

# How do biological traits affect brachiopod taxonomic survival?

A hierarchical Bayesian approach

Peter D Smits

Committee on Evolutionary Biology, University of Chicago



The Paleobiology Database  
revealing the history of life



## Observation

At K/Pg mass extinction, biological traits (except for geographic range) have no effect on taxonomic survival.

(Jablonski, 1986, *Science*)

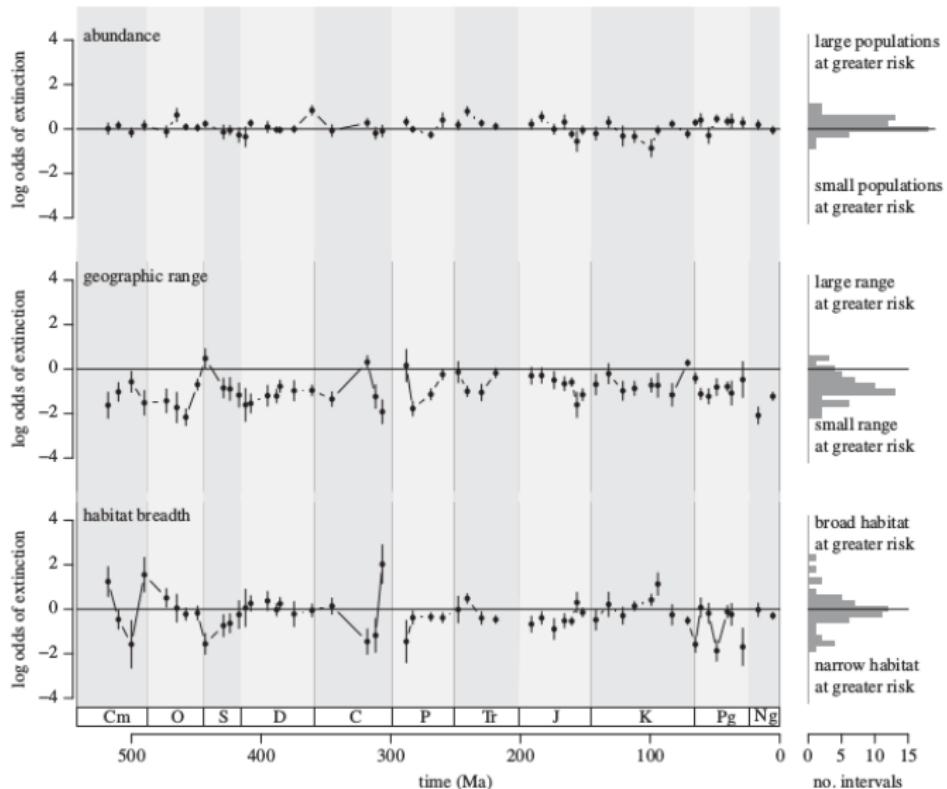
# Macroevolutionary process hypotheses

As extinction risk increases,  
the effect of geographic range  
increases.



As extinction risk increases,  
the effects of other traits  
decrease.

