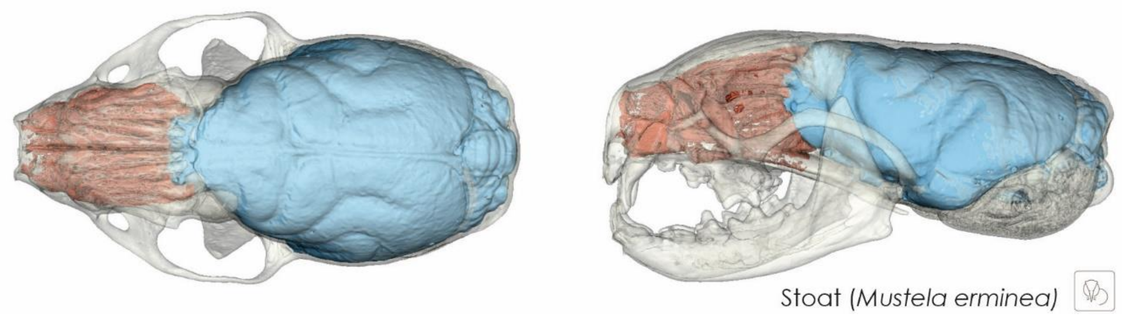
Carnivores in the Anthropocene: linking climate and environmental changes to skull morphology adaptations in mustelids

In the Anthropocene era, wild species confronted a dual threat: exceptionally rapid climate change and anthropogenic alterations to natural habitats. To survive in the face of changing environments, compete effectively for resources, and reproduce, animals must adapt quickly to new habitats and climate dynamics.

Cognitive abilities and brain size have emerged as important factors in facilitating animal adaptation to climate and environmental change. However, as larger brains face thermoregulatory challenges in warming climates, understanding the relationship between brain size, cognitive function and the development of cooling structures within the skull remains an under-explored research topic. Mammalian skulls, particularly the rostrum and bony turbinals responsible for thermoregulation and olfaction, may adapt to prioritise cooling at the expense of olfactory capacity, especially in dietary generalists such as omnivorous mustelids. However, the weakening of olfactory function will not affect the fitness of these species because I expect a parallel shift in their diet towards plant foods, which will be more easily and longer available as the climate warms. Studying changes in the morphology of the skull, braincase and musculature can provide valuable insights into how animals respond to changing biotic and abiotic pressures and shed light on the evolutionary mechanisms driving their adaptability in a rapidly changing world.

In the proposed project, I will investigate three cranial regions responsible for cognition (brain size), food intake (mandible, jaw and orbital part where the muscles are located) and thermoregulation (turbinals in the skull rostrum) based on analyses of micro CT-scans and 3D models of skulls. Specimens collected in natural history museums will enable the analysis of long-term morphological changes in populations inhabiting diverse climates and environments. The trade-off between brain increase to improve cognitive function and brain shrinkage to prevent overheating will be analysed using digital endocranial casts of skulls, which are commonly used as a proxy for brain morphology. The thermoregulatory and cooling capacities of the brain will be estimated by segmentation of respiratory turbinals. Changes in cranial morphology will be correlated with diet changes determined by the proportion of stable isotopes of carbon and nitrogen in bones, as well as with climatic and environmental variables on broad temporal and spatial scales.



Skull, braincase endocast (blue) and thermoregulatory-olfaction structure (red) of specimen from the MRI PAS Zoological Collection (catalogue no. 51760).

Understanding the effects of climate change on animals is crucial for mitigating its negative impacts. This project will provide valuable insights needed to predict future morphological and dietary shifts, as well as their adaptive potential. Understanding the impact of these changes on the ecology of carnivores is crucial for their conservation.