

## Macroevolutionary and morphofunctional patterns in theropod skulls: A morphometric approach

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Theropod dinosaurs are one of the most remarkable lineages of terrestrial vertebrates in the Mesozoic, showing high taxonomic and ecological diversity. We investigate the cranial diversity of non-avian theropods and some basal birds, using geometric morphometrics to obtain insights into the evolutionary modifications of the skull. Theropod skulls mostly vary in the shape of the snout and length of the postorbital region (principal component [PC] 1), with further variation in orbit shape, depth of the postorbital region, and position of the jaw joint (PC 2 and PC 3). These results indicate that the cranial shape of theropods is closely correlated with phylogeny and dietary preference. Skull shapes of non-carnivorous taxa differ significantly from carnivorous taxa, suggesting that dietary preference affects skull shape. Furthermore, we found a significant correlation between the first three PC axes and functional proxies (average maximum stress and an indicator of skull strength). Interestingly, basal birds occupy a large area within the morphospace, indicating a high cranial, and thus also ecological, diversity. However, we could include only a small number of basal avialan species, because their skulls are fragile and there are few good skull reconstructions. Taking the known diversity of basal birds from the Jehol biota into account, the present result might even underestimate the morphological diversity of basal avialans.

**Key words:** Theropoda, geometric morphometrics, macroevolution, feeding ecology, biomechanics, avian evolution, Mesozoic.

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