# Relationship between range size and extinction risk



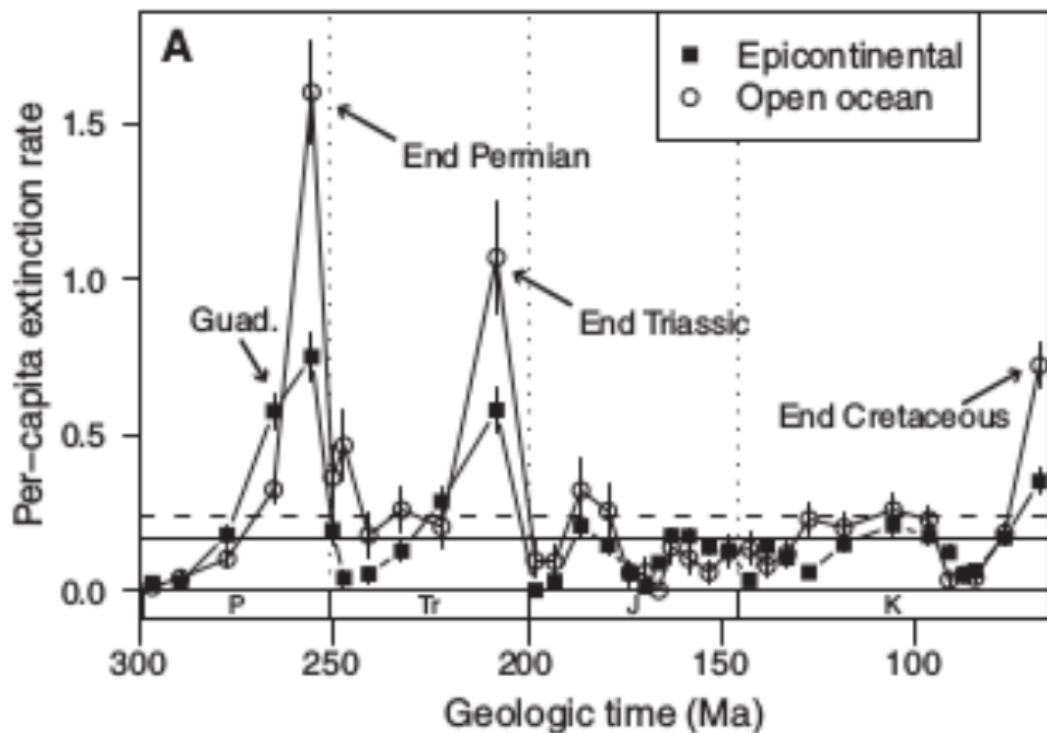
(Harnik and Simpson 2013 *Proc B*)

## Survival of the unspecialized

*When related phyla die out . . . more specialized phyla tend to become extinct before less specialized. This phenomenon is also far from universal, but it is so common that it does deserve recognition as a rule or principle in evolutionary studies: **the rule of the survival of the relatively unspecialized.***

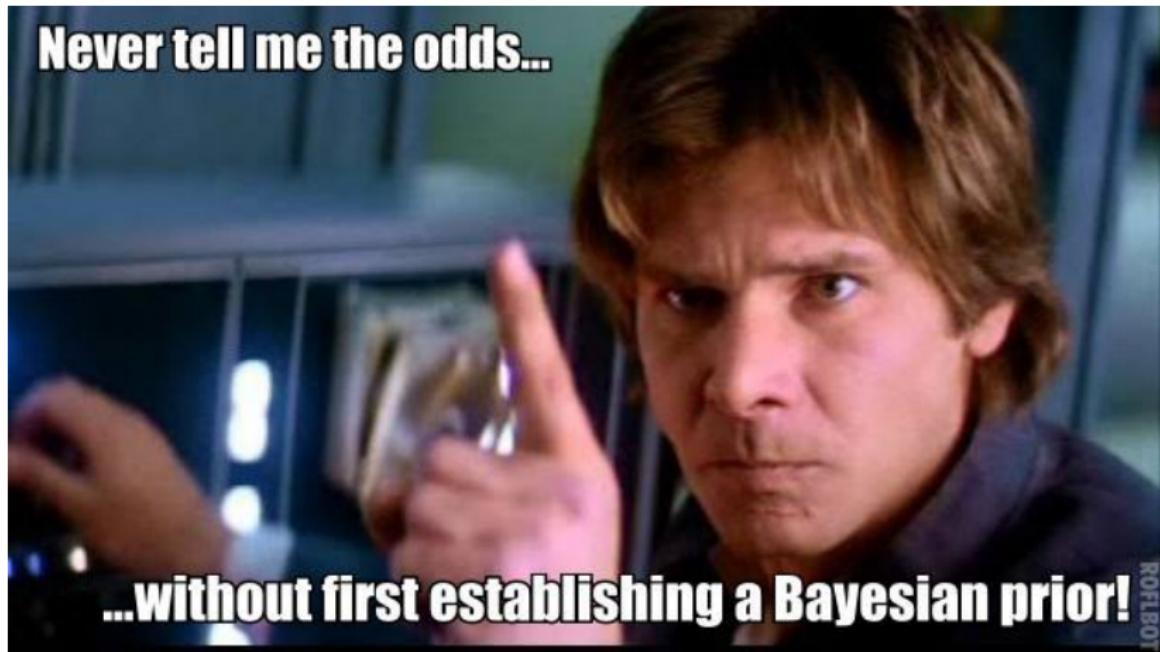
(Simpson, 1944, Tempo and Mode of Evolution, p. 143)

