More Than Just Cats and Dogs:
A Phylogenetic Analysis of Carnassial Tooth Shape in Carnivorans

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Introduction

Mammals in the order Carnivora are characterized by their highly specialized carnassial teeth, adapted for efficient processing of meat. There are two distinct parts of the carnassial; the trigonid is used for shearing, while the talonid basin is used for crushing (Figure 3). However, not all carnivorans are carnivorous; **Hypocarnivores** are carnivorans whose diet consists mostly of non-vertebrate food sources (Van Valkenburgh, 1988). Carnivora's two suborders, Caniformia (dogs and relatives) and Feliformia (cats and relatives), diverged about 65 million years ago (Nyakatura and Bininda-Emonds, 2012). We are interested in the relationship between carnassial shape evolution and dietary strategies in a phylogenetic context. Essentially, we are asking:

Do the evolutionary rates of the trigonid and talonid in the lower carnassial teeth differ? Are these rates influenced by diet?

Phylogeny of Carnivora

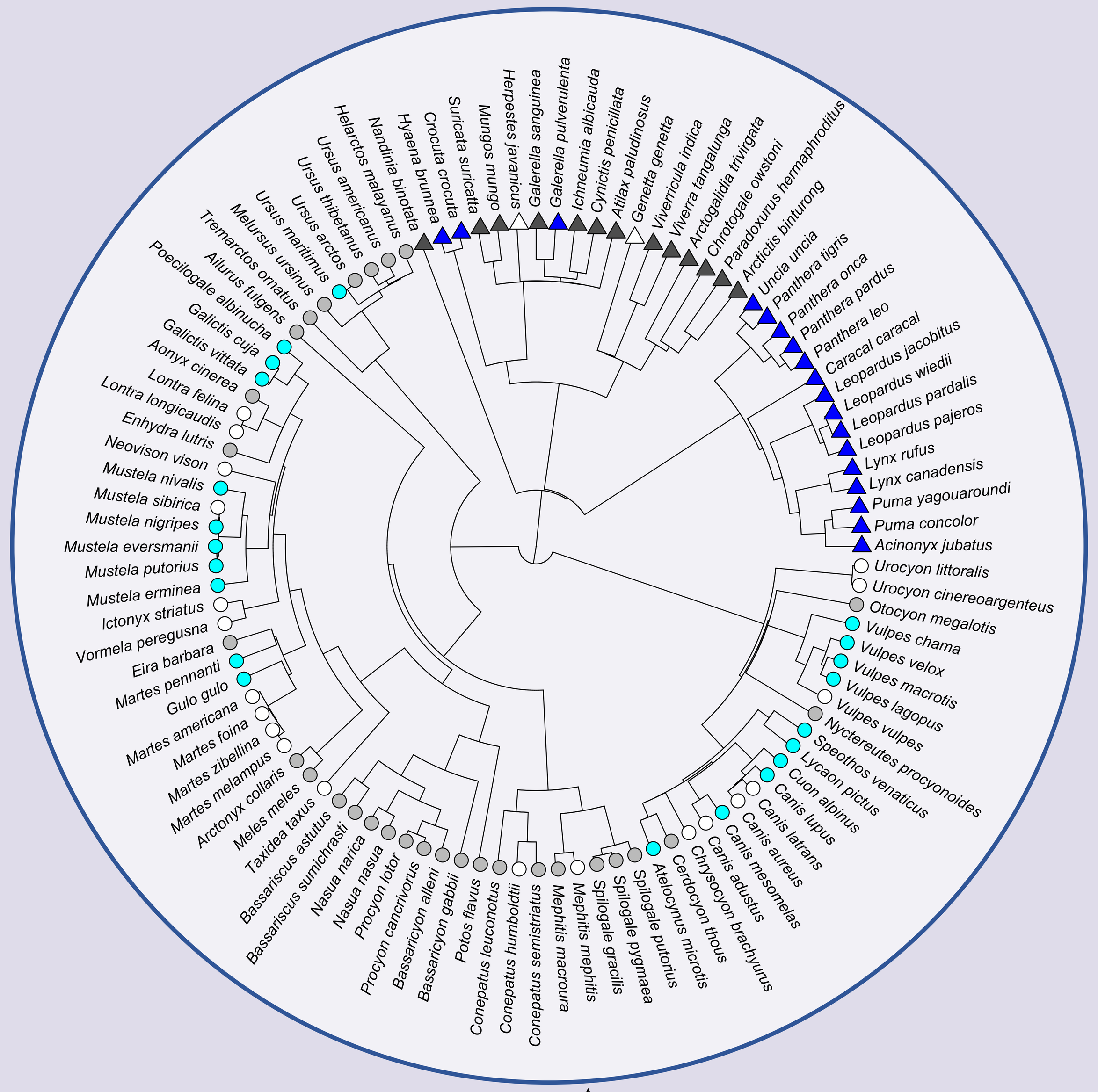

Figure 1

(Phylogeny from Nyakatura and Bininda-Emonds, 2012)

- ▲ Hypocarnivores – Feliformia
- ● Hypocarnivores – Caniformia
- ▲ Hypercarnivores – Feliformia
- ● Hypercarnivores – Caniformia
- △ Mesocarnivores – Feliformia
- ○ Mesocarnivores – Caniformia

Works Cited

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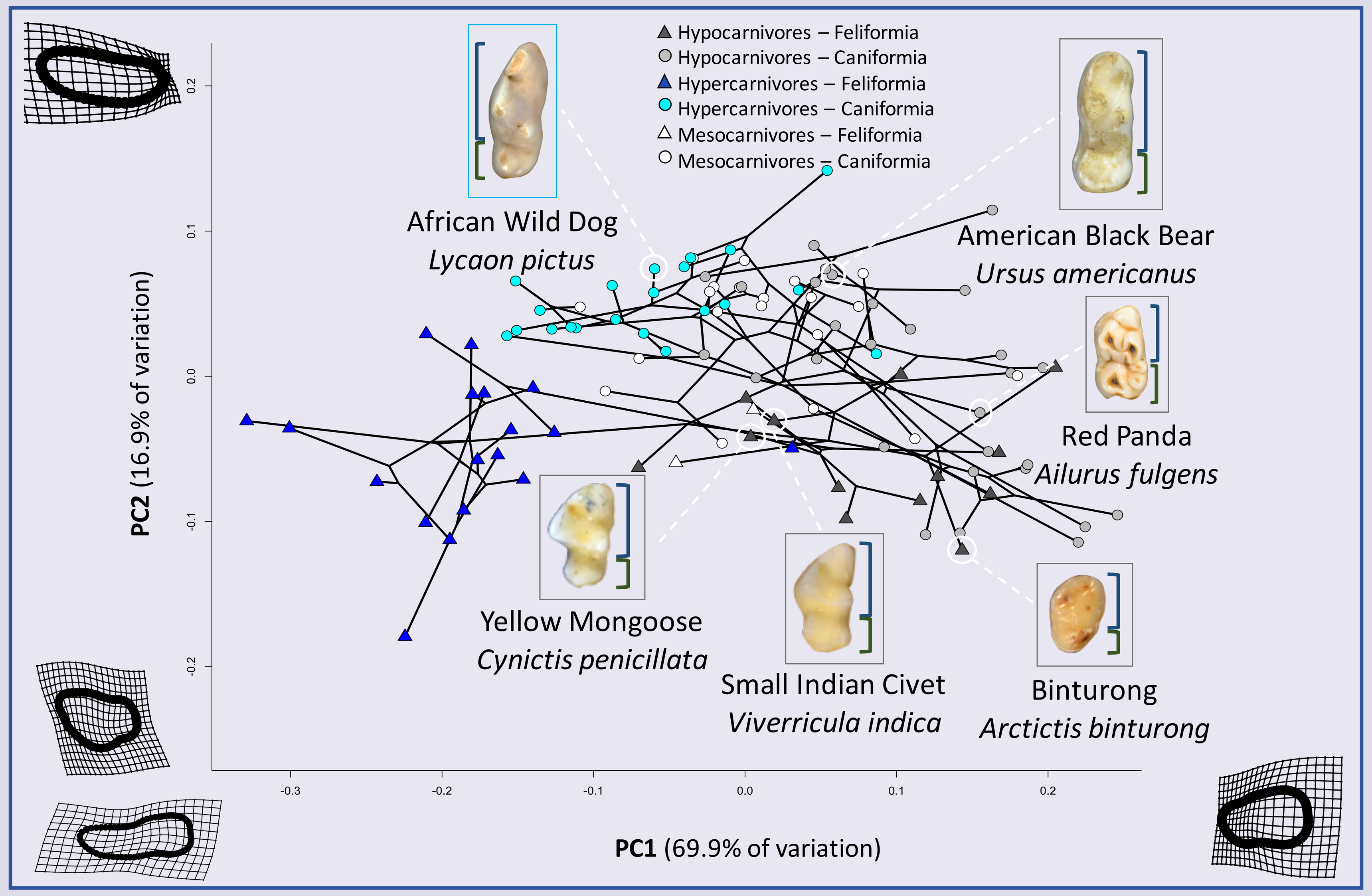
Popowics TE. 1998. Ontogeny of Postcanine Tooth Form in the Ferret, *Mustela putorius* (Carnivora: Mammalia), and the Evolution of Dental Diversity within Mustelidae. Journal of Morphology: 237(1): 69-90.

