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Cranial Sinuses of Bovidae from Late Miocene of Greece

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Cranial morphology of Late Miocene bovid species is presented, as part of a greater project, with the use of computed tomographic methods. The non-destructive nature of this method allows (3D) digital representation of cranial internal features of fossilized material in high resolution, thus giving the unique opportunity to examine otherwise inaccessible parts of the skull.

The cranial internal structures of fossilized mammals are to this day one of the most poorly described features. Most studies of internal morphology concern extant species and the majority of them have focused on primates (Rae and Koppe, 2003; Farke, 2007, Rae, 2008; Kostopoulos *et al*., 2018; Miguel *et al.*, 2018). Indeed, cranial sinuses – air-filled chambers resulting from the removal of bone by a pneumatic diverticulum – have yet to be studied for fossil taxa in order to assess their functional role (Edinger, 1950; Farke, 2010). Frontal sinuses, as part of the paranasal sinuses, are believed to form as pneumatic spaces that develop opportunistically where bone is not mechanically necessary, leading to reduction of the skull mass and so improvement of its performance (Curtis *et al*., 2014). Their function is not well understood, it has been suggested that frontal sinuses might aid the absorption of shock and/or dissipation of stress during feeding and combat (Badlangana *et al.*, 2011; Farke, 2008; Snively and Theodor, 2011; Alsafy *et al.*, 2013; Curtis, 2014).

Fossil bovids from the Late Cenozoic are studied in order to extract data that will clarify the mysterious functions and evolutionary development of internal cranial features. Bovidae are used because of the exceptional diversity in cranial characters in terms of size and shape, which consists an excellent opportunity for identifying the most important morphological aspects. Furthermore, the Late Cenozoic consists a period with major climatic changes and variations, which put these animals under big selective pressure. Therefore, the most successful animals were those that were adapted to specific conditions, which possibly led to their diversification.

This project is extensively using X-ray computed tomography. The skulls of several bovid species were chosen to be subjected to CT imaging. This method was chosen because it is the only high-resolution and non-invasive/non-destructive one available that provides information to inaccessible areas and structures of the skull. Additionally, it gives the opportunity to work on available Museum/University specimens, thus providing more information to the final results. Therefore, a Philips CT 64-slice tomographer from the Konstantopouleio General Hospital ‘Agia Olga’ and an Optima LG CT 64-slice tomographer from the University General Hospital of Thessaloniki ‘AHEPA’ were used. The CT data obtained are imported to advance imaging software (Avizo 8.1 and Mimics) to provide the digital reconstructions of the skulls internally and externally, that allow all digital measurements, volumetric and linear ones.

The results will consist a base for further studies on other groups of mammals, both for the identification of the most useful morphological characters, and for the establishment of a novel methodological framework for this type of work. Lastly, the phylogenetic relationships of bovids will be analysed and provide an explanation of the morphological diversity of the recent species of the group.

Herein we present an example of certain specimens that reveals these sinuses in their entity, and we comment on the expectations of this project in terms of interpreting the function of these features and whether these features add on phylogenetic interpretations.

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