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A BRIEF INTRODUCTION: ORIGIN AND EVOLUTION OF SQUAMATE REPTILES

[1]Debanik Mukherjee

Ph.D. Reptile Taxonomy and Ecology, Field Herpetologist, CEMDE, University of Delhi, INDIA

Abstract: **Reptiles evolved from their Amphibian ancestor's long back during late Carboniferous period. Later on they experienced quite a few major mass extinctions on their evolutionary progression. Although the Mesozoic era is considered as the age of reptiles but the extant reptiles are also successful vertebrates in many parts of the earth, still adapting and evolving in new habitat types and variable climates. Evolution is never static as speciation may appear slow but a continuous process.**

Reptilia was erected originally as a Class by Laurenti (1768), may be considered as a paraphyletic group by excluding some of its descendents such as Mammalia and Aves. Modern reptiles are often represented as creeping, ectothermic vertebrates with dry, protective, moisture proof scales or scutes on their body, largely diverse in the tropics. But reptiles had a fascinating evolutionary history. They are the first tetrapods to get adapted to completely dry lands; lungs are the chief respiratory organs, cleidoic eggs and no larval stage have allowed them to be the first amniotes. They are evolutionary much advanced unlike their amphibian ancestors.

It was the formation of supercontinent (Pangaea) in Carboniferous period, end of the first half called Mississippian epoch (ca. 318 Ma BP), during this time probably because of extreme glacial phase or greenhouse warming the climate of the world was gradually changing from humid to relatively much arid conditions. In Pennsylvanian (later half of Carboniferous) the typical humid tropical rainforests or coal forests were eventually replaced by seasonal, dry, fragmented forest patches. This is also known as (CRC) Carboniferous Rainforest Collapse (Sahney, Benton and Falcon-Lang, 2010). Climatic aridification accompanied with restricted natural resources and elevated extinction rates had major impacts on the dominant Carboniferous amphibians. Their naked, moist skin and amphibious life style gradually becoming harder to adapt in this transformed environmental conditions. Although several lineages of Labyrinthodont and Leposondyl amphibians gave rise to reptiliomorph body forms (convergence), most probably one of the Labyrithodont lineage called terrestrial Anthracosaurs further evolved into first amniotes called Reptiles (Carroll, 1987)

The oldest known true reptiles or amniotes were *Hylonomus* and *Paleothyris* of mid-Carboniferous, the skull of *Hylonomus* was incomplete, while the skull of *Paleothyris* was complete and truly indicated the Anapsid condition.

A Short Communication by:

✉ [1] Debanik Mukherjee
Ph.D. Reptile Taxonomy and Ecology
Field Herpetologist, CEMDE,
University of Delhi, INDIA
E-mail: tomistoma@gmail.com

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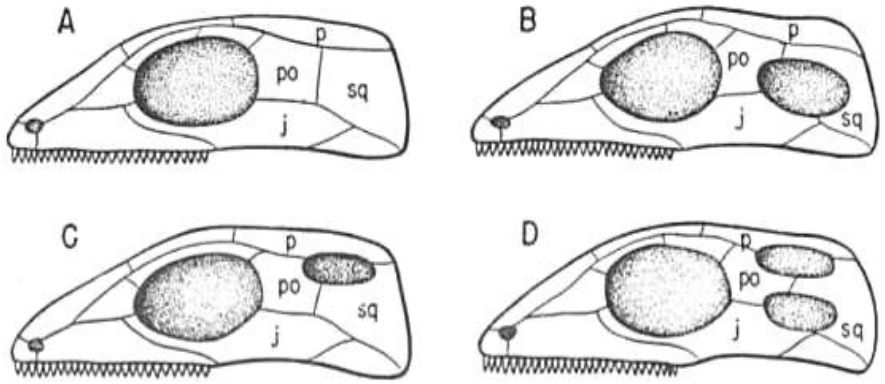

Fig 1. Patterns of temporal fenestrae in first amniotes (reptile) skulls

(A) Anapsida, no opening early taxa like *Hylonomus*, *Paleothyris* and even in modern day Chelonians (B) Synapsida, one lower temporal fenestra includes extinct mammal-like reptiles, (C) Euryapsida, one upper temporal fenestra, probably evolved from Diapsids includes extinct marine Nothosaurs, Plesiosaurs and Ichthyosaurs, (D) Diapsida, with two temporal fenestrae both lower and upper includes archosaurs such as living Crocodilians and extinct Dinosaurs and Pterosaurs, and extant Lepidosauria which includes Sphenodontida and Squamata (lizards, Amphisbaenia and snakes). P parietal, Po postorbital, Sq squamosal, J jugal and the bone between squamosal and jugal is quadratojugal. (Romer, 1956; Benton, 2005)

