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# New post-cranial elements assigned to coelurosaurian theropods from the Late Jurassic of Lusitanian Basin, Portugal

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## Introduction

The Andrés fossil-site is one of the most noteworthy examples of an association of multiple vertebrate taxa preserved in the same quarry from the Late Jurassic of the Portuguese Lusitanian Basin. The quarry is known since the 90s decade when it was described a specimen assigned to *Allosaurus fragilis*, which constituted the first evidence of this species of tetanuran theropods out of the North American Late Jurassic (Pérez-Moreno *et al.*, 1999). Posteriorly, several systematic fieldworks were conducted, resulting on the discovery of a great amount of vertebrate remains. The fossils collected represent a diverse vertebrate fauna, including fishes, sphenodonts, crocodylomorphs, pterosaurs, and several dinosaur forms (Malafaia *et al.*, 2010). Dinosaur elements, particularly those assignable to *Allosaurus*, are the most abundant fossils. The collection of *Allosaurus* remains from Andrés includes abundant cranial and post-cranial remains of at least two individuals, which constitutes the most complete evidence of this tetanuran dinosaur known at the moment in the Portuguese record. Other dinosaur groups are represented mainly by isolated elements belonging to theropods,

sauropods and ornithopods. Among these are scarce teeth recognized as dromaeosaurid theropods. Herein, we report some caudal vertebrae of small sized theropods collected in Andrés with morphology compatible with some coelurosaurs.

The currently known Portuguese record of coelurosaurs is composed by the holotype of *Aviatyrannis jurassica* from the Kimmeridgian of Guimarota (Leiria), some isolated teeth from different Late Jurassic sites and rare elements (teeth, vertebrae and phalanges) collected in Late Cretaceous deposits (Malafaia *et al.*, 2010; Rauhut, 2003; Zinke, 1998; Galton, 1994).

## Geographic and geologic setting

The Andrés fossil-site is located in the northern sector of the Lusitanian Basin, in the Pombal municipality, central-western of Portugal (Fig. 1).

The fossils were preserved in a layer of fine micaceous sandstone with abundant vegetal remains. These levels with low-angle cross-bedding and sigmoid geometries represent filling-up of low-energy fluvial channels. The sandy bodies were intercalated by some lens of red and gray claystones, with abundant freshwater bivalves and some gastropods. The facies association in the area of the quarry indicates a medium to high-sinuosity fluvial system, with multiple channels and crevasses on an extensive floodplain (Malafaia *et al.*, 2010). These deposits are attributed to the Bombarral Formation (*sensu* Yagüe *et al.*, 2006), currently interpreted as Tithonian in age.

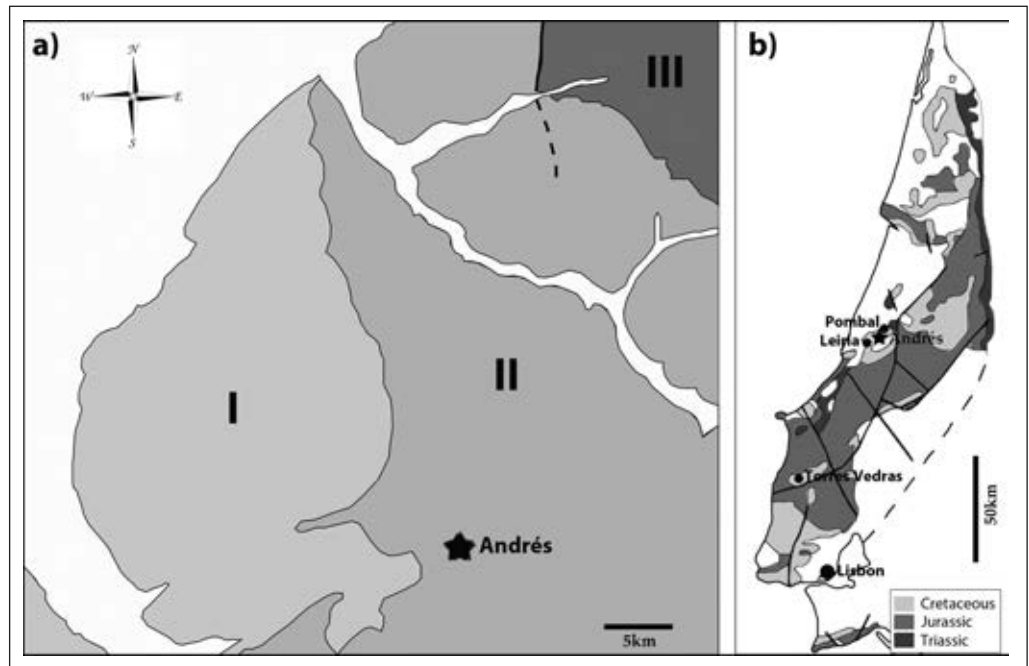
## Material and methods

The specimens herein described consist of two small sized caudal vertebrae (Fig. 2). These fossils are curated in the vertebrate paleontology collection of the Museu Nacional de História Natural e da Ciência (Universidade de Lisboa) and are identified with the acronym MNHNUL/AND.

