Upper Jurassic Theropod Dinosaur embryos from Lourinhã (Portugal)

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Abstract

Key-words: embryos; theropod; Jurassic; nesting.

Upper Jurassic nesting site from Paimogo (Lourinhã, Portugal) yielded the oldest dinosaur theropod embryos ever found. Numerous bones, including skull bones, from the skeleton of these embryos have been collected. The study of bones and embryos offers the possibility to learn more on the early life of theropod dinosaurs.

Resumo

Palavras-chave: embriões; terópode; Jurássico; nidificação.

Foi descoberto, em depósitos do Jurássico superior de Paimogo (Lourinhã), um local de nidificação com os mais antigos embriões conhecidos de dinossauros terópodes. Foram colhidos numerosos ossos de embriões, alguns do crânio; o seu estudo representa significativo progresso dos conhecimentos acerca dos primeiros estádios de vida de dinossauros terópodes.

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The discovery of clutches, eggs and embryos of a theropod dinosaur at Paimogo (Lourinhã, Portugal), in an Upper Jurassic level, constitutes an exceptional event (MATEUS *et al.,* 1997).

Until now, most of the dinosaur eggs collected around the world were more recent, most of them being of Late Cretaceous age. Moreover, these eggs are generally empty; only a few clutches from the Late cretaceous of Montana or Mongolia have yielded well preserved embryos of ornithopods and, more recently, theropods.

That is why the presence, at Paimogo, of the remains of several embryos among the some hundred eggs recovered, should bring new interesting data on the first stages of life of theropod dinosaurs.

2. The bones

The fossiliferous level which contains the eggs is 30 cm thick; most of the clutch area has been taken (sediment as well as eggs) and six large blocks have been transported to the laboratory. Globally, they contain more than 100 closely grouped eggs. The first of these blocks, prepared from the top, contains 34 eggs strongly appressed against each other. Most of these are closed, but four of them (n^{os} 10, 45, 48 and 56) disclose small bones *in situ;* the egg no. 10, open along its long axis, even shows bones in connexion, probably the distal extremity of a femur articulated with a tibia and fibula.

Moreover, following the washing and sieving of the sediment surrounding the clutches, several hundred of bones and osseous fragments have been recovered. A preliminary examination of these remains has already brought valuable information on the skeleton of the embryos and allowed us to confirm their theropod identification.

All these bones are very small: one femur with the head being less than 5 mm broad, vertebrae with a centrum 3 to 5 mm long and 1.5 to 4.2 mm in diameter. The neural arches of the vertebrae are not fused to the centra and the surface of the bones, which is rugose, shows calcified cartilaginous trabeculae with clearly recognizable fibers.

Among the collected bones, several elements can be identified: well preserved skull fragments with a noticeable portion of a skull floor connected with the occipital condyle and basisphenoidal tubercles; a fragment of a premaxillar with two teeth; two maxillary fragments, one

with four teeth, the other with two teeth. The material also includes more than 100 vertebrae, either cervical, dorsal, sacral or caudal. Among the girdle bones is a well preserved scapula. Finally, one can identify numerous fragments of limb bones: femur, tibia, fibula and metapods, some of them still in articulation.

3. The bones being reported to a Theropod

All the bones collected at Paimogo are strong with thick walls; they undoubtedly are reptile bones.

Moreover, the structure of the limb bones' extremities, as well as the straightness of the femoral and tibial diaphyses indicate that these bones are those of small dinosaurs.

Furthermore, the shape of the femoral head, the disposition and profile of its distal condyles, together with the shape of the proximal plateau of the tibia, the anatomy of the maxillary and premaxillary fragments, the presence of teeth with characteristic laminae, all concur to prove that these elements are those of theropod dinosaurs.

Finally, the disposition and the typical shape of the small trochanter below the femoral head evokes very strongly the equivalent element of the allosauroid femur.

4. Embryos or newly-hatched?

Two facts allow us to assert that the skeletal elements found in the Paimogo clutch are embryonic, and not those from newly-hatched dinosaurs:

— the no. 10 egg shows *in situ* articulated bones inside the shell;

— a vertebral centrum is still adherent to the internal surface of a shell fragment.

However, it cannot be excluded that the embryos of the clutch had reached different developmental stages. It is also possible that newly hatched youngs were present at the nesting area: some theropod vertebrae which are relatively broader than the embryonic vertebrae could support this hypothesis.

From the dimensions of the eggs, the length of an embryo from head to tail can be estimated as being around 40 cm.

