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Size Scaling in the Skull of North American Felids as Adaptations for Prey Acquisition

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Abstract

This comparative study explores the relationship between skull morphology and general body size among felids (house cat, lynx, puma), mustelids (minks, weasels, badgers), and canids (foxes, coyotes, wolves); with a focus on North American felids, as it relates to prey acquisition. Previous studies have focused on the evolution of the carnivore skull shape, which include the species examined in this study. Using measurement methods laid out by Radinsky (1981a; 1984), the size of skull components are compared to overall body size to determine the rate of scaling of skull features with body size.

Statistical evaluations of skull measurements within and between the three selected North American carnivore groups allowed it to be determined which features scaled with body size; skull length, jaw length, and tooth row length. Additionally, some of these skull features showed significant correlation with the body size of possible prey, indicating there are limitations on prey size based on skull parameters related to bite strength. When compared against body size, measurements relating to the temporalis muscle didn't fit the regression lines as well as other data, indicating that the temporalis doesn't scale directly with body size which is a major component in bite strength differences related to prey size that can be taken. Across all families, the moment arm of the temporalis and the zygomatic arch width showed significant differences between species within a family. In most comparisons, temporal fossa width differences were also significant.

INTRODUCTION

Carnivores have been the focus of many studies examining various features of the skull and evolution as they relate to function (Radinsky, 1981a; 1984). Canine function and its importance to prey acquisition has been another area explored in other studies. To deepen the understanding of how skull components relate to prey acquisition, this study is designed to evaluate how various skull functional components scale with body size and how that affects the prey size each carnivore is able to acquire.

To evaluate skull scaling, species were selected that would be able to interact in the wild from three families; felids, canids and mustelids in North America. From each family a representation of large, medium, and small were selected and prey diets of each species was gathered.

Felidae	
Domestic cat	*Felis catus*
Bobcat	*Lynx rufus*
Puma	*Puma concolor*
Mustelidae	
American mink	*Neovison vison*
Striped skunk	*Mephitis mephitis**
American badger	*Taxidea taxus*
Canidae	
Red fox	*Vulpes vulpes*
Grey fox	*Urocyon cinereoargenteus*
Coyote	*Canis latrans*
Gray wolf	*Canis lupus*

*moved to own family: Mephitidae

Species	Body Size	Prey Weights
Domestic Cat	3.3kg-4.5kg	18.5g-542.5g
Lynx	4.1kg-15.3kg	13g-112.5g
Puma	36kg-103kg	62.5g-125kg
Red Fox	4.1kg-5.4kg	10.05g-295g
Gray Fox	1.8kg-7kg	22.5g-1150g
Coyote	7kg-20kg	23.22g-112.5kg
Grey Wolf	18kg-80kg	4175g-675kg
American Mink	681g-2310g	3.22g-9kg
Striped Skunk	700g-2500g	5.52g-62.5g
American Badger	4-12kg	62.5g-4175g

Material and Methods

BCAL	Basicranial Axis Length	Measured from midventral border of foramen magnum to basisphenoid-presphenoid suture	Estimator of body size, without jaw variations
BWT	Body Weight	From literature	General body size
JL	Jaw Length	Measured from back of condyle to front of median incisor alveolus	Resistance moment arm when biting with front teeth
MAT	Moment Arm of Temporalis	Measured from the condyle to the apex of the coronoid process	Estimator of moment arm of a portion of the temporalis
POC	Postorbital Constriction	Measured across narrowest portion of cranium posterior to postorbital bar	Used with ZAW to estimate temporalis size
SL	Skull Length	Measured from back of occipital condyles to anterior tip of premaxilla	Estimator of body size
TFL	Temporal Fossa Length	Measured from the most posterior point of the lambdoidal crest to back of supraorbital process	Estimator of temporalis size
TFW	Temporal Fossa Width	Calculated by subtracting width at the postorbital constriction from width across zygomatic arches	Estimator of temporalis size
TRL	Tooth Row Length	Measured parallel to palatal midline, from a point level with back of the last tooth to the front of median incisor alveolus	Estimator of location and size of temporalis
ZAW	Zygomatic Arch Width	Measured across the widest portion of zygomatic arches	Influenced by brain size and jaw muscle size