## Description

The specimens correspond to small sized individuals (see table I).

The transverse processes are missing on both specimens suggesting that they belong to the distal end of the tail. The centra are strongly elongated

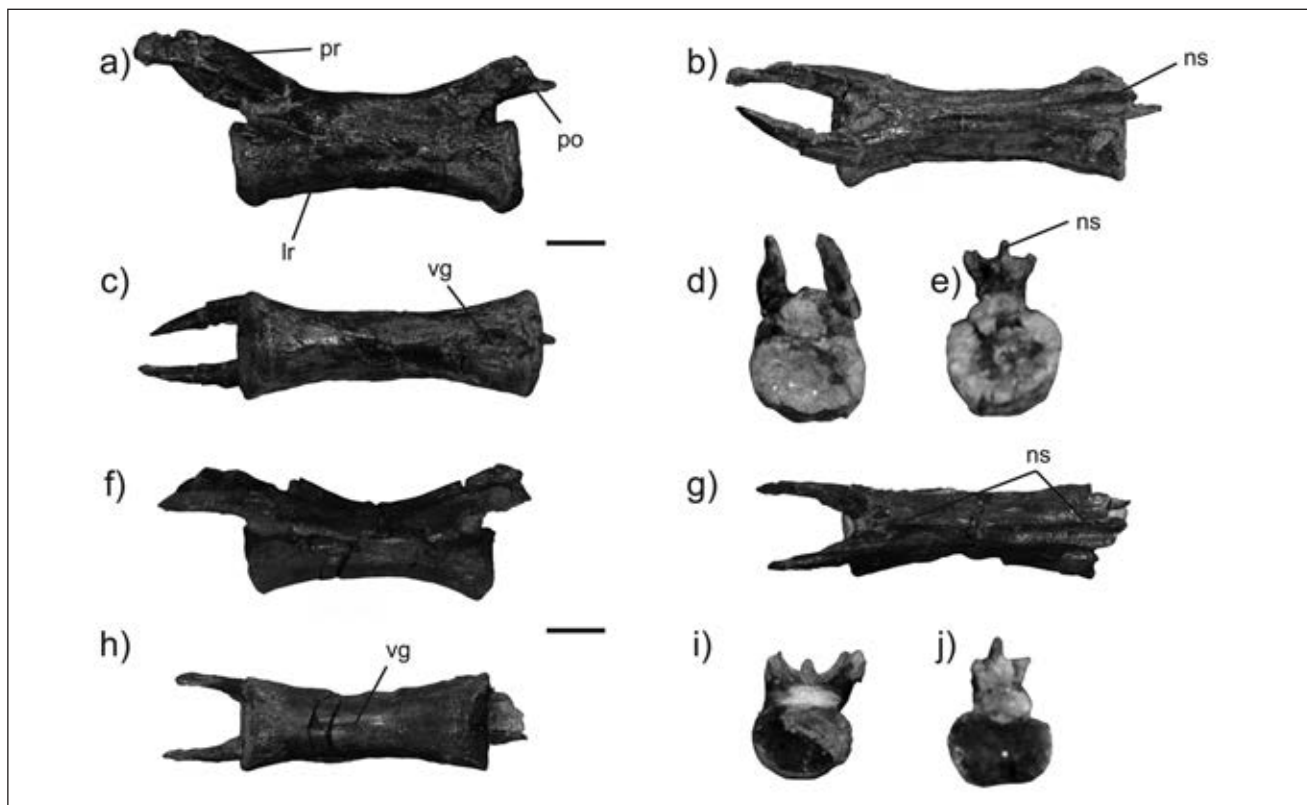


**Figure 1.** Geologic and geographic setting of the Andrés fossil-site. (A) Simplified geological map in the area of the quarry. Legend: I, Cretaceous; II and III, Late Jurassic (II, Tithonian, Bombarral Formation; III, Late Kimmeridgian – early Tithonian, Alcobaga Formation). Modified from Manuppella (1974). (B) Map of the Lusitanian Basin with the location of Mesozoic deposits.

