Comparative neuroanatomy and sensory abilities in birds.



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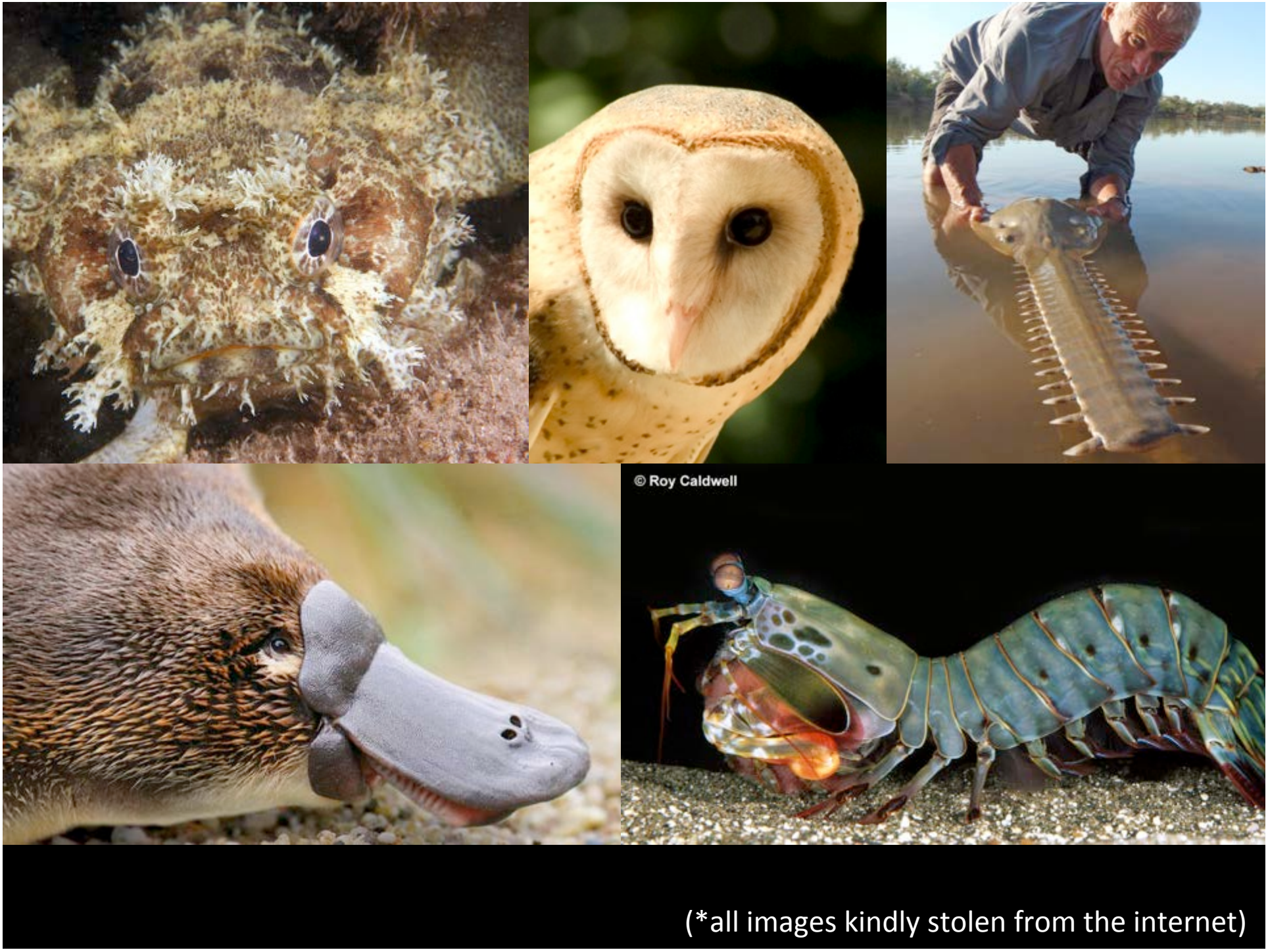


(*all images kindly stolen from the internet)

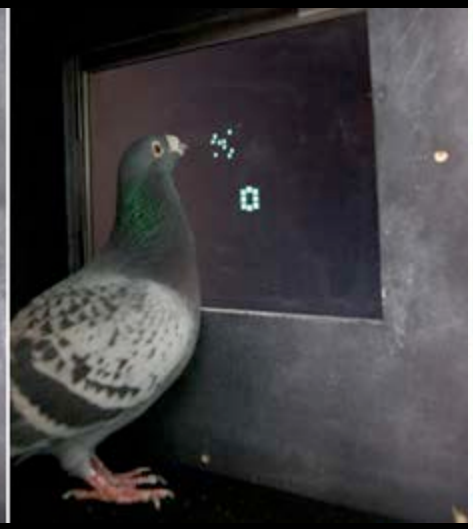
Testing acuity and sensitivity

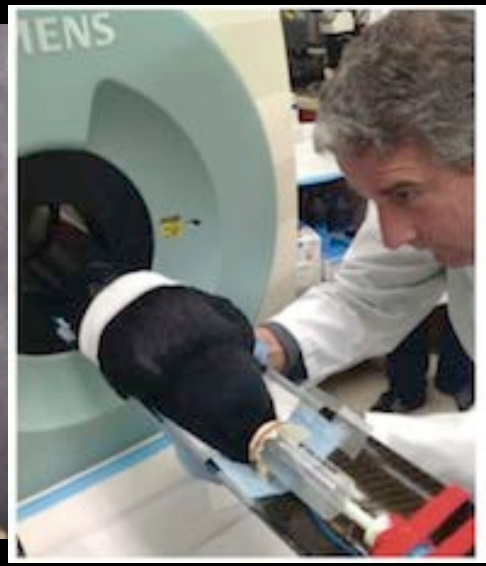
Behavioural

- time consuming
- expensive
- effects of captivity
- stimulus presentation

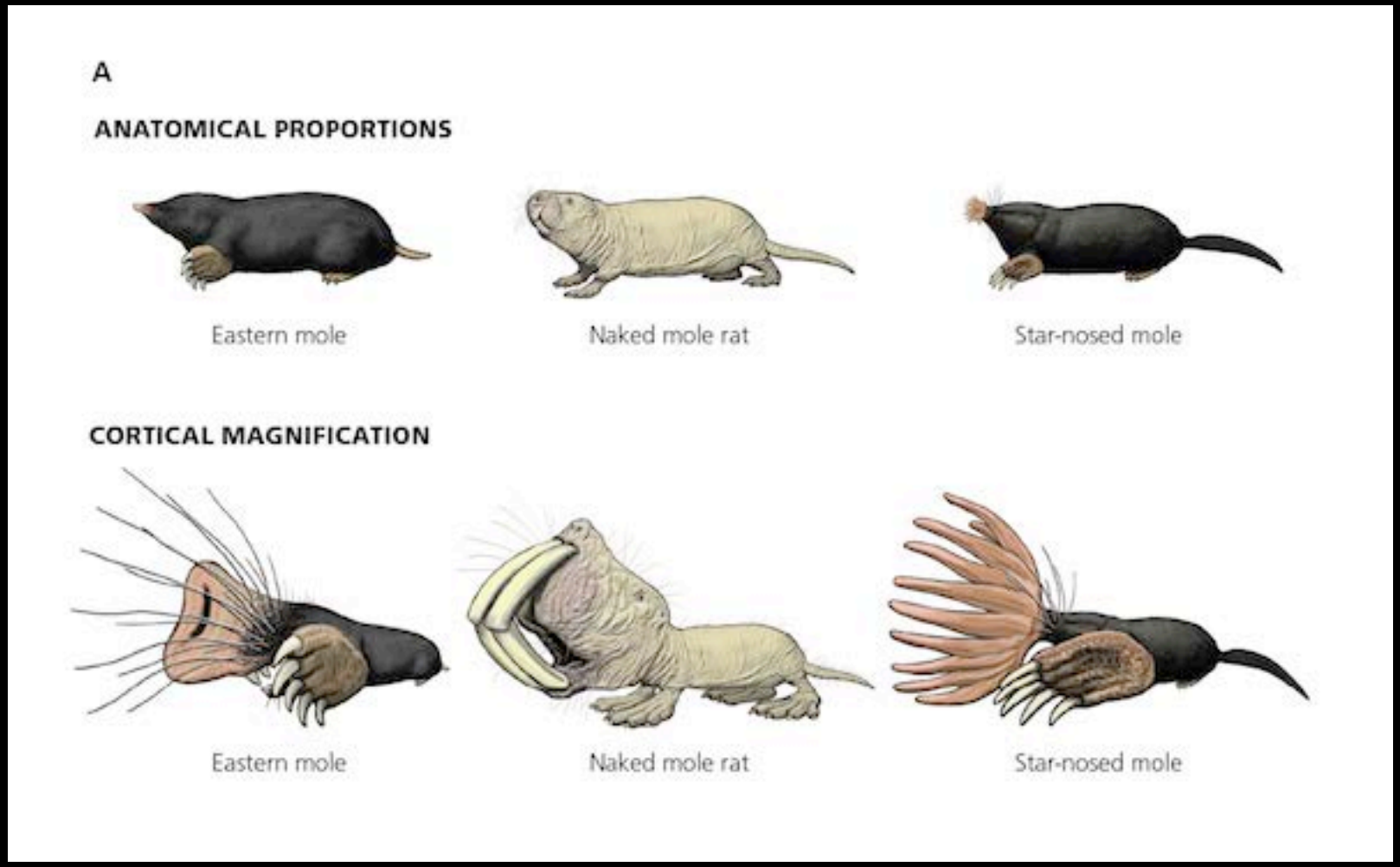
Physiological

- feasibility
- expensive
- logistics
- stimulus presentation



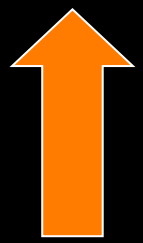


Anatomy and behaviour are linked

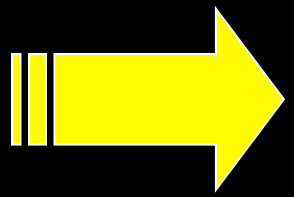


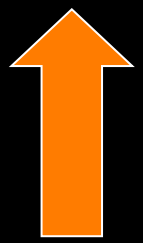
Principle of Proper Mass

"The mass of neural tissue controlling a particular function is appropriate to the amount of information processing involved in performing the function."



processing demands





brain region size

Relationship between anatomy and sensory abilities extends to birds

Comparative anatomy can provide information on the sensory ecology of critically endangered, intractable and extinct species.

