

On a theropod scapula (Upper Cretaceous) from the Marília Formation, Bauru Group, Brazil

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WITH 5 FIGURES

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Abstract: The record of theropod dinosaurs in Brazil is very scarce. One of the most promising lithostratigraphic units for those reptiles is the Bauru Group. The dinosaur remains found in this unit are mainly those of sauropods, while theropods are represented mostly by teeth. Here we describe a right scapula (housed at the Earth Science Museum of the Departamento Nacional de Produção Mineral/Rio de Janeiro) that is the first theropod scapula reported from the Cretaceous of Brazil and only the second osteological evidence of the Tetanurae from the Bauru Group. The specimen was recovered from the outskirts of Peirópolis, in Minas Gerais State. Comparisons with other theropod dinosaurs are limited, but the overall morphology of the new specimen indicates that it is neither a member of the Abelisauridae nor a member of the Avialae. It also differs from more basal members of the Theropoda, but its overall shape is consistent with several derived members of the Tetanurae, likely a non-avian maniraptoran. Despite the lack of precision in its taxonomic position, the new specimen confirms the presence of non-avian Maniraptora in the Bauru Group.

Keywords: Dinosauria • Theropoda • scapula • Bauru Group • Upper Cretaceous • Brazil

Kurzfassung: Der Fossilbericht theropoder Dinosaurier von Brasilien ist immer noch sehr dürftig. Eine der aussichtsreichsten Gesteinseinheiten für das Auffinden dieser Reptilien ist die Bauru-Gruppe. Bisher gefundene Dinosaurier aus dieser Einheit sind überwiegend Sauropoden, während Theropoden hauptsächlich durch Zähne vertreten sind. Wir beschreiben hier eine rechte Scapula (aufbewahrt im Geowissenschaftlichen Museum des Departamento Nacional de Produção Mineral/Rio de Janeiro), welche die erste Theropoden-Scapula aus der Kreide Brasiliens und erst den zweiten Skelett-Nachweis von Tetanuren aus der Bauru-Gruppe darstellt. Das Exemplar stammt aus der Umgebung von Peirópolis, im Bundesstaat Minas Gerais. Obwohl Vergleiche mit anderen Theropoden limitiert sind, deutet die generelle Morphologie des Exemplares darauf hin, dass es sich weder um einen Abelisauriden noch um einen Avialen handelt. Es unterscheidet sich auch deutlich von den Scapulae anderer basaler Theropoden, ähnelt jedoch jenen fortschrittlicher Tetanuren und gehört höchstwahrscheinlich zu einem Maniraptoren außerhalb der Avialae. Trotz dieser Unsicherheit in der taxonomischen Zuordnung bestätigt dieses neue Material somit das Vorhandensein nicht-avianer Maniraptoren in der Bauru-Gruppe.

Schlüsselwörter: Dinosauria • Theropoda • Scapula • Bauru-Gruppe • obere Kreide • Brasilien

Introduction

In the last decade, there has been an increase in the studies of South American dinosaurs, particularly in Argentina (e.g., NOVAS & PUERTA 1997; MAKOVICKY et al. 2005; Calvo et al. 2007). More recently, important dis-

coveries have also been made in Brazil, but the remains of those reptiles can still be considered comparatively scarce in the country (e.g., KELLNER & CAMPOS 1999; LANGER 2004; LEAL et al. 2004). This is particularly true for theropods, whose remains are remarkably rare (KELLNER & CAMPOS 2000). Among the deposits with

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the greatest potential for new Brazilian dinosaur discoveries is the Bauru Group, considered the largest Cretaceous continental deposit in the country. This unit is divided into several formations (e.g., FERNANDES & COIMBRA 2000), with Theropod remains restricted to the incomplete skeleton of *Pycnonemosaurus nevesi* KELLNER & CAMPOS, 2002, a few isolated remains including teeth, and an ungual (Bertini et al. 1993; KELLNER & CAMPOS 2002; CANDEIRO et al. 2004; NOVAS et al. 2005).

Here we report a scapula housed at the Earth Science Museum of the DNPM/Rio de Janeiro (MCT 1718-R; cast at the Museu Nacional/ Universidade Federal do Rio de Janeiro - MN 7022-V). Up to date, theropod scapulae from Brazil have been reported only in the Triassic taxa *Staurikosaurus* and *Guaibasaurus* (COLBERT 1970; BONAPARTE et al. 1999), although their theropod nature is still debated (LANGER 2004). In any case, MCT 1718-R is the first theropod scapula from the Cretaceous of Brazil and the second osteological evidence of Tetanurae from the Bauru Group. The specimen was recovered from sandstones of the Marília Formation that outcrop in the outskirts of Peirópolis, in Minas Gerais State. It was briefly mentioned in the literature (MACHADO et al. 2005) and is fully described here.

