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## STUDY OF SMALL THEROPOD DINOSAUR TEETH FROM THE ANDRÉS FOSSIL SITE (UPPER JURASSIC OF PORTUGAL)

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### ABSTRACT

The Andrés fossil record reveals a rich and diverse Late Jurassic vertebrate fauna from the Lusitanian Basin. The most abundant are dinosaur remains, represented by sauropods, ornithopods, and theropods. Here, we present a taxonomic study of six isolated theropod teeth from this locality, based on morphometric and phylogenetic methods. Five of these teeth are assigned to small dromaeosaurids, and a small tooth crown is interpreted as belonging to a juvenile *Allosaurus*.

*Keywords:* Andrés, Theropoda, Kimmeridgian-Tithonian, Morphometrics, Cladistics.

### 1. INTRODUCTION

The Upper Jurassic dinosaur record from the Lusitanian Basin is abundant, including bones, teeth, footprints, and gastroliths. Theropods are represented by medium to large sized-taxa, most of them closely related to taxa described in the North American Morrison Formation (*e.g.* Pérez-Moreno *et al.*, 1999; Hendrickx & Mateus, 2014), although some taxa have been considered endemic of the Portuguese Late Jurassic (*e.g.* Mateus, 1998; Malafaia *et al.*, 2020). A great diversity of small theropods have also been described, mostly represented by fragmentary specimens. One of the most important localities for the study of Late Jurassic vertebrates is the Guimarães mine (Leiria), where several groups of theropods were described, including ma-

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terial referred to the possible tyrannosauroid *Aviatyrannis jurassica* and a small maxilla interpreted as belonging to a hatchling *Allosaurus*, together with a diverse collection of isolated teeth attributed to Compsognathidae, Troodontidae, Dromaeosauridae, *Richardoestesia*, and *Paronychodon* (e.g. Zinke 1998; Rauhut, 2000, 2003; Rauhut & Fechner, 2005). Andrés (Pombal) is another important Late Jurassic fossil site, with a high diversity of vertebrates, including fishes, sphenodonts, crocodylomorphs, pterosaurs, and several dinosaur groups. The theropod fossil record from this locality mostly consists of material of *Allosaurus*, including the first specimen attributed to this taxon found outside North America (Pérez-Moreno *et al.*, 1999) and some isolated teeth attributed to indeterminate dromaeosaurids (Malafaia *et al.*, 2010).

In this work we studied a set of isolated theropod teeth from Andrés based on morphometric and phylogenetic methods to approach their taxonomic identification. Further, we have been testing different tools to study dental wear and palynological analyses have been also carried out, to study the paleoecology of these Late Jurassic theropods.

## 2. MATERIALS AND METHODS

The material studied consists of six isolated theropod teeth collected in the Andrés fossil site. The quarry is located in the parish of Santiago de Litém (Pombal municipality), approximately 170 km north of Lisbon. These deposits, essentially composed of fine and micaceous sandstones containing some coal remains and intercalated with brown and reddish lens of clays, have recently been interpreted as belonging to the Bombarral Formation, whose age is considered to be Kimmeridgian to lower Tithonian (Manupella *et al.*, 2000; Malafaia *et al.*, 2010).

Different methods were used to support the taxonomic identification of the teeth, including discriminant and cladistic analyses. For the discriminant analyses we followed the methodology proposed by Smith *et al.* (2005) and Hendrickx *et al.* (2020) and we used the dataset published by the latter. To obtain a better visualization of the results, we reduced the dataset to taxa identified in Upper Jurassic records. For the cladistic analyses we used the updated version of the data matrix with 146 characters published by Hendrickx *et al.* (2020) and followed the methodology described by the authors. We codified MNHN/UL.AND.206, MNHN/UL.AND.208, MNHN/UL.AND.212 as lateral teeth and MNHN/UL.AND.26, MNHN/UL.AND.209, MNHN/UL.AND.213 as mesial teeth, based on the shape of the basal cross section and the relative position of the denticulated carinae.

## 3. RESULTS AND DISCUSSION

The specimens studied are small and well-preserved tooth crowns, with a height between 2,79 and 12,83 mm and crown base length ranging from 2,57 to 9,46 mm (Fig.1).