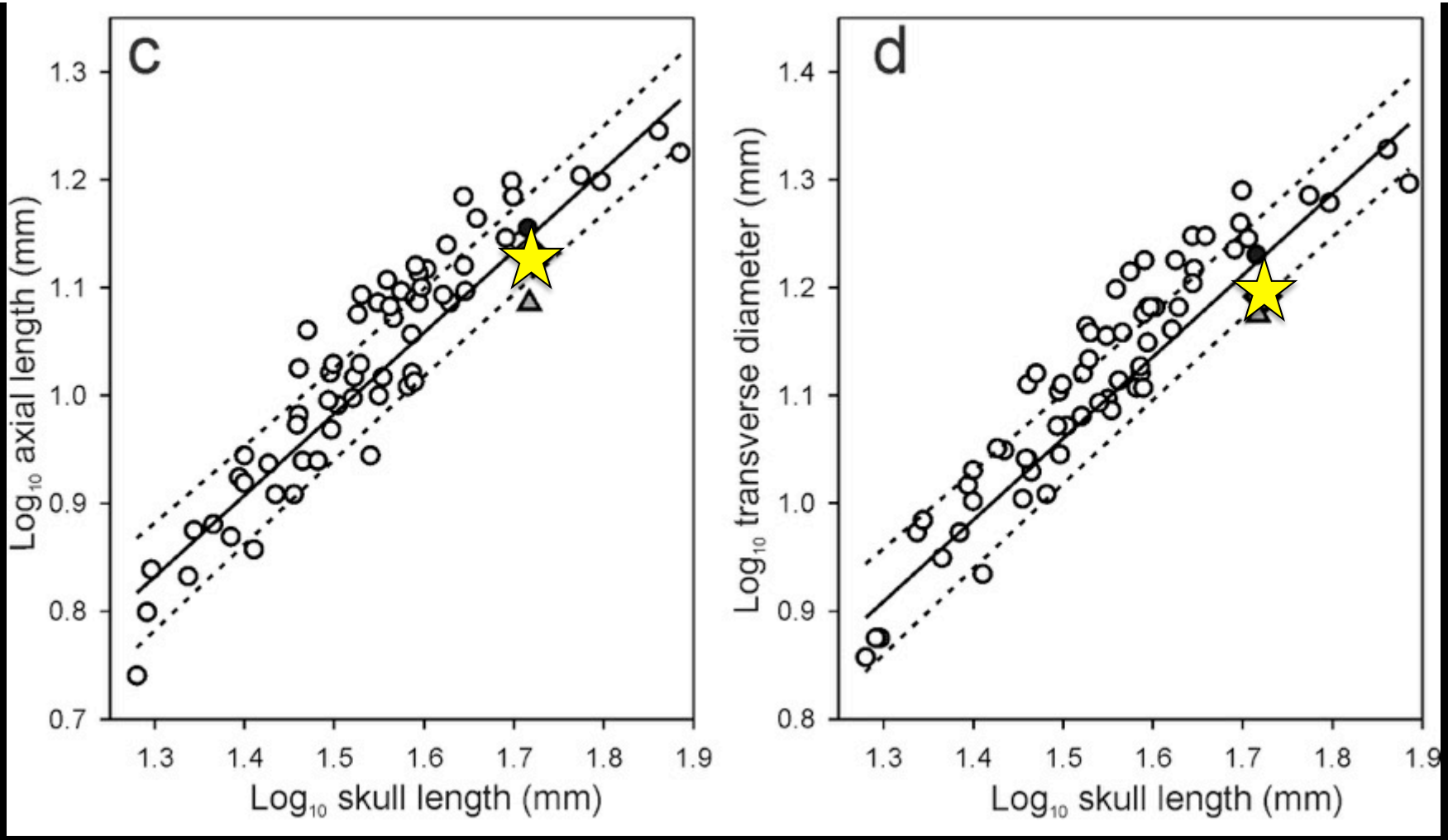
Vision in a critically endangered parrot

Sensory ecology of New World vultures

Sensory ecology of extinct species

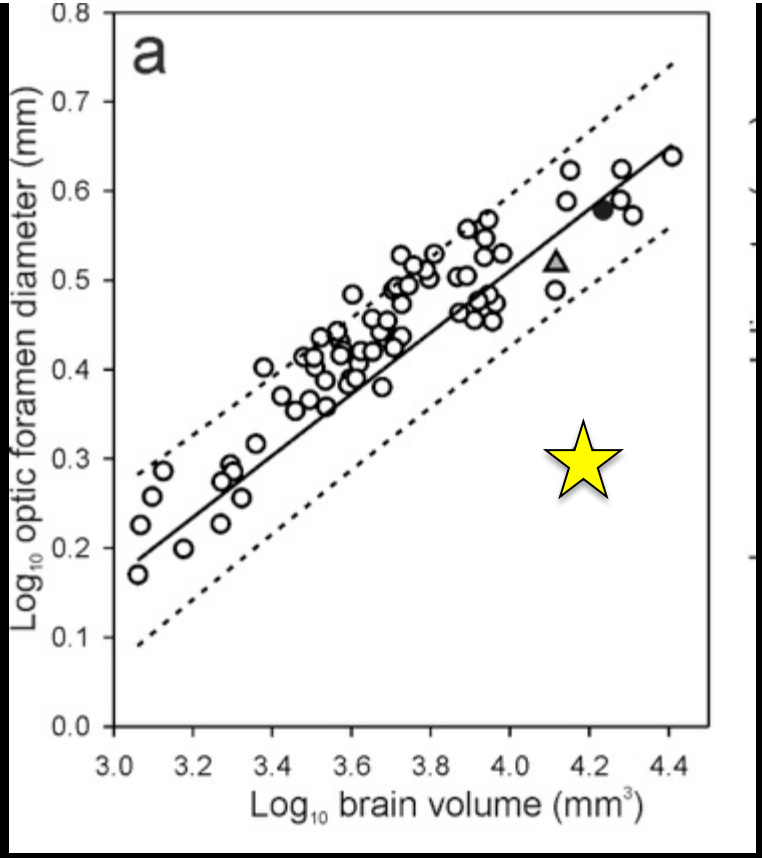
Kakapo visual system anatomy

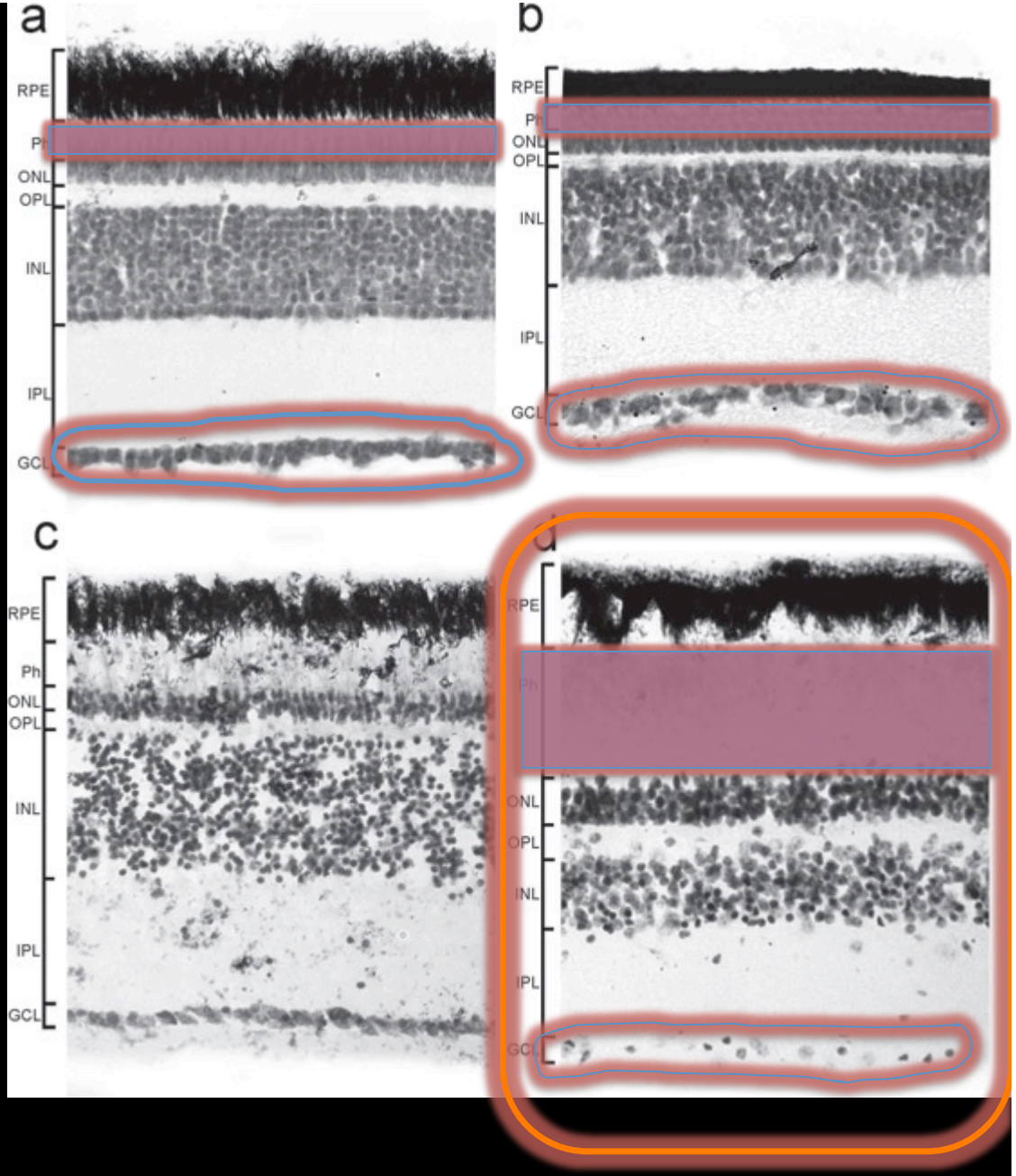
- Eye size and shape
- Optic nerve and retinal anatomy
- Orbit orientation (i.e., frontal or lateral)
- Brain morphology
- n = 1



Eye size (and shape) not different from diurnal parrots

Corfield et al. (2011) Plos One 6:e22945.

