Talks, travel, grants

Brachiopods

Mammals

Talks

- Evolution 2014: basic comparison between NA and European mammal survival
- GSA 2014: current fully Bayesian model of brachiopod survival
  - lots of positive feedback, ideas

Travel and grants

- AMNH: tooth measures for all notoungulate specimens identified to species level
- DDIG: applied; travel to Argentina; collaboration with Rick Madden

Current brachipod survival model

Target and developing survival model

Point/counting process of fossils in the record

(overdispersed) Poisson model of occurrence

Hierarchical genera in groups from Foote and Miller

Count of fossil occurrences per bin per genus for duration of observed geneus

How to model?

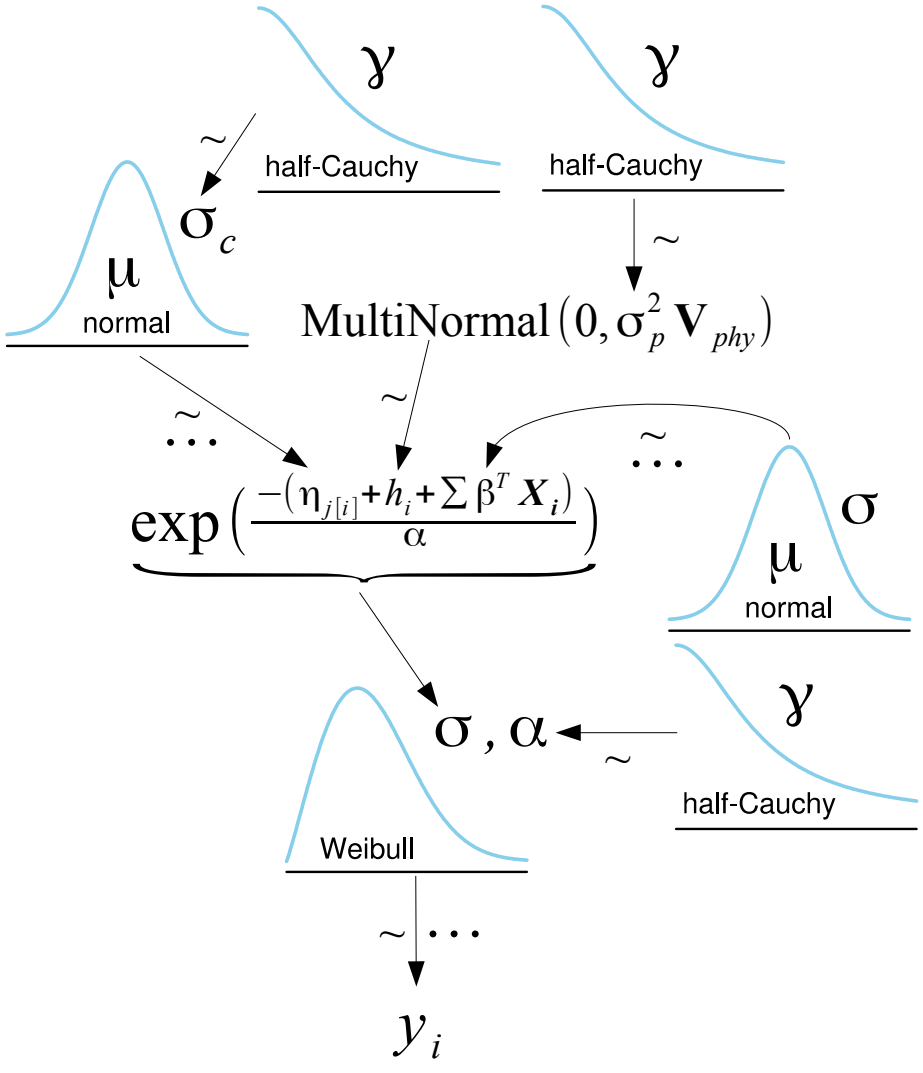
Death and Taxa: biological, temporal, and historical effects on mammal species duration

North American survival

- species duration as measure of survival
- traits
  - organismal: diet, locomotor categories
  - species: body size, bioprovince occupancy
- origination cohort
- phylogeny primarily based on taxonomy