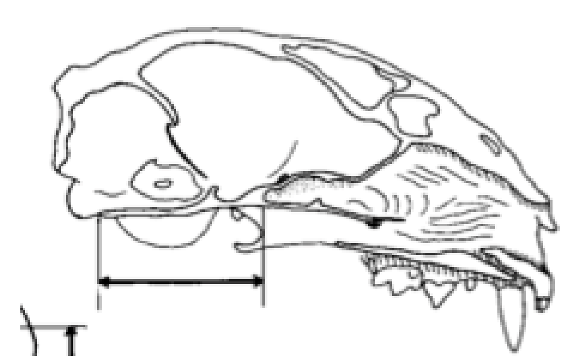
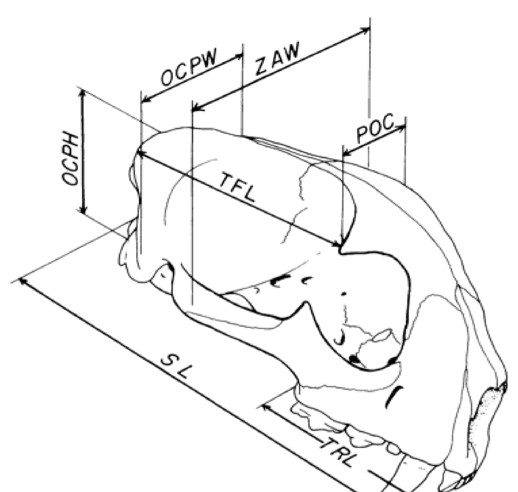


Figure 1 – Basicranial length (double arrow) as measure in this study (from Radinsky, 1984)



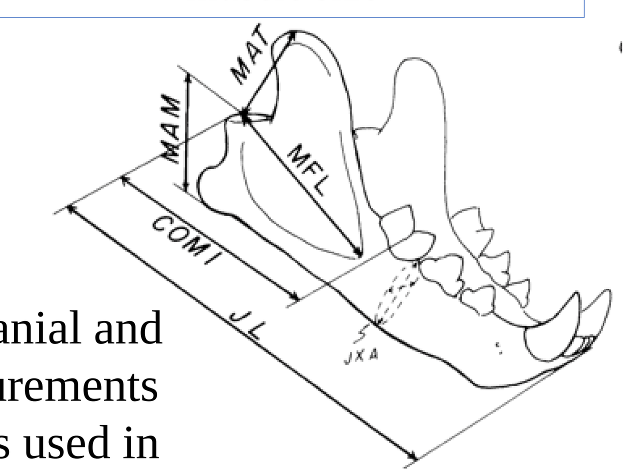


Figure 2 – Cat cranial and mandibular measurements (double arrows) as used in this study (from Radinsky, 1981a, 1982) .

