Triassic-Jurassic Terrestrial Transition

Paleobiology
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Competitive wedge
The overarching framework
Early Triassic

- Primitive proto-mammals (Synapsids)
  - Dicynodont (Two-Dog Tooth)
    - Herbivores characterized by two tusks.
  - Cynodonts (Dog Teeth)
    - Carnivorous and herbivorous
    - Ancestors of modern mammals

- Primitive proto-dinosaurs (Diapsids)
  - Thecodonts (Socket Teeth)
    - Teeth are set in sockets in the jawbone, but mammals also have this feature, hence why the term is now obsolete.
    - Now, we just say Archosaurids. Basically crocodiles.
Middle Triassic

- **Primitive proto-mammals (Synapsids)**
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    - Herbivores characterized by two tusks.
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  - **Thecodonts (Socket Teeth)**
    - Teeth are set in sockets in the jawbone, but mammals also have this feature, hence why the term is now obsolete.
    - Now, we just say Archosaurs (ruling reptiles). Basically crocodiles.
  - **Rhynchosaurus (Beak Lizards)**
    - Broad skulls indicating powerful jaw muscles.
    - Had a scissor like bite.
    - Described as swine-like herbivores
Late Triassic

- Archosaurs split into two major lineages
  - Ornithodira (“bird necks”) / Avematatarsalia (“bird feet”)
  - Dinosaurs, Birds, and Pterosaurs

![Image of Archosaur skeletons and illustrations]

- Lewisuchus (Nesbitt, 2011)
- Lesothosaurus
- Saturnalia
- Herrerasaurus
- Pampadromaeus (LRT)
- Pisanosaurus
- Thecodontosaurus
- Massospondylus
- Daemonosaurus
Late Triassic

- Archosaurs split into two major lineages
  - Crurotarsi ("cross ankles")
    - More crocodile like stuff
  - Phytosaurs ("Plant Reptile")
    - Elongated snout with front nostrils
  - "Rausichians"
    - The apex predators of the Triassic
What makes a dinosaur

- Elongated deltopectoral crest
- Open acetabulum
- Temporal musculature extends anteriorly onto skull roof
- Epipophyses on the cervical vertebrae
- Articulation facet for fibula occupying less than 30% of the transverse width of the astragalus
- Femoral fourth trochanter asymmetrical, with distal margin forming a steeper angle to the shaft.
- Posterior process of the jugal bifurcated to articulate with quadratojugal
The old view

- Polyphyletic
  - Dinosaurs arose several times through convergent evolution, as a result of similar competitive pressures.

- Timing
  - The origin of dinosaurs was a long drawn-out affair, involving long-term competition from the Middle Triassic though to the Jurassic.

- Competition
  - Dinosaurs had superior mobility
  - Dinosaurs were warm blooded
  - Dinosaurs grew faster

- Evolutionary Progress
  - Species become superior through time.
Erect Dinosaurs
Erect Dinosaurs
Dinosaur growth
Arguments for endothermy

- Agility and Endothermy
  - Dinosaur morphology indicates great agility, generally metabolism is proportional to locomotion.

- Competition
  - Endotherms generally “outcompete” ectotherms in modern ecosystems, so the Dinosaurs had to have been endotherms to outcompete mammals.

- Blood pressure
  - Erect posture of large dinosaurs requires high blood pressure, like a giraffe. This means that a four-chambered heart is required.

- Bone structure
  - Dinosaur bone is more similar to mammal and avian bone in cross section than it is to ectothermic bone.
Counters to the old view

- **Abrupt Transitions**
  - Dinosaurs take-over at major boundaries, rather than gradually replacing the non-dinosaurs

- **Early Adaptation**
  - The earliest dinosaurs (Middle Triassic) were also ectothermic and erect, but they did not radiate until much later.

- **Shared Adaptation**
  - Some Archosaurs also had erect or semi-erect gait.