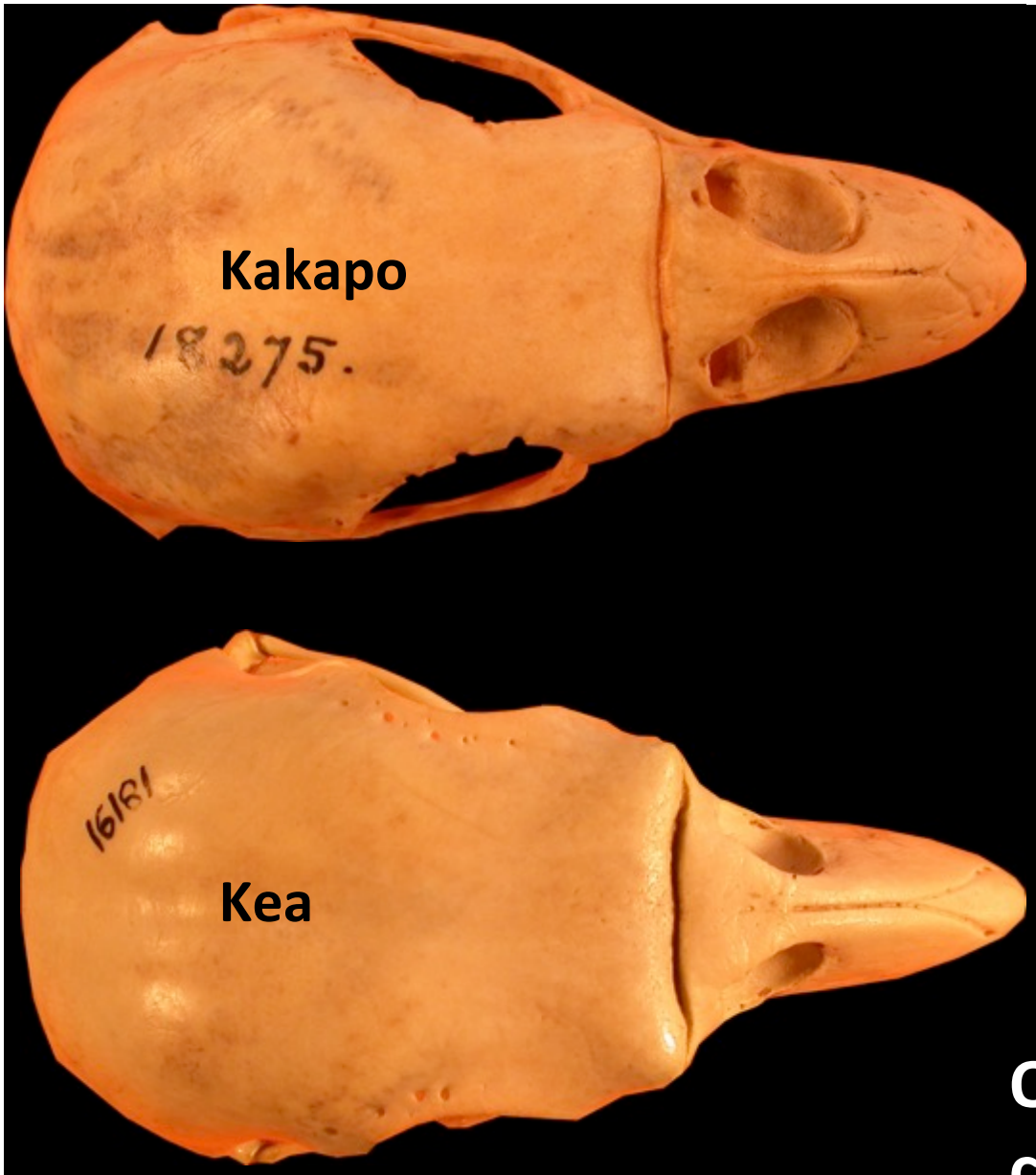


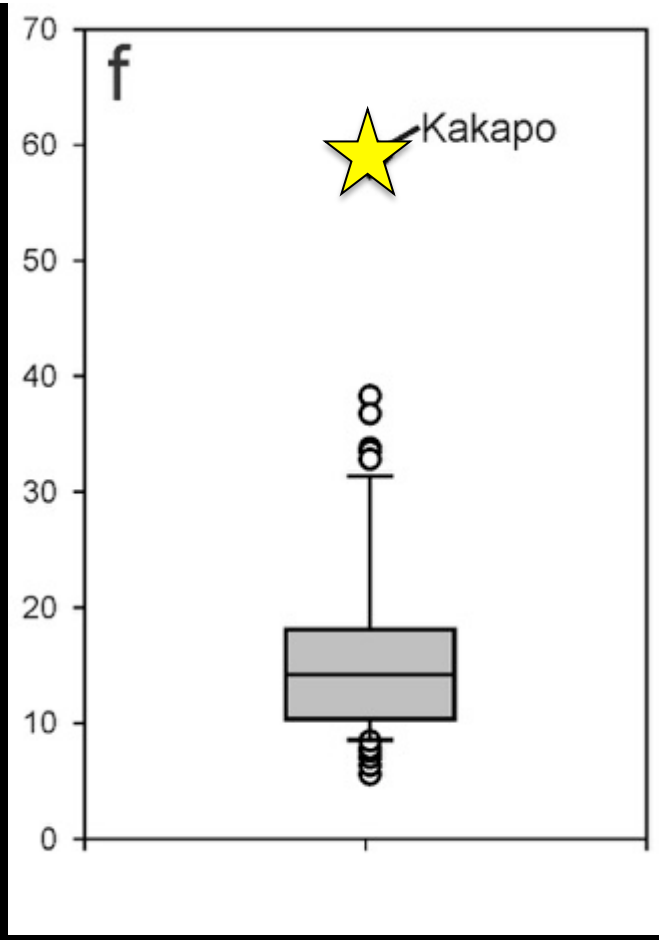


Ridiculously small optic nerve

LOTS of photoreceptors and relatively few retinal ganglion cells

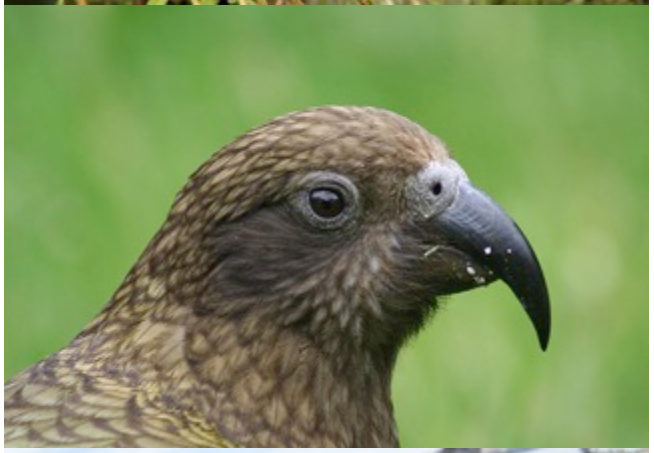
Corfield et al. (2011) Plos One 6:e22945.





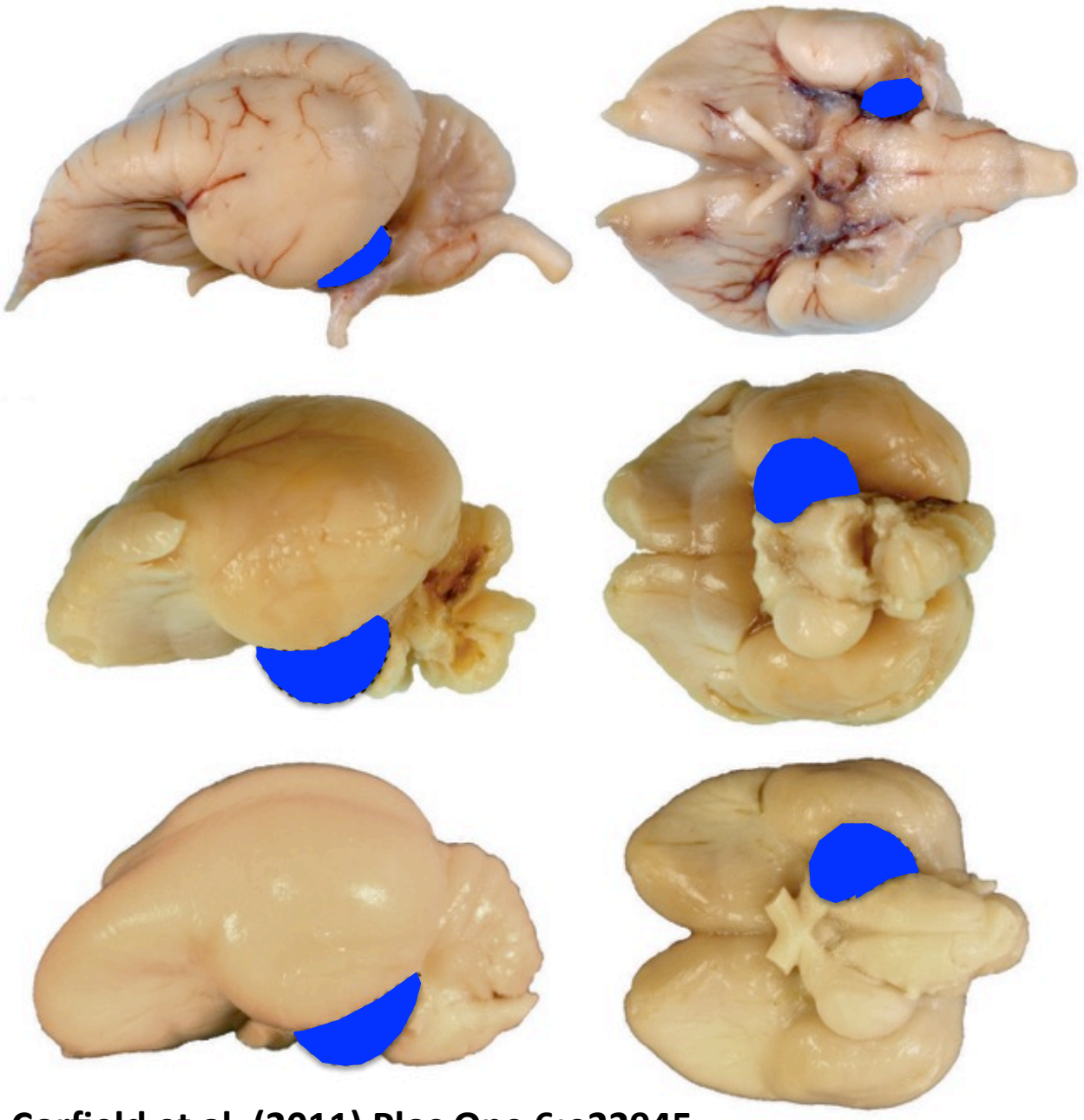
Orbits are MUCH more convergently oriented

Corfield et al. (2011) Plos One 6:e22945.

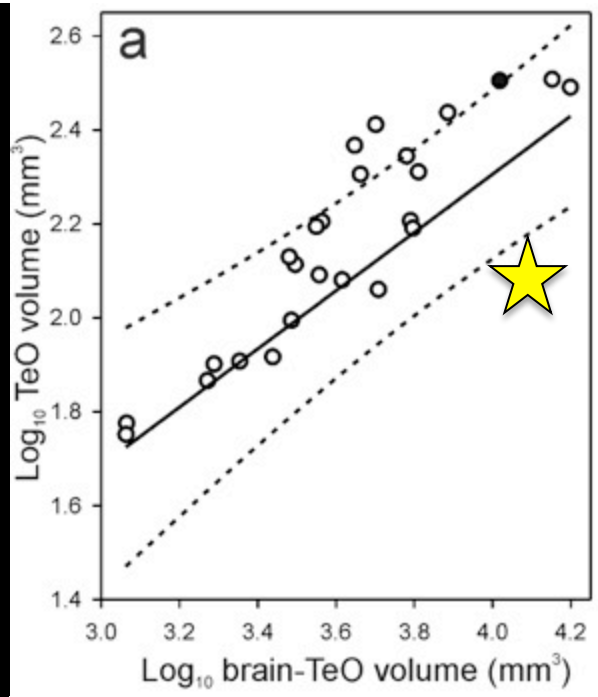


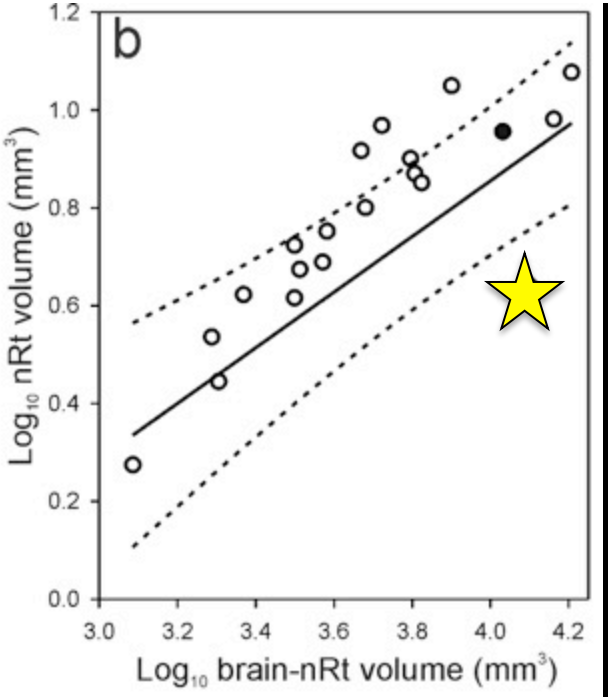
Lateral

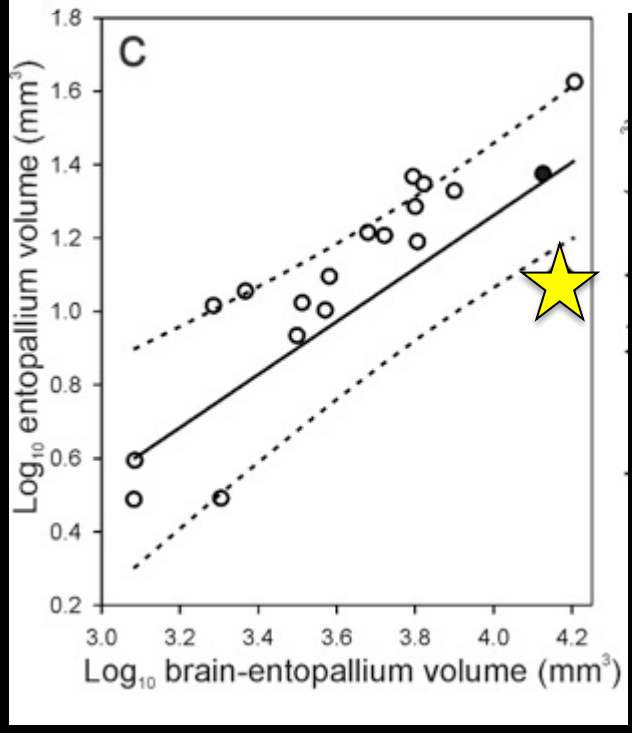
Ventral



Corfield et al. (2011) Plos One 6:e22945.