# Hypotheses of effect of environmental preference



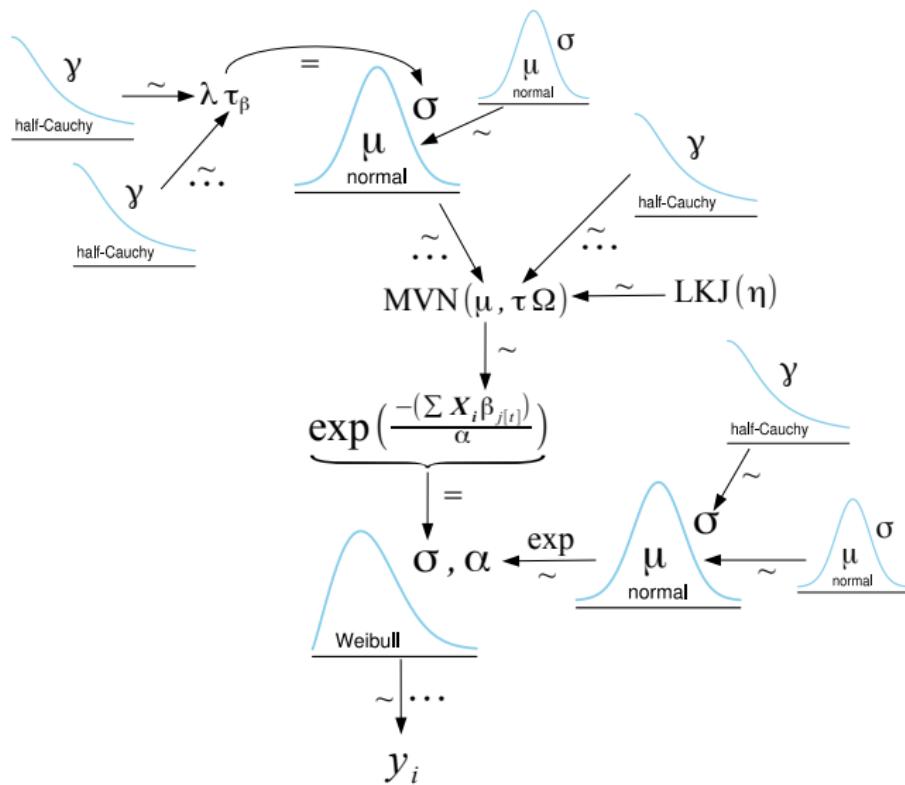
(Miller and Foote 2009 *Science*)

