Genus-level comparison of bone material and structural variation of diaphyseal morphology of *Hylobates* (Gibbons) and *Lagothrix* (Woolly monkey)

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Introduction

A. This study explores whether frequency of brachiation drives biomechanical variation on diaphyseal morphology.
B. We compared femora and humeri of *Lagothrix* and *Hylobates*, which exhibit similarities in size, diet, lifestyle, and home range, except suspensory style[1,3,4].
   - *Lagothrix* engages in "tail-assisted" suspensory and quadrupedal locomotion,
   - *Hylobates* are specialized brachiators relying on forelimb swings and extended hindlimbs[2].



Gibbon *(Hylobates lar)*
By © Nicolas Loeuillet



Humboldt's Woolly monkey
(*Lagothrix lagotricha*)
By © Hans Hillewaert

Methodology

Materials

- *Hylobates* (15 individuals, 69 bones)
- *Lagothrix* (8 individuals, 12 bones)
  9 juveniles[8], 5 subadults[8], and 7 adults[8]

Method

- Scanning Parameters: Voltage: 100kV, Current: 200 µA, Power: 20W
- Mineral density calibration is done in 800 mg HA/cm3 on micro-CT phantom
- CT reconstructions are done in VGStudio Max. 3D Slicer is used for 3D model creation. Analysis is done in R[7]

Results

Overall Postural Behavior Distribution

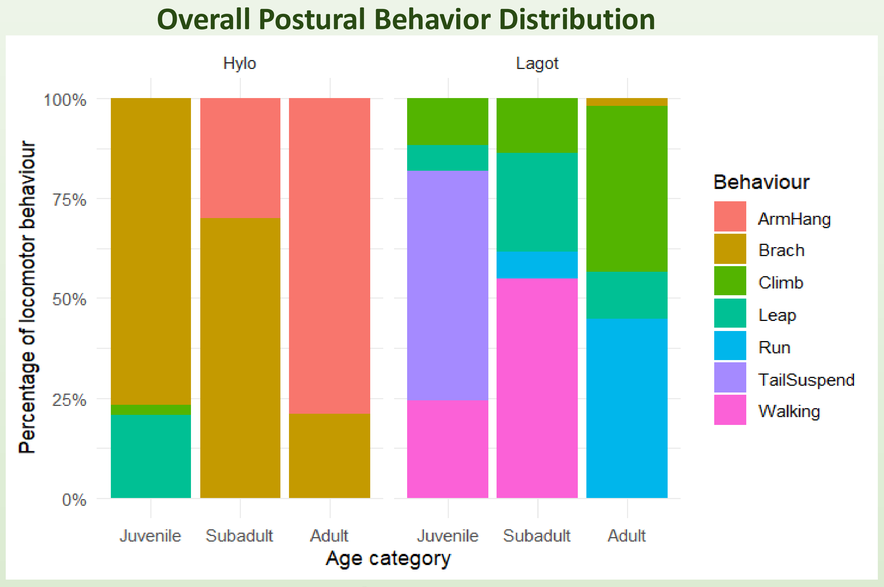


Fig. 1: *Hylobates* juvenile[9] brachiate 75.6%, leap 20.33% and climb. *Lagothrix* juvenile[10] tail-suspend 23.15%, leap, and climb. *Hylobates* adult[11] arm-hang 46.7%, and *Lagothrix* adult run and climb mostly.

Cortical Area Results

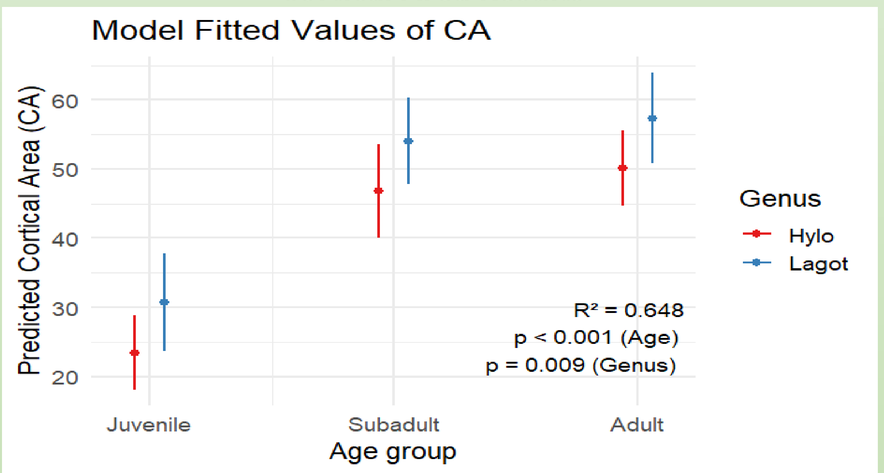


Fig. 2: Linear mixed models show that age and genus are strong predictors of CA, but sex, bone type, and bone side are not. Juveniles are very different than adults (-26.68 (p < 0.001)), and *Lagothrix* individuals are +7.23 units higher than *Hylobates* (p = 0.009).

