Synopsis of Vertebrate Evolution

Tetrapoda (Amphibia)

BIO308/508 Comparative Anatomy
Will We Ever Know How It Really Happened?
Phylogeny

Actinistia (coelacanths) → Dipnoi (lungfish) → Eusthenopteron → Panderichthys → Tiktaalik → Acanthostega → Ichthyostega → Hynerpeton → Lissamphibia (modern amphibians) → Amniota → Tetrapoda → Sarcopterygia
Tetrapodomorpha

Tetrapodomorpha: Evolutionary Trends

Acanthostega (Top), Tiktaalik (Middle), and Eusthenopteron (Bottom) reconstructions with pectoral and pelvic girdles (proportions were derived from refs. 10, 16, and 17 and NUFV108).

Neil H. Shubin et al. PNAS 2014;111:3:893-899
left pectoral fin of *Eusthenopteron*

- cleithrum
- clavicle
- humerus
- ulna
- radius
- radials
- scapulocoracoid
Panderichthys
Tiktaalik

Neil H. Shubin et al. PNAS
2014;111:3:893-899
Acathostega & Ichthyostega
Digits of Early Tetrapods

- humerus
- ectepic
- radius
- intermediate
- ulna
- femur
- tibia
- fibula
- tarsal bones
- phalanges
- forelimb
- hindlimb
- cartilaginous support
- ankle bones
- leading edge of three digits
Modern Amphibians: Lissamphibia
Modern Amphibians: Lissamphibia
A stem batrachian from the Early Permian of Texas and the origin of frogs and salamanders

Jason S. Anderson, Robert R. Reisz, Diane Scott, Nadia B. Fribiachi, & Stuart S. Sumida

The origin of extant amphibians (Lissamphibia: frogs, salamanders and caecilians) is one of the most controversial questions in vertebrate evolution, owing to large morphological and temporal gaps in the fossil record. Current discussions focus on three competing hypotheses: a neoselachian origin within either the lissamphibians or a sister group of the lissamphibians and vertebrates (with frogs and salamanders arising among neoselachians and caecilians among the lissamphibians); or a neoselachian origin with frogs and salamanders arising among neoselachians and caecilians among the lissamphibians. These molecular analyses are also controversial, with criticisms for the batrachian (frog-salamander) divergence significantly older than the palaeontological evidence supports. Here we report the discovery of an amphibian taphoscolex from the Early Permian of Texas that bridges the gap between either Palaeoselachii and the earliest known salamanders and caecilians from the Mesozoic. The presence of a mosaic of salamander and caecilian characters in this small fossil makes it a key taxon close to the batrachian (frog-salamander) divergence. Phylogenetic analysis suggests that the batrachian divergence occurred in the Middle Permian, rather than the Late Carboniferous as recently estimated using molecular clocks, but the divergence with caecilians corresponds to the deep split between taphoscoleids and tylototritons, which is congruent with the molecular estimates.

Tetrapoda, 1982
Tennisonops (Gill, 1884)
Amphibian
1989
Goswami et al., 2019

Halopets
United States National Museum of Natural History (Smithsonian Institution): USNM 49071. Discovered by P. Koeppel, a Museum Specialist at the USNM.

Etymology
Greek (Greek): meaning age or elder, and batrachus (Greek): meaning frog. Species epithet in honour of the late S. H. Hinton, vertebrate palaeontologist from the USNM.

Locality and horizon
Locality number USNM 4977, ‘Doe’s Swamp Fish Quarry’, Clear Fork Group, Bailey County, Texas, USGS Snap Creek-7.2 quad. More specific locality information is on file at the USNM.

Age
Early Pennsylvanian.

Diagnosis
Amphibian taphoscolex with 21 tiny pedunculate teeth on the premaxilla and 17 prismatic teeth shares with crown group salamanders a basal coxal (combined distal trochanter 1 and 2) and subcoxal (intertrochanteral sulci and a quadrigeminate acetabulum) on the axis with salamanders and caecilians an anteriorly expanded groove, teeth shares with Tylototriton and crown group frogs a basal, laterally directed plate, lower jaw with posteriorly expanded column, teeth with mesotmethamuloid frogs and basal tylototritons, and salamanders a deep set of teeth with posteriorly expanded column, teeth shares with Salamandra, Tylototriton, and crown group frogs a broad skull, shortened plesistematal column, teeth with postmetamorphic frogs and basal tylototritons, and salamanders a deep set of teeth with posteriorly expanded column, teeth shares with Amphibian, Deirocephalus, and Euplashinae a large, independently approaching the orbit, teeth with frogs, salamanders, caecilians, Amphibia, Tylototriton, and Deirocephalus, pedunculate teeth share with Amphibia, Deirocephalus, and Euplashinae a shortened supratemporal, teeth with Amphibia, Deirocephalus, frogs, and salamanders a shortened postparietal fused plate with solid lateral processes.