## Hierarchical Bayesian modeling approach

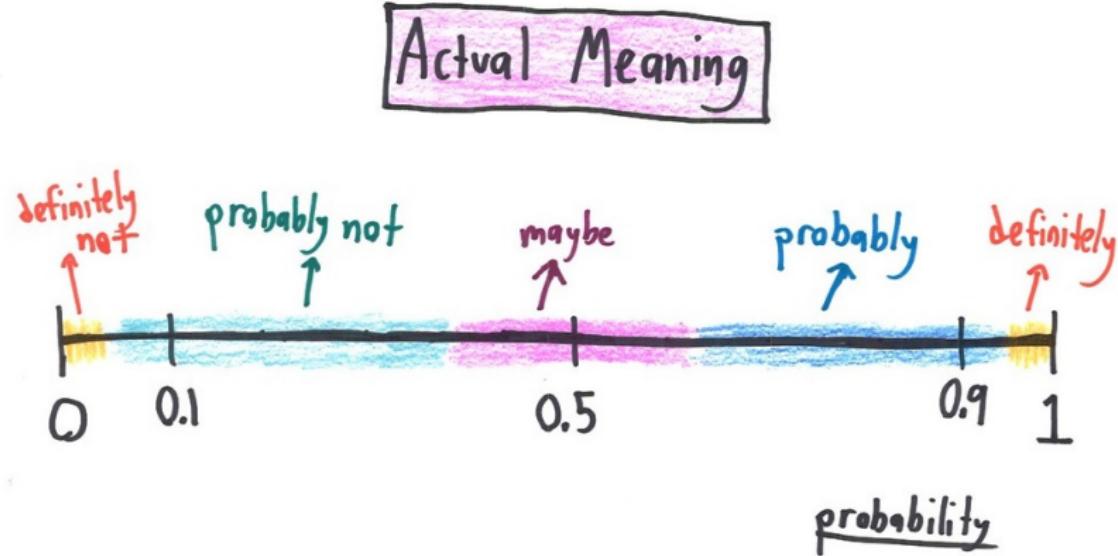


([www.countbayesie.com](http://www.countbayesie.com))

