Cranial shape changes with age in male and female adults of *Papio*

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Introduction

Ontogenetic changes to skull shape throughout adulthood in primates are rarely researched in comparison to those occurring earlier (Bramblett, 1969; Joganic and Heuze, 2019). In this study, we used geometric morphometric methods (GM) to investigate the effect of age on cranial shape after reaching adulthood, which is important for a better comparison of fossil specimens of differing ages, age estimation in forensic anthropology, and understanding of the aging process.

Methods

- Forty-five landmarks digitized using a Microscribe-3DX on 347 wild-collected baboon crania (Table 1; Fig. 1; Frost et al., 2003).
- Upper third molar wear used as a proxy for ontogenetic age, based on the approach of Delson (1973) using a scale from 0 to 16 (Fig. 2), then added 1 to the wear stage and transformed them by the natural logarithm.
- Generalized Procrustes analysis to superimpose the landmark configurations and standardize them for geometric size, position and orientation.
- Adjusted for size and sex through multivariate regression analysis, then regressed the adjusted coordinates against wear stage, in order to test for a significant age effect; all statistical analyses were performed in MorphoJ (Klingenberg, 2011).

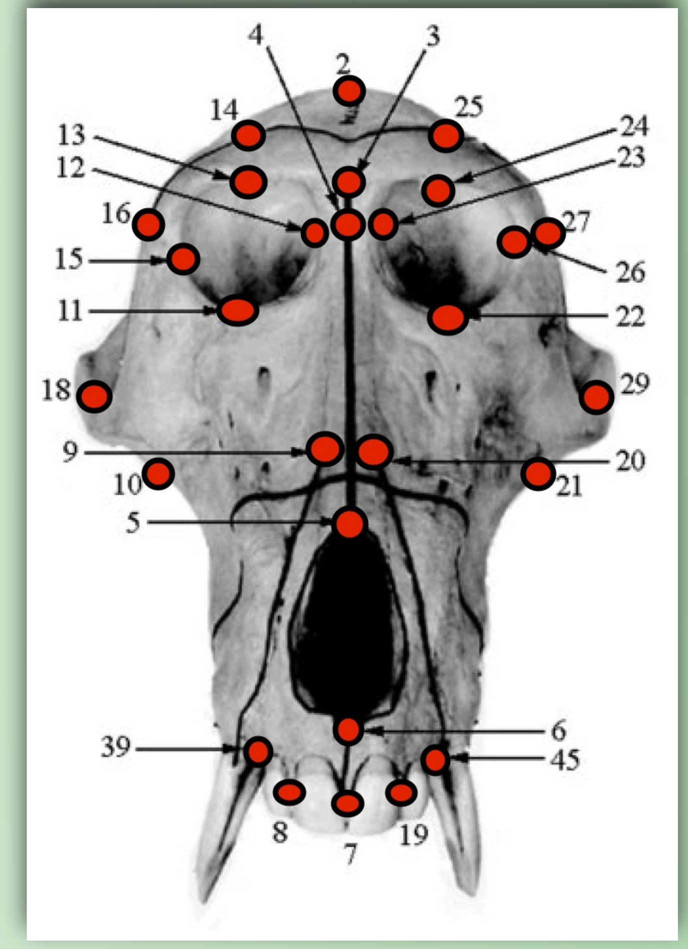


Fig 1. A Hamadryas Baboon skull (Papio hamadryas ursius, male) with 29 of the 45 landmarks, indicated by the red dots.