Van Valkenburgh B. 1988. Trophic Diversity in Past and Present Guilds of Large Predatory Mammals. Paleobiology, 14(2): 155-173.

Results

Figure 2

Phylomorphospace of Carnivora, showing tight clustering of hypercarnivores in the morphospace (suggesting greater convergence) and a larger region of the morphospace occupied by hypocarnivores (suggesting no/little convergence). PC1 (x axis) differentiates trigonid vs. talonid emphasis very clearly, while PC2 (y axis) trends are less clear.



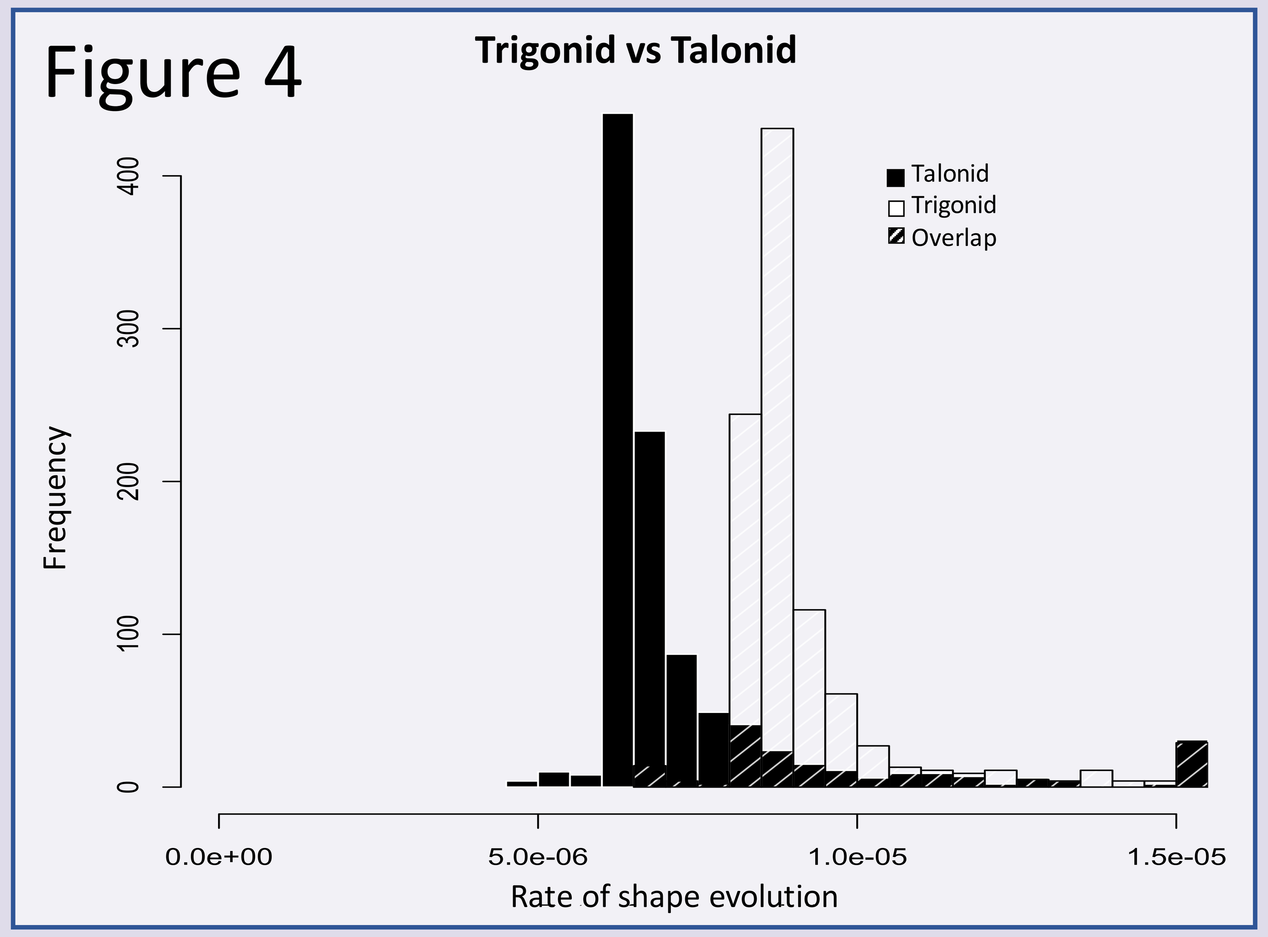


Figure 4 shows a significantly faster rate of shape evolution in the trigonid across all carnivoran teeth.

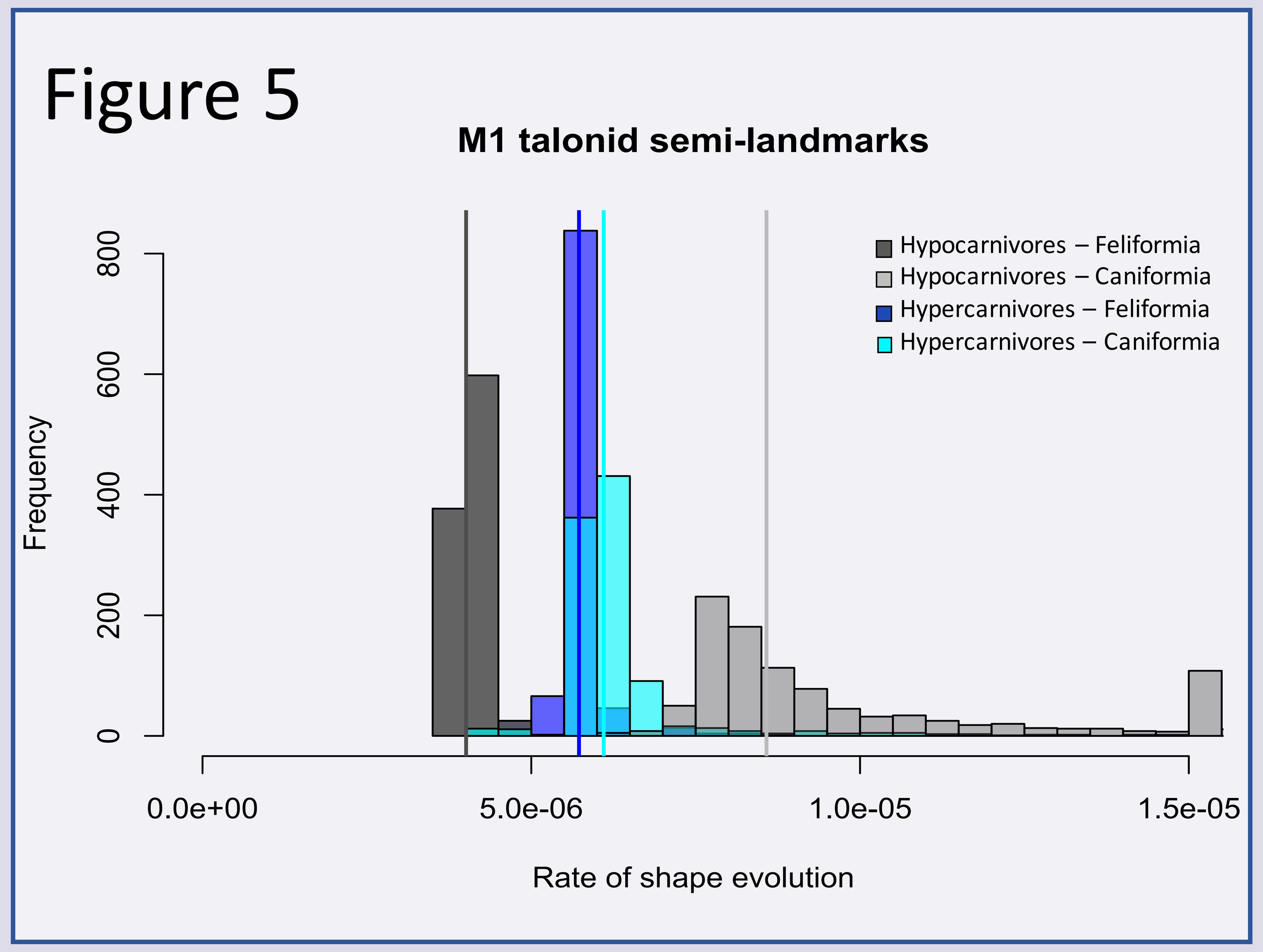
- Median p-value = 0.003996, mean p-value = 0.03278