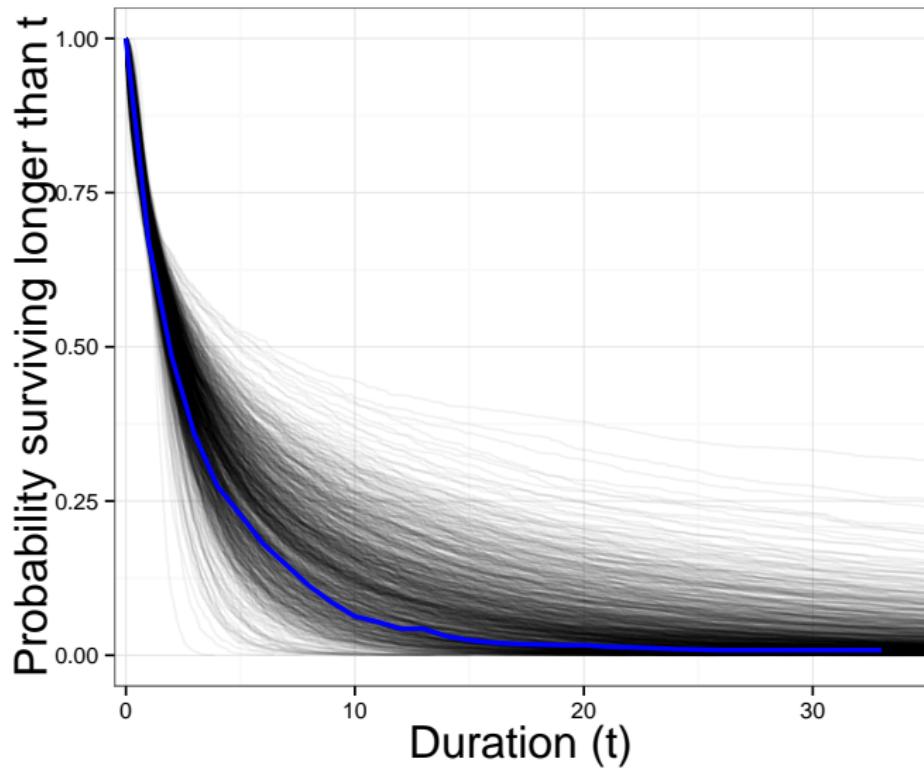
## Hierarchical survival model



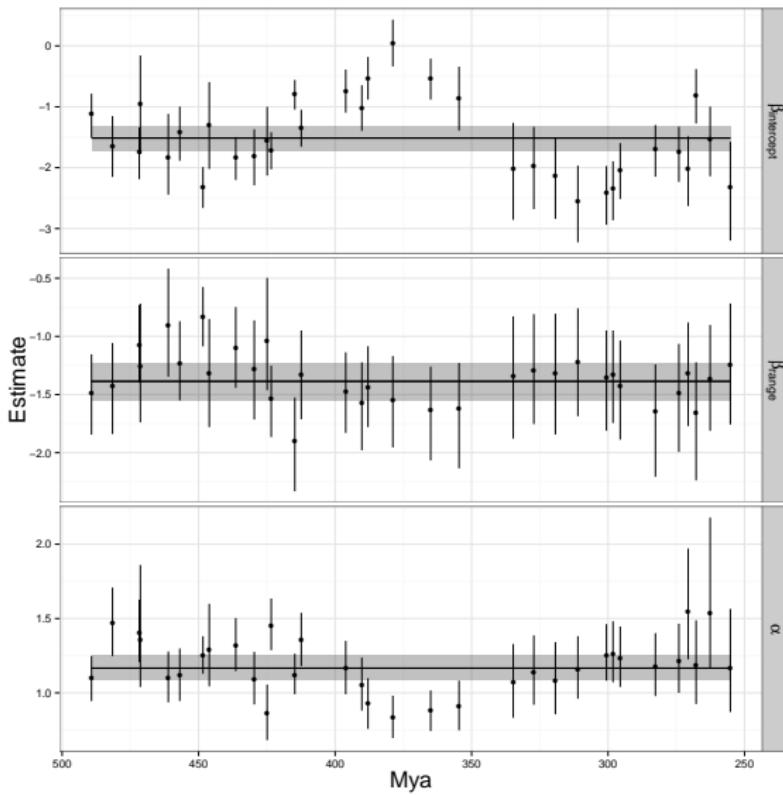
# Refresher on probability



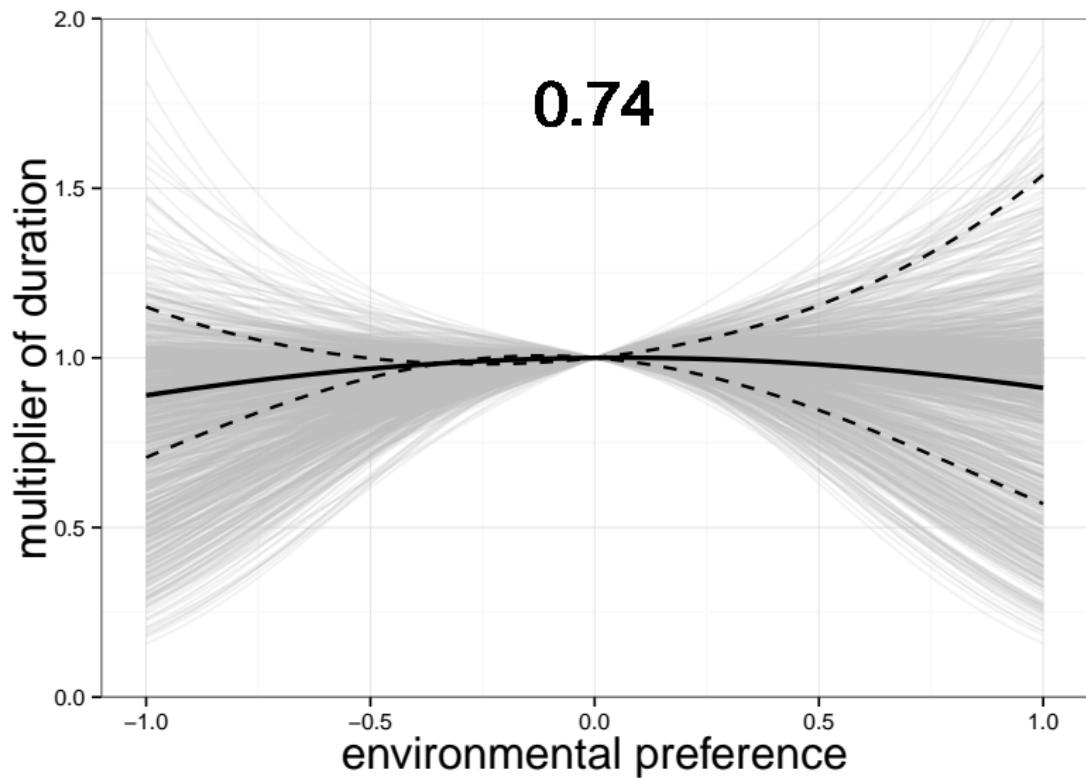
# Posterior predictive distribution of $S(t)$