RESULTS

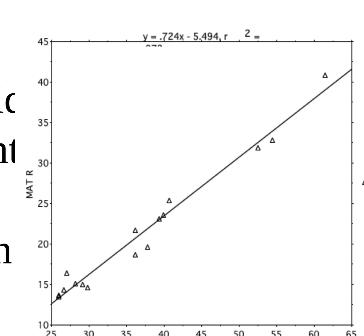


Fig.4A Felid Rt. Moment Arm Regression

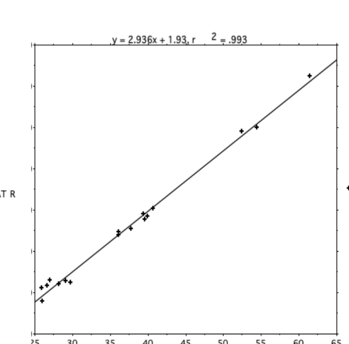


Fig. 3A Felid Skull Length Regression

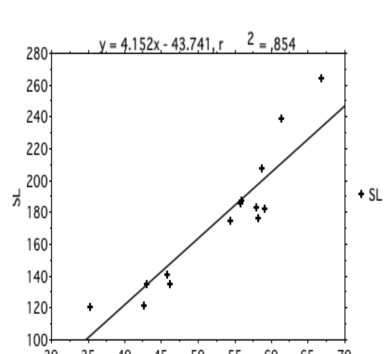


Fig. 3B Canine Skull Length Regression

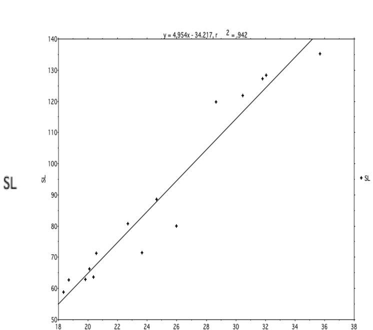


Fig. 3C Mustelid Skull Length Regression

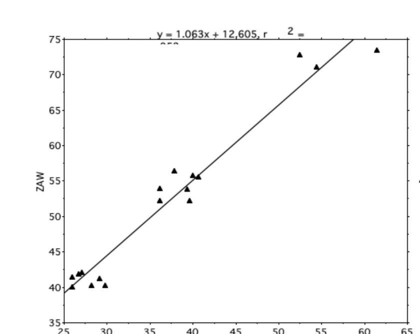


Fig.5A Felid Zygomatic Arch Width Regression

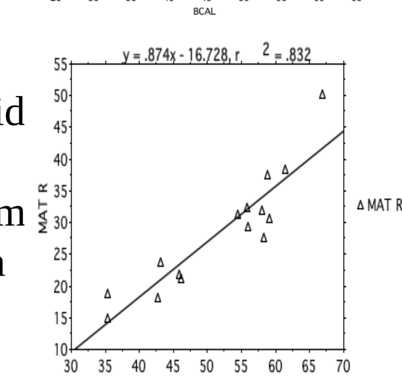


Fig.4B Canid Right Moment Arm Regression

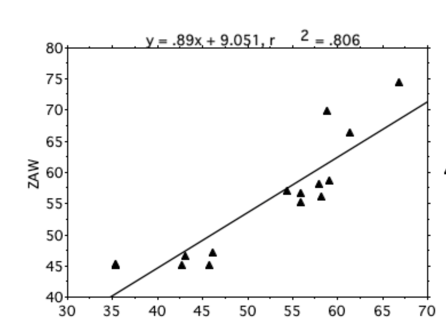


Fig.5B Canid Zygomatic Arch Width Regression

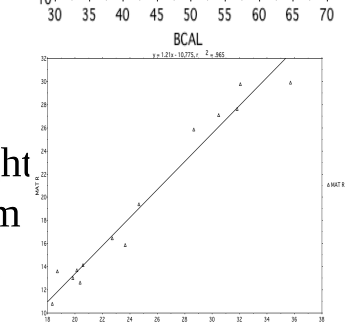


Fig.4C Mustelid Right Moment Arm Regression

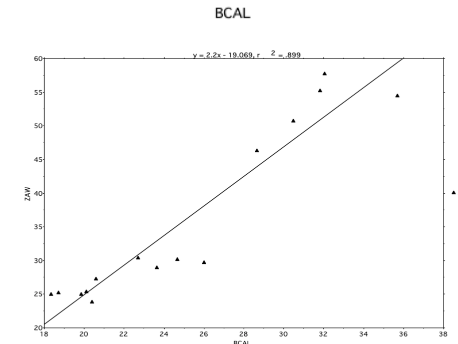


Fig.5C Mustelid Zygomatic Arch Width Regression

Statistical analysis showed many of the skull features scaled fairly well with body size like skull length and tooth row length (See figures 3A-C). However, measurements relating to the size and use of the temporalis muscle didn't fit regression lines as well such as the moment arm and the zygomatic arch width (See figures 4A-C and figures 5A-C). The temporalis muscle is a major component determining bite strength which impacts what prey can be acquired.

Conclusions

Based on the regression lines that didn't fit as well, ANOVA analysis revealed significant differences in moment arm and zygomatic arch width compared with body size. Temporal fossa width, in most cases, also showed significant differences (See figure 6). This indicates that the size of the temporalis muscle isn't only impacted by the body size of the carnivore.

Focusing on the measurements that didn't seem to scale with size, correlation analysis was done between skull measurements and prey weight data gathered. In felids differences in prey size were correlated with in size of the temporalis muscle and thus bite strength. For canids, differences in prey size were correlated with mechanical advantage (leverage) for the temporalis muscle and size of the temporalis both of which assist in creating bite strength. Surprising, mustelids showed no correlations of any cranial parameter to prey size.

Figure 6	R MAT/BCAL	POC/BCAL	TFW/BCAL	ZAW/BCAL
Cat vs Lynx	X	*	X	X
Lynx vs Puma	X	*	X	X
Puma vs Cat	X	*	X	X

	L MAT/BCAL	R MAT/BCAL	TFW/BCAL	ZAW/BCAL
Fox vs Coyote	X	X	X	X
Coyote vs Wolf	X	X	X	X
Wolf vs Fox	X	X	X	X

	MAT R/BCAL	MAT L/BCAL	POC/BCAL	TFW/BCAL	ZAW/BCAL
Mink vs Skunk	X	X	X	*	X
Skunk vs Badger	X	X	X	X	X
Badger vs Mink	X	X	X	X	X

X=significant *= not significant

REFERENCES

Dayan, T., Simberloff, D., Tchernov, E., & Yom-Tov, Y. (1990). Feline Canines: Community-Wide Character Displacement Among the Small Cats of Israel. The American Naturalist, 136(1), 39-60. Retrieved May 17, 2020, from www.jstor.org/stable/2556345

Greaves, W. S. (2012). *The Mammalian Jaw: A Mechanical Analysis* (1st ed.). Cambridge, England: Cambridge University Press.

Nowak, R. M., & Wilson, D. E. (1999). *Walker's Mammals of the World (2-Volume Set)* (6th ed.). Baltimore, MD: Johns Hopkins University Press.

Radinsky, L. (1981). Evolution of Skull Shape in Carnivores. 1. The Origin and Early Radiation of the Modern Carnivore Families. Paleobiology, 8(3), 177-195. Retrieved May 17, 2020, from www.jstor.org/stable/2400405

Radinsky, L. (1982). Evolution of Skull Shape in Carnivores. 3. The Origin and Early Radiation of the Modern Carnivore Families. Paleobiology, 8(3), 177-195. Retrieved May 17, 2020, from www.jstor.org/stable/2400405

Radinsky, L. B. (1984). Basicranial axis length v. skull length in analysis of carnivore skull shape. *Biological Journal of the Linnean Society*, *22*(1), 31–41. https://doi.org/10.1111/j.1095-8312.1984.tb00797.x

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