Cenozoic mammals and the biology of extinction

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May 22, 2014

Extinction

All species that have ever lived are, to a first approximation, dead.

(Raup 1986 The Nemesis Affair)

Foundation

Question

Why do certain taxa go extinct while others do not?

In context of this study

Rephrased

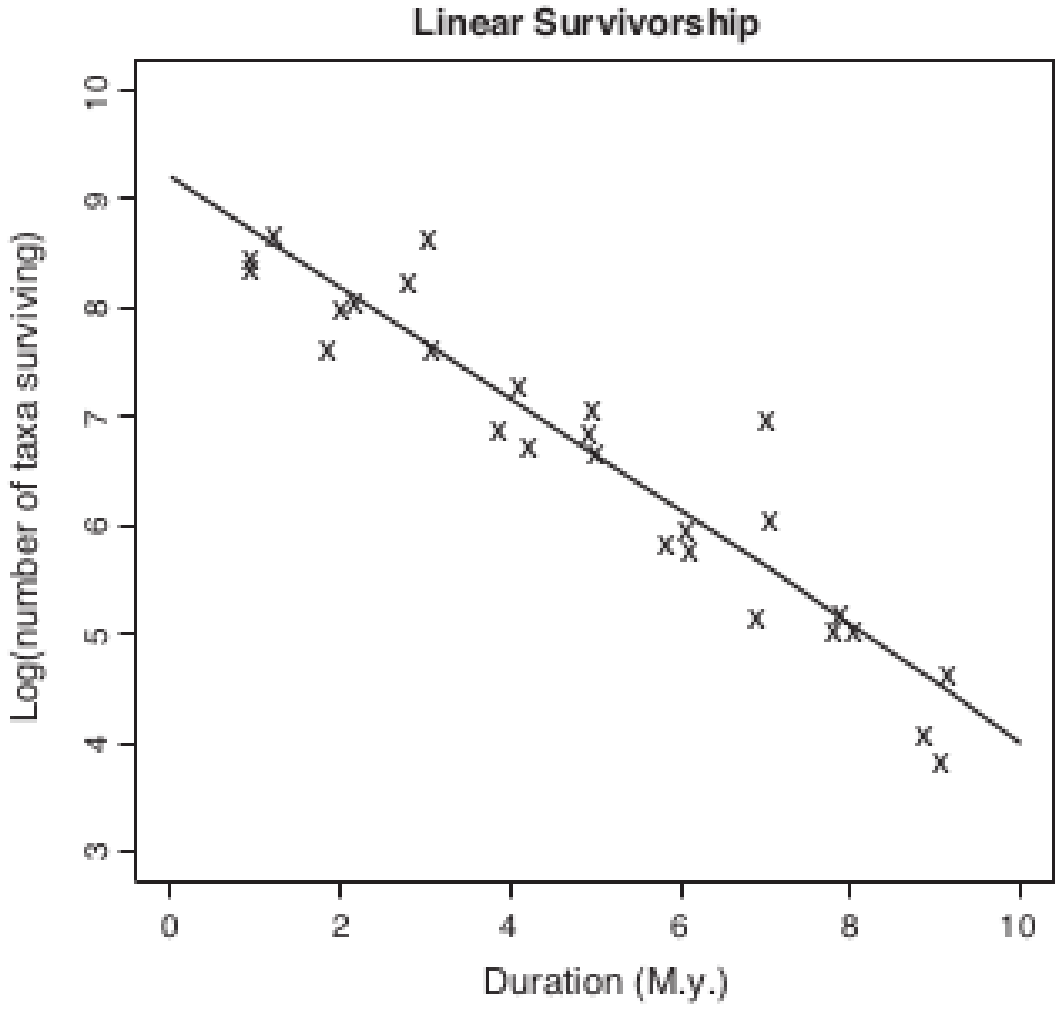
How does a taxon's adaptive zone affect extinction risk?

Modes of extinction

Field of Bullets – Wanton – Fair Game

(Raup 1991 Extinction: Bad Genes or Bad Luck?)

Van Valen's observation



(Liow et al. 2011 *TREE*)

Law of Constant Extinction

Definition

Extinction rate, in a given adaptive zone, is taxon–age independent.

(Van Valen 1973 *Evol. Theory*)

Biology and extinction

Questions

- Do interactions involved in environmental preference predict differential survival?
  - Is survival best modeled by a single interactor or multiple interactors?
  - How do factors, such as climate, contribute?
- Is extinction taxon-age independent or dependent?
- Do genera and species have fundamentally different survival distributions?