Although, the incomplete fossil records make tremendously difficult for paleontologists to establish and re-establish evolutionary gaps and give a complete picture of tetrapod relationships, it is almost certain that during end of the Carboniferous three major reptilian lineages Anapsids (Protorothyridid), Synapsids (Ophiacodontid) and Diapsids (Petrolacosaurid) were already evolved apparently from a single ancestral stalk. Anapsid skull conditions may be most primitive among reptiles hence, may not be a synapomorphy probably rather symplesiomorphy (still found in existing turtles and tortoises). Whereas, Synapsids and Diapsids were probably derived from Anapsids and Euryapsids from Diapsids. Evolution of reptiles may not always be a Phyletic Gradualism (anagenesis) but often shows Punctuated Equilibrium (cladogenesis).

In the Permian period, the supercontinent Pangaea and its gradually favourable climatic conditions gave enough scope for various reptiles to distribute world-wide and diversify. Synapsids were mostly dominant, Anapsids with their sister group Parareptiles were diversified but the sister lineage died out in late Triassic. Diapsids radiated during late Permian after an unusual and apparent gap in early Permian (Olson's Extinction) may not be comparable to the Romer's Gap during early Carboniferous. Two major lineages of end Permian Diapsids were Prolacertiforms, closely related to Archosauromorphs (ruling reptiles) and Younginiforms (Eosuchia), closely related to early Lepidosauromorphs.

Archosauria excluding extinct Pterosaurs, Dinosaurs and ancestral Crurotarsi, still contains living taxon Crocodilia and Lepidosauria apart from extinct marine Sauropterygians and Mosasaurids, still includes living Rhynchocephalians and Squamates (Saurians or Lacertilians, Amphisbaenians and Ophidia or Serpentes).

The end Permian extinction (ca. 251 Ma BP) was one of the largest mass extinction in the earth's history, which wiped out almost 70% of terrestrial and 90% of marine species. This cataclysmic event gave rise to a very different Mesozoic (Triassic, Jurassic and Cretaceous) world. Where the Archosaurians started dominating, this was the "Golden age of Reptiles". Although, the ancestors of all modern reptiles existed that time but it was largely Dinosaurs, Pterosaurs and marine lizards were predominant during the Mesozoic.

From Jurassic to Cretaceous the drifting of supercontinent and formation of Laurasia (North America and Eurasia) and Gondwanaland (South America, Africa, Antarctica, Australia and India), and their further splitting into present day world had enormous effect on distribution and speciation of various reptiles. It was the late Cretaceous catastrophe and mass extinction of Dinosaurs, Pterosaurs and Mosasaurs played a major role for modern reptiles to evolve and radiate world-wide.

Among all recent reptiles Chelonians the only living representatives of Anapsids perhaps a Parareptile too, Archosaurs (Diapsid) with only existing Crocodilians, Rhynchocephalians (Diapsid) showed very little change from their ancestral

Lepidosaurs, whereas Squamates (Diapsid) are much diversified and comparatively more successful taxa. Throughout Cenozoic, with newly emerged habitats, different climatic conditions and vacant niches created by the extinction of ruling Archosaurs; much agile, smaller bodied (various forms) Squamates started adapting and radiating much faster than Chelonians and Crocodilians.

Saurians are common and widespread till today, during late Cretaceous few adapted for subterranean life style by gradual degeneration of phalanges, limbs and even eyes. Still many lizard lineages have extant limbless representatives. However, during late cretaceous various squamates showed gradual degeneration of limbs, two very different and distinct limbless lineages one the Dibamid and Amphisbaenia and the other was Ophidians. The evolution of snakes is most fascinating as well as confusing for years among paleontologists. They probably evolved from Platynotan lizards and went on transforming, it may be possible that snakes had both semi-aquatic or aquatic and burrowing phases in the early history of their evolutionary lineage. Their much derived Diapsid skulls from Lizards, specialized jaw articulations (advanced Streptostyly), elongated limbless body, secretive but agile nature and various internal changes have made them most advanced compared to other Squamate reptiles.

It is always challenging and difficult to imagine with evidence and reinterpret millions year of evolutionary changes where even individual theories differs, as hypotheses are never constant and ever changes. Continental drifts, Vicariance and Dispersals had played major impacts on reptile speciation. It is not only Allopatric but Sympatric speciation, various Convergent evolution among several lineages of extant squamate reptiles are largely accepted by evolutionary researchers. Geographic and climatic changes, adaptation to habitat variability, variation in resource segregation patterns are potential factors for small bodied squamates to evolve, diversify and speciate further into new taxa.

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