relatively to its height and are amphicoelous. In ventral view the centra are almost straight with the articular facets only slightly offset. The ventral surfaces have shallow longitudinal grooves extending along the entire length of the centra but that are more pronounced near the posterior articular surface. Chevron facets are present but poorly developed. The specimens have oval shaped articular facets, slightly lateromedially wider than dorsoventrally high. The centrum of the vertebra MNHNUL/AND.100 has a pair of longitudinal crests, one dorsal extending along the base of the neural arch and the other along the ventral margin (Fig. 2A). A similar dorsal ridge is present on the vertebra MNHNUL/AND.101 but the ventral one is absent. The prezygapophyses are strongly elongated; its length is about 53% the centrum length. The postzygapophyses project dorsally at an angle of about 45° with respect to the dorsal margin of the centrum. On the other hand, the prezygapophyses project anterodorsally roughly parallel to the dorsal border of the centrum. A small blade-shaped segment of the neural spine is visible

**Table 1.** Measurements of the specimens described. All measures are in mm.

|                                     | MNHNUL/AND.100 | MNHNUL/AND.101 |
|-------------------------------------|----------------|----------------|
| Centrum length                      | 41             | 37             |
| Centrum height                      | 10             | 5              |
| Width of anterior articular facet   | 16             | 14             |
| Height of anterior articular facet  | 11             | 10             |
| Width of posterior articular facet  | 15             | 14             |
| Height of posterior articular facet | 13             | 10             |



**Figure 2.** Caudal vertebrae of coelurosaurian theropods from the Andrés quarry. (A) – (E) specimen MNHNUL/AND.100; (F) – (J) specimen MNHNUL/AND.101. (A) and (F) left lateral; (B) and (G) dorsal; (C) and (H) ventral views; (D) and (I) anterior articular facet; (E) and (J) posterior articular facet. Legend: lr, lateral ridge; ns, neural spine; po, postzygapophysis; pr, prezygapophysis; vg, ventral groove. Scale bar = 10mm.

between the postzygapophyses in the vertebra MNHNUL/AND.100 (Fig. 2B). The neural spine is more developed in the vertebra MNHNUL/AND.101, suggesting a more anterior position of this element despite its smaller size. In this last specimen a well developed anterior spur of the neural spine is visible between the prezygapophyses (Fig. 2G).

## Discussion

The vertebrae previously described are identified to Theropoda on the basis of their strongly elongated centra with slightly concave articular facets. The morphology of the two vertebrae is similar and both are assigned to the same morphotype. The general morphology of these specimens is fairly similar

to distal caudal vertebrae identified to *Allosaurus* and they share with this taxon the great elongation of the centra relative to its height, and the presence of long prezygapophyses (Madsen, 1976). However, there are also striking differences. The specimens herein described have the ventral surface of the centra almost straight in lateral view whereas the posterior caudal vertebrae of *Allosaurus* are strongly arched ventrally. Besides, the posterior caudal vertebrae of *Allosaurus* lack the longitudinal ridge present on the lateral surfaces of these specimens.

The small vertebrae herein described have strongly elongated prezygapophyses, extending more than half of the centrum length, as is typical of most coelurosaurs. The presence of a bifurcated neural spine is

a character shared by many theropods including tetanurans as *Allosaurus* or *Acrocanthosaurus* and coelurosaurs as *Sinosauropteryx* (Currie and Chen, 2001; Currie and Carpenter, 2000; Madsen, 1976). Although, a similar bifurcated neural spine was not reported in compsognathids as *Compsognathus* (Peyer, 2006). The specimens from Andrés also share with some maniraptoran theropods the presence of distinct longitudinal ridges along the lateral surface of the centra and the oval shape of the articular facets with significantly greater transverse width than height (Carpenter *et al.*, 2005; Rauhut and Xu, 2005).

These specimens from Andrés generally resemble some small vertebrae described by Galton (1994) from the Late Cretaceous of Viso (Figueira da Foz, Portugal) and assigned to maniraptoran theropods. The specimens from Andrés share with these vertebrae from Viso the presence of longitudinal ridges on the lateral surface of the centra and the almost straight ventral margin of the very elongated centra.

## Conclusion

The vertebrae previously described present a set of morphological characters that allows its identification to Coelurosauria theropods and within this clade they may be tentatively assigned to Maniraptora based on the presence of a distinct lateral ridge. These specimens corroborate the presence of small derived theropods in the Andrés quarry, which was previously suggested based on some isolated teeth. The new specimens are the only post-cranial elements identified to this group of theropods known at the moment in the Andrés collection and one of the few coelurosaurian specimens in the Late Jurassic record of the Lusitanian Basin.

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