Survival analysis

Definition

Analysis of time till event data.

i.e. Time from origination to extinction (**duration,** T).

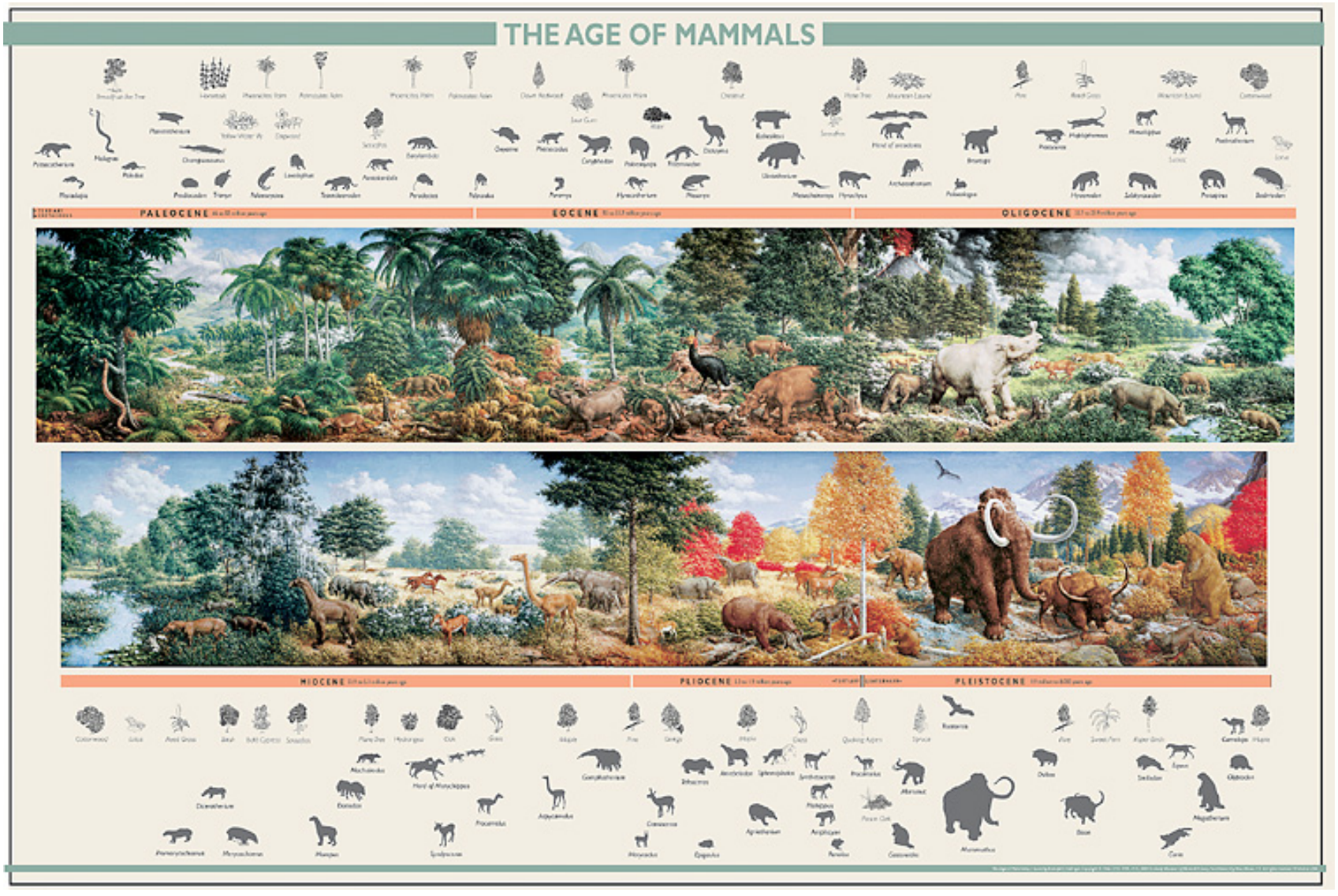
Formalization of Van Valen

Law of Constant Extinction

$T \sim Exp(\lambda)$

T: survival time
λ: expected number of extinctions per unit time

Mammals



