Comparative brain morphology of specimens with different adaptative behaviors the bongo, the Java deer mouse, the maki catta and the sea lion

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Abstract

One aim of comparative neuroanatomy is to better understand brain function among species. It is tempting to try and explain brain differences throughout the animal kingdom by differences in adaptive behaviors as well as ecological factors.

Based on this idea, we explored, with MRI, the brain morphology of three species with different sociality and predator avoidance (Bongo, Java deer mouse and Maki Catta). Brains were collected after death of natural causes and MR-imaged. Brain and body weights were collected, and volumes of brain were estimated after MRI segmentation.

The brain-to-body weight ratio was close to 1 for the Java deer mouse (1.04%) and the maki catta (1.05%) but only 0.26% for the bongo. Encephalization quotients (EQ) were calculated using formulas defined for human (hEQ, constants 0.12 and 2/3; Cairó 2011, doi:10.3389/fnhum.2011.00108) and for dog (dEQ, constants 0.14 and 0.528; Saganuwan 2021, doi:10.1186/s13104-021-05638-0). Whatever the method, the Java deer mouse EQs were the smallest (hEQ=0.98; dEQ=0.88). The maki catta had a higher hEQ (1.23) than the bongo (1.14) whereas the order was reversed for the dEQ (maki catta dEQ=1.21; bongo dEQ=1.96). These values are coherent with the idea that EQ is higher in prey species using active predator avoidance (bongo) and in social species (bongo and maki catta).

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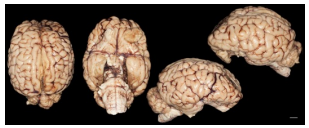
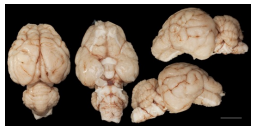
Adaptative behaviors of specimen

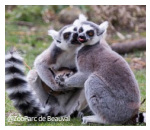
BONGO
Tragelaphus eurycerus
Herbivore
Gregarious
Prey (vigilance in group, escape)

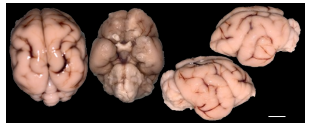


JAVA DEER MOUSE
Tragulus Javanicus
Herbivore
Solitary
Prey (hiding, fight)



MAKI CATTA
Lemur catta
Omnivore
Gregarious
Hierarchy
Prey (vigilance in group)





SEA LION
Zalophus californianus
Piscivore
Gregarious
Hierarchy
Predator (hunts alone, in group or in cooperation)

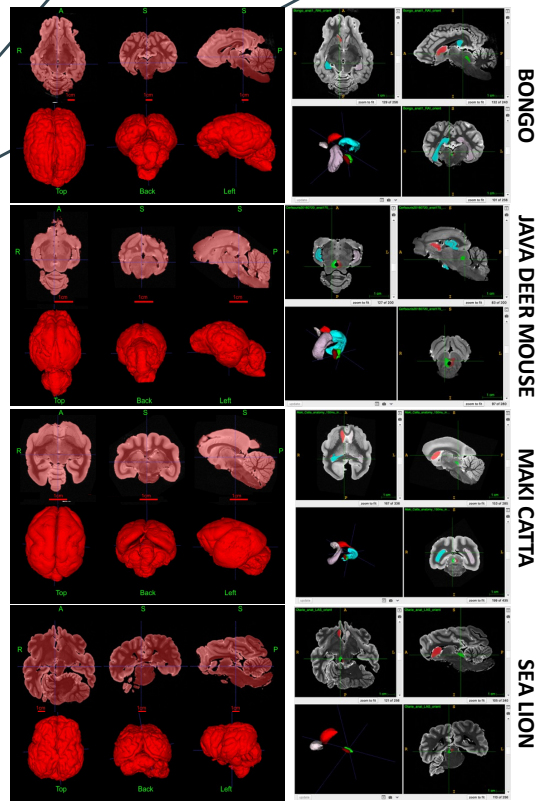
Declaration of death
→ Autopsy → Body weight
→ Brain sample → Brain weight
→ Brain Fixation
→ MRI acquisition
→ T²w
→ Images conversion DICOM to NIFTI
→ AC-PC reorientation
→ Segmentation

Encephalization quotient

$$hEQ = \frac{Brain\ weight}{(0.12 \times Body\ weight^{(\frac{2}{3})})} \times 10 \qquad dEQ = \frac{Brain\ weight}{(0.14 \times Body\ weight^{0.528})} \times 10$$

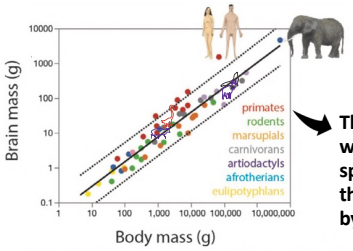
SPECIMEN	BONGO	JAVA DEER MOUSE	MAKI CATTA	SEA LION
Body weight (kg)	150	1.438	2.75	212
Brain weight (kg)	0.386	0.015	0.029	0.4
Brain-Body weight ratio	0.26	1.04	1.05	0.19
hEQ	1.14	0.98	1.23	0.94
dEQ	1.96	0.88	1.21	1.69

Brain volume **ROIs volume**



	SPECIMEN	BONGO	JAVA DEER MOUSE	MAKI CATTA	SEA LION
Volume (mm³)	Brain	353600	12080	25590	377800
	Caudate nucleus	1988 *0.56% to the brain*	63 *0.52% to the brain*	398 *1.56% to the brain*	4315 *1.14% to the brain*
	PAG	704 *0.20% to the brain*	58 *0.48% to the brain*	43 *0.16% to the brain*	214 *0.06% to the brain*
	Hippocampus	6320 *1.79% to the brain*	639 *5.29% to the brain*	624 *2.44% to the brain*	N.D.

If the proportion of the brain occupied by a structure has a functional significance, is the place occupied by the PAG related to the strategy of a prey against a predator (Bongo and Maki catta: vigilance in group; Java deer mouse: hiding and fight; sea lion: predator)?



The ratio of brain to body weight of the studied specimens is consistent with the data previously described by Herculano-Houzel (2019).

The hQE values found in the four specimens are coherent with the relationships already proposed in the literature between adaptive behaviour and EQ. The highest values are associated with social and gregarious species such as Bongo and Maki catta.

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