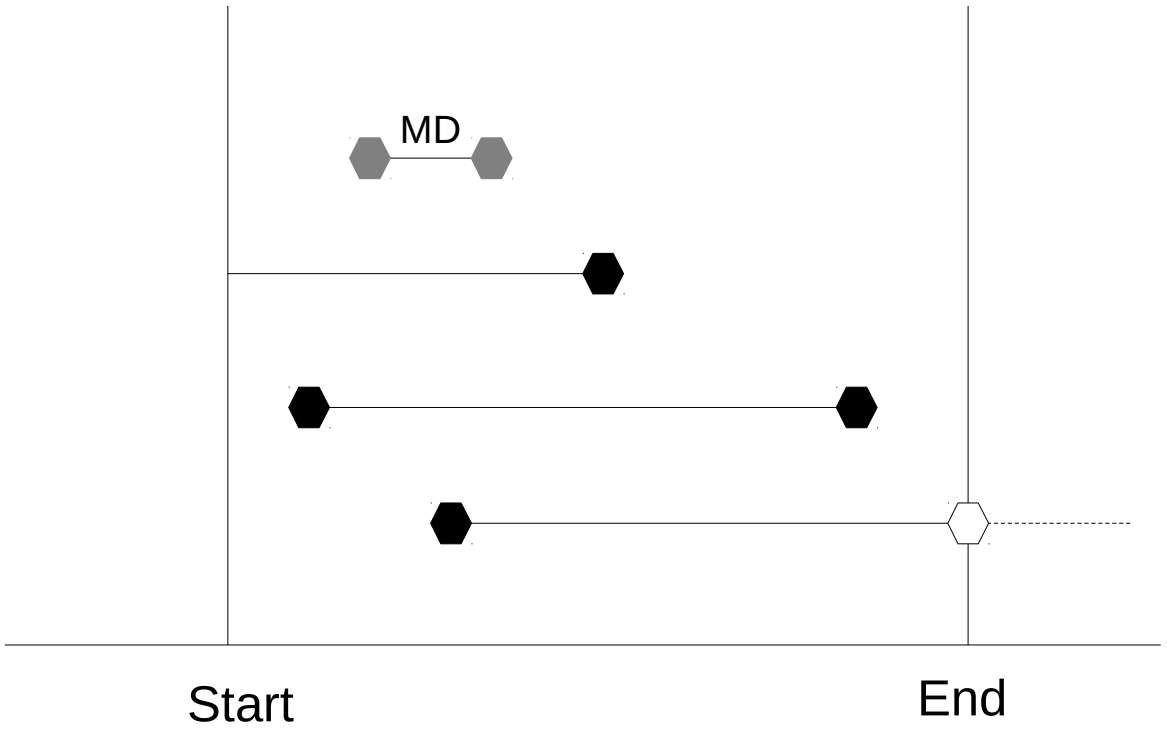
- duration defined as number of 2My bins from FAD to LAD, inclusive
- fully Bayesian hierarchical model
- censoring approach
  - if still extant, right censored
  - if not extant and duration of only 1 bin, left censored

Model diagram



$$y_i \sim \text{Weibull}(\sigma, \alpha)$$
$$\eta_{j[i]} \sim \text{Normal}(0, \sigma_c)$$
$$\sigma_c \sim \text{half-Cauchy}(2.5)$$
$$h_i \sim \text{MultiNormal}(0, \Sigma)$$
$$\Sigma = \sigma_p^2 \mathbf{V}_{phy}$$
$$\sigma_p \sim \text{half-Cauchy}(2.5)$$
$$\beta \sim \text{Normal}(0, 10)$$
$$\alpha \sim \text{half-Cauchy}(2.5)$$

