Reanalysis of morphological data supporting *Spinosaurus* as a generalist, near-shore wader

Introduction

Spinosaurus is one of a rare few non-avian dinosaurs that have been suggested to be semi-aquatic [1]. Recent work has provided solid morphological (shape) evidence suggesting *Spinosaurus* hunted in shallow water, catching prey in a manner reminiscent to modern storks as opposed to hunting submerged in the water like dolphins [2]. Here we aim to evaluate these claims with data by comparing skull morphology between a number of terrestrial, semi-aquatic and marine groups to that of *Spinosaurus*.

Materials and Methods

- 100 taxa across 9 clades were sampled and grouped by both clade and ecology (terrestrial, semi-aquatic, or marine).
- 6 measures were taken of the skull of each taxa: skull length, width, height, distance of naris to anterior and dorsal margins, and distance of orbit to dorsal margin.
- Body size was controlled by calculating a geometric mean of each skull, using that to create a 'Mosimann shape variables' which were then log transformed [3].
- Principal component (PC) analysis was performed on 93 taxa (7 lacked at least 1 measurement) the logged data and a morphospace plot created. MANOVAs were performed to test separation of clades and ecologies.
- Cluster analyses (classical and K-means (K=3)) were performed to group the most similar taxa.

Discussion

- The inability to separate *Spinosaurus* from other theropods and marine taxa, in both cluster and PC analyses, despite each having very distinct skull shapes [1,4,5] (Fig. 2), suggests our measurements failed to capture aspects of skull morphology linked to ecology.
- Possibly due to using only 6 measurements, with high variance [6], or due to some measures having small absolute values [7].
- Body size seeming to be the primary clustering factor suggests size information persisted in our data despite controlling for it in two ways [3].

Conclusion

Future studies seeking to explore ecology through skull morphology should examine different measurements in an attempt to find those which carry more ecological information than those used here.

The persistence of size information in log transformed Mosimann shape data is concerning, as this is a common method to control for body size in the absence of reliable size estimates, and should therefore be investigated further.

Results

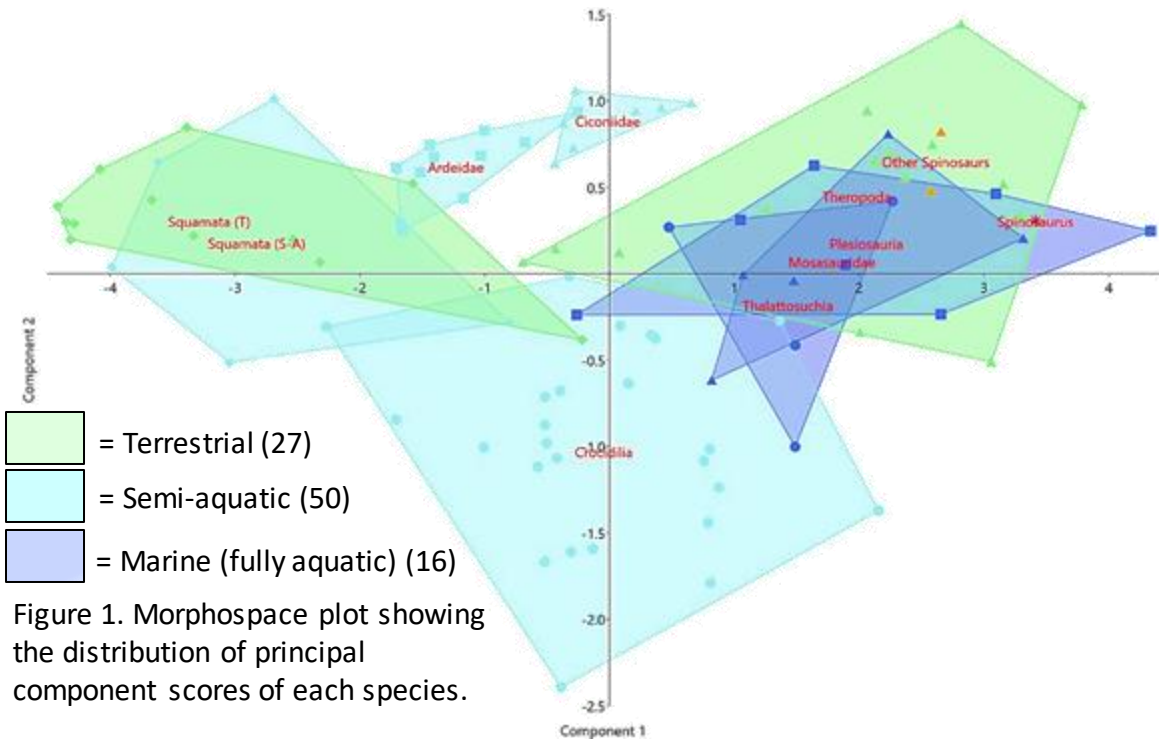
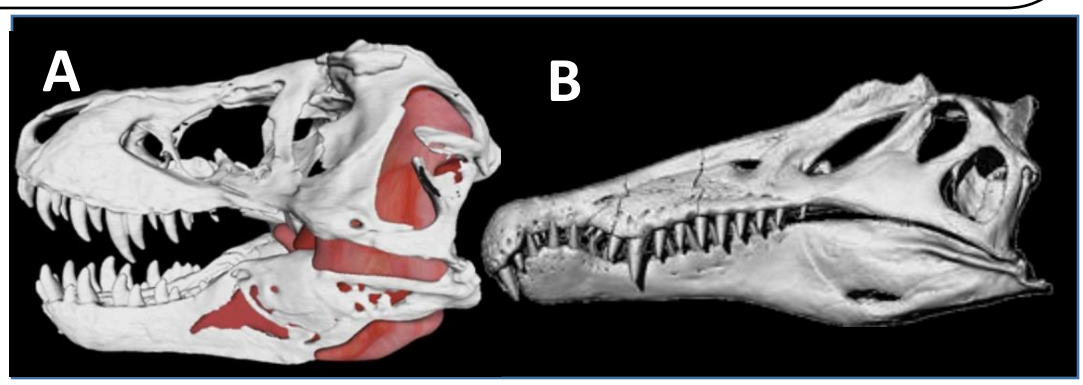


Figure 1. Morphospace plot showing the distribution of principal component scores of each species.

PC1 was influenced approximately equal by all variables, PC2 was dominated by distance from naris to ant. margin and orbit to dor. margin.

Spinosaurus and kin's morphology fell within morphospace occupied by theropods and overlapped with that of marine taxa (Fig. 1). All ecologies were statistically distinct ($p < 0.001$). Only crocodilians were significantly different than Spinosaurs ($p < 0.01$).

All cluster analyses dominated by body size, showing minimal ecological signal.



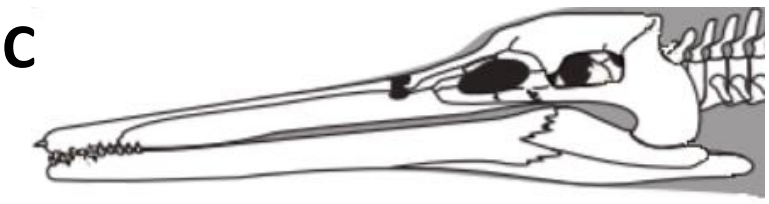


Figure 2. Skulls of (A) the terrestrial theropod *Tyrannosaurus rex* [4], (B) *Spinosaurus* [1], and (C) the marine plesiosaur *Luskhan* [5].

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