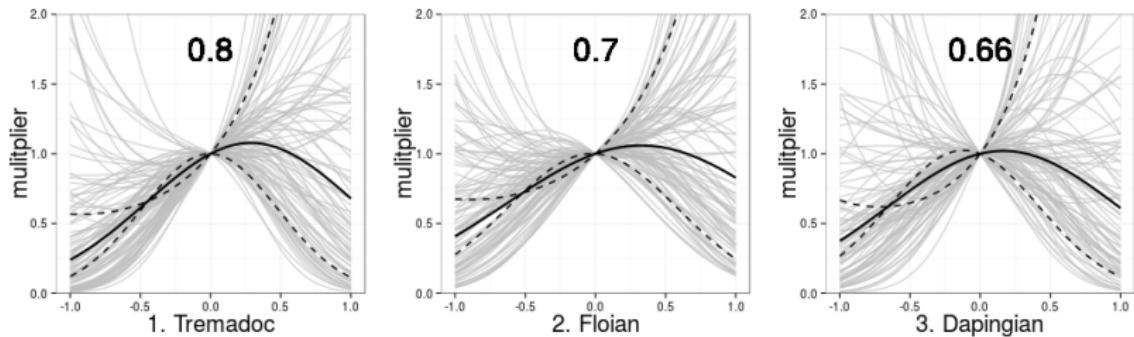
# Change in trait effects between cohorts



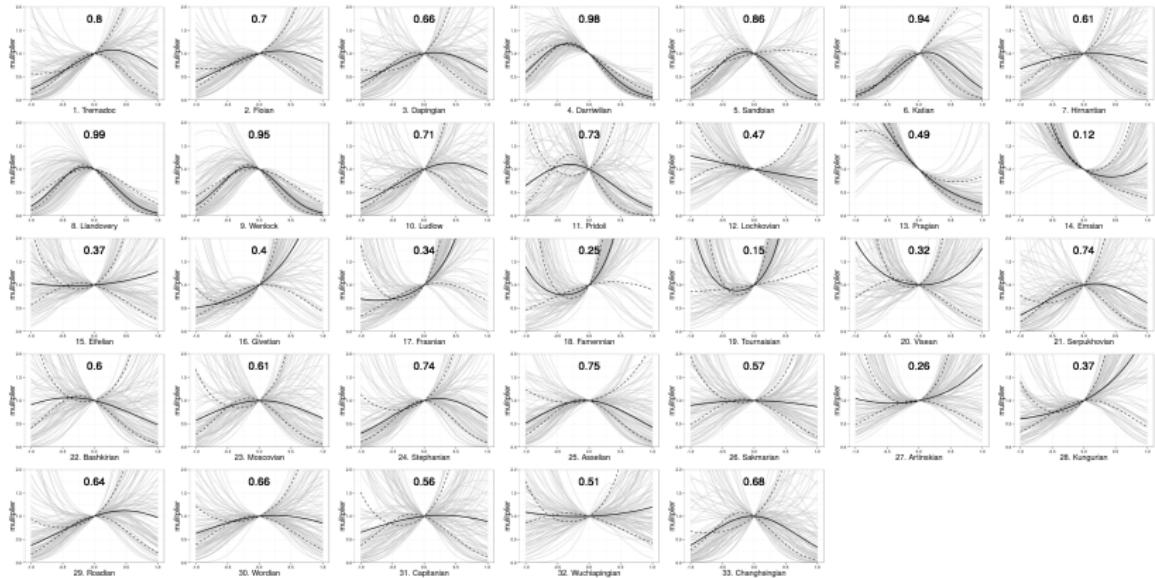
# Overall effect of environmental preference