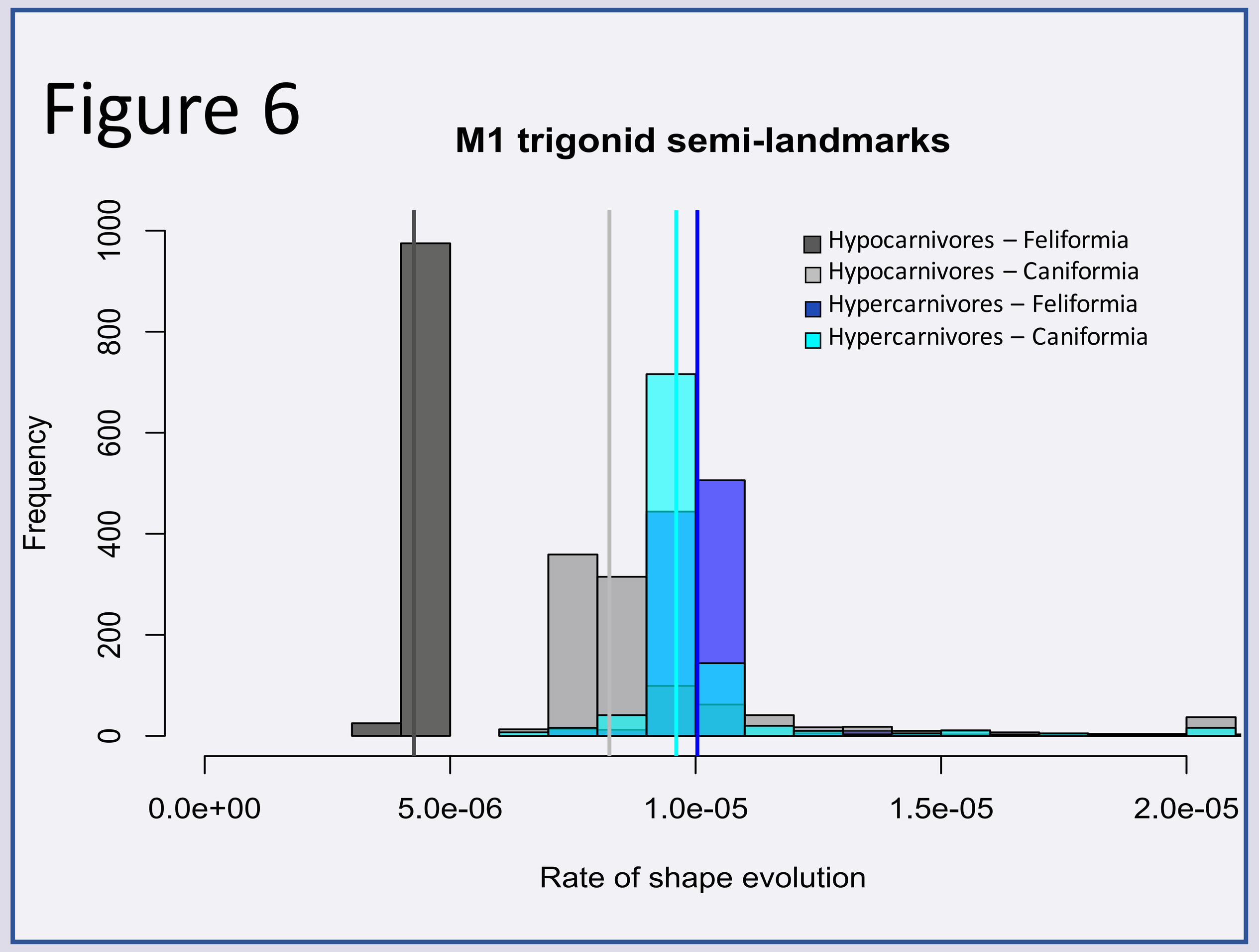
Figure 5 shows that talonid shape evolves at significantly slower rates in hypocarnivorous feliforms and at significantly faster rates in hypocarnivorous caniforms