The Bauru Group

The Bauru Group is very fossiliferous, and remains of several groups have been recorded such as isolated mollusks, fishes, amphibians, turtles, crocodylomorphs, dinosaurs, and mammals (BERTINI et al. 1993). The outcrops of this unit are present in several states in Brazil (Paraná, São Paulo, Minas Gerais, Goiás and Mato Grosso do Sul), and also found in Paraguay (FERNANDES & COIMBRA 1996). SOARES et al. (1980) recognized four Formations within the Bauru Group: Caiuá, Santo Anastácio, Adamantina and Marília. To these, SOUZA (1984) added the Uberaba Formation, which is interdigitated with the Adamantina Formation. Later, FERNANDES & COIMBRA (1996) proposed that the strata comprising the Bauru Group should be regarded as a new depositional area, the Bauru Basin. They erected the Caiuá Group, divided into the Santo Anastácio, Rio Paraná and Goio Erê Formations, and the Bauru Group, composed of the Adamantina, Uberaba and Marília Formations. Later, FERNANDES & COIMBRA (2000) reviewed the eastern portion of the Bauru Basin, recognizing the following Formations within the Bauru Group: Uberaba, Vale do Rio do Peixe, Araçatuba, São José do Rio Preto, Presidente Prudente, and Marília. The Marília Formation, where the specimen described here was found, is the uppermost unit of the Bauru Group (Carnian and/or Maastrichtian, SOARES et al. 1980; BERTINI et al. 1993).

Theropods from Brazil

Up to date, the non-avian theropod record in Brazil is very restricted. Other than Cretaceous footprints (e.g., LEONARDI 1994) and fossilized feathers regarded as avian (e.g., KELLNER et al. 1994), only seven species of theropod dinosaurs based on osteological material have been described, some recently being questioned. The most primitive one is *Staurikosaurus pricei* COLBERT, 1970, from the Triassic Santa Maria Formation (Paraná Basin), regarded as one of the earliest dinosaurs found in South America (COLBERT 1970; GALTON 2000). Also from Triassic strata (The Caturrita Formation) comes *Guaibasaurus candelariensis* BONAPARTE, FERIGOLO & RIBEIRO, 1999. It should be noted that the theropod nature of those Triassic taxa remains to be confirmed (KELLNER & CAMPOS 2000; LANGER 2004). The Lower Cretaceous Santana Formation, known by the extremely well preserved paleontological content (e.g., MAISEY 1991; FARA et al. 2005), has provided four species thus far: two small coelurosaurians (with soft tissue preservation), *Santanaraptor placidus* KELLNER, 1999 and *Mirischia asymmetrica* NAISH, MARTILL & FREY, 2004, and the spinosaurids *Irritator challengerii* MARTILL, CRUICKSHANK, FREY, SMALL & CLARKE, 1996 and *Angaturama limai* KELLNER & CAMPOS, 1996 (MARTILL et al. 1996; KELLNER & CAMPOS 1996; KELLNER 1999; NAISH et al. 2004). Although some have argued that this two species as pertaining to the same taxon (SERENO et al. 1998), and even to the same individual (HOLTZ 1998), we have several reasons (including difference in size) to believe that they did not pertain to the same individual (MACHADO & KELLNER 2005). The possibility that they belong to the same species, first pointed out by KELLNER (1996), cannot be determined at this point since the holotype of both species belong to different parts of the skull.

The only named theropod from Late Cretaceous deposits of Brazil is the abelisaurid *Pycnonemosaurus nevesi*, known from an incomplete skeleton collected in Mato Grosso. The deposits where this theropod was found have been tentatively associated with the Bauru Group (KELLNER & CAMPOS 2002).

Some isolated non-avian theropod remains were also reported from the Late Cretaceous strata of the Bauru Group: an abelisaurid preorbital region with the remains of five teeth (BERTINI 1996) and some undescribed skeletal remains including a femur, a tibia, and metatarsals found near Peirópolis, assigned to coelurosaurians (BERTINI et al. 1993); and one manual ungual assigned to a maniraptoran theropod (NOVAS et al. 2005). Besides these, isolated theropod teeth were reported by several authors and assigned to different clades such as Coelurosauridae (BERTINI et al. 1993), Abelisauridae and Carcharodontosauridae (CANDEIRO et al. 2004). CANDEIRO et al. (2004) also reported isolated spinosaurid teeth from the Bauru Group. However, compared to published spinosaurid teeth (KELLNER & MADER 1997;

SERENO et al. 1998; MEDEIROS 2006; MEDEIROS & SCHULTZ 2002) this material more likely belongs to crocodyliforms.