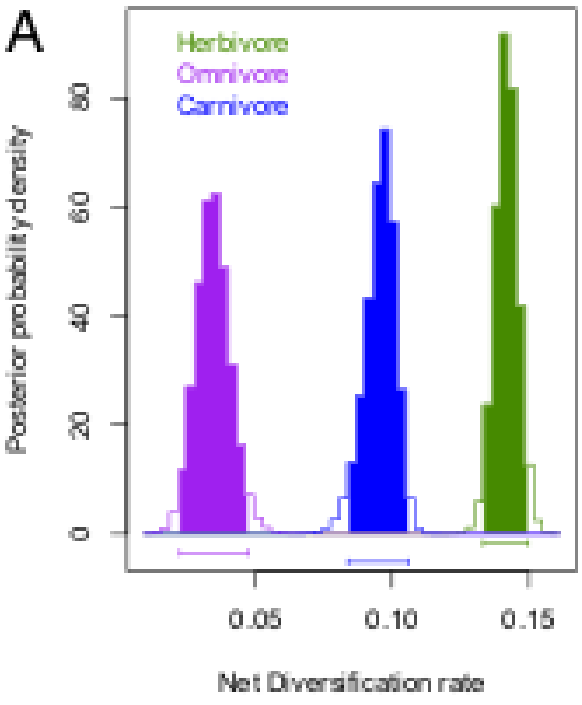
(Yale Peabody Museum)

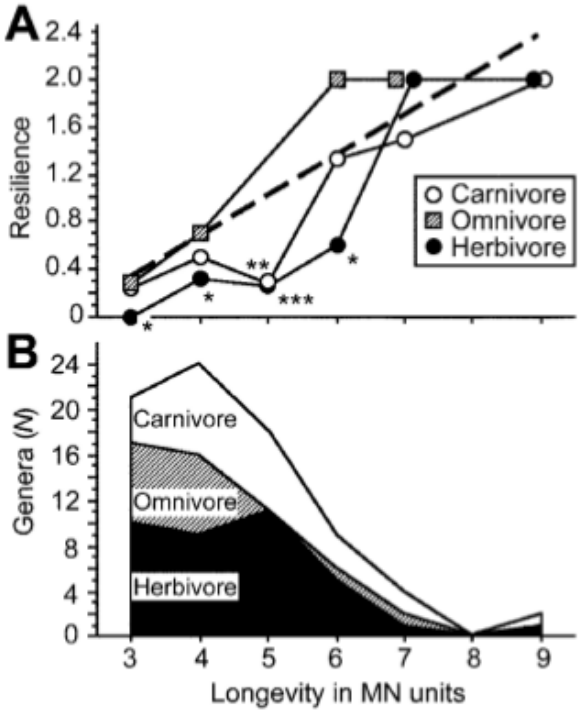
Regions

North America:
2366 species, 1003 genera

Europe:
1767 species, 658 genera

Diet





carnivore, herbivore, omnivore, insectivore

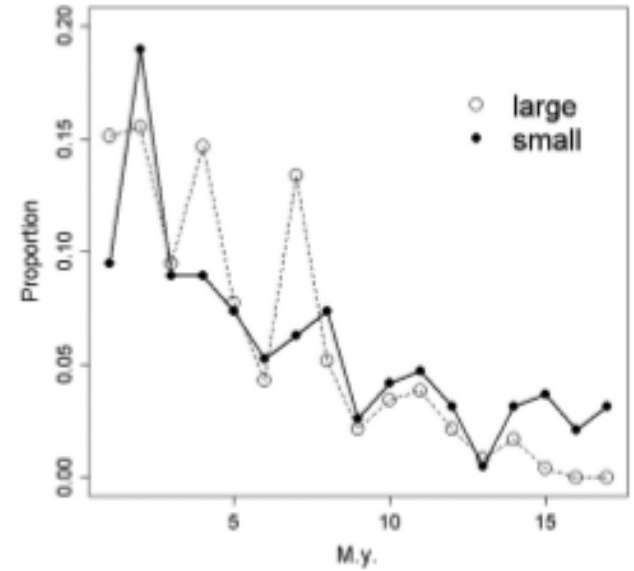
herbivore $>$ carnivore omnivore $\simeq$ carnivore insectivore ?