Censoring



Probability with censoring

Right censored if not yet extinct

ccdf (1 - cdf) at observed duration given model

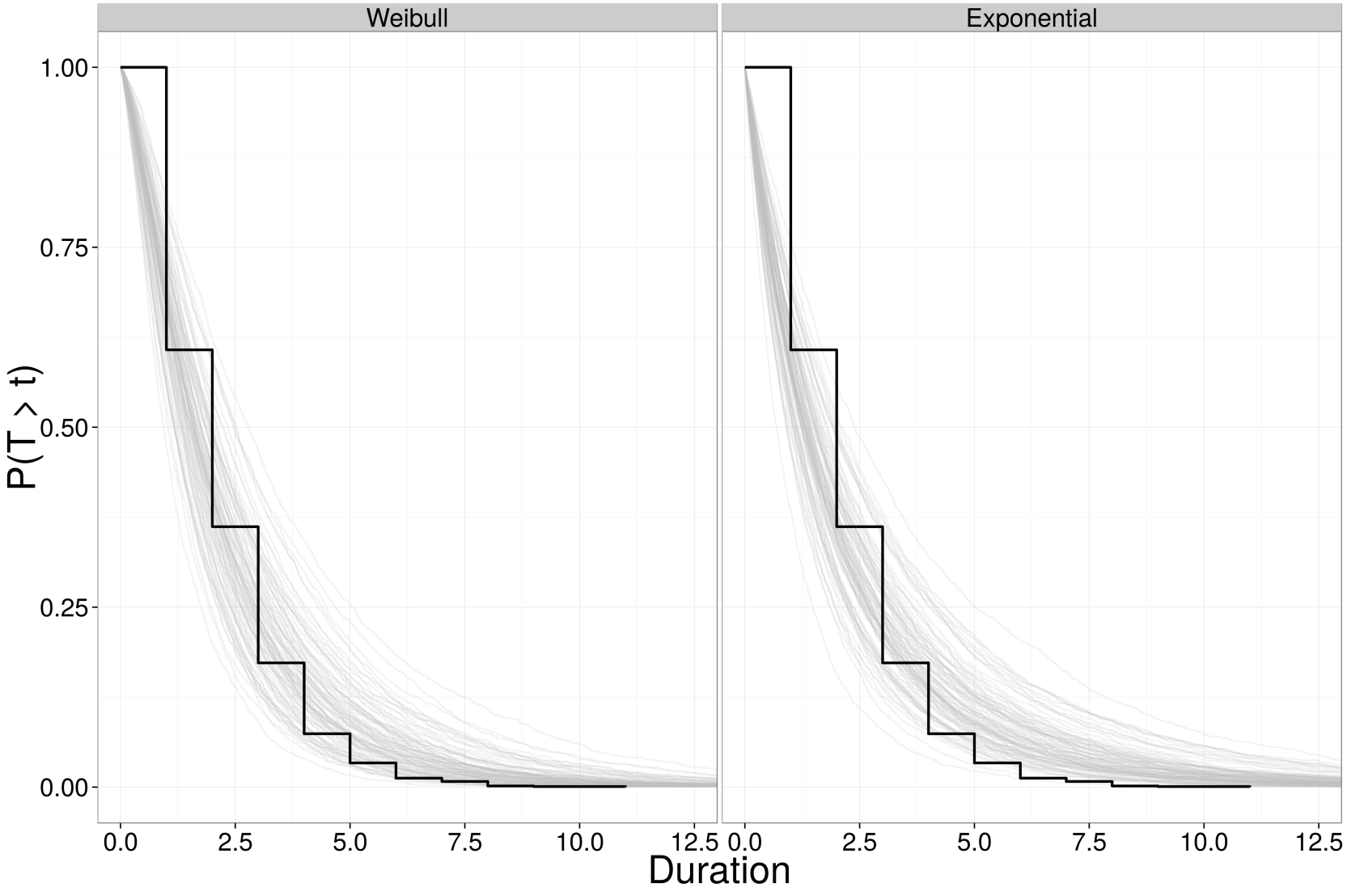
$$\Pr[T > T_i] = \int_{T_i}^{\infty} \text{Weibull}(T_i|\alpha, \sigma) dy = 1 - F(T_i|\alpha, \sigma) \quad (1)$$

