Quantifying variation of the ostrich wing (Aves: Palaeognathae)

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Biology

Background

- All ratites share the common trait of flightlessness, which through evolution can lead to the adaptation of novel cursoriality elements
- *Struthio camelus* (the Common Ostrich) has no keel on the sternum and reduced forelimbs that characterize most ratite taxa
- Despite not being able to fly, most ratites (aside from the extinct Moa) have retained their wings for a variety of uses
- Ostriches use their wings in mating displays, as shelter for offspring in the African heat and for balance while running
- Natural variation due to environmental and genetic pressures cause the formation of new cursorial elements amongst the ratite taxa
    - Kiwis (*Apteryx*) and ostriches both contain a double patella but in cassowaries (*Casuarius*), this adaptation is absent
- A structure under relaxes selection should display more variation within humeri (distal) as compared to the scapula (proximal) (Maxwell & Larsson, 2007)
- By using geometric morphometric variation to analyze the bones within the forelimb, inferences can be made to the degree of usage the forelimb experienced in life.

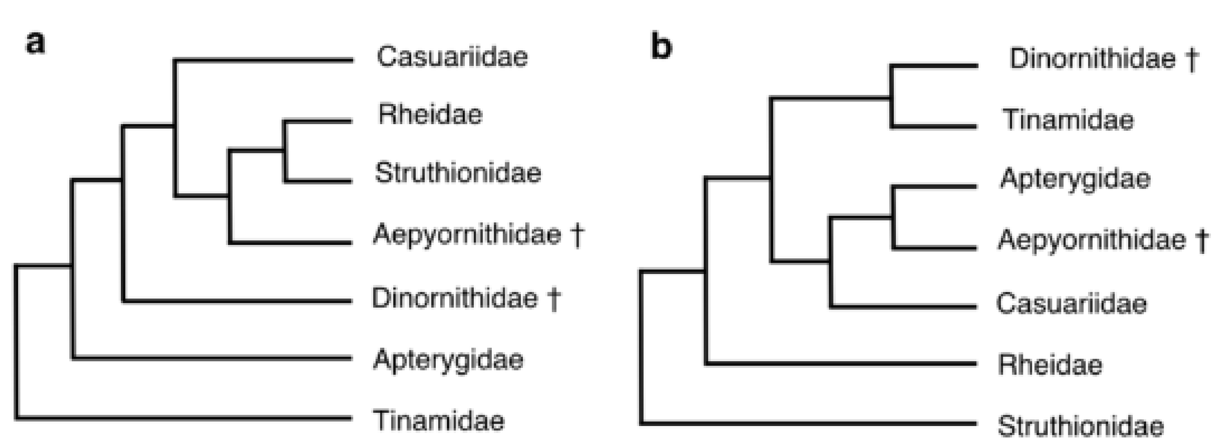


Figure 1. Previous (a) and current (b) hypotheses of Palaeognathae phylogeny (Widrig & Field, 2022).

Materials & Methods

- 32 scapulae and 36 humeri representing both left and right sides of *S. camelus* individuals were photographed in the collections of the American Museum of Natural History (AMNH) and Carnegie Museum of Natural History (CMNH).
- Scapulae were analyzed in lateral view and humeri in anterior view
- Geometric morphometric methods were used to quantify variation of these bones
- tpsDig, tpsRelw32 and tpsUtil32 was used to place digitized landmarks around homologous spots of each specimen (Rohlf, 2006).
- Semilandmarks were then placed between the major landmarks to capture the curved regions of the bone
- Principal component analysis (PCA) was then performed using MorphoJ (Klingenberg, 2011)

Figure 2. Image of scapula CNMH 0883 R in tpsDig. The red dots around the perimeter of the bone are the landmark points placed at homologous sites of all the scapula specimen. The blue outline connects the semi landmarks before the application of a curve in tps relw32.