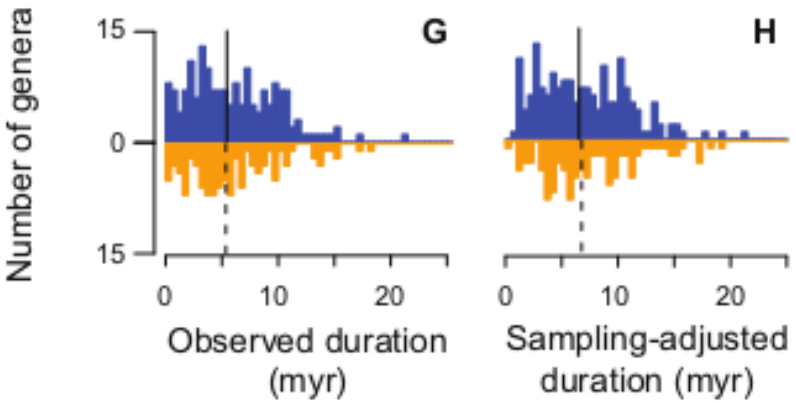
Locomotion

ground dwelling, scansorial, arboreal

- ground dwelling $>$ arboreal
- scansorial $\simeq$ ground dwelling

Body size





↑ mass, ↑ range size, ↑ survival

OR

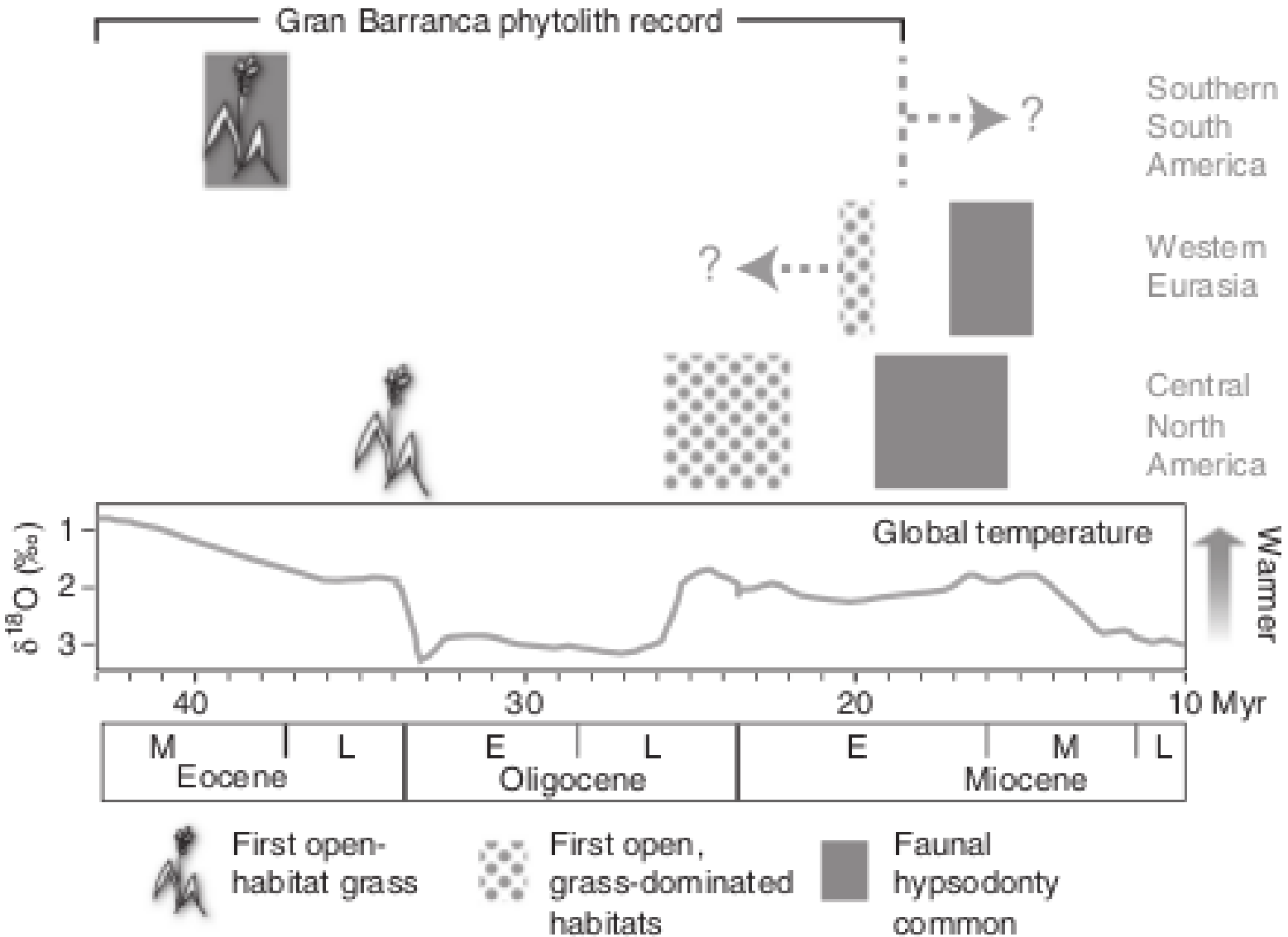
↑ mass, ↓ reproductive rate, ↓ survival

The Elephant in the Range

mean, CV occupancy

$\uparrow$ occupancy, $\uparrow$ duration

Climate



(Strömberg *et al.* 2013 *Nature Com.*)