Left censored if both extinct and only one stage

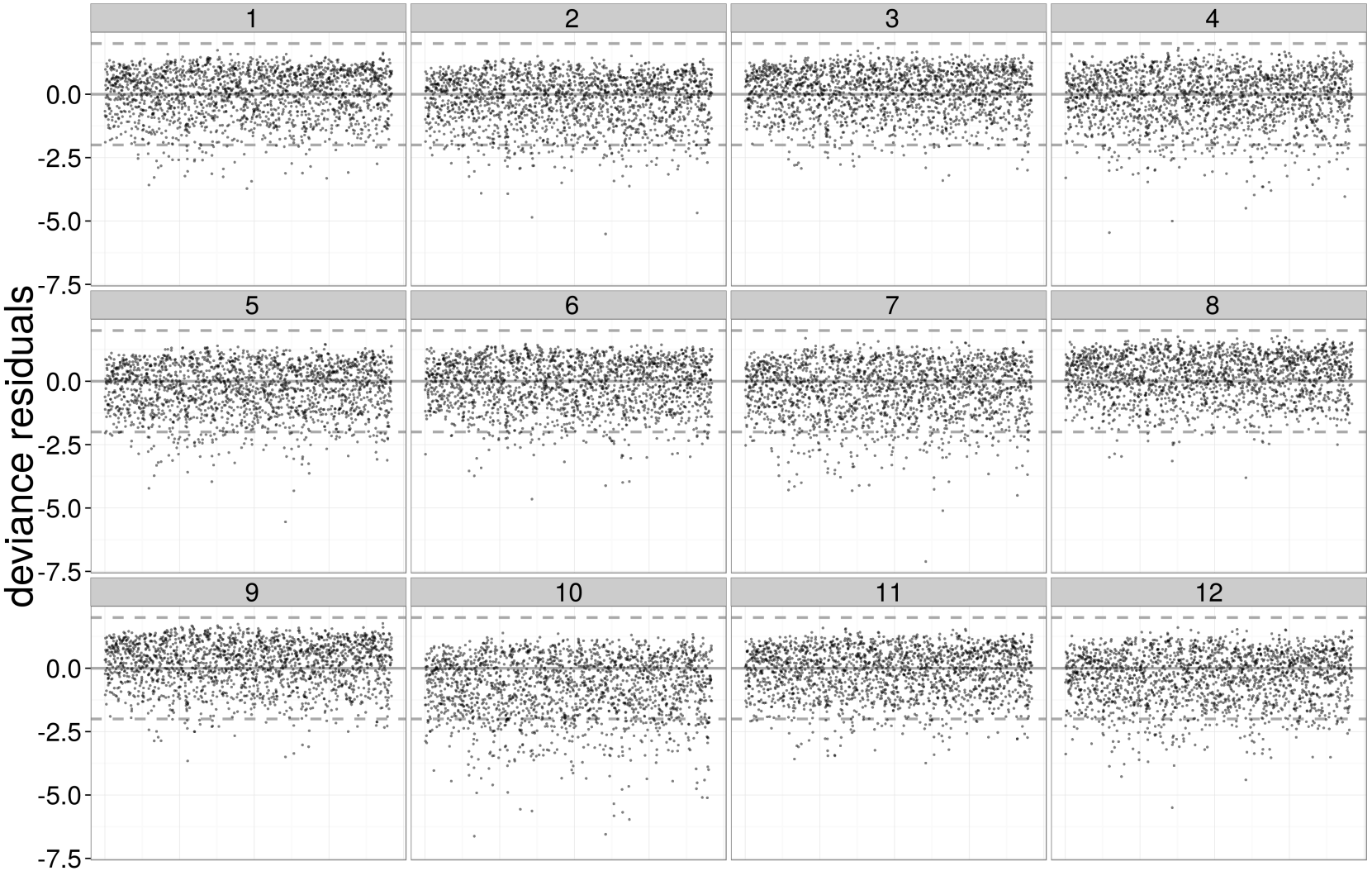
cdf at observed duration given model

$$\Pr[T < T_i] = \int_{-\infty}^{T_i} \text{Weibull}(T_i|\alpha, \sigma) dy = F(T_i|\alpha, \sigma) \quad (2)$$

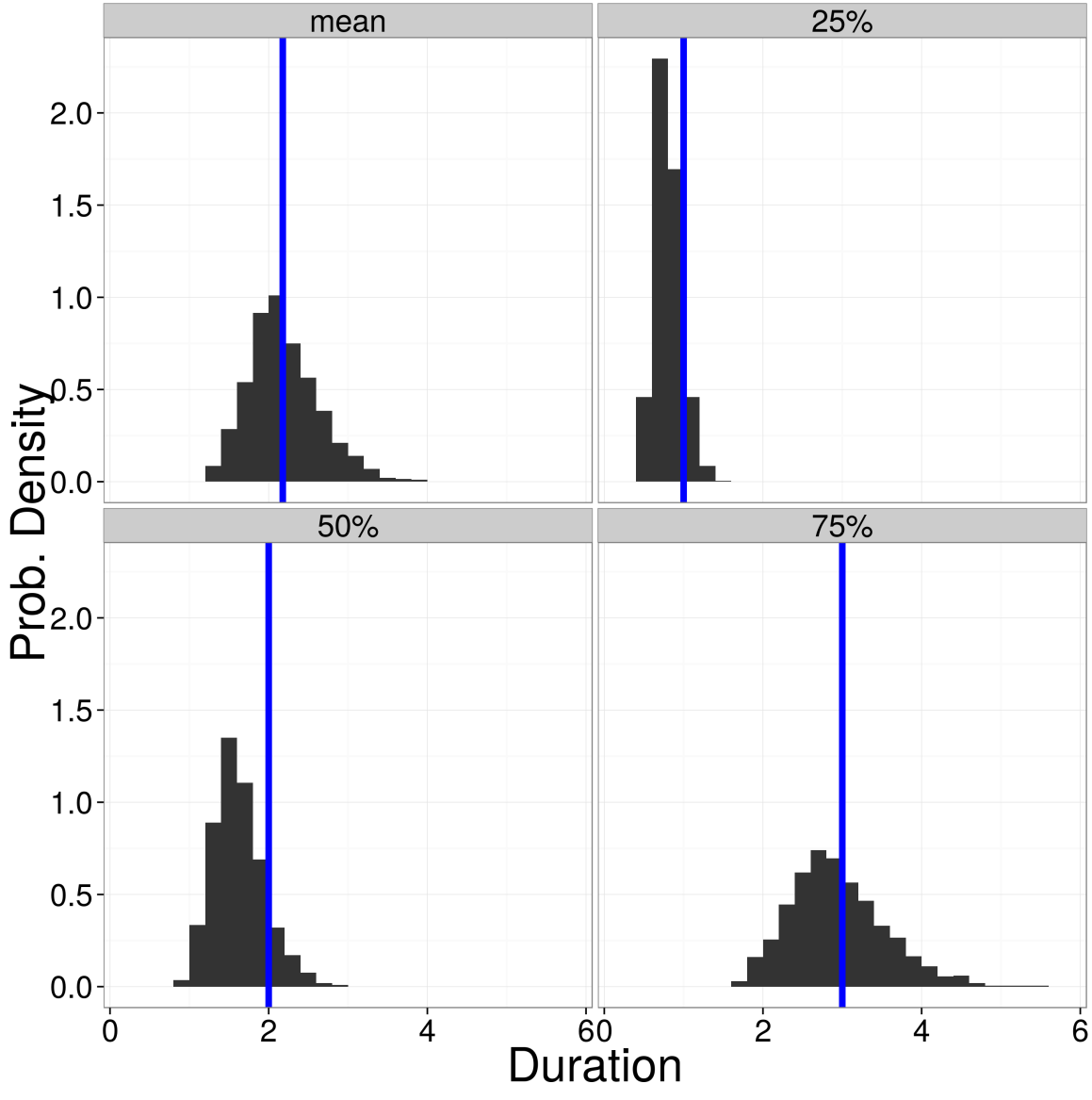
Posterior predictive checks: S(t)



