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Upper Cretaceous titanosaur nesting sites and their implications for sauropod dinosaur reproductive biology

by

P. Martin Sander, Christian Peitz, Frankie D. Jackson and Luis M. Chiappe

With 14 text-figures

Summary

Megaloolithid dinosaur eggs are distributed nearly worldwide in Late Cretaceous terrestrial sediments, the most important regions of occurrence being southwestern Europe, central India, and the spectacular Auca Mahuevo site in Argentina. Based on finds from the Argentinian site, eggs classified within the oogenus *Megaloolithus* of the traditional fossil egg parataxonomy are believed to have been produced by titanosaurian sauropods.

Here we review the geologic context, taphonomy, nest structure, clutch morphology, shell thickness variation, and shell porosity of *Megaloolithus* occurrences from Europe, India, and Auca Mahuevo, Argentina. We focus on the implications of the data for the reproductive biology of sauropod dinosaurs. Although virtually all occurrences are from paleosols of varying maturity, there are striking differences between the European and Indian sites on one hand and Auca Mahuevo on the other. Clutch size is < 8 in the former and < 40 in the latter, shell porosity is very high in the former and low in the latter. Eggs at Auca Mahuevo are also smaller than those in Europe and India. Based on detailed data for inter-clutch and intro-clutch variation of shell thickness and porosity in clutches from the Spanish site of Coll de Nargó, all *Megaloolithus* eggs from Spain and probably from southern France pertain to a single oospecies, *M. mammilare*. Those from Auca Mahuevo belong to *M. patagonicus.*

Clutches from Europe and India were buried in the substrate and incubated by environmental heat, whereas those from Auca Mahuevo were deposited in an open nest structure and remained uncovered by sediment or plant material. Colonial nesting cannot be proven for the Indian and European occurrences, high density of clutches being the result of prolonged use of a site. Colonial nesting seems likely at Auca Mahuevo, but contradictions in the interpretation of this site remain.

Very small clutch size and clutch mass compared to estimated adult female mass suggests that the European and Indian titanosaurs produced multiple clutches per nesting season. In both the European and Indian as well as the Auca Mahuevo occurrences, small egg size and inferred large egg number suggests that titanosaurian sauropods were r-strategist. This reproductive strategy was obligatory due to the obligatory ovipary imposed by the calcareous eggshell combined with biomechanical limitations on maximum egg size.

Key words: *Megaloolithus* – Sauropoda – reproductive biology – r-strategy – Upper Cretaceous – Argentina – France – India – Spain

Zusammenfassung

Dinosaurier-Eier aus der Oofamilie Megaloolithidae kommen fast weltweit in oberkretazischen terrestrischen Sedimenten vor. Die wichtigsten Fundregionen sind Südwesteuropa, Zentralindien und die spektakuläre Fundstelle Auca Mahuevo in Argentinien. Aufgrund von Funden von Embryonen in Eiern von dieser Lokalität wird angenommen, dass Eier des Oogenus *Megaloolithus* von titanosauriden Sauropoden gelegt wurden.

Addresses of the authors: Prof. Dr. P. Martin Sander, Institute of Paleontology, University of Bonn, Nussallee 8, D-53115 Bonn, Germany; e-mail: martin.sander@uni-bonn.de
Dr. Christian Peitz, Institute of Paleontology, University of Bonn, Nussallee 8, D-53115 Bonn, Germany,
e-mail: christian.peitz@projekt-past-present.de
Dr. Frankie D. Jackson, Department of Earth Sciences, Montana State University, Bozeman, MT 59717, USA, e-mail: frankiej@montana.edu
Dr. Luis M. Chiappe, Department of Vertebrate Paleontology, Natural History Museum of Los Angeles County, 900 Exposition Boulevard, Los Angeles, CA 90007, USA; e-mail: lchiappe@nhm.org

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