Evolutionary paleoecology and the biology of extinction

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Introduction and theory

Brachiopods, environmental preference, and extinction

Ecology and survival in Cenozoic mammals

Community connectedness in Cenozoic mammals

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Evolutionary paleoecology

. . . the consequences of distinct ecological factors on differential rate dynamics, particularly rates of faunal turnover and diversification.

(Kitchell 1985 Paleobiology)

Emergent properties

Species level

Trait that cannot be reduced to organismal level

Product of one or more traits/factors

Range size

Large range size means lower origination and extinction rates than small range size.

Range size is emergent

Survival

Survival function

$$S(t) = P(T > t) \qquad (1)$$

directly describes survival

Hazard

Hazard function

$$h(t) = \lim_{\Delta t \to 0} \frac{P(t \leq T < t + \Delta t | T \geq t)}{\Delta t} \tag{2}$$

Law of Constant Extinction

Van Valen 1973 "Red Queen" paper.

Definition

Survival probability and extinction risk is taxon–age independent.

translation: hazard is constant with respect to time (exponential)

$$h(t) = \lambda \iff S(t) = \exp^{-\lambda t} \tag{3}$$

Brachiopods and mammals: a comparison

Permian versus Cenozoic

marine versus terrestrial

warming verus cooling

single region versus multiple regions

Series of questions

- generic level survival in brachiopods
  - effect of ecological traits (emergence)
  - distribution of survival
- specific level survival in mammals
  - generic versus specific survival
  - anagenesis/species:genus simulation
  - distribution of survival
- community connectedness in mammals
  - global versus regional versus local scale processes

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Ecological traits

- substrate affinity
  - physical, chemical
  - availability
- habitat preference
  - energetics
  - availability
- affixing strategy
  - energetics
  - optimality

Substrate affinity

Habitat preference

Affixing strategy

Assigning substrate and habitat

Probability of assignment

$$P(H_1|E) = \frac{P(E|H_1)P(H_1)}{P(E|H_1)P(H_1) + P(E|H_2)P(H_2)} \quad (4)$$

(Simpson and Harnik 2009 Paleobiology)

Models

Preliminary results

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Ecological traits

- dietary category
  - energetics
  - availability
- locomotor category
  - availability
  - dispersal
- body size
  - energetics
  - home range size

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Community connectedness

Average relative number of endemics

$$E = \frac{\sum_{i=1}^{L} \frac{u_i}{n_i}}{L} \qquad (5)$$

Average relative occupancy per taxon

$$Occ = \frac{\sum_{i=1}^{N} \frac{l_i}{L}}{N} \qquad (6)$$

Biogeographic connectedness

$$BC = \frac{O - N}{LN - N} \qquad (7)$$

Code length

Global versus regional versus local scale processes

General expectations: dietary category

General expectations: locomotor category

Community connectedness of North America

Community connectedness of Europe

Community connectedness of South America

Models

Preliminary results

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