Diaphyseal Shape (Imax/Imin) Results

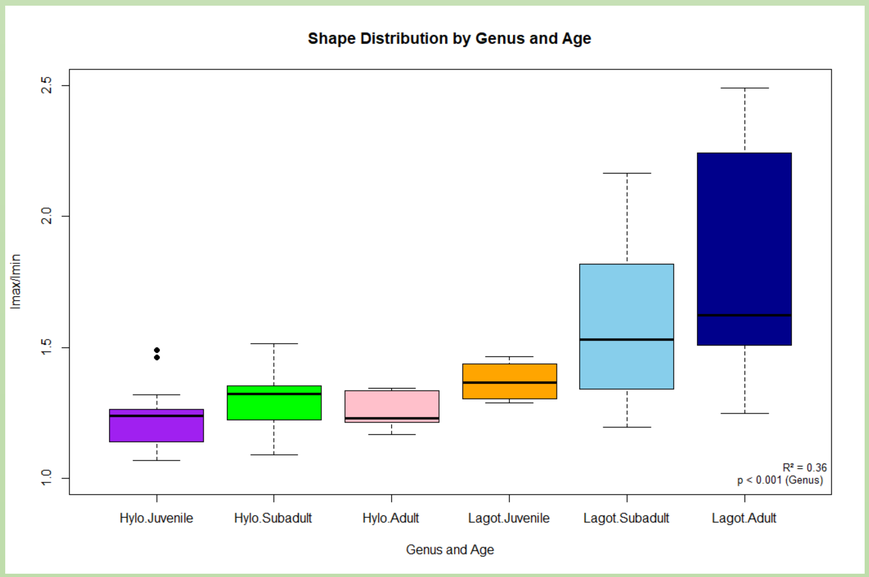


Fig. 3: The only strong predictor is genus, which consistently increases shape (*Imaxmin*). Genus alone explains ~36% of the variation (p < 0.000001). Sex and age don't significantly affect the diaphyseal shape change.

Strength (Polar Section Modulus- Zpol) Results

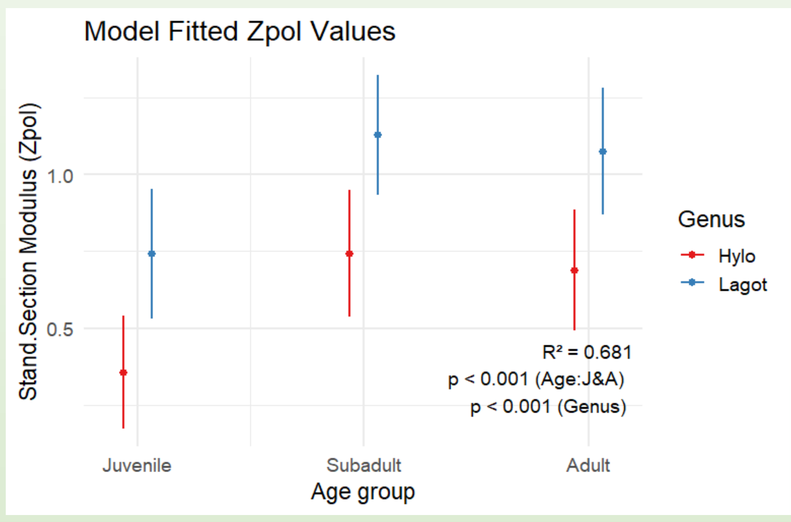


Fig.4: Standardized polar section modulus (Zpol) is significantly affected by age (juvenile vs. adult), and the genus, *Lagothrix* has significantly higher SZpol than the *Hylobates* (about 0.39 units higher(p <0.001). Differences between bone types exist, but are relatively small compared to individual variation.

Bone Material Content Results

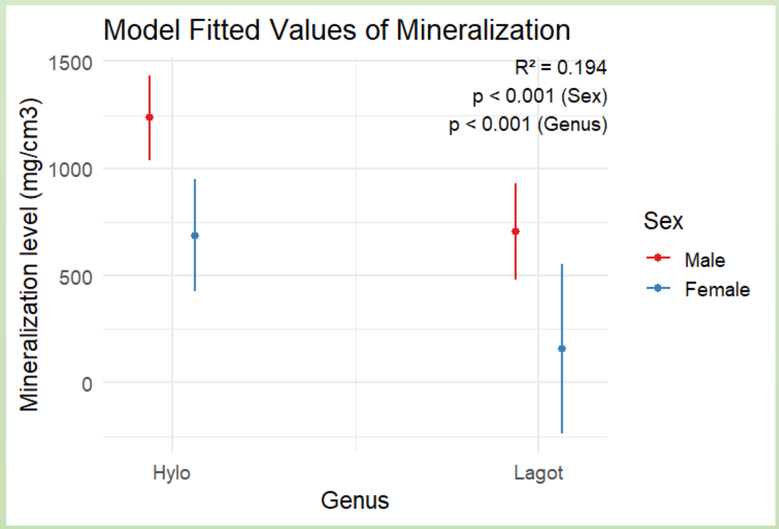


Fig.5: 17–19% of variation in MinStand is explained by genus, and sex (R2: 0.195, Adjusted R2: 0.172) . Genus *Lagothrix* has significantly lower mineralization values (~531 units lower) (p < 0.001), and males have significantly higher MinStand (~548 units higher) (p < 0.01).

Discussion

This study partially agrees with the two main ideas compared in the debate:

✓A. Specific locomotor frequency isn't the primary selective pressure on muscle-bone architecture[5].
✓B. Specific locomotor frequencies have a primary effect on bone morphology[6].

Without Postural Behavior:

- Genus alone explains 36% of shape change, and supports the cortical area results.
- Age and genus are strong predictors of cortical area and *Zpol* value. As expected, juveniles have a smaller cortical area due to growing bones. *Lagothrix* has a larger cortical area, and *Zpol* than *Hylobates*.
- However, *Hylobates* has significantly higher mineralization level than *Lagothrix*.

With Postural Behavior:

- The locomotion-only model is selected as the best model compared to our biological (genus, age, sex) and saturated models, which explains CA (MR^2: 0.71), Zpol (MR^2: 0.67), and Imax/min (MR^2: 0.51) change.
- Based on AIC, the saturated model explains the mineralization change best (MR^2: 0.30).
- Future question: ***Is the negative correlation between mineralization level and structural properties recurrent in other genera in the primate order?***

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Bibliography