Description

The scapula described here is from the right side. For descriptive purposes, this bone is oriented with the main axis vertical, the distal end positioned dorsally and the coracoidal articulation surface ventral.



Fig. 1. Theropod right scapula (MCT 1718-R) from the Marília Formation in lateral view. – Abbreviations: acr, acromial process; ad, acromial depression; a sc-c, articulation between scapula and coracoid; g, glenoid fossa. – Scale bar = 10 mm.

Overall, the element is well preserved and lacks any evidence of distortion or compaction. The dorsal tip of the scapular blade and part of the acromial process are incomplete. The total length of the preserved portion is approximately 145 mm, indicating that it belongs to a small to medium-sized animal. The long and slender shaft is oval in cross-section close to the glenoid fossa but gradually becomes more compressed and blade-like towards its distal end. Although the tip of the scapular blade is missing, its anterior and posterior margins are subparallel, suggesting a lack of distal expansion. The posterior portion is slightly thicker than the anterior one.

In lateral view, the shaft curves slightly anteriorly (Fig. 1). The scapular blade is long and strap-like with subparallel margins. The scapula possesses a curvature in anterior or posterior view, to fit into the shape of the animal's body. (Fig. 2) The glenoid fossa is directed lateroposteriorly. The anterior border of the shaft slightly turns into the acromial area. The lateral surface between the acromial process and the coracoid articulation is slightly depressed (Fig. 3). In medial view, a marked longitudinal depression is observed near the posterior border, dorsal to the rim of the glenoid (Fig. 4).

The articulation surface with the coracoid does not show any sign of breakage, indicating that the coracoid (not preserved) was not fused with the scapula. This articulation is mediolaterally thick (15.0 mm) and subtriangular in shape, comprising the thickest portion of this bone (Fig. 5).

Comparisons and discussion

The overall morphology of the scapula, particularly the strap-like blade and the curvature seen in anterior or posterior view is thought to be typical of theropods (e.g., HOLTZ et al. 2004; CHARIG & MILNER 1997), indicating that it belongs to a theropod dinosaur.

Previous phylogenetic analyses of the Theropoda utilize very few characters of the scapula (e.g., orientation of glenoid cavity, width of blade), and most of those are in relation to other bones that are not preserved in this material (e.g. coracoid and humerus) what makes the systematic assignment of MCT 1718-R difficult. A narrow scapular blade has been assigned as a tetanuran synapomorphy (GAUTHIER 1986; BROCHU 2003), indicating that the Brazilian specimen belongs to this clade. The glenoid fossa is oriented lateroposteriorly and not posteriorly as in most non-avian theropods (NOVAS & PUERTA 1997; NORELL & MAKOVICKY 1999), and neither laterally as in avialans and closely related taxa (e.g., *Unenlagia comahuensis* NOVAS & PUERTA, 1997). MCT 1718-R has the anterior border of the scapula slightly turning into the acromial area, a feature that, although present in the more primitive *Carnotaurus*, is regarded as typical of more derived theropods (BONAPARTE et al. 1990). In fact, this region is more angular in basal theropods such as *Allosau-*



Fig. 2. Theropod scapula (MCT 1718-R) from the Marília Formation in anterior view. – Abbreviations as in Fig. 1. – Scale bar = 10 mm.

rus and *Ceratosaurus* (MADSEN 1976; BONAPARTE et al. 1990; MADSEN & WELLES 2000). Those features, and the overall shape of the glenoid cavity, which is similar to that in maniraptorans (e.g., NORELL & MAKOVICKY 1999), suggests that MCT 1718-R is a member of the Maniraptora (but not of the Avialae).