Model selection

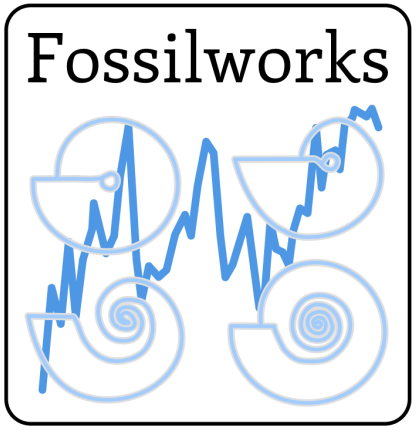
“Best” model

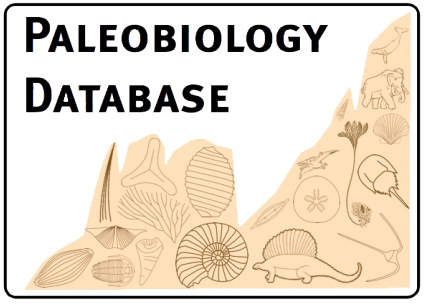
Parameter interpretations

Conclusions, future work

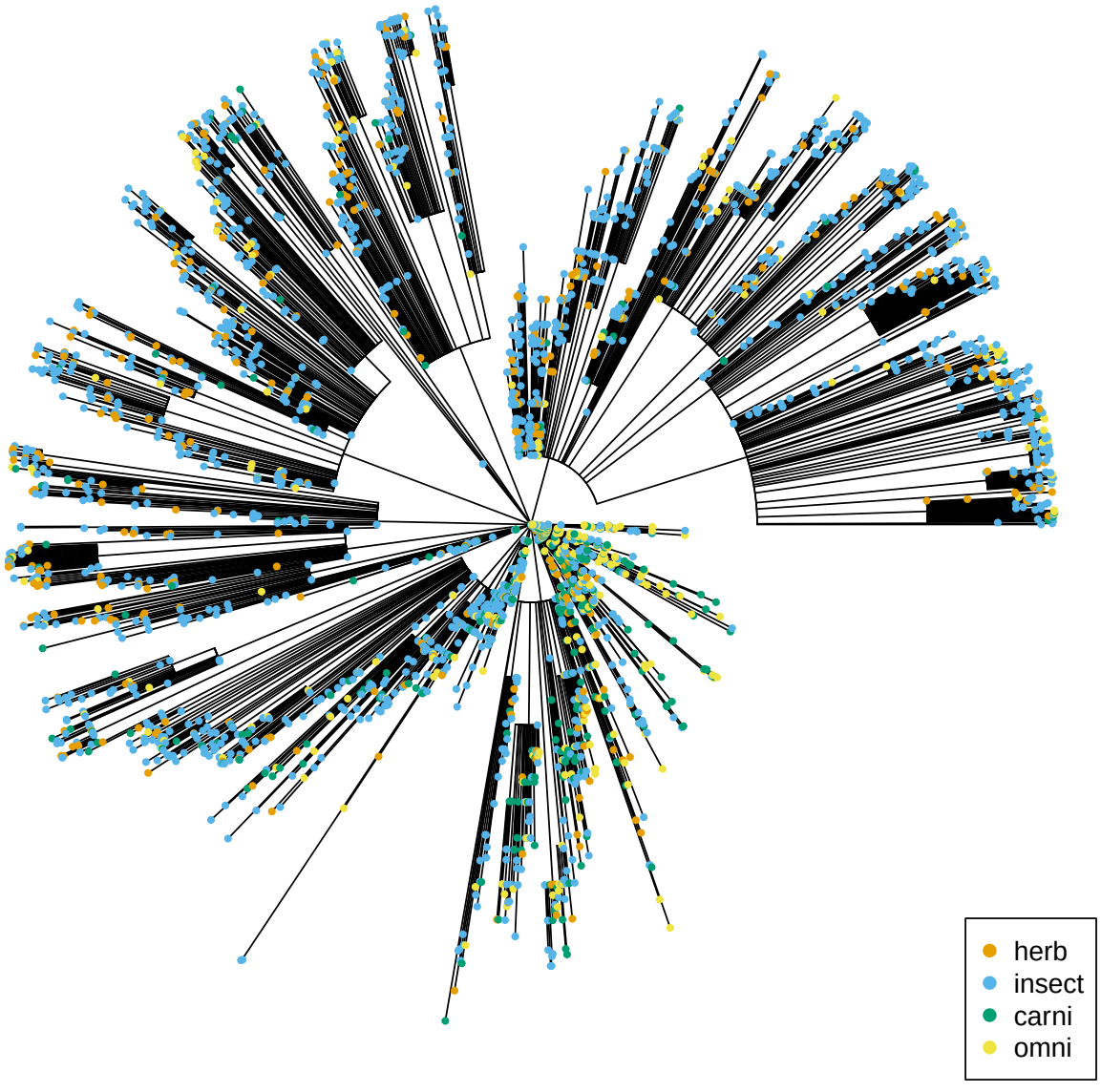
Acknowledgements

- **Committee**
  - Kenneth D. Angielczyk (co-advisor)
  - Michael J. Foote (co-advisor)
  - P. David Polly
  - Richard H. Ree
- Discussion
  - David Bapst, Megan Boatright, Ben Frable, Colin Kyle, Darcy Ross, Liz Sander
