Innovative evolutions in the skeleton of Mesozoic aquatic amniotes

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Amniota, a clade including mammals, reptiles, and birds, appeared as vertebrates that were adapted to life on the dry land during Carboniferous Period. In the Permian, however, some amniote clades including mesosaurs (Mesosauria) and eosuchians (Eosuchia) secondarily returned to the life in water. Various marine amniotes appeared after the Permian/Triassic boundary and flourished so much that they replaced top predators niche, which had been occupied by fishes. Mesozoic marine amniotes are often introduced as typical examples for structural evolution functionally constrained by swimming and diving, which may show viviparity, streamlined body, dorsal and caudal fins like those of fishes, or flippers like those of penguins and drastic change in bone compactness. On the other hand, being relieved from constraints of life on land, some marine amniotes acquired a characteristic body that is far different from basic terrestrial amniote body plan. For instance, placodonts (Placodontia) and saurosphargids (Saurosphargidae), which are found from the Triassic of Tethys, acquired osteoderms covering their body, and in some cases bones form exoskeleton-like structure, which is comparable to the turtle shell. Ichthyopterygians (Ichthyopterygia) appeared in the Early Triassic and showed outstanding hyperdactyly (excess number of digits), hyperphalangy (excess number of phalanges) or mesopodialization (loss of morphological identity of limb bone elements). Plesiosaurs appeared in the Late Triassic possessed a long neck with high number of cervical vertebrae, and finally acquired 76 cervicals in the Late Cretaceous. Hupehsuchians (Hupehsuchia) is known only from the Lower Triassic of China and possessed unique skeletal structures such as 1-3 layers of overlapped massive osteoderms along the dorsal midline, broad ribs without any intercostal spaces, a longitudinal low of osteoderms (or gastralia) like the scutes of carangid fishes along the body sides, and the neural spine of vertebrae segmented into dorsal and ventral parts. As above examples, the skeletal evolution of the Mesozoic aquatic amniotes took place with quite a high flexibility, and especially in the Triassic ocean, their skeleton may have deviated from the basic body plan of amniotes. Reconstructing the skeletal structure of these animals and their developmental mechanisms might be a key to revealing true plasticity in the morphological evolution of amniotes and understanding the constraints that selected the amniote morphology.

Keywords: Paleontology, Vertebrata, morphology, adaptation, Amniota, P/T boundary

