Structural and material compliance in the alveolar process of colobine mandibles.

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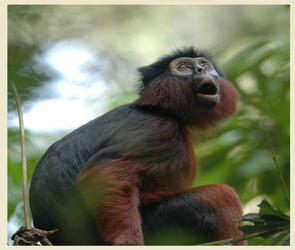
Problems associated with mandibular morphology

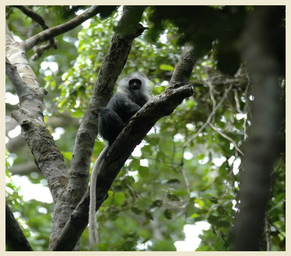
- Modeling stress and strain in the facial skeleton requires an understanding of the material properties of bone.
- Comparative models implicitly assume all bone is structurally and materially identical throughout the face (Daegling and Hylander 2007).
- The alveolar process of the mandible may be more prone to stress concentrations than the basilar portion.
- These observations suggest that greater compliance of alveolar bone is biomechanically advantageous for mitigating stress concentrations.
- Material or structural inhomogeneity (e.g., mineralization versus porosity) may account for how alveolar bone is able to resist stress concentrations.
- Existing data conflict over the relative stiffness of alveolar bone in the primate mandible.

Ecomorphology of West African colobines

Daegling and McGraw (2001) compared the jaws of sympatric colobines from West Africa to test the effect of diet on mandibular form. The Upper Guinea Red Colobus (*Procolobus badius badius*) and the Western Pied Colobus (*Colobus polykomos polykomos*) are comparable in body size and occupy the same habitat yet differ in diet primarily due to the exploitation of hard seeds by *C. polykomos* (Korstjens et al. 2007). Daegling and McGraw (2001) predicted that *C. polykomos* was expected to possess more robust mandibular form than *P. badius*. From their results, they found that the jaws of *C. polykomos* did not differ consistently from those of *P. badius* in terms of biomechanical function. They predicted that a variety of factors, including material inhomogeneity, may account for the apparent failure of mandibular morphology to reflect differences in diet and feeding behavior (Daegling and McGraw 2001).



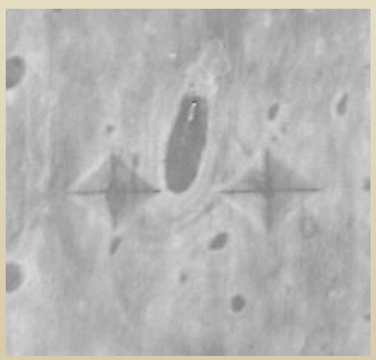
Upper Guinea Red Colobus (*Procolobus badius badius)*



Western Pied Colobus (*Colobus polykomos polykomos*)

Materials and methods

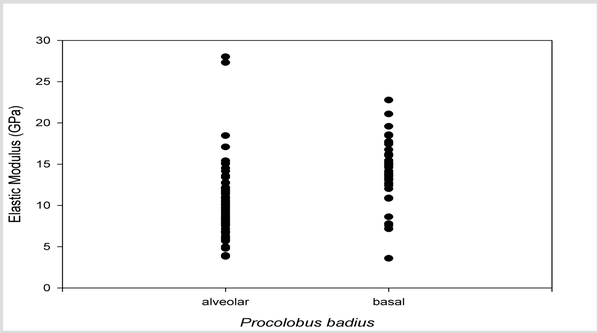
Mandibles of *P. badius* (N=1) and *C. polykomos* (N=1). Specimens are subset of larger sample (>40).



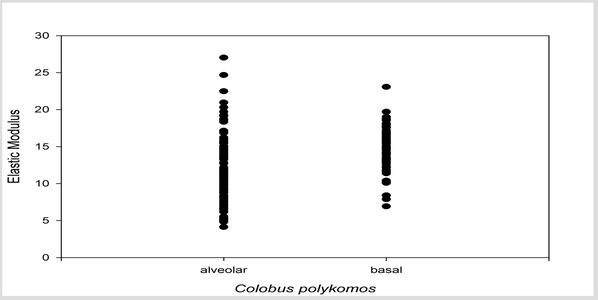
Vickers microindentations

To test the hypothesis of material inhomogeneity and the differences between the structural properties of alveolar versus basal mandibular bone between taxa, serial transverse sections of rehydrated mandibular bone were sampled using microindentation (>100 indentations per specimen). Vickers hardness values were converted to elastic modulus via established regression (Johnson and Rapoff 2007).

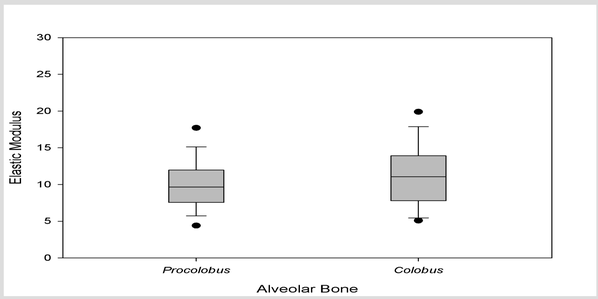
Microindentation of colobine mandibles



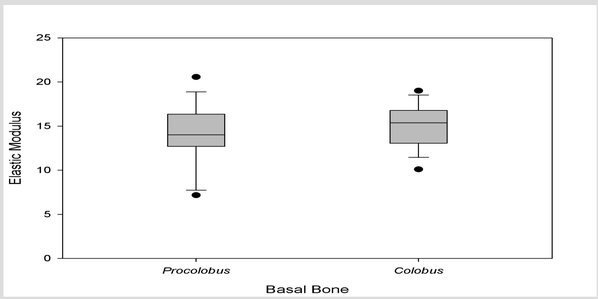
Elastic modulus in *Procolobus badius* revealing a wide range of values throughout the mandible, but a significantly different mean value between alveolar and basal sections.



The range of values seen in the alveolar portion of *Colobus polykomos* encompasses those seen in the basal, but mean elastic modulus of the basal portion still remains higher, suggesting a greater degree of material stiffness.



Elastic modulus values for alveolar bone in both *P. badius* and *C. polykomos.* Mean modulus data show a distinction between each taxon.



The higher modulus seen in the basal bone is consistent throughout both taxon. *C. polykomos* retains a greater mean modulus in the basilar portion.

Procolobus badius ***Colobus polykomos***

Discussion and Conclusion

- Based on preliminary tests, we found that the elastic modulus of alveolar bone is significantly less than basal bone.
- These findings suggest that the greater compliance of alveolar bone is achieved by both structural and material means.
- The reduced stiffness and increased porosity of alveolar bone likely prevents development of large local stress concentrations associated with bite forces.
- Results from microindentation suggest that regional differences observed in elastic modulus in both *Procolobus badius* and *Colobus polykomos* have important implications for understanding the relationship between dietary specialization and bone morphology.
- Findings from this study provide valuable information that should be incorporated in future models of mandibular form.

Literature Cited

Daegling DJ, McGraw WS (2001) Int J Primatol 22:1033-1055.

Daegling DJ, Hylander WL (1997) J Human Evolution 33: 705-717.

Johnson WM , Rapoff AJ (2007) J Material Science 18: 591-597.

Korstjens et al. (2007) in *Monkeys of the Taï Forest: An African Primate Community* (McGraw, Zuberbühler, Noë, eds), Cambridge University Press.