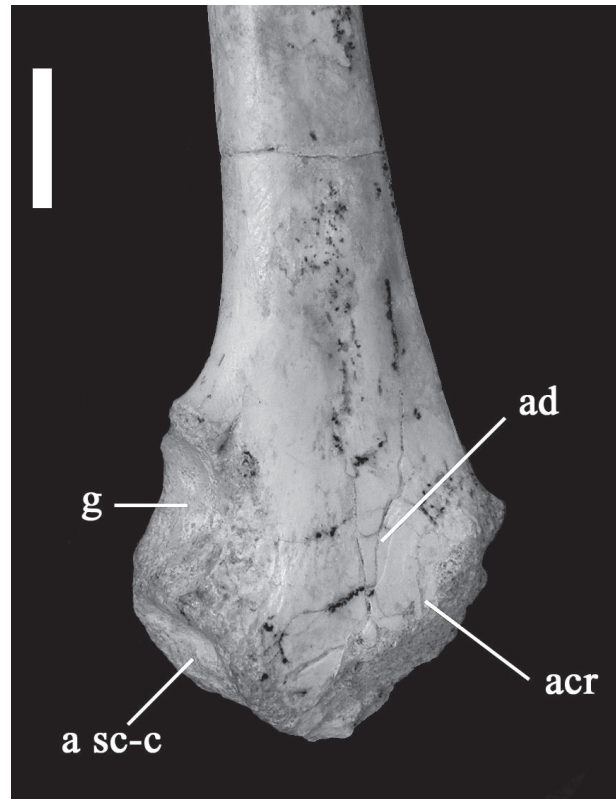


Fig. 3. Detail of the acromial depression of the theropod scapula (MCT 1718-R) from the Marília Formation in lateral view. – Abbreviations as in Fig. 1. – Scale bar = 10 mm.

Within maniraptorans, the anterior curvature of the scapular blade of MCT 1718-R (seen in lateral view) is similar to the condition in the non-avian theropod *Mononykus olecranus* PERLE, NORELL, CHIAPPE & CLARK, 1993 (PERLE et al. 1994; ZHOU 1995). However, there are several features that distinguish the Brazilian specimen from the scapula of the latter taxon, such as the lack of a dorsally expanded scapular blade, being more likely to *Alvarezsaurus calvoi* BONAPARTE, 1991. Considering *Mononykus* and *Alvarezsaurus*, MCT1718-R shows a similar angle between the scapular shaft and the coracoid, being less than 90° (remembering that although the material does not have a coracoid, its position can be confirmed by the scapula articulation).

The similarities between MCT 1718-R and *Unenlagia comahuensis* is restricted to the curvature of the shaft in anterior (and posterior) view (NOVAS & PUERTA 1997) but the Brazilian specimen differs in the orientation of the glenoid. The same is true for *Buitreraptor gonzalezorum* MAKOVICKY, APESTEGUÍA & AGNOLÍN, 2005 (MAKOVICKY et al. 2005).

Conclusions

Comparisons of MCT 1718-R with other theropod dinosaurs are limited but the overall morphology of this



Fig. 4. Theropod scapula (MCT 1718-R) from the Marília Formation in medial view. – Abbreviations as in Fig. 1. – Scale bar = 10 mm.

specimen indicates that it pertains to Tetanurae, likely to a non-avian maniraptoran.

Up to date, the only theropod named from Late Cretaceous Bauru Group of Brazil is the abelisaurid *Pycnonemosaurus nevesi*. Therefore, although the systematic position of the dinosaur represented by MCT 1718-R is not clear, the new material establishes the presence of another theropod lineage in the Bauru Group. The existence of maniraptorans in those deposits, which was previously suggested on the basis of isolated teeth and one ungual, can be confirmed.

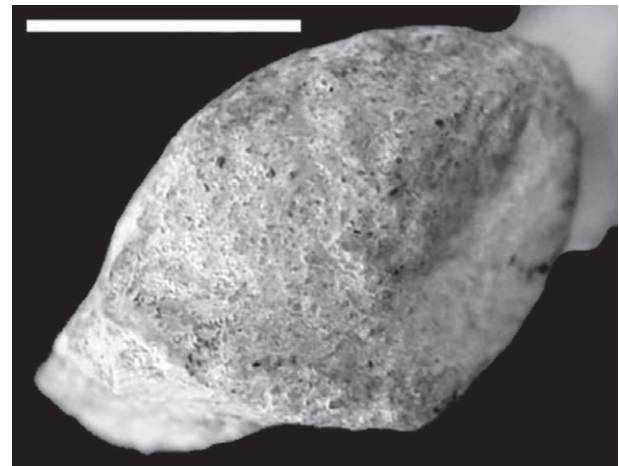


Fig. 5. Detail of the coracoidal articulation of the theropod scapula (MCT 1718-R) from the Marília Formation in proximal view. – Abbreviations as in Fig. 1. – Scale bar = 10 mm.

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