A few specimens are somewhat distorted, incomplete, and show large wear surfaces, so the codification of some characters is not possible, which could explain the polytomies recovered in the cladistic analyses. MNHN/UL.AND.213 presents similarities to an indeterminate small theropod tooth from Guimarota (Zinke, 1998), such as the serrated distal carina mostly labially positioned, the rounded basal cross-section and a slight recurvature. MNHN/UL.AND.209 presents the most strongly recurved and elongated crown of all studied morphotypes. The lingual surface is almost flat, and the labial one is strongly convex. The denticulated distal carina with asymmetrically convex apical denticles and the absence of mesial denticles, at least in the preserved part of the crown, allow us to tentatively assign this tooth to Velociraptorinae (Hendrickx *et al.*, 2019). This latest feature is also present in the tooth MNHN/UL.AND.208, recovered as an indeterminate Coelurosauria. This latter specimen has a strongly compressed crown, with asymmetrically convex denticles and a relatively strong curvature, which are features typical of Dromaeosauridae teeth, being here tentatively related to Velociraptorinae (*e.g.* Larson & Currie, 2013; Hendrickx *et al.*, 2019). The tooth MNHN/UL.AND.212, also presents the lingual surface more flattened than the labial one (although not so evident as in MNHN/UL.AND.209), the distal denticles are elongated mesiodistally and with rounded distal margins, the crown is strongly recurved, and the mesial carina is absent, at least in the preserved part of the crown, which is compatible with the dentition of Velociraptorinae (*e.g.* Krumeacker *et al.*, 2016; Hendrickx *et al.*, 2019).



Figure 1. Selected isolated theropod teeth from the Upper Jurassic of Andrés: MNHN/UL.AND.206 (A, B, C, J), MNHN/UL.AND.213 (D, E, F, K) and MNHN/UL.AND.212 (G, H, I, L) in lateral (A, D, G), mesial (E, H), distal (B) views, basal cross section (J, K, L) and distal denticles (C, F, L). Scale bar: 2 mm (A, B, D, E, G, H, J, K, L) and 500  $\mu$ m (C, F, I).

The tooth recovered as a dromaeosaurid (MNHN/UL.AND.206) is similar to Dromaeosaurinae teeth, presenting serrated mesial and distal carinae and  $DSDI > 1,2$  (*e.g.* Hendrickx *et al.*, 2019). The tooth MNHN/UL.AND.206 has denticulated mesial and distal carinae, with the latest extending beneath the cervix and strongly labially deflected, and short and poorly developed

interdenticular sulci, which is a combination of features present in Allosauridae (Hendrickx *et al.*, 2019). Although this tooth is significantly smaller, it is similar to some lateral teeth of *Allosaurus* from Andrés, possibly corresponding to a juvenile specimen. The results obtained in both analyses for this tooth may be explained by the absence of juvenile specimens in the original dataset.

The discriminant analyses classified four teeth as dromaeosaurids, one as a basal coelurosaurian (MNHN/UL.AND.209) and one as a piatnitzkysaurid (MNHN/UL.AND.206). The cladistic analyses recovered only one tooth as dromaeosaurid (MNHN/UL.AND.26), two as non-tyrannosaurid Tyrannosauroidae (MNHN/UL.AND.206 and MNHN/UL.AND.212), one as an indeterminate Coelurosauria (MNHN/UL.AND.208), and two on a polytomy with other early-branching theropods (MNHN/UL.AND.213 and MNHN/UL.AND.209).

#### 4. CONCLUSIONS

Some isolated teeth studied in this work show non denticulated mesial carinae, which is a feature shared with some velociraptorines. In most other specimens that have mesial denticles, the denticles density is higher in the mesial carina than in the distal one ( $DSDI > 1,2$ ), a feature typical of the dentition of dromaeosaurids. Based on these features and the results obtained in the morphometric and cladistic analyses performed, these teeth are here attributed to Dromaeosauridae. MNHN/UL.AND.206 is the only specimen in this sample assigned to a non-dromaeosaurid theropod. This specimen is interpreted as belonging to a juvenile *Allosaurus*, based on the similarity with other isolated teeth collected in Andrés, sharing, for example, the presence of denticulated mesial and distal carinae with the distal one extending beneath the cervix, a strongly labially deflected distal carina, and poorly developed interdenticular sulci.

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