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Paleoneurology of Therapsida (Synapsida) and the Evolution of soft tissue traits in the mammalian ancestry

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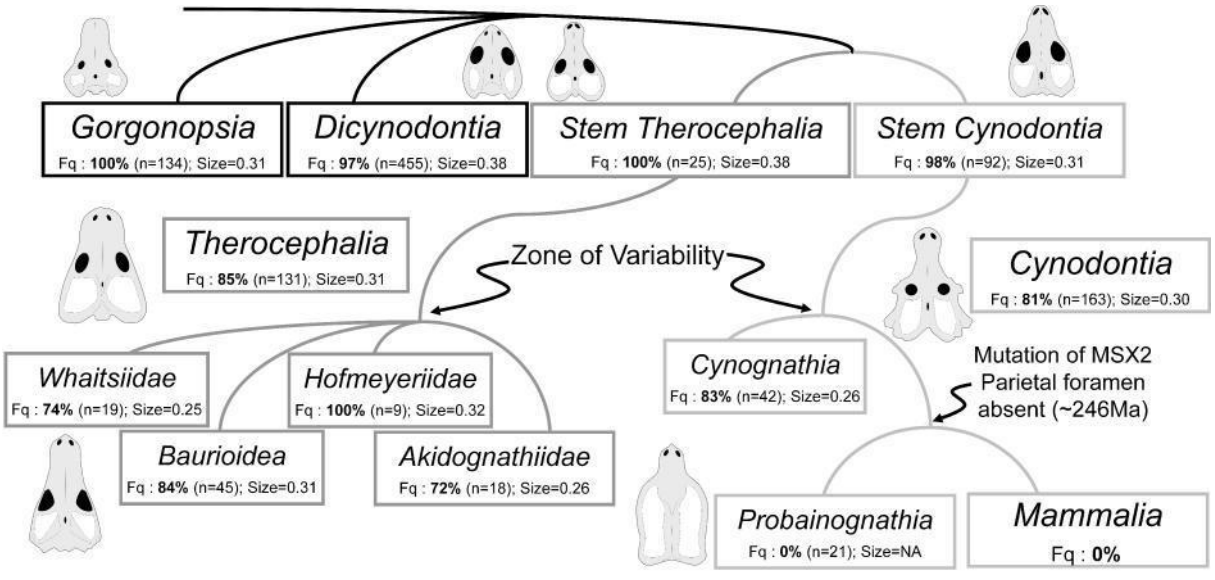
The evolution of the physiology and defining soft tissue characters of mammals, such as mammary glands and hairs, in mammalian ancestors (Therapsida) is difficult to assess because they do not readily fossilize. Virtual 3D palaeoneurology using CT-scan offers opportunities to find bony correlates of these biological and physiologcal features. Here we show that the parietal foramen for the pineal (or third) eye tends to be smaller and absent more frequently in eutherocephalians and eucynodonts in a convergent manner. Among cynodonts, the parietal foramen is completely lost in Probainognathia, the lineage leading to mammaliaforms. Given the role played by the pineal eye to achieve fine -tuned thermoregulation in extant ectotherms (i.e. 'cold-blooded' vertebrates) [1], this increasingly frequent loss of the pineal eye may be correlated with the evolution of a high metabolic rate (endothermy) in these derived therapsids. The zone of character variability may correspond to the transition through a mesothermic metabolism, and the definitive loss of the parietal foramen in Probainognathia would correspond to the acquisition of complete mammalian endothermy. Also, the loss of the parietal foramen in all Probainognathia may be pleiotropically linked to the appearance of mammary glands and mammalian body hair coverage since these traits and the complete ossification of the parietal fontanelle are all controlled by the same homeogene, Msx2, in mice [2]. This indicates that body insulation may have evolved in relation to the loss of the parietal foramen in Probainognathia, which supports our hypothesis. The presence of a mammalian infraorbital canal in the more derived probainognathians suggests that they displayed tactile vibrissae, which strengthens the possibility of the presence of hairs elsewhere on the body. To conclude, our data indicate that maxillary vibrissae, fur, mammary glands, an enlarged cerebellum, and endothermy first evolved in Probainognathia, some 246 mya, and that in silico paleoneurology is a very powerfull tool to reconstruct the evolution of soft tissue character and physiology.



Evolution of the frequency of presence of the parietal foramen (Fq), average size of the parietal foramen (Size), and number of specimens examined (n) in Therapsida.

References:

[2] Ralph CL et al. (1979) Biol Rev 54:41-72
[3] Satokata I (2000) Nat Genet 24(4): 391-395