Results

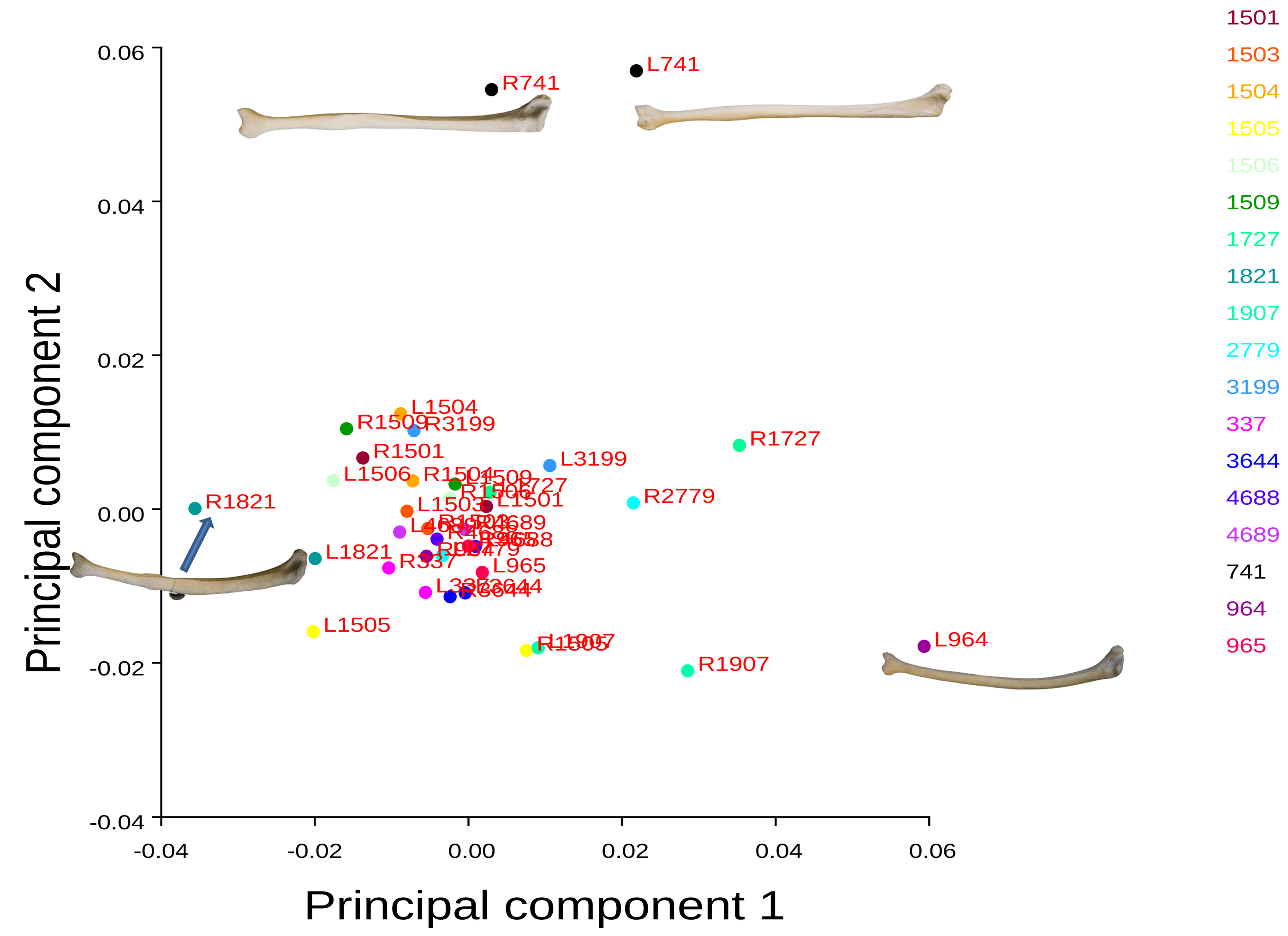


Figure 3. Results from PC analysis of humeri in MorphoJ. The distance between the points in the shape space indicates there is not a lot of variation between each specimen.

Figure 4. A visual comparison of two humeri from two different *S. camelus* specimens. The PC1 and PC2 values of the bones are both about 0.00 and -0.015, respectively. (top, AMNH 4688 L, and bottom, AMNH 965 R).