3 visual brain regions greatly reduced in size

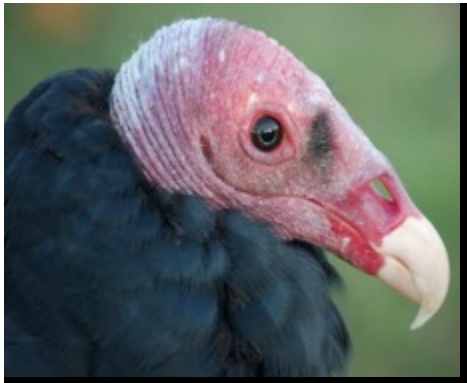
Corfield et al. (2011) Plos One 6:e22945.

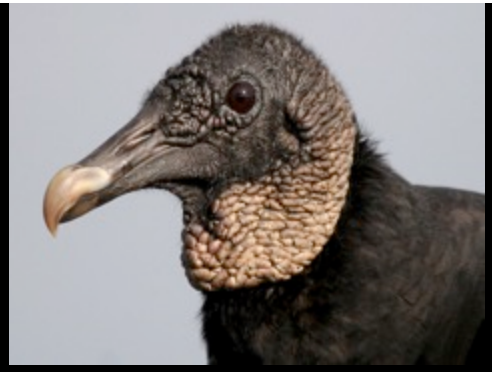
- **poor visual acuity**
- **enhanced low light vision**
- **broader binocular visual field**
- **in other words, it is definitely “owl-like”**

Black Vulture
- small nostrils
- relies primarily on vision

Turkey Vulture
- large nostrils
- relies primarily on olfaction

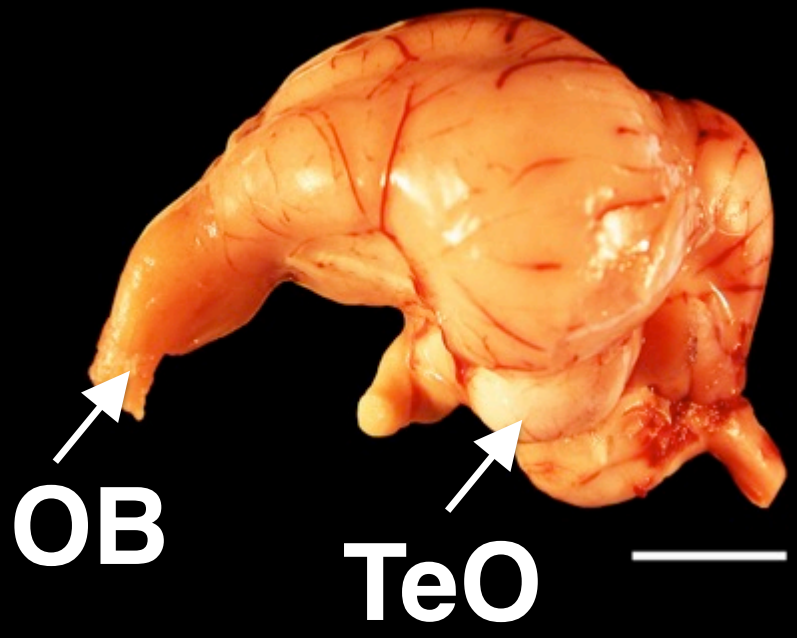
Purported differential use of olfaction and vision is ornithological mythology.

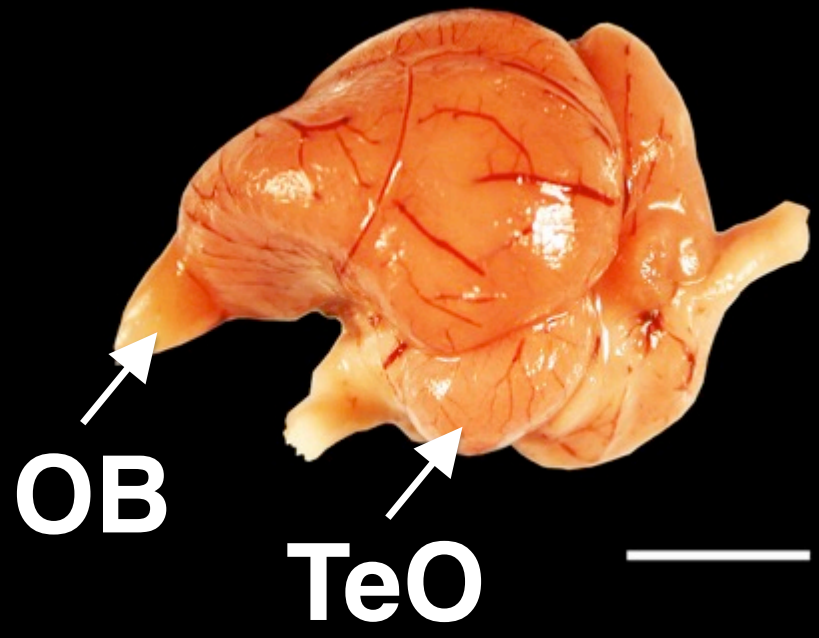




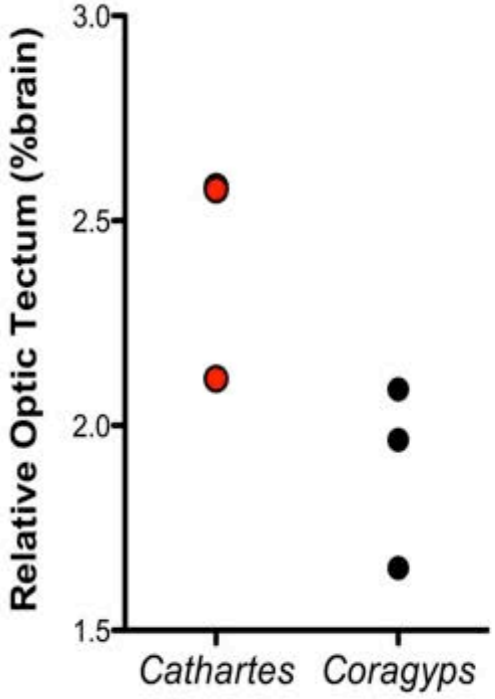
Turkey Vulture

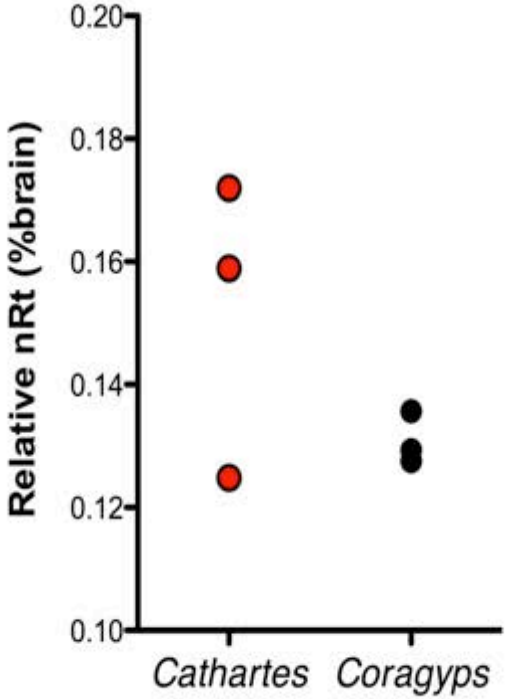
Black Vulture

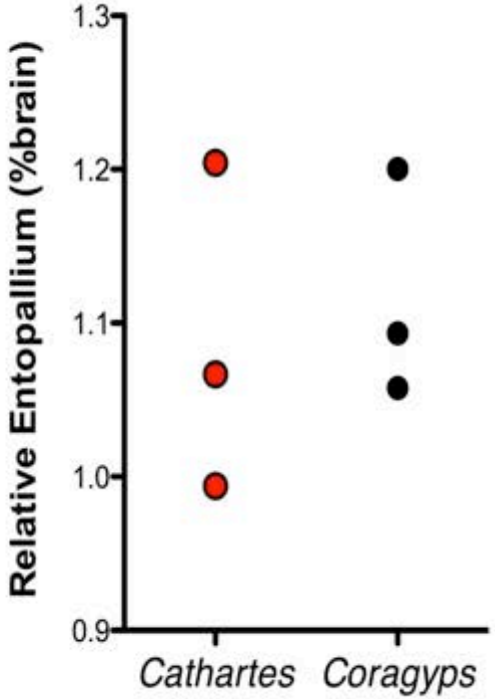




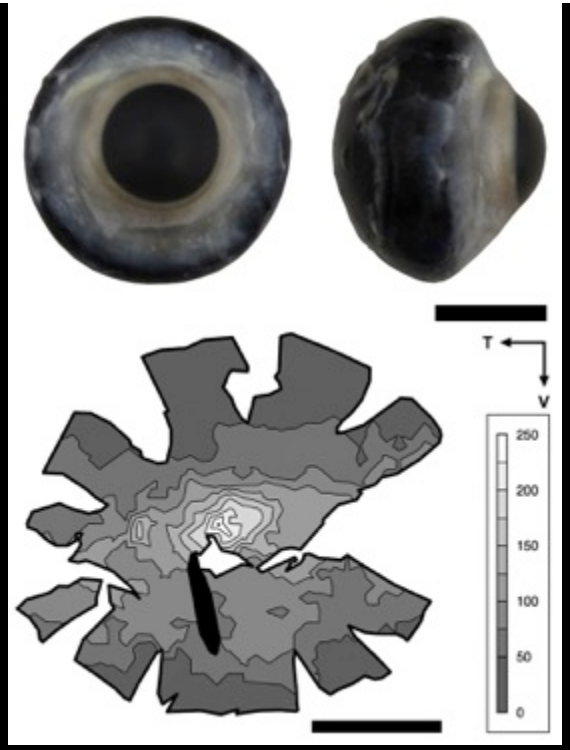
Visual system



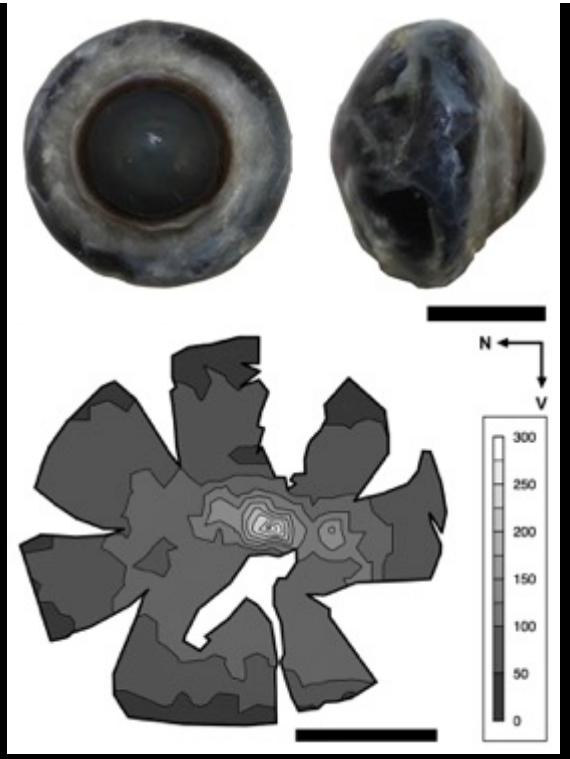




No significant differences in relative size of visual brain regions.