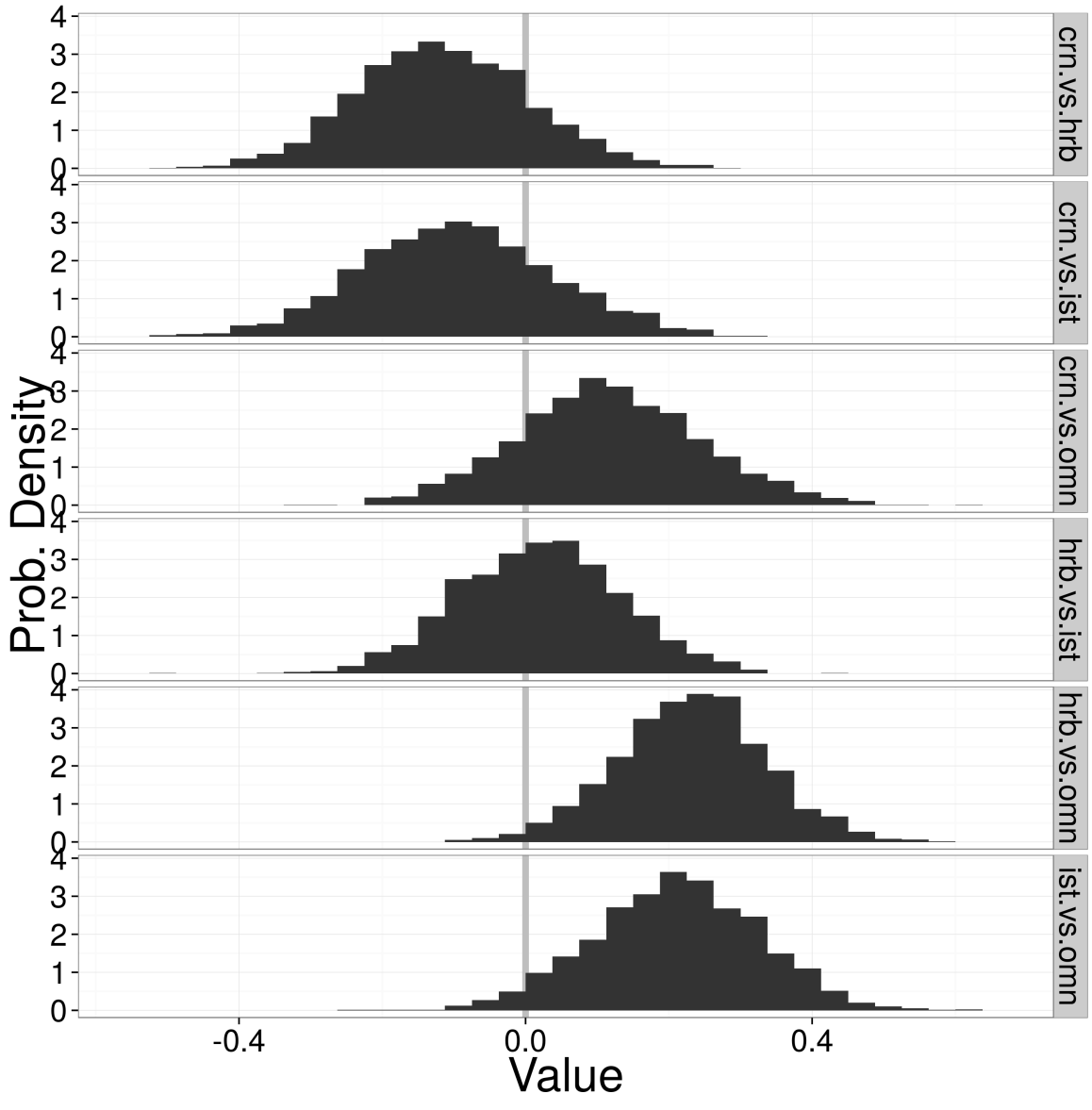
Posterior predictive checks: deviance residuals