5. Palaeobiology

It still is too soon to draw firmly argumented conclusions from the distribution of the eggs at the Paimogo site. It is excluded that only one female would have been able to lay 100 eggs. In Montana, the clutches contain a number of eggs varying from 12 to 24. In China, some clutches can have as many as 26 eggs. It is thus possible to formulate some hypotheses in order to explain such a concentration of eggs in a so restricted area:

a) the site has been occupied several times by theropod females; several clutches would have been laid successively and distinctly before being covered by sediments;

b) several clutches of one or more dozen of eggs have been washed away by a mud flood and accumulated together in a single place;

c) several females came to lay eggs at the same place, like extant ostriches, which assemble their eggs in a nursery under the care of one male;

d) several females came to one place to lay their eggs, the way do colonial birds such as penguins and guillemots: each female looks after its one egg, that she recognizes from the shell decoration.

The preparation of the six blocks collected, and the study of the . sediment underlaying or covering the eggs, will perhaps offer some clues as to the conditions of deposition, thus giving us some information on the way of life of the theropod females which came to lay their eggs at the site.

Finally, the presence, close to the theropod eggs, of 3 eggs with a thin crocodyloid shell, suggests the existence of predators like crocodiles near the dinosaur site; such an idea has already been proposed by KlRKLAND (1994) for the Late Jurassic clutches" of Colorado. Similarly the recovery, in the vicinity of the dinosaur eggs, of a small multituberculate jaw, erects the suspicion that small mammals could have been attracted by a very rich source of proteins: indeed, nowadays in the wild, eggs of turtles, crocodiles and birds are particularly attractive for numerous predators from various zoological groups.

6. Conclusions

Future work and studies on the conditions of deposition, on the geometry of the clutches, on the structure and histology of the embryonic bones, should help to solve the many questions that remain, but the importance of the Paimogo discovery can already be stressed.

The abundance of bones of these theropod embryos, the quality of their preservation and their ancient geological age contribute to make the Lourinhã area of Portugal, a country, already so rich in dinosaur, crocodile, turtle and fish bones, one of the most famous palaeontological sites in the world.

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PLATE I

Figure 1 - Partly prepared clutch of 34 eggs. **a.** A view of the clutch. **b.** Position of the eggs. Block size, *ca.* 75 y 78 cm.

Figure 2 - Egg no. 10 with bones of one embryo. Length, 130 mm; width, 80 mm.

PLATE I

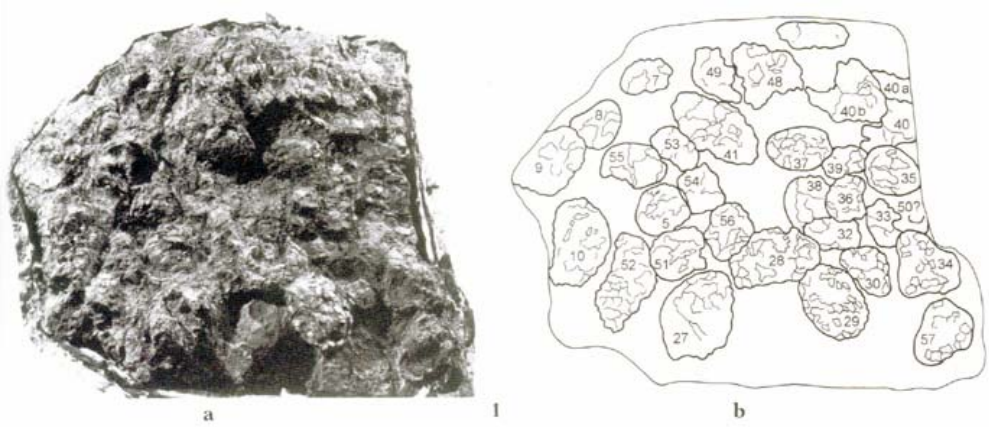
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PLATE II

Figure 3- Small bones of theropod embryos. Bar = 1 mm. **a.** Vertebrae: centrum attached to the internal surface of a shell fragment. **b.** Vertebrae: two centra in connexion. **c.** Centrum of an anterior dorsal vertebra with its pleurocoel cavity in antero-dorsal position. **d.** Proximal part of a right femur in anterior view. **e.** Tibial surface of a right tibia in proximal view. **f.** Proximal part of a tibia in lateral view. **g.** Proximal part of a left scapula in lateral view. **h.** Distal part of a femur in anterior view. **i.** Distal part of a left femur in distal view. **j.** Part of a skull floor in ventral view with the occipital condyle and the spheno-occipital tubercles.

PLATE II