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Evolutionary and ontogenetic skull variation among birds and their closest relatives

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Birds, the only surviving branch of the theropod dinosaurs, are one of the most species-rich extant vertebrate clade with more than 10,000 species. They show a great diversity in terms of size, color, shape and ecology, occupying almost all habitats on Earth. Compared to their ancestors, the skull of living birds is characterized by a toothless beak, enlarged round orbits, a complex kinetic system, a highly pneumatized skull, and an extreme fusion of bones. Beside the morphological studies of fossil birds, one key source for understanding the evolutionary history of the bird skull is their ontogeny, which describes the developmental history of an individual organism from fertilization to death. The prenatal development of birds has been extensively studied on the basis of a handful of species, whereas processes that occur during postnatal development are poorly documented so far. The aim of this thesis is to obtain a deeper understanding of the postnatal ontogenetic variation of avian skulls, in order to obtain better insights into the origin and evolution of bird skulls.

To do so, I first investigated and described the morphology and ontogenetic variation in the skull of two bird species with different developmental mode and ecology: Pica pica and Struthio camelus using 3D reconstructions based on CT scans. Using geometric morphometrics and multivariate statistics, I investigated the impact of allometry on the shape variation of the vomer to highlight the influence of size on shape, which is crucial for both taxonomic and ontogenetic analyses. By comparing the sutural closure of multiple bird species, using univariate and multivariate statistical analysis, I demonstrated that skull bone fusion follows a common across bird species and can be used as a proxy for the ontogenetic stage. Here, I showed that the speed of the bone fusion is significantly different between altricial and precocial birds, confirming previous studies on growth patterns as well as egg and hatchling size of birds. Finally, to explore the origin of the skull bone fusion, I compared the skulls of multiple juvenile and adult extant bird species with those of non-avian dinosaurs and Alligator mississippiensis, using anatomical network analysis. The results reveals that the bone organization of juvenile birds resembles the one of their non-avian ancestors and that bird have a peramorphic skull with respect to their ancestors regarding bone organization.

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