Turkey vulture

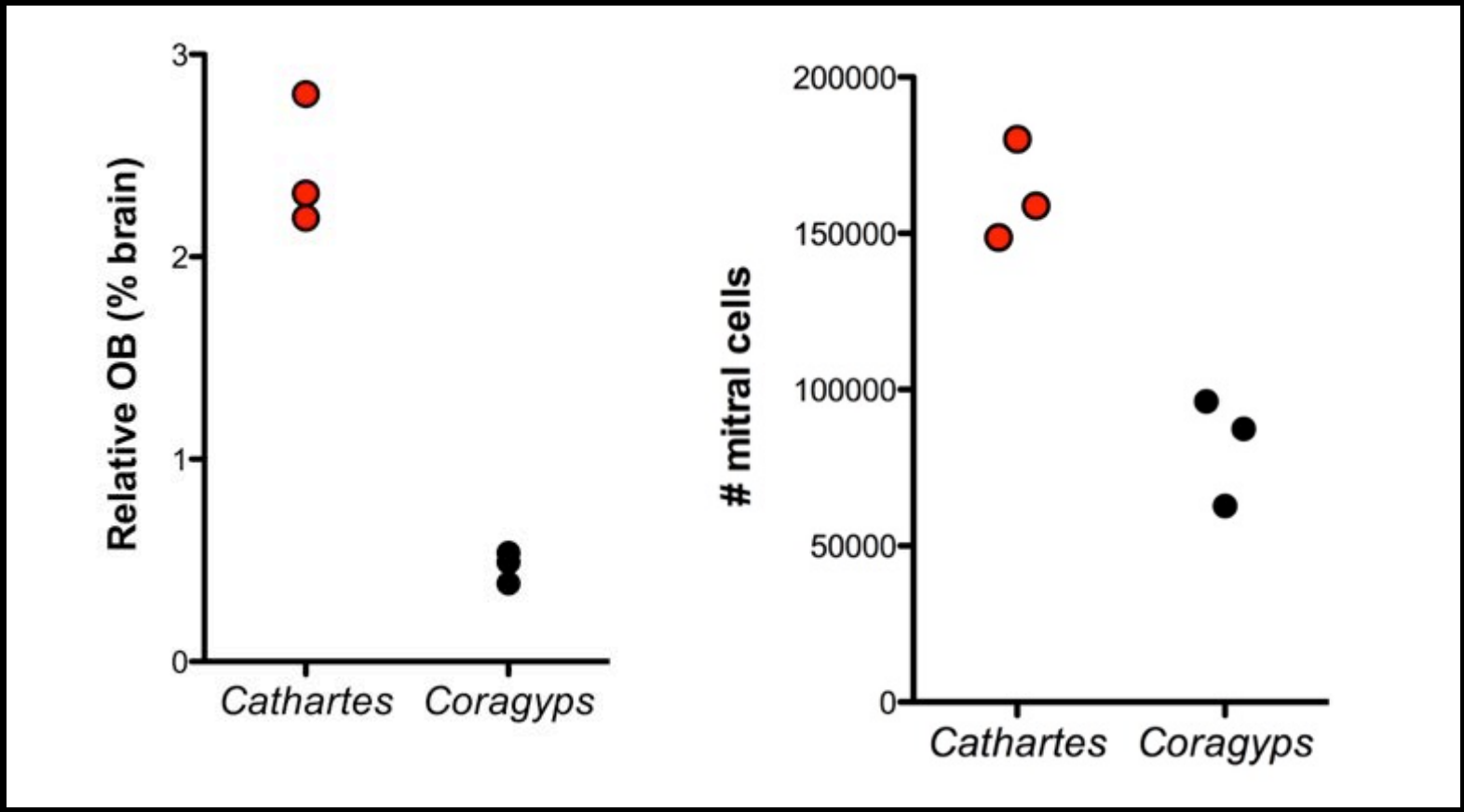


Black vulture

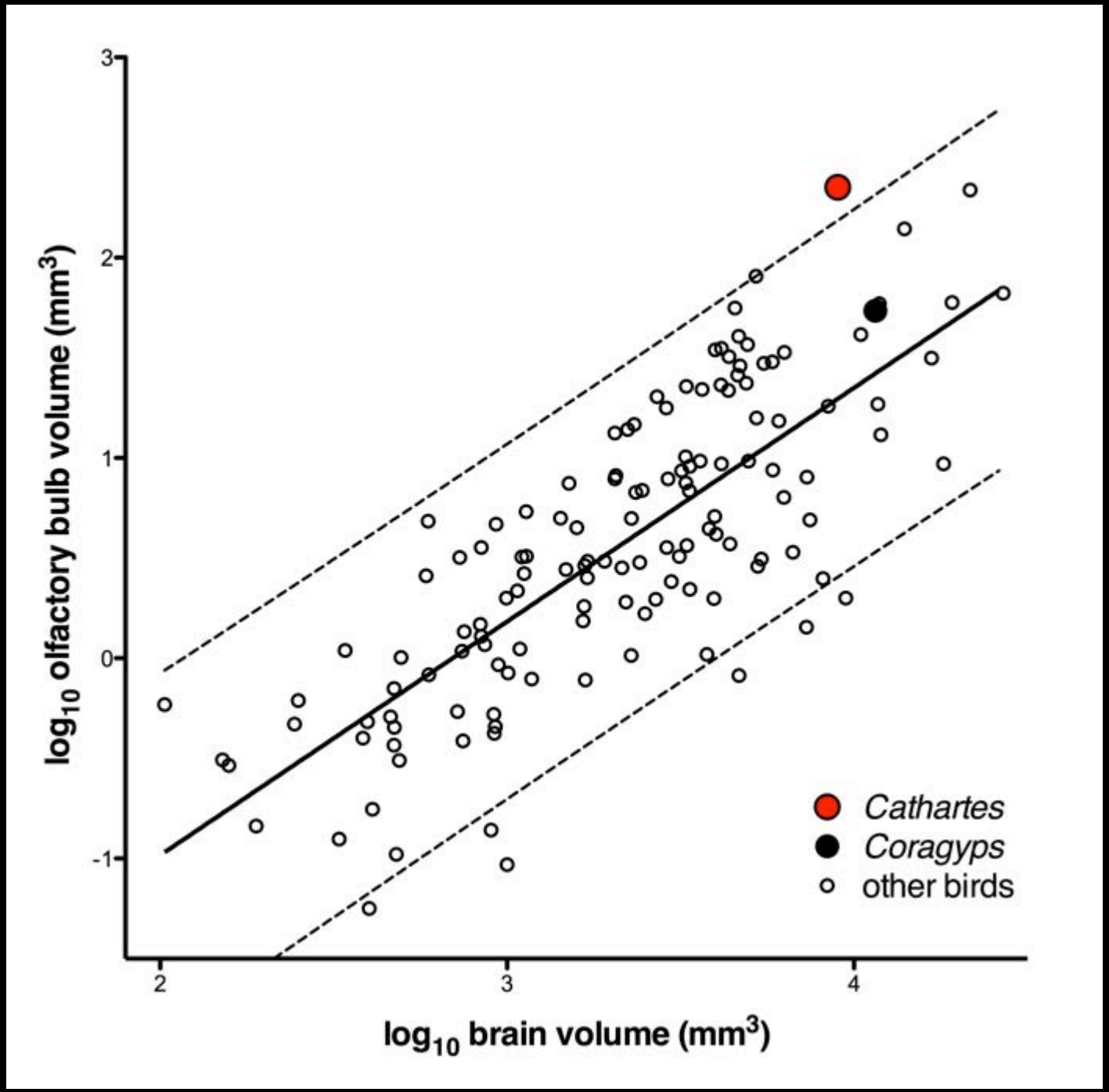
Corroborates general lack of differences in eye and retinal anatomy between species.

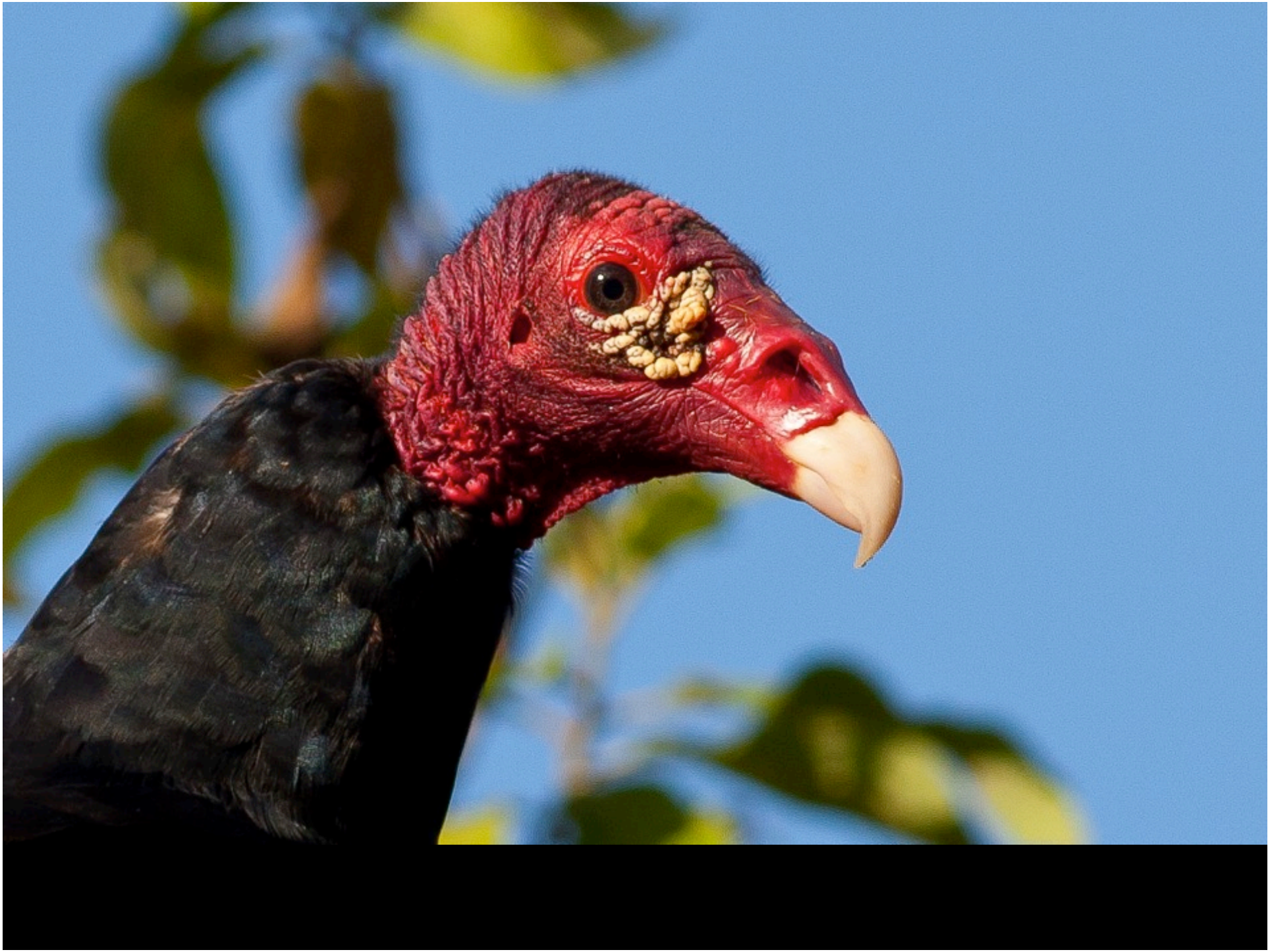
Lisney et al. (2013) Anat Rec 296: 1954-1970.