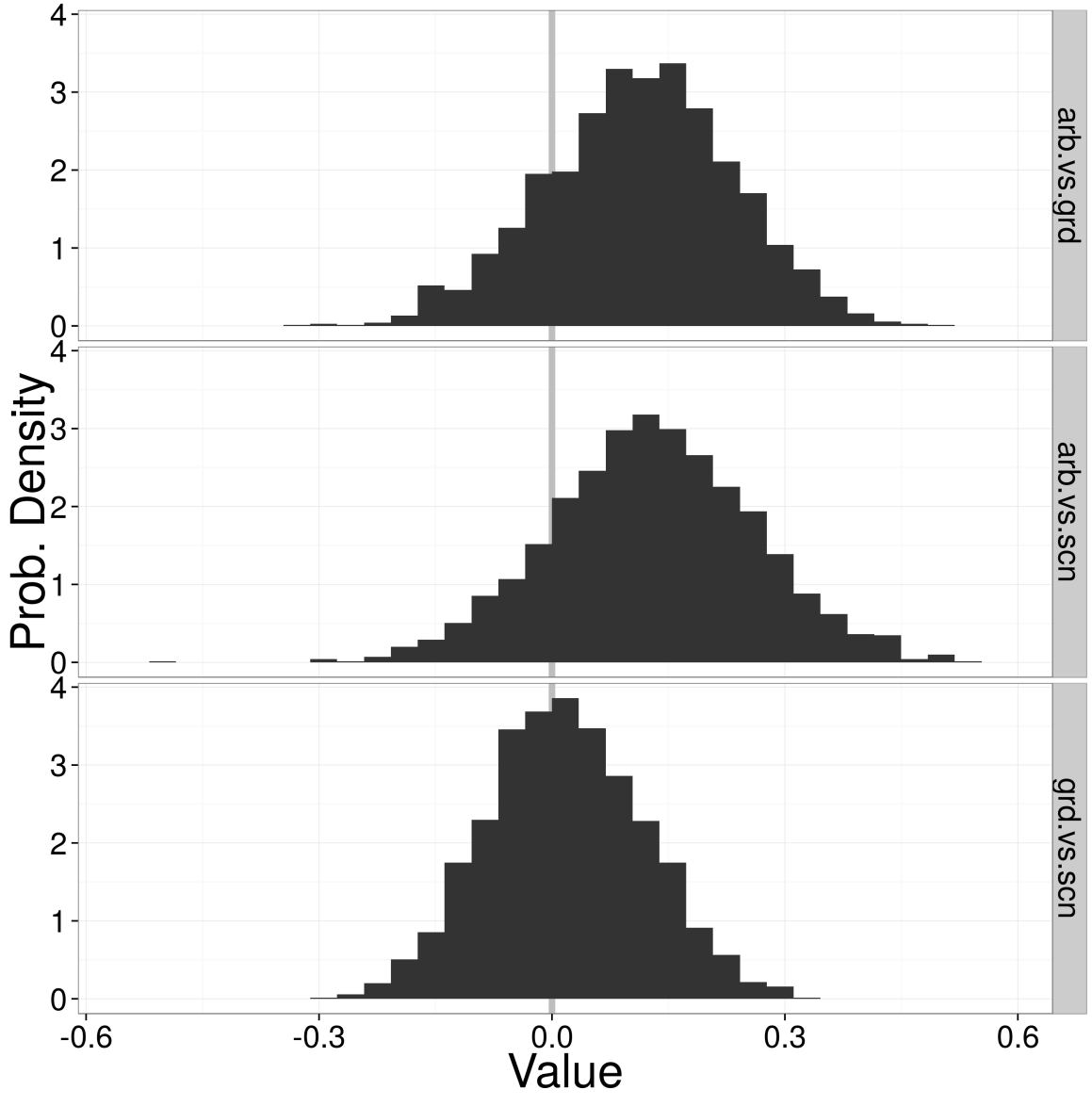
Posterior predictive checks: point checks



