THE INFLUENCE OF SKULL SHAPE MODULARITY ON INTERNAL SKULL STRUCTURES: A 3D-PILOT STUDY USING BEARS

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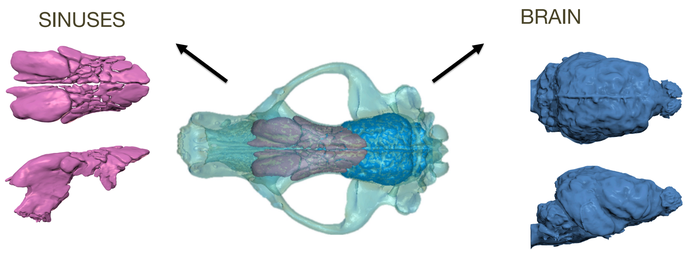
INTRODUCTION

The internal skull structures, such as the sinuses or the brain are usually studied using CT scans.

Therefore, the morphology of these internal structures have been comparatively less studied than the external morphology of the skull.

We explore sinuses and brain shape variation related to external skull shape modularity and we assess if these internal structures of the skull could be studied analyzing solely the external shape

We use the family Ursidae (Carnivora, Mammalia) as study case



MATERIAL & METHODS

We digitized a set of landmarks in 3D with a Microscribe G2X

The skulls of seven bear species were CT-scanned

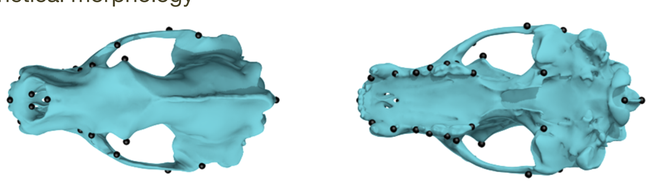
We divided the landmarks in two modules (splanchnocranium and neurocranium) following previously published articles

We perform a 2B-PLS to explore the intraspecific (static) morphological changes in the skull of bears with the software *MorphoJ*

The external changes plus the associated variation for the sinuses and the brain accounted for the first three PLS axes were visualized by creating 3D models at the extremes of each axis using the morphing technique in the software *Landmark* (IDAV)

Models for the external shape plus the sinuses and the brain for each axis were created with each of the seven CT scans to explore if the associated internal shape variation depends on the CT scan used

We also calculated the volumes of the sinuses and the brain for each hypothetical morphology



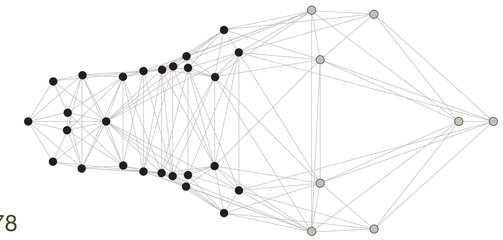
Landmarks digitized

RESULTS & DISCUSSION

1

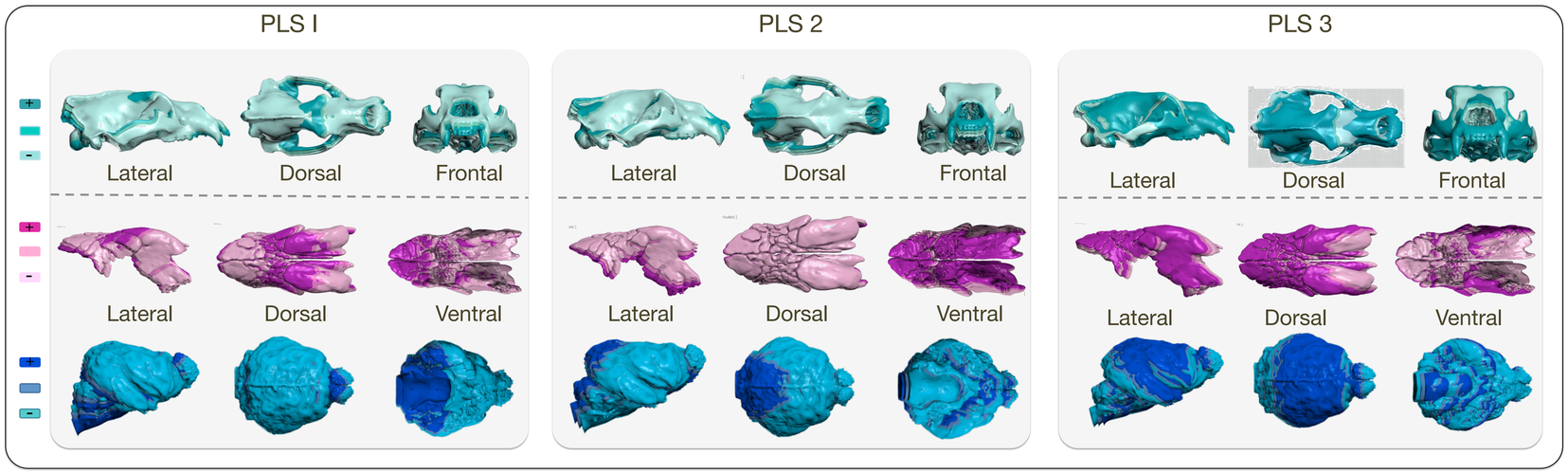
The MODULARITY TEST indicates that the neurocranium and the splanchnocranium are two real modules in each bear species

RV coefficient = 0.294 ; P = 0.0078



2

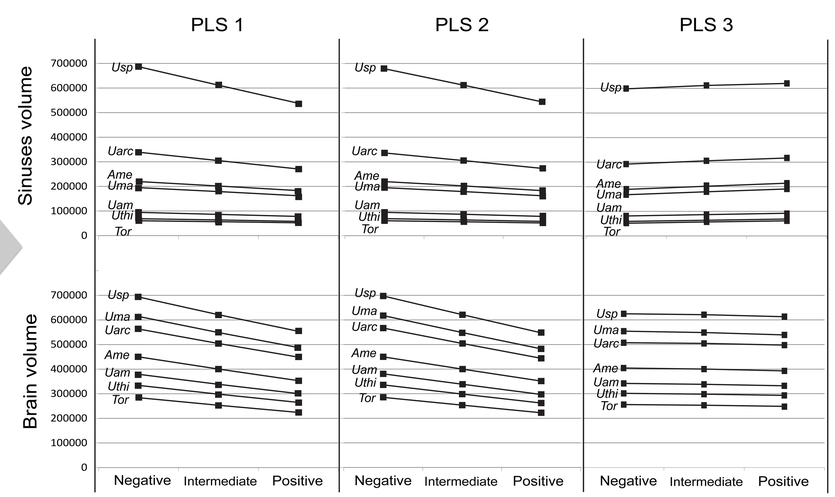
THE 2B-PLS ANALYSIS reveals that the three first PLS axes are associated externally with changes in basicranial angle, face length and skull height and width. The associated changes in the sinuses and the brain with these external shape variation, using a CT of a brown bear, are shown below as an example



3

THE ESTIMATED VOLUMES OF THE SINUSES AND THE BRAIN USING THE CT SCAN FOR EACH BEAR SPECIES FOLLOW THE SAME TREND IN EACH PLS AXIS

This indicates that changes in the internal structures associated with the external shape do not depend on the CT scan used to create the 3D models of the extreme shapes in each PLS axis



CONCLUSIONS

We can extend morphological interpretations of external skull shape modularity to internal structures

In this particular case we have obtained that the external shape variation accounted for the first two PLS axes is accompanied by parallel changes in volume expansion of sinuses and brain. However, the third PLS axis account for an opposite trend in the volume expansion of sinuses an brain