But, the olfactory system…

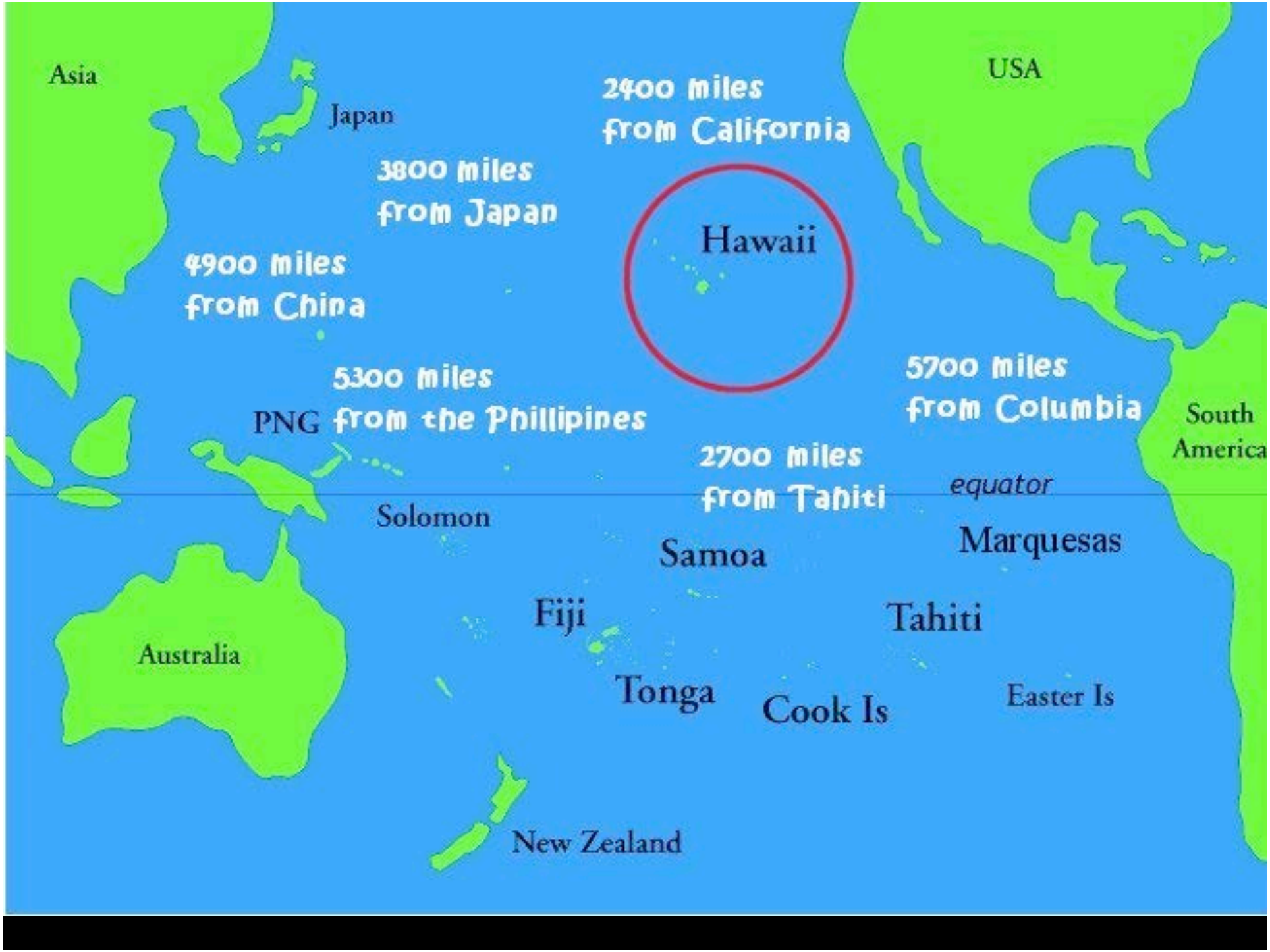


- 4 to 5 times larger in the turkey vulture
- and with twice as many mitral cells

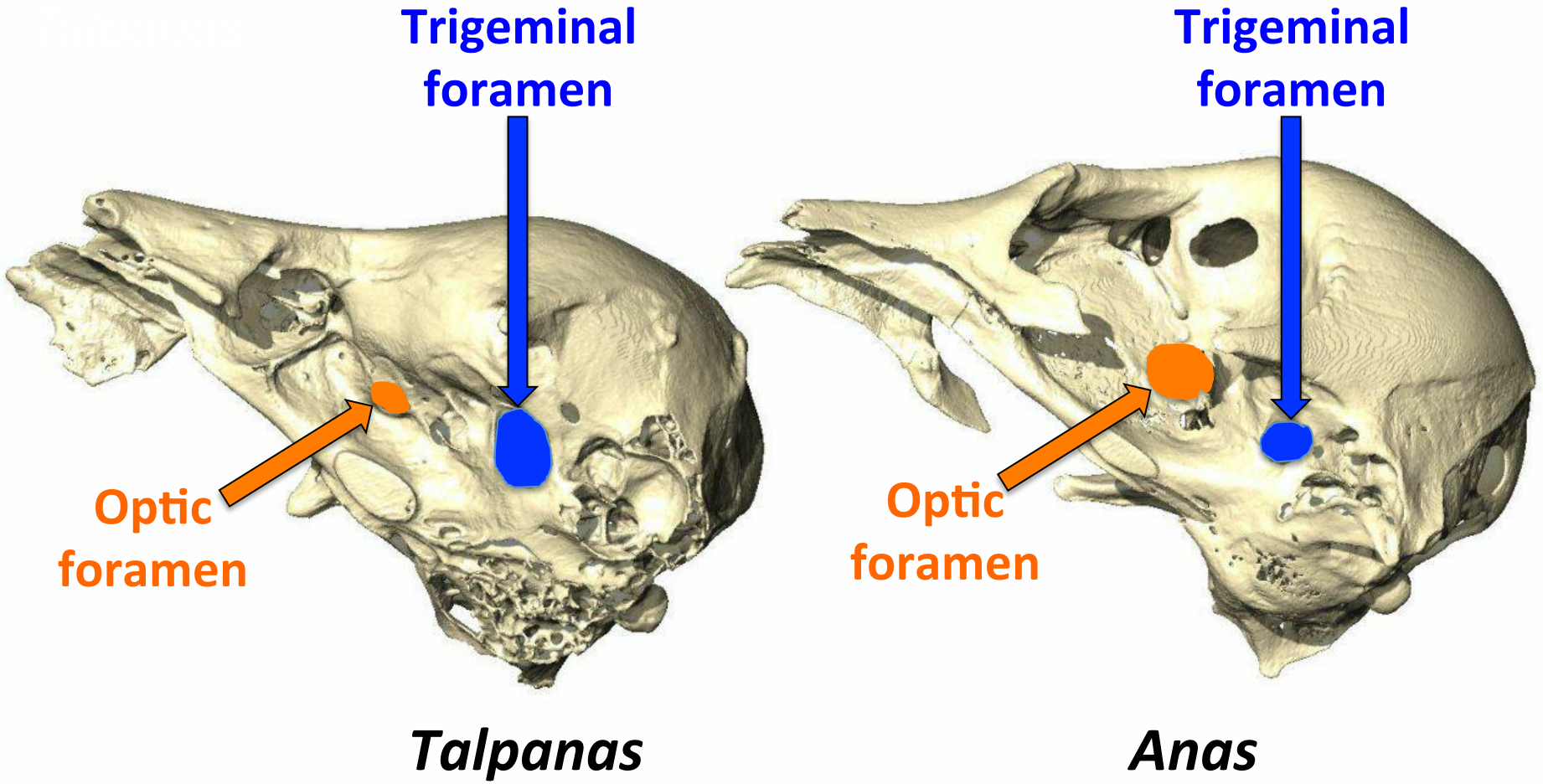

3
2
1
0
-1
2
3
4
log10 olfactory bulb volume (mm3)
log10 brain volume (mm3)
Cathartes
Coragyps
other birds



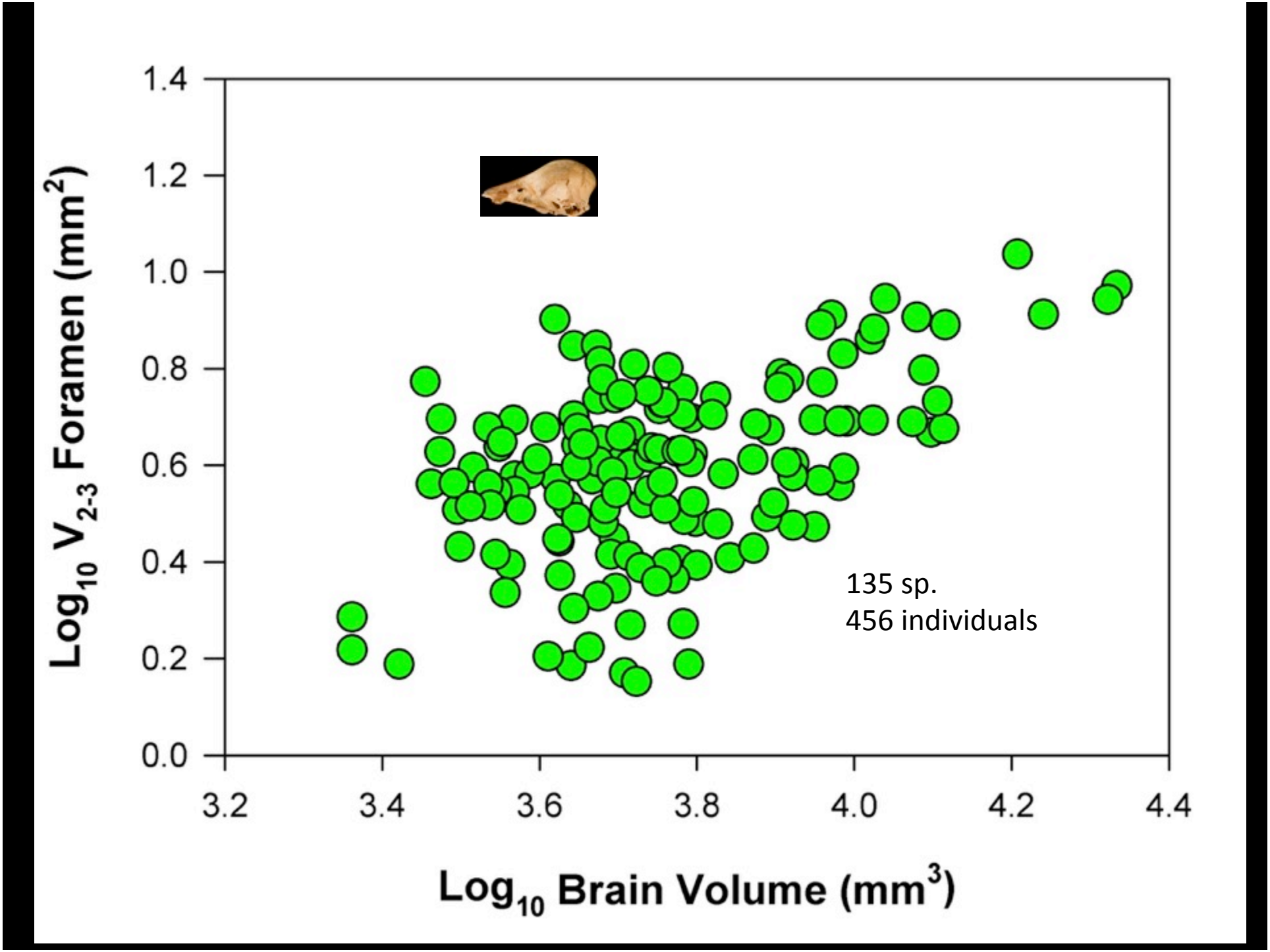
Can we use this information to understand the behaviour of extinct species?