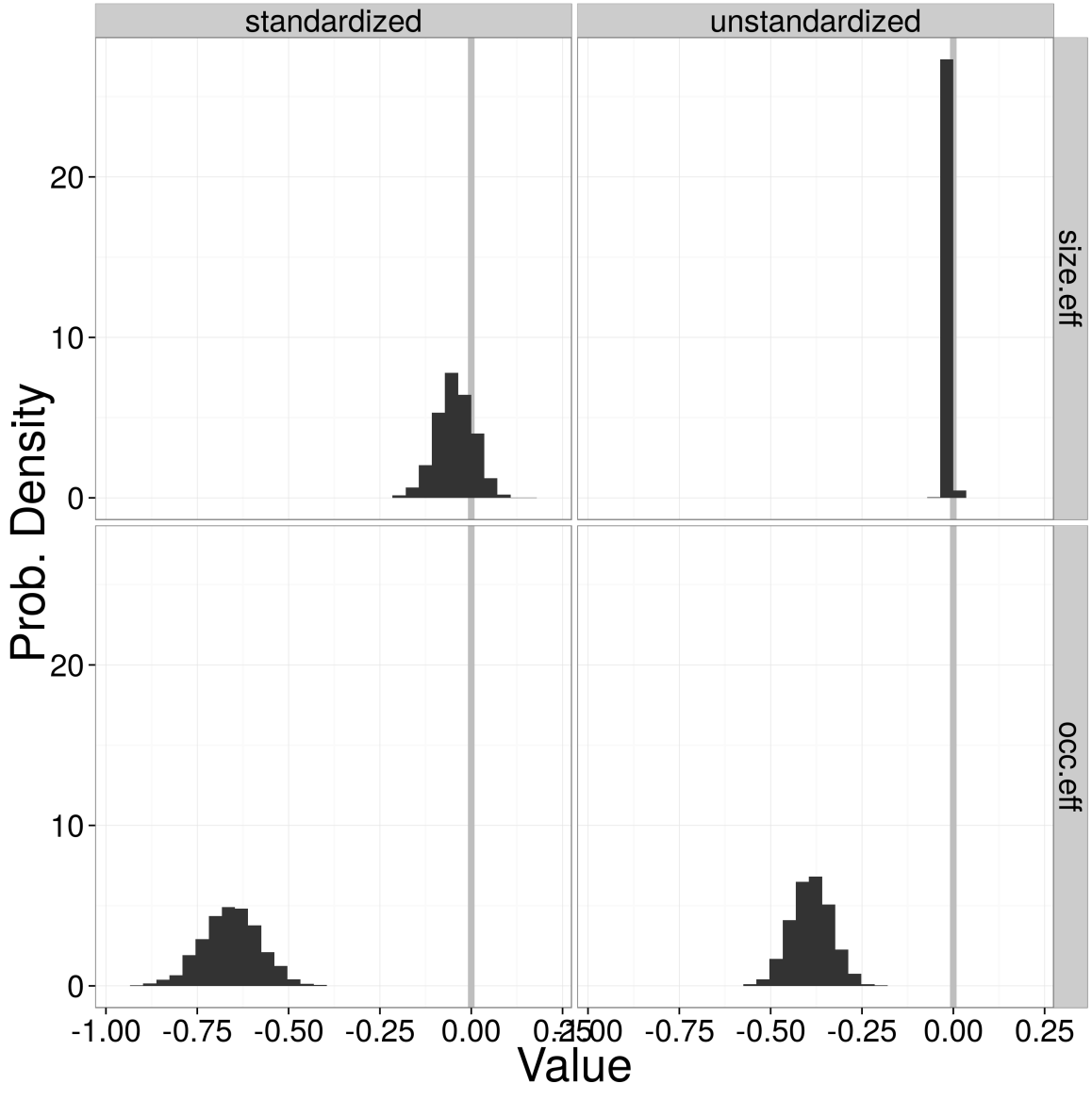
Pairwise differences of β, dietary category