  - John Alroy, Graeme Lloyd, Kathleen Ritterbush, Carl Simpson, Graham Slater





(Informal) phylogeny

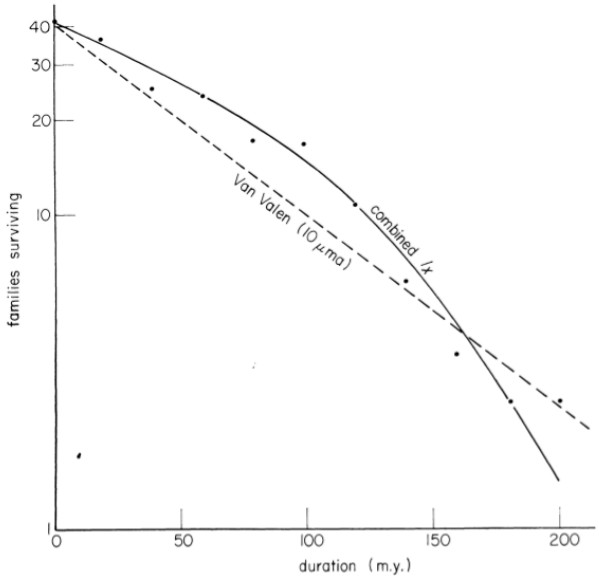


Analytical approach

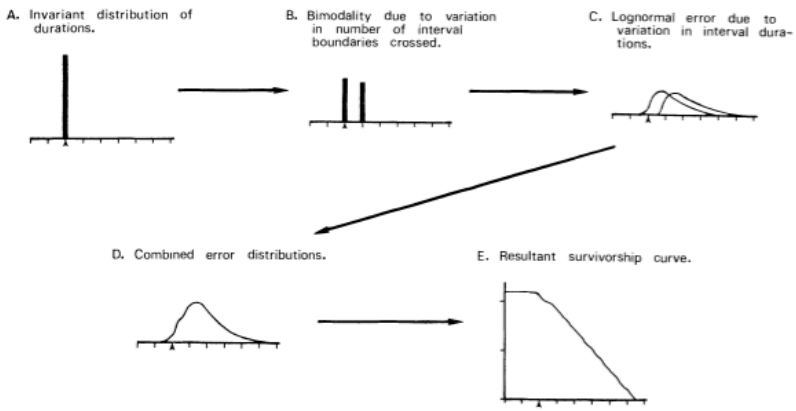
frailty coefficient

conditional autoregressive prior

Differential preservation and survival



(Raup 1975 *Paleobio.*)



(Sepkoski 1975 *Paleobio.*)

two groups in four scenarios

- = birth, death; =preservation
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