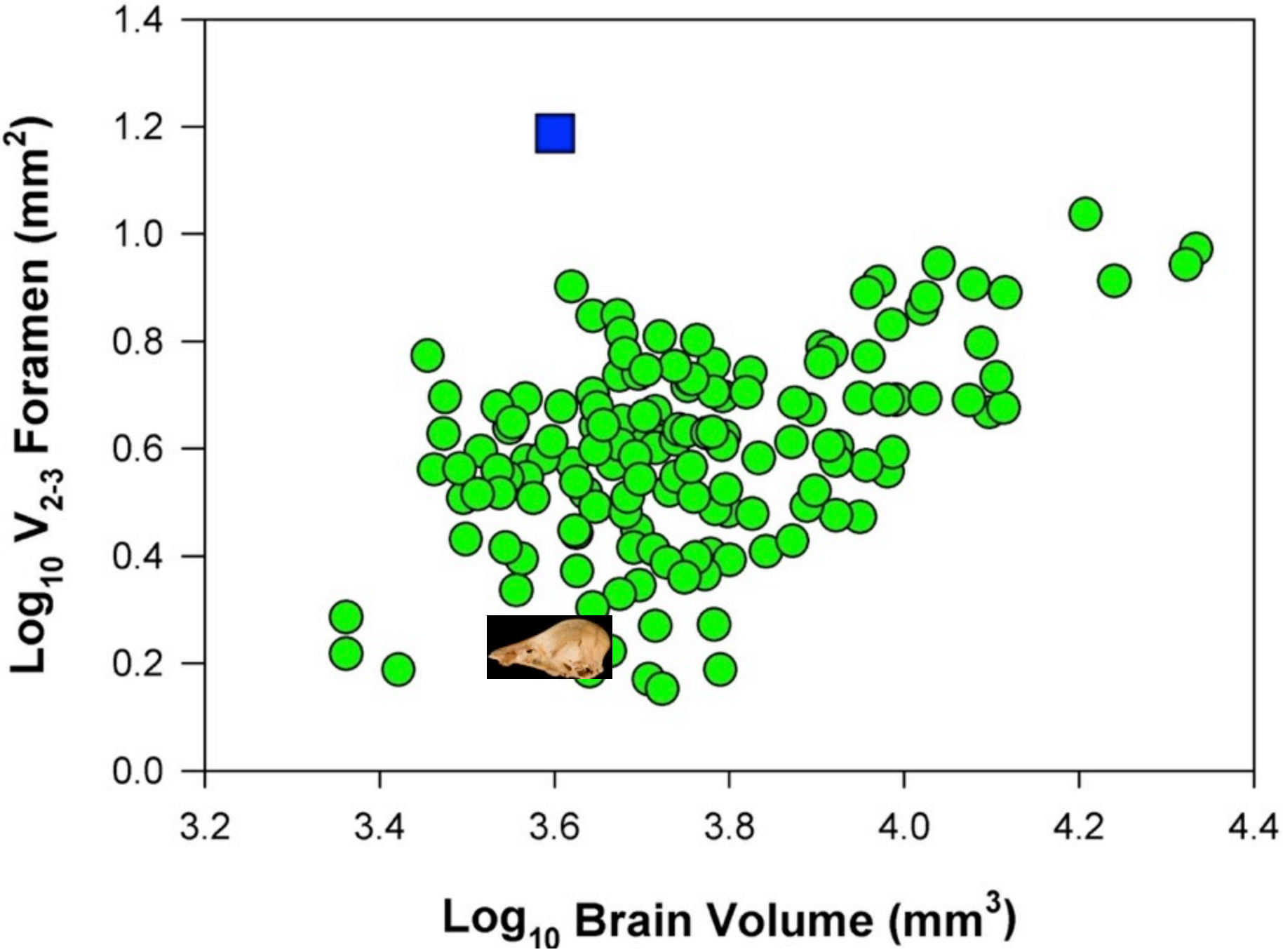

Asia
Japan
2400 miles
from California
USA
3800 miles
from Japan
Hawaii
4900 miles
from China
5300 miles
PNG from the Phillipines
5700 miles
from Columbia
South
America
2700 miles
from Tahiti
equator
Solomon
Samoa
Marquesas
Fiji
Tahiti
Australia
Tonga
Cook Is
Easter Is
New Zealand

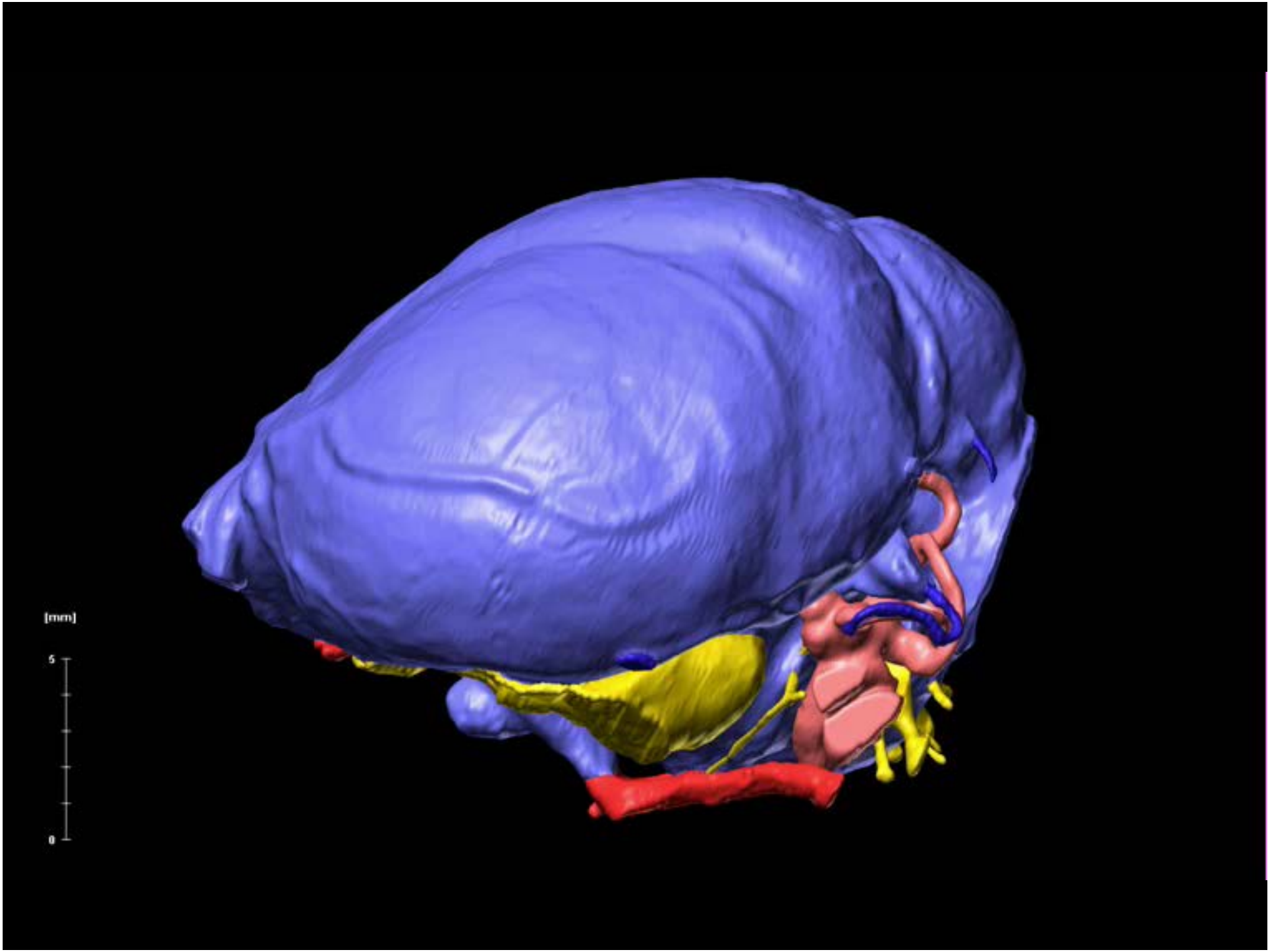

Talpanas lippa
The nearly blind mole-duck
Iwaniuk et al. (2009) Zootaxa 2296: 47-67.

