seen today in birds. In light of this evidence, we find it perplexing that Geist and Jones suggest that "the nesting behavior of dinosaurs was likely similar to that of modern crocodilians."

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References and Notes

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5. We thank M. Novacek and D. Frost. Supported by NSF grant DEB-9407999.

Response: Norell and Clark dismiss the importance of our conclusion that all known juvenile dinosaurs were probably precocial. However, since 1988, when it was proposed that some dinosaurs were altricial (nestbound) (1), several authors have tacitly accepted dinosaur altriciality without question (2). We also hypothesized in our report that dinosaur neonate pelvic ossification is a reliable indicator of maturity at hatching.

Norell and Clark object to our assertion that their previous statements linked brooding in *Oviraptor* with possible egg incubation and endothermy. However, Norell *et al.* have written previously that "very exceptionally, some extant ectotherms are also known to brood their nests ..." and, consequently, that apparent brooding behavior in *Oviraptor* is "strongly suggestive" of a correlation between brooding behavior and endothermy (3, p. 776). In fact, nest-brooding, whether for thermoregulatory or protective purposes, is known to occur in many modern amphibians and reptiles (more than 100 species) and in birds. Brooding is likely to be a primitive archosaurian attribute and so is not "strongly suggestive" of endothermy.

The fact that modern brooding crocodylians do not "curl their legs up under themselves" in the avian fashion does not obviate our conclusion that there is little to differentiate brooding in dinosaurs from that in crocodylians. Modern crocodylians are relatively short-limbed, a condition that would make it difficult to curl their legs up beneath themselves. Nevertheless, both birds and crocodylians brood their eggs by resting their body directly on the nest, regardless of the position of the legs. Furthermore, investigations of nests now assigned to *Oviraptor* concluded that the eggs were laid directly in their final position without manipulation (4). To imply that the brooding behavior of *Oviraptor* is necessarily more bird- than crocodile-like seems without foundation.

Finally, Norell and Clark imply that much can be gleaned about *Oviraptor's* reproductive biology because "birds are living dinosaurs." This may or may not be so (5). We merely point out that *Oviraptor* fossils present no significant evidence that precluded their reproductive biology from having resembled that of modern crocodylians.

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