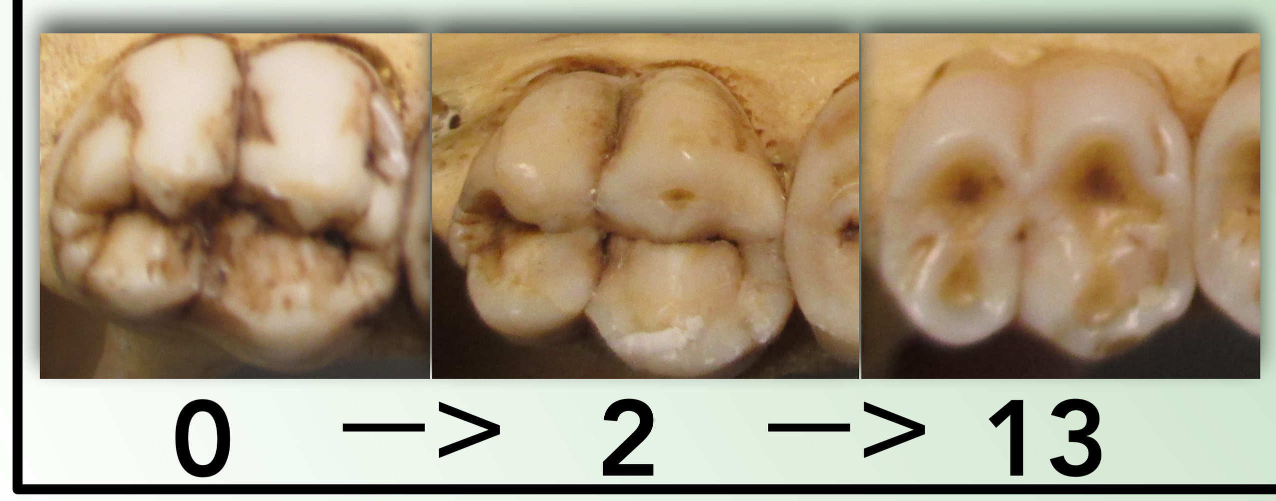
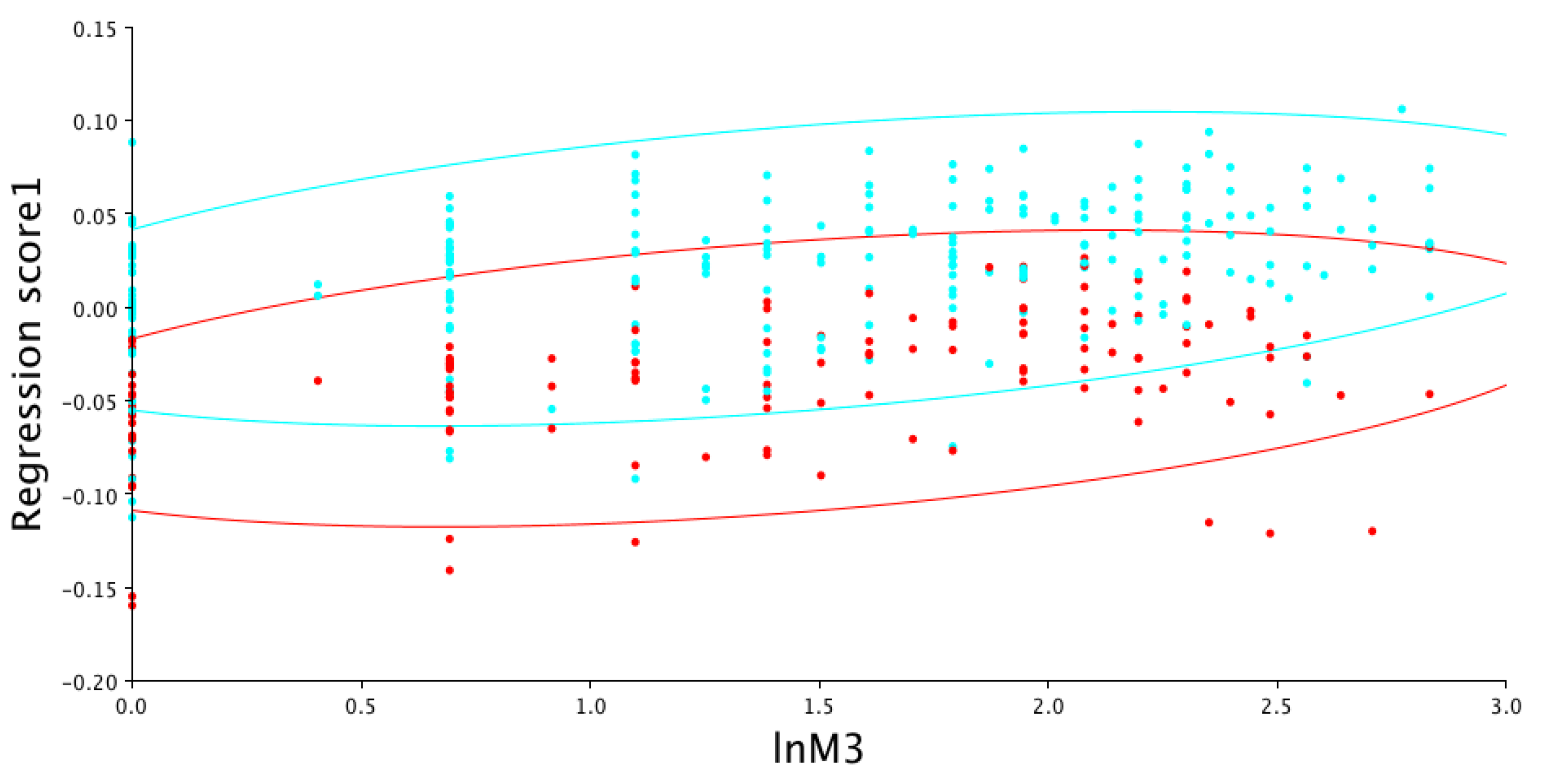


