Evolution of thalattosuchian crocodylomorphs – the role of the neurosensory system in adaptations to a secondarily aquatic lifestyle

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During the Mesozoic Era, numerous reptile groups secondarily adapted to an aquatic lifestyle. One prime example are crocodylomorphs (crocodylians and their extinct relatives). During the Mesozoic not only did they occupy semi-aquatic environments, but even terrestrial and pelagic-marine ones. This diversity demonstrates that they have been remarkably successful during the last 200 Million years of their evolutionary history. The best adapted to a life in the open ocean were Thalattosuchia. These ancient crocodylomorphs evolved from terrestrial ancestors into semi-aquatic forms and then adapted to a pelagic marine lifestyle. From the Early Jurassic to the Early Cretaceous these globally distributed crocodylomorphs include two families: the Teleosauridae and the Metriorhynchidae. The former are characterised by gharial-like body plan, with an elongated, slender snout, osteoderms covering their dorsal surface and unspecialised limbs. They occupied shallow marine environments with a semi-aquatic lifestyle similar to extant gharials. Metriorhynchids, adapted to open marine environments with paddle shaped limbs, lack of bony osteoderms and a vertically oriented tail fluke. While these osteological changes are well known, their sensory evolution remains poorly understood. Functional aspects of their neuroanatomy are essential to get an insight into paleobiology, behaviour and how ancient animals interacted with their environment.

Based on digitally segmented endocranial structures (such as the brain cavity, bony labyrinth and sinuses) derived from CT datasets, we can draw inferences about thalattosuchian sensory capability and evolution. Thalattosuchians, like cetaceans underwent a similar land-to-sea transition with reduction of air sinuses and semicircular canal size. In the most basal thalattosuchians (e.g. Pelagosaurus typus, Steneosaurus cf. gracilirostris), the pharyngotympanic sinus system is reduced and does not enclose the bony labyrinth and brain cavity dorsally, compared to most other crocodylomorphs (including extant crocodylians). Further reductions in the pharyngotympanic sinus system are present in the pelagic metriorhynchids. The overall bony labyrinth shape and especially the three semicircular canals show a reduction convergent to other secondary aquatic vertebrates such as cetaceans and various marine reptiles.

Secondary adaptation to a life in the open ocean represents a prime example of a major evolutionary transition. Our findings show that thalattosuchian neuroanatomy adapted to a marine lifestyle before large-scale osteological shifts (i.e. evolving flippers and a tail fin) and these could have underpinned the success of this remarkable group of animals.