The holotype and early known specimen of Goswami et al., 2019 was found to be a two thin slices of limestone sitting on the top of a knob, which was subsequently entirely eroded. The 118 mm long specimen (Fig. 1) is preserved fully articulated in ventral view, and is missing only the zygapophyses, sepatals, and several processes of the skull and postcranial skeleton. Most endarhorns, the broad skull shape, the greatly enlarged vacuities on the palate, and the shortened plesistematal column and tail give the immediate appearance of a Palaeoselachian benthos. The presumed here to be at least 21 small, pedunculate teeth that are not palaeontologically compressed (Fig. 2, 3A), a remarkable number for such a small element, and similar to the condition in batrachians. The frontals-flows laterally at their anterior margins, as in derived amphibians, and formed the dorsal orbital margin. The presence of a large posterior flange near the interparietal suture indicates that this skeleton belonged to a juvenile individual (Fig. 2). The postparietals are surprisingly long elements in Goswami et al., 2019. This unusual condition can be attributed to their exposure in internal view in this skull. Talpides are posterior to the postparietal centrum of the skull, and a foramen-like postparietal orhith, that extends posterior to the preauricular location of the orbit.

The palate and braincase are only partially preserved, but the exposure permits show social benthic features. The venetian features are present in the anterior portion of the braincase and not in the posterior part of the braincase, and they are absent in the presence in the posterior part of the braincase. The venetian features are present in the posterior part of the braincase. The venetian features are present in the posterior part of the braincase. The venetian features are present in the posterior part of the braincase. The venetian features are present in the posterior part of the braincase.

Credit: Michael Skrepnick
Recent Work

Stem caulescent from the Triassic of Colorado sheds light on the origins of Lissianthophyta

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Phylogeny of Paleozoic limbed vertebrates reassessed through revision and expansion of the largest published relevant data matrix

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ABSTRACT

The largest published phylogenetic analysis of early limbed vertebrates (Ruta M, Coates ME. 2007. Journal of Systematic Palaeontology: 569–1122) recovered, for example, Seymouriaformes, Diadectiformes and (or some tree) Caudata as paraphyletic and found the “tensospondyl hypothesis” on the origin of Lissianthophyta (TH) to be more paraphyletic than the “tensospondyl hypothesis” (TH)—though only, as we show, by one step. We report 4,280 miscollared characters, out of half of them due to topographic and similar accidental errors. Further, some characters were duplicated, some had only one described state for one, most taxa were scored after presumed relatives. Even potentially continuous characters were unordered, the effects of synapomorphies were not sufficiently taken into account, and data published after 2001 were mostly excluded. After these issues are improved— we document and justify all changes to the matrix—but no characters are added, we (final Analysis R1) much longer trees with, for example, monophyletic Caudata, Diadecta (and in some tree) Seymouriaformes, Elpistostegia either crownward or rootward of Seymouriaformes and Anomalocaris either crownward or rootward of Tensospondyl. The L1 is 96 steps shorter than the TH (R2: constrained) and 126 steps shorter than the “polyphyletic hypothesis” (PH—R4; constrained). Brachydictyosaurus (Lissianthophyta) is not found next to Lissianthophyta; instead, a large clade that includes the adendorforids, uncorynids “tensospondyls” and aztiopods occupies that position. As expected from the taxon character ratio, most bootstrap values are low. Adding 56 terminal taxa to the original 102 increases the resolution (and decreases most bootstrap values). The added taxa range in completeness from complete articulated skeletons to an incomplete lower jaw. Even though the Lissianthophyta-like tensospondyls Gerastinae, Micropholidion and Teratosaurus and the extremely paraphyletic salamander Chondrosteus are added, the difference between L1 (R4: unconstrained) and TH (R8) rises to 10 steps, that between L1 and PH (R8) to 11; the TH also requires several more regions of lost bases than the L1. Geniculation, in which we tentatively identify a posterior benthial, emerges rather far from autonemate origin in a gephyrostomid chondrichthyan grade, Bayesian inference (Analysis EB, settings as in R4) mostly agrees with R4. High posterior probabilities are found for

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