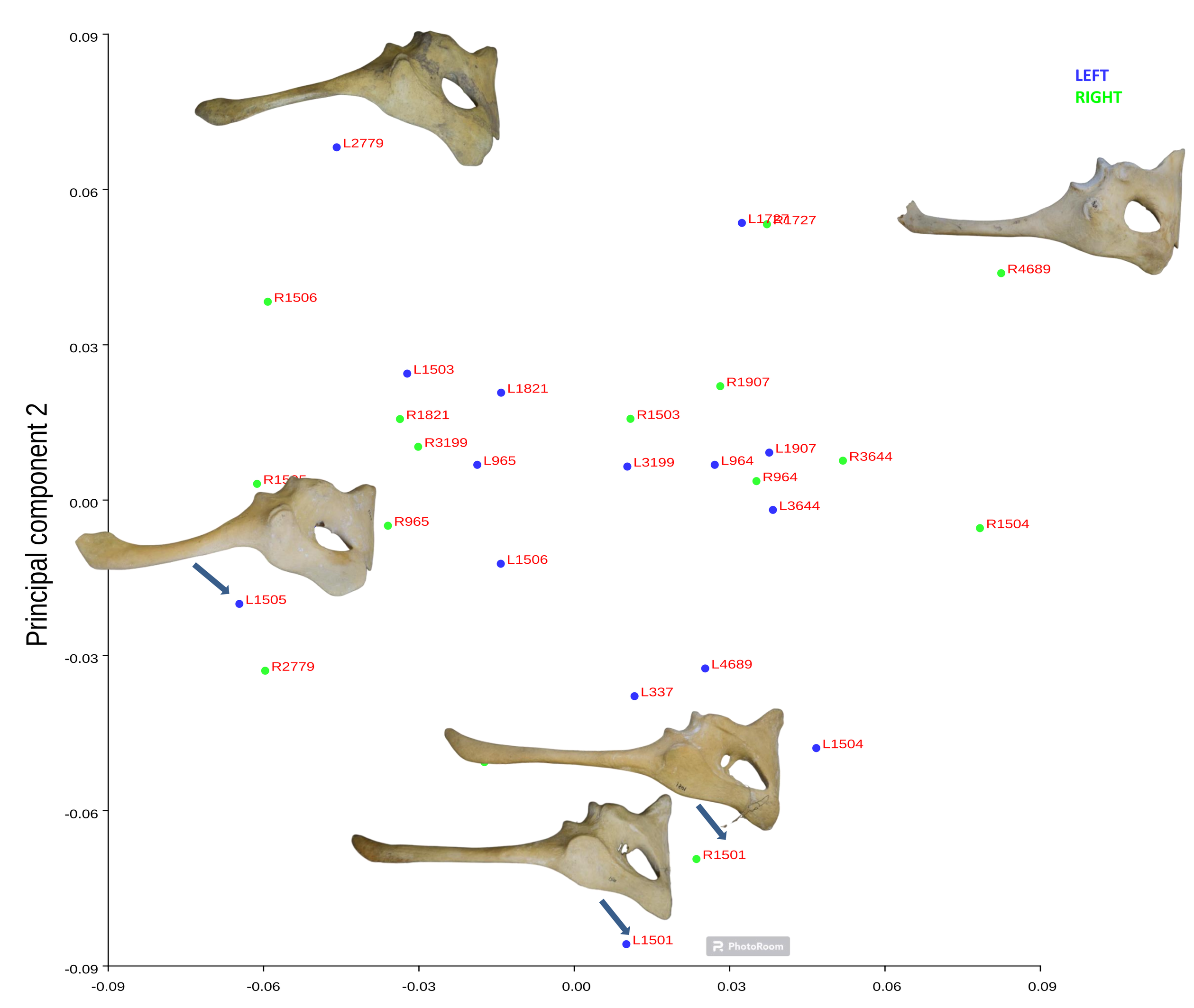


Figure 5. Results from PC analysis of the scapula in MorphoJ. The points in the shape space are less centralized and more spread out than in figure2.

