Difficulty in identifying mass extinctions amongst tetrapods (Late Permian – Early Jurassic)

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Why the Late Permian – Early Jurassic?

• Period of major change amongst tetrapods
• Earliest: mammals, dinosaurs, pterosaurs, ichthyopterygians, sauropterygians, turtles, crocodiles, frogs, and caecilians
• Triassic bounded by two ‘Big 5’ events (+ third?)
• Received relatively little study
• Lacks a thorough analysis (Weems, 1992)
• Until now…
The Datasets

- 204 families and 810 genera
  - Stratigraphic range (stage)
  - Geographic range (continent)
  - Taxonomic class (amphibians/reptiles/mammals)
  - Body size (small/medium/large)
  - Diet (invertebrates/tetrapods/browser/fish/molluscs)
  - Habitat (marine/freshwater/terrestrial/aerial/arboreal)
Origination and Extinction

- Origination and Extinction seem to support end-Permian and end-Triassic events
- There is no evidence to support an end-Carnian event
Proportional Familial Representation by Class

Proportional Generic Representation by Class
Summary of Ecological Change

- End-Permian event consistently associated with ecological change
- Marine taxa suffer a major extinction at the end-Carnian whilst mammals radiate
- End-Triassic significant only in ecological conservation
Pairwise Association I: 
Late Permian – Early Jurassic tetrapods

Pairwise Association II: 
K-T bivalves*

*(Data from McClure and Bohonak, 1995)
Pairwise Association III: Conclusions

- Cause and effect impossible to discern
- Taxonomic selectivity may imply non-preservation of traits
- Great constraints on tetrapod evolution
- Could different variables be used?
- Geological signals are pervading the data
- New methodology required

Phylogeny to the rescue? I:
Darwin identifies the problem

“[We continually over-rate the perfection of the geological record, and falsely infer, because certain genera or families have not been found beneath a certain stage, that they did not exist before that stage.”

The Origin of Species (1859)
Phylogeny to the rescue? II: Virtues of ghost range over stratigraphic range usage

- Boosts sample size - more stage-crossing taxa
- Corrects collection biases (e.g. Rauhut, 2003: Gondwanan vs. Laurasian theropods)
- Corrects preservation biases (e.g. pterosaurs vs. sauropterygians)
- Ghost range variations $\leq$ MPTs
- Fills 'certain' gaps (e.g. E. Cretaceous choristoderes, M. Jurassic pterosaurs etc.)
- Tetrapods are phylogenetically well understood
- But, requires massive trees and range extension asymmetric
- Effects every analysis undertaken here

Conclusions

- End-Permian extinction important event in tetrapod evolution
- Important ecological changes also occur at end-Carnian; lack of an extinction signature possibly a timing issue
- Interpreting end-Triassic problematic due to poor Early Jurassic record
- High pairwise association of variables prevents determination of causation (selectivity)
- Genus is a valid species proxy in tetrapod macroevolution
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