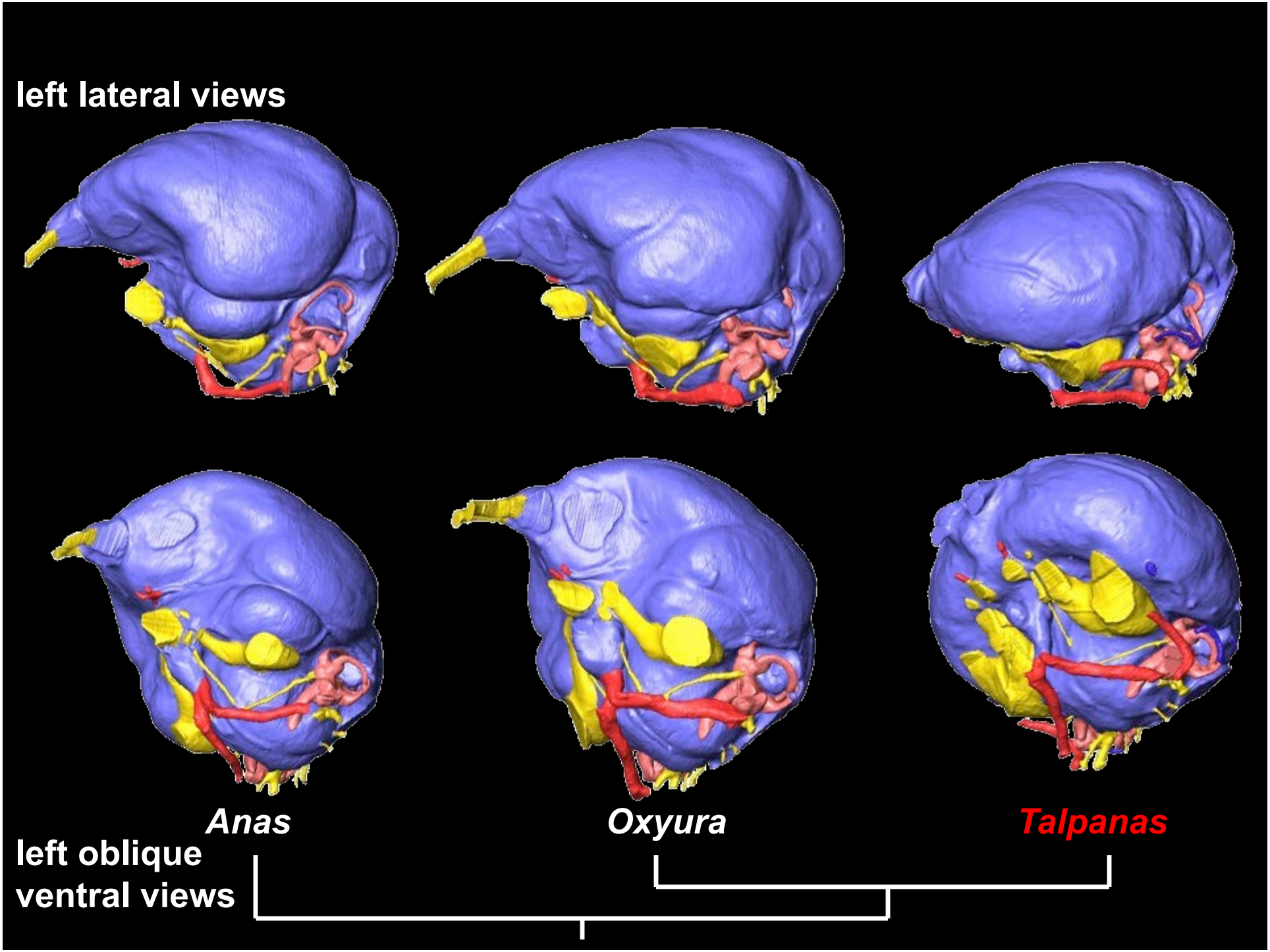


***Talpanas*: Somatosensation > vision**

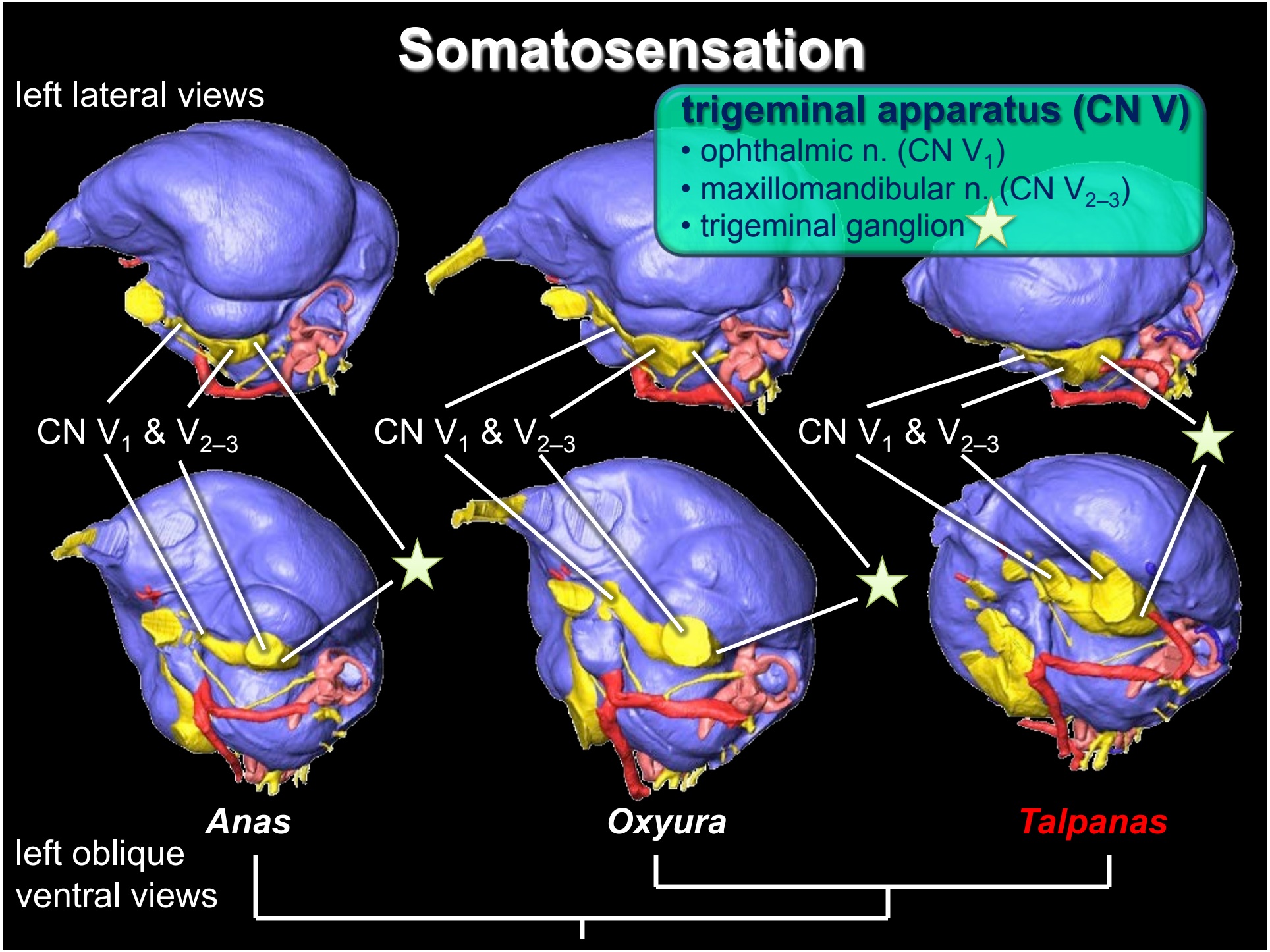

1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Log10 V2-3 Foramen (mm2)
3.2
3.4
3.6
3.8
4.0
4.2
4.4
Log10 Brain Volume (mm3)
135 sp.
456 individuals

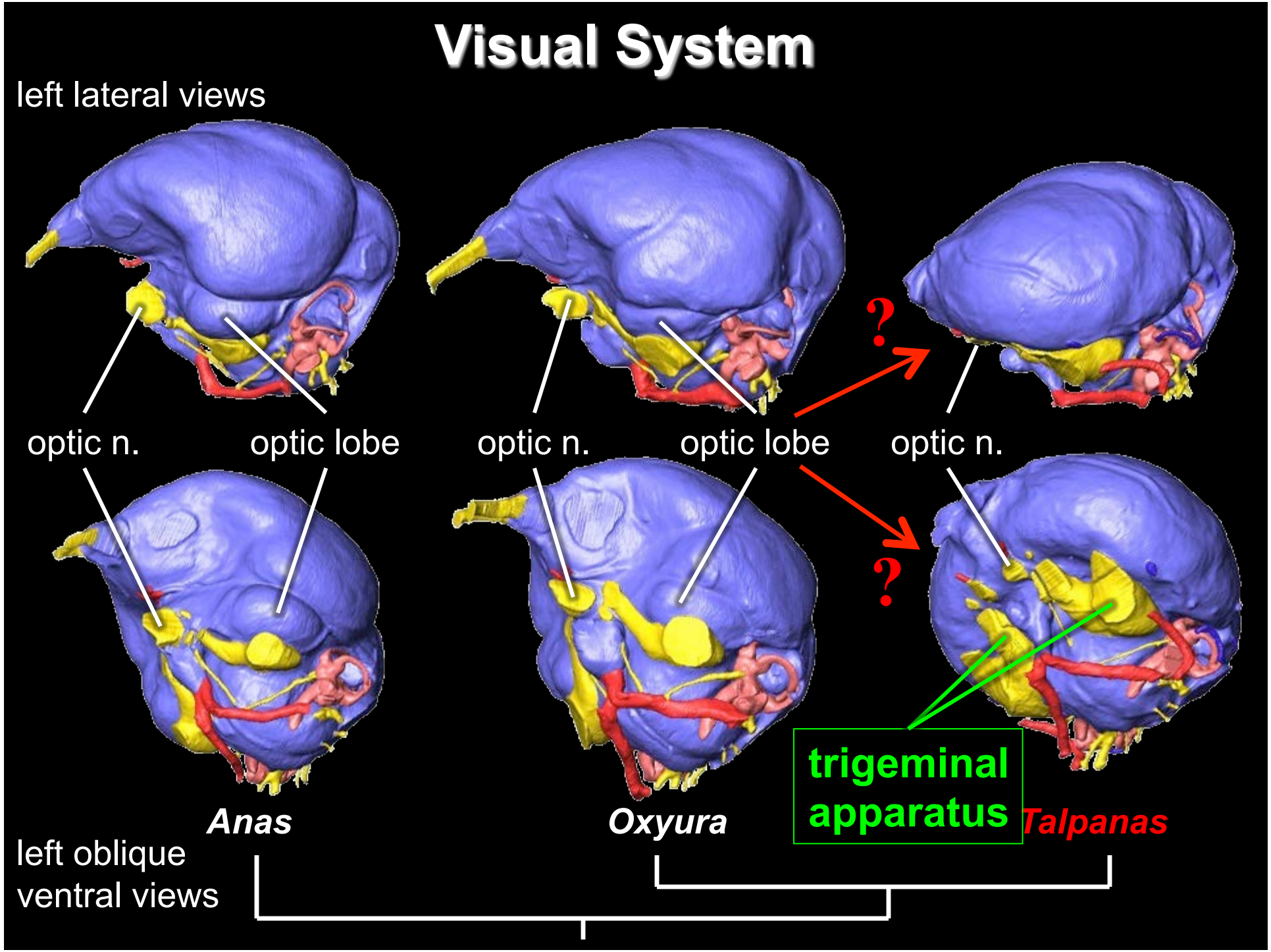

1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Log10 V2-3 Foramen (mm2)
3.2
3.4
3.6
3.8
4.0
4.2
4.4
Log10 Brain Volume (mm3)

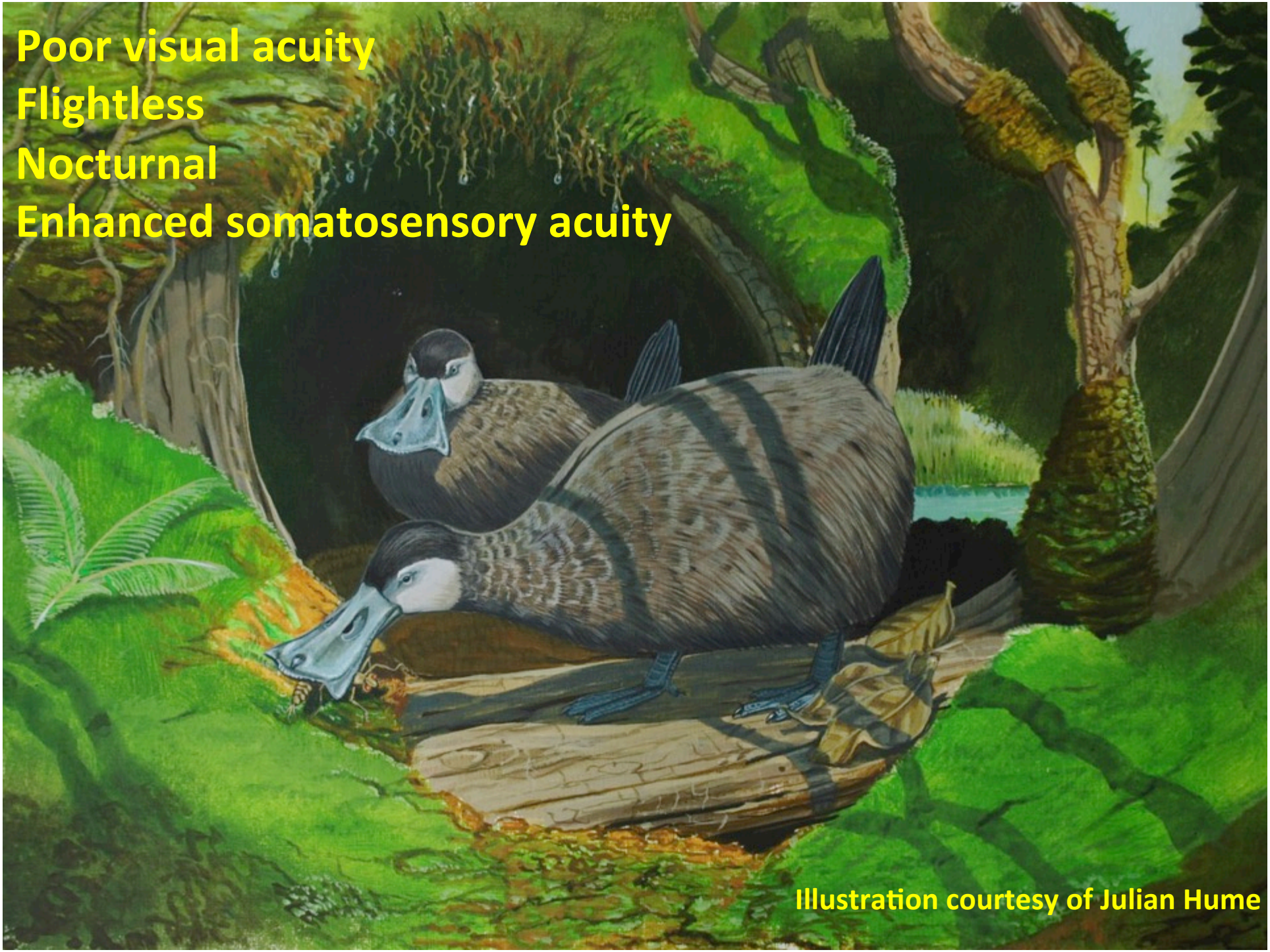

[mm]
5
0


left lateral views
left oblique ventral views
Anas
Oxyura
Talpanas

Somatosensation




Visual System
left lateral views
optic n.
optic lobe
optic n.
optic lobe
optic n.
?
?
trigeminal apparatus
Anas
Oxyura
Talpanas
left oblique ventral views


Poor visual acuity
Flightless
Nocturnal
Enhanced somatosensory acuity
Illustration courtesy of Julian Hume

Contrary to ‘popular’ belief…

- scavenged material can be incredibly useful and important
- anatomy can provide insight into behaviour
- relationship with ‘cognition’ is another matter
- size is <u>not</u> everything, but it DOES MATTER

Cognitive Ecology of Food Hoarding: The Evolution of Spatial Memory and the Hippocampus

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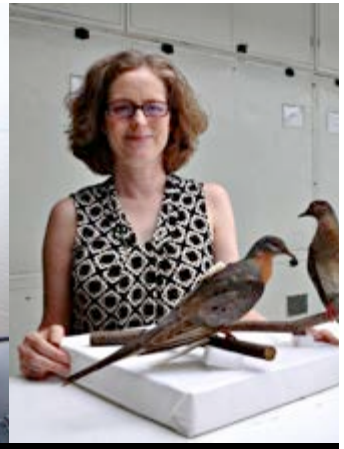
Justin Krilow (MSc)

Jeremy Corfield (PDF)



Gary Graves, Storrs Olson, Helen James

Larry Witmer

Doug 'Sunshine' Wylie

Smithsonian
National Museum of Natural History

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