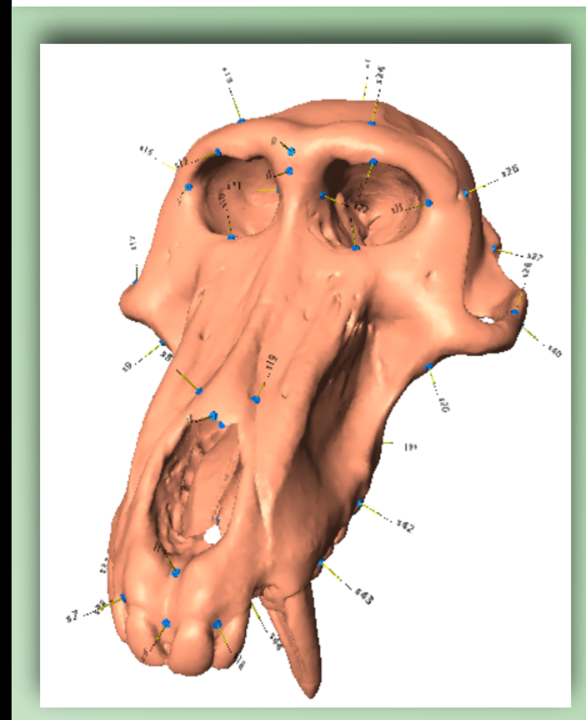
Fig 2. M3 wear from left to right: B. Score of 0, B. Score of 2, D. Score of 12. Specimens located at the American Museum of Natural History.

Table 1. The number of specimens in each taxa used in the project, consisting of 6 subspecies of *Papio;* majority of the dataset were males

Taxon	Males	Females	Both
Papio hamadryas anubis	85	39	124
Papio hamadryas cynocephalus	14	9	23
Papio hamadryas hamadryas	21	2	23
Papio hamadryas kindae	5	7	13
Papio hamadryas papio	15	1	16
Papio hamadryas ursius	80	68	148
Total	221	126	347

Fig 3. A regression score plot with sex-specific taxon and mean centroid size on the y-axis, and M3 wear on the x-axis. Females are in red and males are in blue.





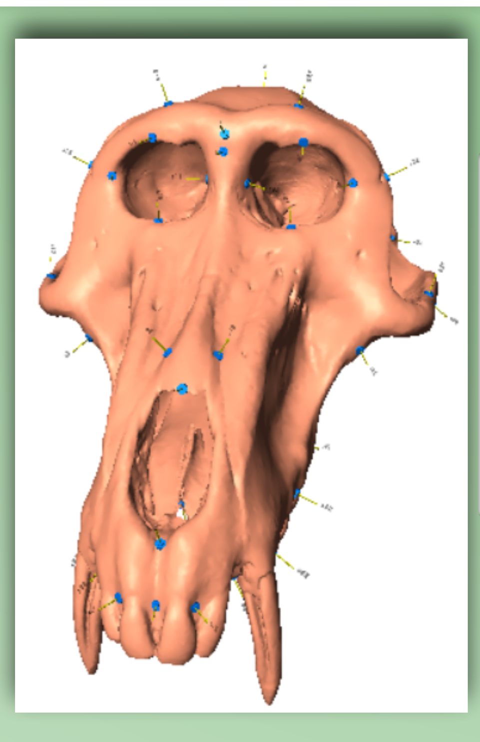
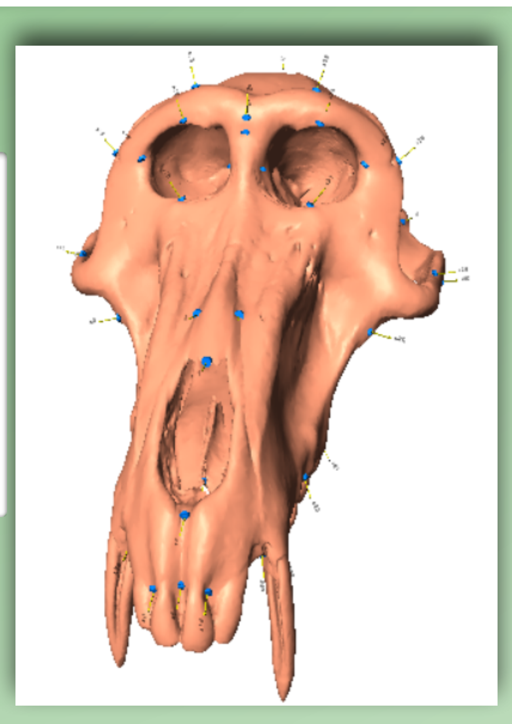


Fig. 4 (left) Cranial scan using the consensus individual's landmarks; (center) Scan warped to show aging affects halfway on the Fig. 3; (right) Scan warped to show maximum aging effects on Fig. 3 with each landmark multiplied by 5. Effects are so subtle that multiplying the data would better show the differences in skull shape.