- In Feliformia: mean p-value = 0.001, median p-value = 0.001
- In Caniformia: mean p-value = 0.009, median p-value = 0.001

Figure 6 shows the same trend in Feliformia and Caniformia, significantly slower rates of shape evolution in hypocarnivores.

- In Feliformia, mean p-value = 0.001, median p-value = 0.001
- In Caniformia, mean p-value = 0.005, median p-value = 0.001





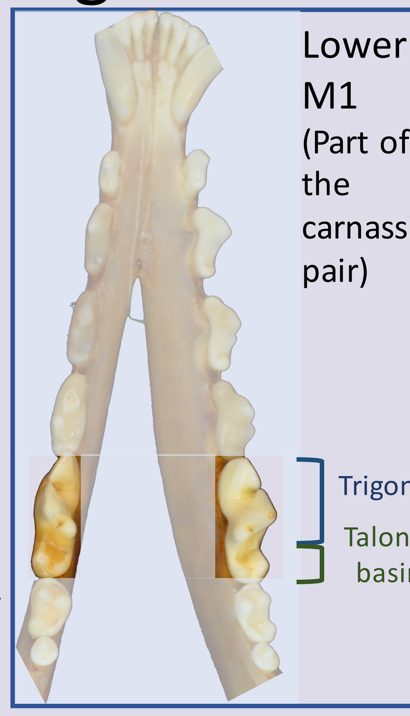
Methods

We quantified lower carnassial (M1) occlusal tooth shape of 129 species of extant terrestrial carnivorans using geometric morphometrics.

- Semi-landmarks captured the outline of both the talonid and trigonid.
- Estimated relative change in evolutionary rates with multivariate Brownian motion models (Adams, 2013).
- Significance of difference in rate of evolution between trigonid and talonid estimated using method by Denton and Adams (2015).
- Geomorph-package in R used to account for polytomies.

Diet information was collected from the literature, hyper/hypocarnivory definitions from Van Valkenburg (1988).

Figure 3



Vulpes macrotis mandible

Discussion

Do the evolutionary rates of the trigonid and talonid in the lower carnassial teeth differ?

- The trigonid evolves at significantly faster rates than the talonid (see Fig 4). Unlike other mammals, the trigonid is the first to develop in Carnivora (Popowics, 1998).
- The early development of the trigonid during ontogeny may allow for this faster rate of evolutionary change.

Are these rates influenced by diet?

- Rates of shape evolution seem to be influenced by both dietary strategy and suborder classification (Figs 5 & 6).
- Separation into suborders reveals differences between diet in the talonid; hypocarnivorous caniforms have a faster rate than hypercarnivorous caniforms (Fig 5).
- The slower rate in the talonids of hypocarnivorous feliforms is surprising given the importance of the talonid for the consumption of plant material (Fig 5).
- Slower rates of shape evolution in hypocarnivorous feliforms (fig 5 & 6) suggest constraint on the shape of M1's in Feliformia, perhaps in development or due to morphological specialization of this suborder.
- Mesocarnivores were grouped with the hypercarnivores in Fig 5 and 6, and when grouped with hypocarnivores (to focus on hypercarnivores) we observe similar trends.
- Essentially, there must be forces in addition to diet influencing rates of shape evolution.

Acknowledgements

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