- **Coevolution**
  - Other taxa go extinct in tandem with the “Thecodonts” and “Synapsids”, most importantly the transition from seed ferns to conifers.
Actual evidence?
Counters to the Counter view

- **Abrupt Transitions (What is abrupt?)**
  - Dinosaurs take-over at major boundaries, rather than gradually replacing the non-dinosaurs

- **Early Adaptation (Tempo and Mode?)**
  - The earliest dinosaurs (Middle Triassic) were also ectothermic and erect, but they did not radiate until much later.

- **Shared Adaptation (So what?)**
  - Some Archosaurs also had erect or semi-erect gait.

- **Other extinctions (Opposite direction?)**
  - Other taxa go extinct in tandem with the “Thecodonts” and “Synapsids”, most importantly the transition from seed ferns to conifers.
Red Queen and Court Jester

Speciation

REVIEW

The Red Queen and the Court Jester: Species Diversity and the Role of Biotic and Abiotic Factors Through Time

Michael J. Benton

Evolution may be dominated by biotic factors, as in the Red Queen model, or abiotic factors, as in the Court Jester model, or a mixture of both. The two models appear to operate predominantly over different geographic and temporal scales: Competition, predation, and other biotic factors shape ecosystems locally and over short time spans, but extrinsic factors such as climate and oceanographic and tectonic events shape larger-scale patterns regionally and globally, and through thousands and millions of years. Paleobiological studies suggest that species diversity is driven largely by abiotic factors such as climate, landscape, or food supply, and comparative phylogenetic approaches offer new insights into clade dynamics.
<table>
<thead>
<tr>
<th>Red Queen</th>
<th>Court Jester</th>
<th>Multilevel mixed</th>
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<tbody>
<tr>
<td>Interspecific competition</td>
<td>Waxing and waning of clades in association with tectonic and oceanographic events (2, 17)</td>
<td>Vicariance and dispersal in major phylogenetic splits (17)</td>
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<td>Character displacement</td>
<td>Mass extinctions and smaller extinction events triggered by extrinsic causes such as eruptions, climate change, anoxia, impact (10, 11)</td>
<td>Latitudinal diversity gradient (22–24)</td>
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<td>Evolutionary arms races (1)</td>
<td>Coordinated turnovers, originations, and extinctions in response to physical perturbations—termed “coordinated stasis” or “turnover pulse” hypothesis (2, 29, 30)</td>
<td>Occupation of new ecospace (25)</td>
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<td>Constancy of ecological guilds through time (25)</td>
<td>Nonconstant probability of extinction (3, 11)</td>
<td>Subdivision of niches/specialization (10, 25)</td>
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<td>Incumbency advantage (3, 24)</td>
<td>Lack of evidence for a global carrying capacity and equilibrium levels (8, 10)</td>
<td>Declining global extinction rates through time (1, 5)</td>
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<td>Lack of cohesiveness of the great “evolutionary faunas” (12)</td>
<td>Onshore-offshore patterns and disturbance (3)</td>
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<td>Species richness–energy relationship (18, 19)</td>
<td>Resource use: stenotopes are more speciose than eurytopes (29, 30)</td>
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<td>Inverse relationship between global temperature and biodiversity (21)</td>
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<td>Lack of clear correlation of species richness with body size or other biotic factors (16)</td>
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True Red Queen

- The probability of extinction for a subtaxon within a given group (i.e., a species within a family) remains constant over time.

- There is no correlation between the age of a taxon and its probability of extinction (relative to other members of the same group).

- What this means, if true, is that we can assume the evolutionary properties of species are essentially “equivalent”, which means we can model them as interchangeable evolutionary entities.
Fig. 2. Taxonomic survivorship curves for Mollusca and Brachiopoda.

Fig. 5. Taxonomic survivorship curves for mammals. For Primates, Madagascar genera are omitted because the island lacks pre-Pleistocene fossils. Polyprotodonta includes Caenolestoida.
True Red Queen
Alternative testing methods

Phanerozoic trends in the geographic range selectivity of genus survivorship.

A

Selectivity (log-odds)

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B

Selectivity (log-odds)

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Age (millions of years ago)
True Red Queen
Coevolution