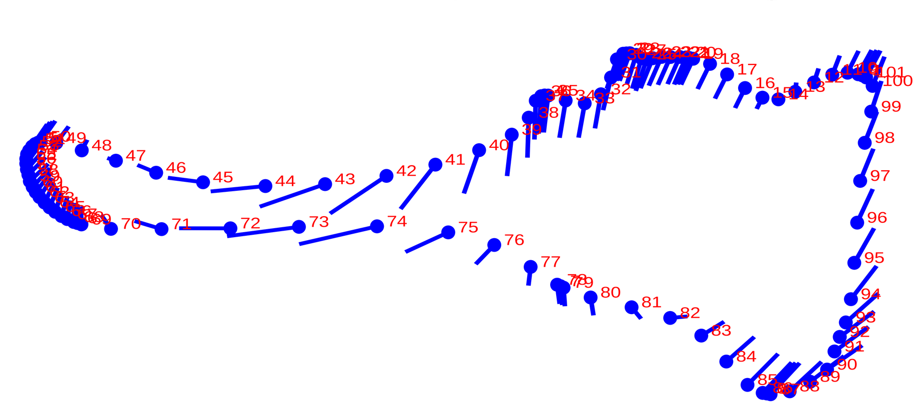
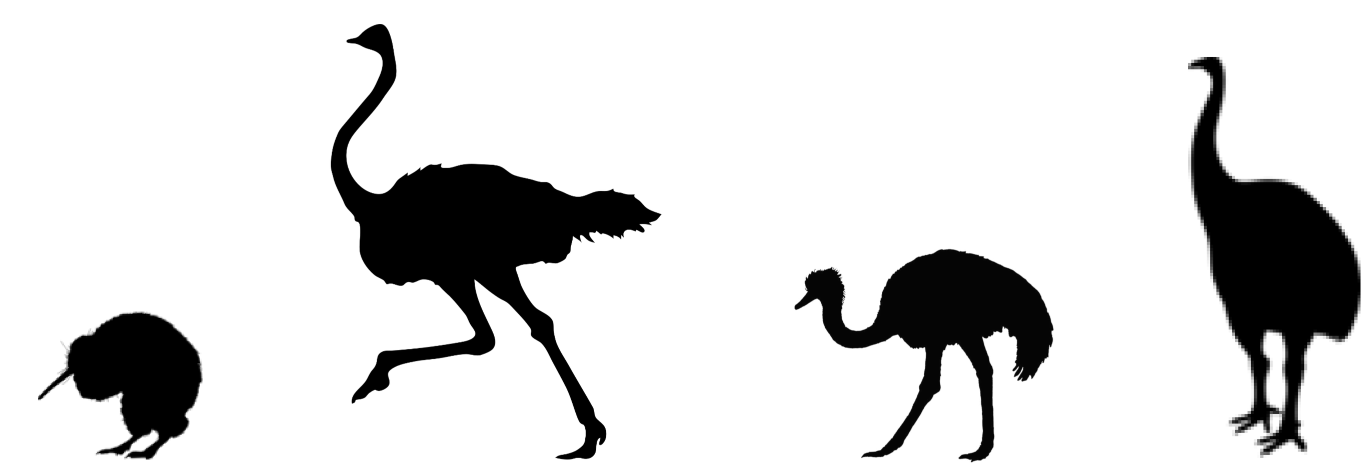


Figure 6. Lollipop graph of PC1 shape changes. Each "ball" represents the mean shape for each of the 32 scapula (landmarks). Each "bar" represents the shifts of landmarks to the target shape.

Conclusion

- The results of the PCA scores indicate the degree of variation between individual specimens and between the left and right bones from the same specimen was not unusual
- Despite each of the bones being from opposite sides of two different specimens, the visual differences in their shape are left mostly undetected (Fig. 4)
- The grouping of points from the left and right bones of different specimens in figure 2 also indicate "normal" levels of variation with the exception of specimen CMNH 741
- If a high degree of variability were to have been observed, it would have likely been a result of environmental or genetic factors
- The broader spread of the points within the shape space of figure 4 shows there is more variation amongst individual scapula. This is unusual given that bones more distal to the body undergo reduction and therefore exhibit more variation than bones that are more distal



Future Research

- Continue to digitize elements of the forelimb (ulna and radius) and manus
- Comparing variation in different Palaeognathae taxa such as tinamou, rhea, emu, cassowary, and kiwi
- Environmental and behavioral comparison to extinct taxa (e.g., Moa)
- Contrasting cursorial elements in modern Palaeognathae to members of Theropoda

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