# Change in effect of environment between cohorts

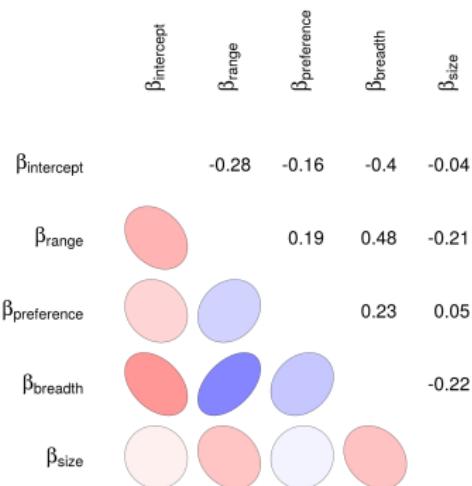


# Change in effect of environment between cohorts

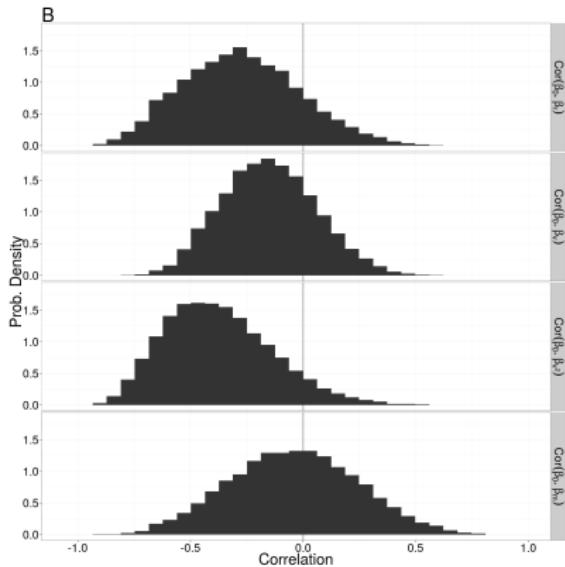


# Correlation of effects between cohorts

A



B



## Effect summary

- ▶ No effect of body size, environmental preferences equal.
- ▶ Very weak support for survival of unspecialized as generalization.

## Correlation of effects

- ▶ As effect of geographic range increases, decrease in selection on environmental breadth.

## Macroevolutionary process

- ▶ As extinction risk increases, the effect of geographic range “washes out” the effects of other traits.
  - ▶ Support for hypotheses presented by Raup in the 90's.

# Acknowledgements

- ▶ Advising
  - ▶ Kenneth D. Angielczyk,  
Michael J. Foote,  
P. David Polly,  
Richard H. Ree,  
Graham Slater
- ▶ Angielczyk Lab
  - ▶ David Grossnickle,  
Dallas Kentzel,  
Jackie Lungmus
- ▶ Foote lab
  - ▶ Marites Villarosa Garcia,  
Nadia Pierrehumbert
- ▶ Stewart Edie,  
Elizabeth Sander,  
Laura Southcott,  
Courtney Stepien
- ▶ David Bapst,  
Ben Frable,  
**Arnold Miller**,  
Peter Wagner



The Paleobiology Database  
revealing the history of life