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## Facial Reduction across Three Representative Taxa: A Geometric Morphometric Approach

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Facial reduction is a phenomenon described extensively in the evolutionary, clinical, and veterinary literature. Despite the fact that this phenomenon applies to a variety of species and can even be found in the clinical medical and veterinary literature (midfacial hypoplasia, craniosynostosis conditions, etc.), it has not been analyzed comprehensively using a geometric morphometric approach. The goal of this study was to improve our understanding of facial reduction as both an evolutionary process and as the result of selective breeding. Three representative taxa (bats, primates, and dogs) were selected for this project for their presence of both a normocephalic and brachycephalic morphotype. Bats and primates evolved their facial reduction as the result of natural selection and other evolutionary processes over a long period of time with a large amount of genetic diversity. Dogs, on the other hand, developed their squished-face morphotype over the space of a few thousand years. Despite this fact, dogs have been proposed as a model for evolutionary facial reduction. Although dogs were able to achieve similar—if not more pronounced—facial reduction, they did so in a completely different way than bats and dogs. This project included the analysis of specific patterns of localized shape change across these representative three taxa. The impact of this facial reduction on the soft tissue structures of the skull—namely, the brain—was assessed through the study of canine endocasts. We analyzed all three taxa through the analysis of six previously-established modules. These modules include the six main areas proposed by Goswami (2006): face, orbit, oral, zygomatic, cranial vault and cranial base. Modularity and integration were evaluated for these modules in order to better understand the constraints present during facial reduction. Finally, both global and modular facial reduction were analyzed in the three representative taxa using geometric morphometric analysis. Despite being proposed as a model of evolutionary facial reduction, dogs demonstrate major differences in cranial morphology as the result of selective breeding processes. Furthermore, facial reduction that is the result of evolutionary processes is not consistent between bats and primates, and instead, bats share much of their cranial morphology in common with dogs. Overall, it is clear that facial reduction is a multi-faceted morphological phenomenon of evolutionary significance.

Goswami, A. (2006). Cranial modularity shifts during mammalian evolution. *The American Naturalist*, 168(2), 270-280.

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