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Patterns of brain evolution within carnivoran mammals

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Background

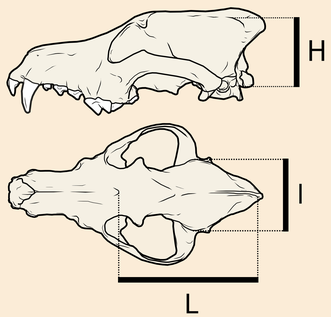
Encephalization (larger brain size than predicted for a given body size) is presumed to confer selective advantages due to enhanced cognition and broader behavioural flexibility. In this study, we investigated the effect of ecological adaptations, environmental factors, biological parameters and social complexity on evolution of encephalization in terrestrial carnivoran species (wolfs, panthers and relatives).

Aims

1. **Explore the macroevolutionary patterns of brain evolution**
2. **Identify what factors influence the encephalization**

Material

We sampled **174 species** of terrestrial carnivores. We estimated the volume ot the brain using 3 external measurements of the cranium (**Figure 1**).



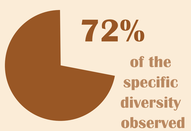


Figure 1. External measurements of the cranium used to estimate the brain volume (Finarelli, 2006). Illustrations represent a wolf cranium (*Canis lupus*).

Methods

We gathered and analyzed **13 variables**:

- **ECOLOGIC**
  Diet, locomotion, home range & activity pattern
- **GEOGRAPHIC**
  Geographic range & temperature
- **METABOLISM & REPRODUCTION**
  Hibernation, litter size, gestation length, weaning length & time between litters
- **SOCIAL**
  Group size & social complexity

We used the **RRPhylo approch** to investigate the macroevolutionary patterns on our whole sample.

We used **Phylogenetic Generalized Least-Squares** regressions on a subsample of 124 species to identify what variables influence the encephalization

Results

- We found a strong correlation between the brain volume and the body mass (**Figure 2**).
- PGLS model including the **geographic range** and the **home range** best predict the encephalization evolution.
- We found an accelerated rate of encephalization for the **Canidae** and some **Mustelidae**, and a decelerated rate for the node including the **Herpestidae**, **Eupleridae** and **Hyaenidae** (**Figure 3**).

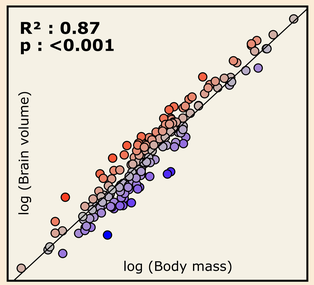


Figure 2. Correlation between brain volume and body mass in terrestrial carnivorans using a PGLS regression.

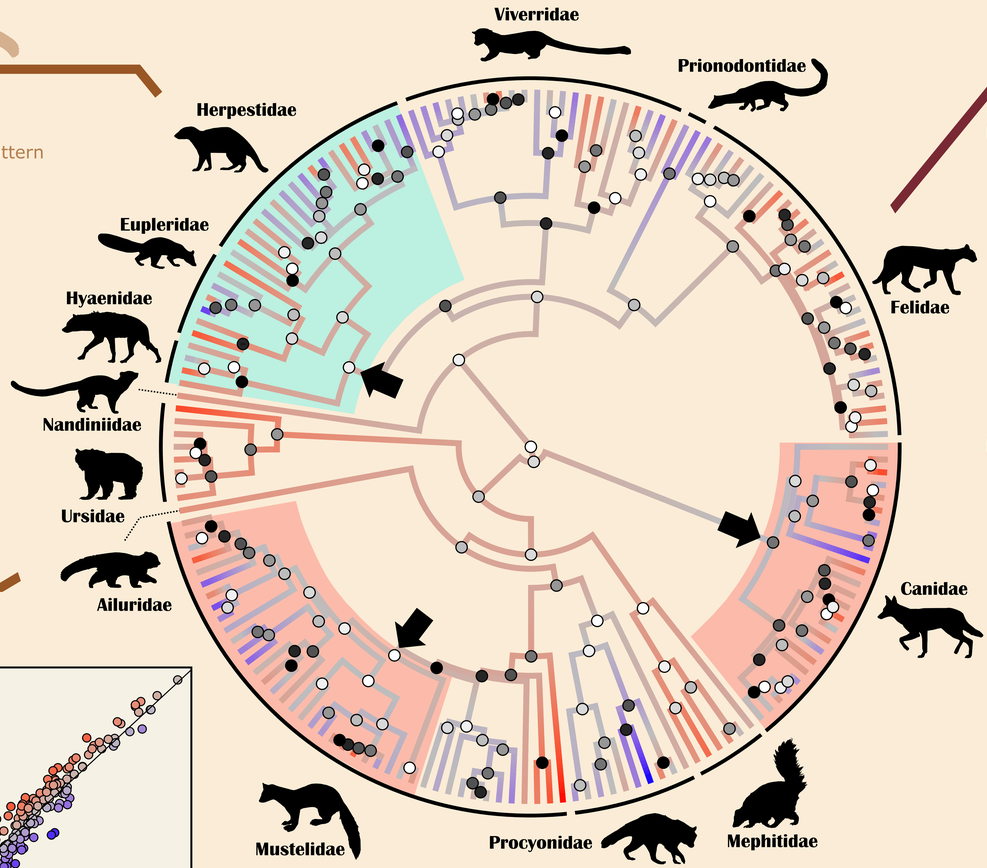
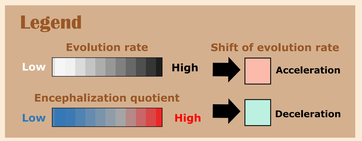


Figure 3.
Phylogeny of terrestrial carnivorans showing the repatriation of the encephalization quotient and estimation of its evolutionary rate and shifts at the ancestral nodes.



Conclusions

1 Macroevolutionary patterns of brain evolution

98% of brain size variation is explained by the body size.

Ursidae (bears), Ailuridae (the red panda) and Hyaenidae (hyaenas) displays the **highest encephalization quotient** (whereas the Mephitidae (skunks and relatives) and the Prionodontidae (linsangs) displays the **lowest quotient**.

2 Factors that influence encephalization

Home range is positively correlated with encephalization whereas the geographic range is negatively correlated. We suggest that during the evolution terrestrial carnivorans, a **trade-off** have occured between the **cognitive advantages** of acquiring a relatively large brain allowing to adapt to **specific environments**, and the **metabolic costs** of the brain which may constitute a **disadvantage** when facing the need for extending its geographic repartition to **colonize new environments**.

Results of PGLS analyses mostly depend on the **taxonomic level**.

We found **no support for the Social Brain Hypothesis** (Dunbar, 1998).

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References

Finarelli JA. 2008. Testing hypotheses of the evolution of encephalization in the Canidae (Carnivora, Mammalia). *Paleobiology* 34: 35–45.

Dunbar RIM. 1998. The social brain hypothesis. *Evolutionary Anthropology* 6: 178–190.

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Illustrations

All illustrations have been made by Margot Michaud and are available in the website : Momento Animalis