Results

Cranial shape was highly correlated with molar wear, even after we accounted for sex and size differences. The effect is subtle, however with allometry accounting for approximately 42% of total variance, and sex an additional 4%,whereas molar wear accounted for 4.5% . There was no interaction between molar wear and sex; males and females appear to age similarly (Fig. 3). Coefficients from the regression of molar wear on cranial shape were used to visualize the shape (Fig. 4). The orbitals and supraorbital torus appear to recede posteriorly, while the pre-maxillae and maxillae become anterior-posteriorly longer and shifted.

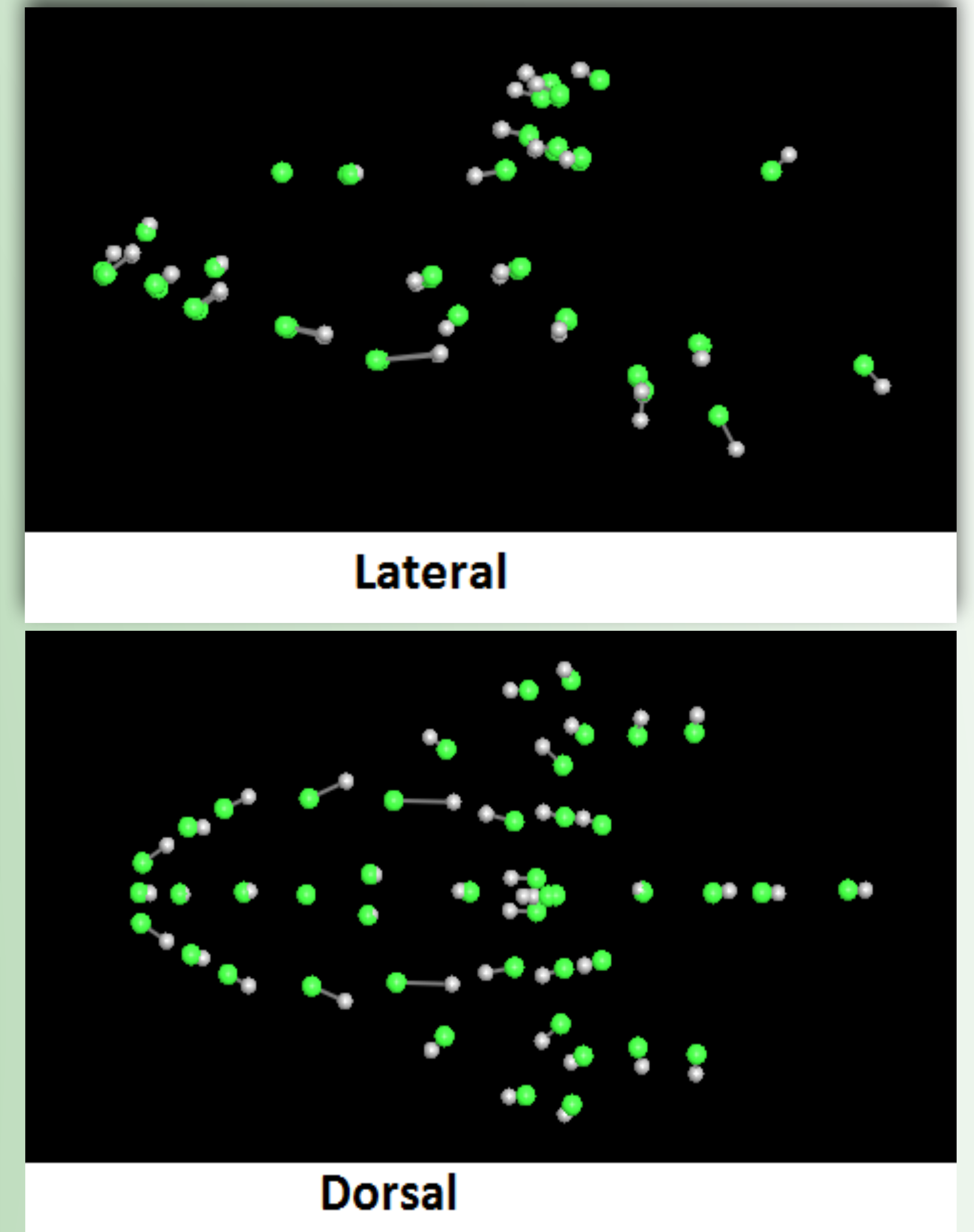


Fig 5. Diagrams displaying the positive and negative vectors calculated from the sum of the consensus individual and the regression coefficients. The grey points are the negative vectors and the green points are the positive vectors.

Discussion

Age, as measured by molar wear, has a clear but subtle effect on skull shape during the adult stage of life. Understanding these changes can facilitate more informed comparison of rare fossil crania. Further investigation will be required to determine the causes of these age-related shape changes.

Acknowledgments

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