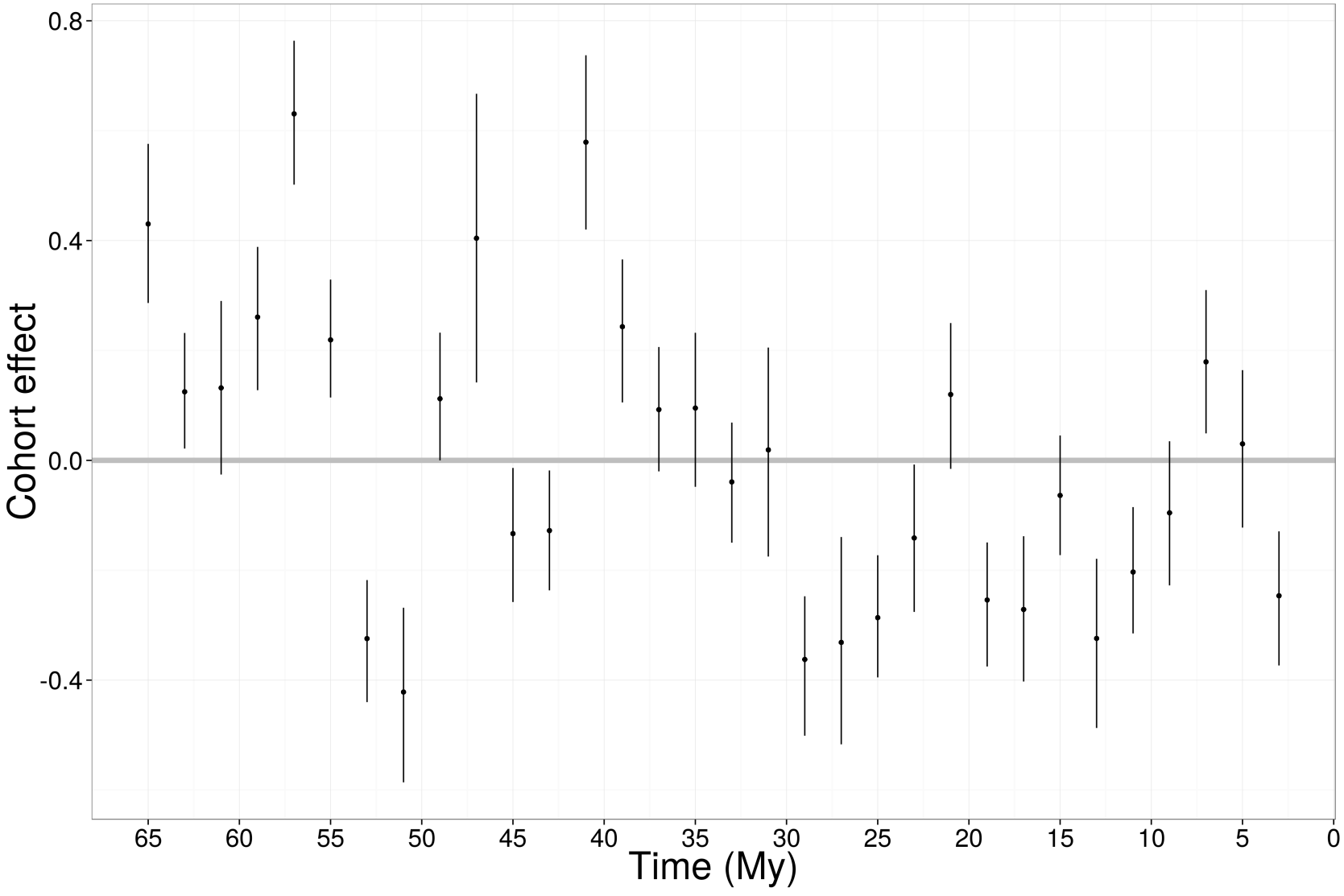
Pairwise differences of β, locomotor category



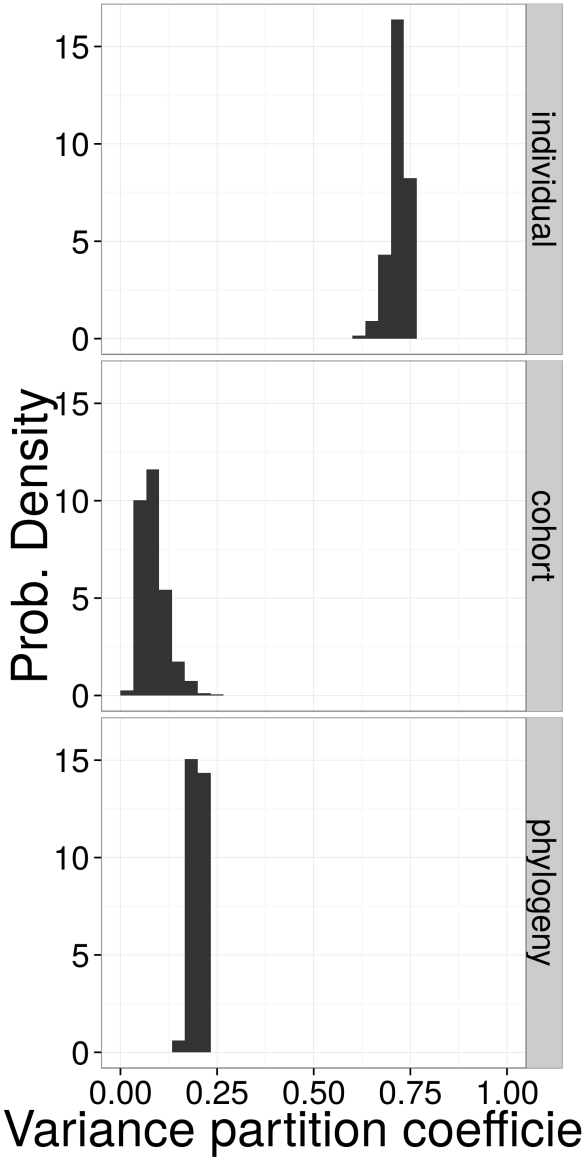
Other traits



Cohort effect

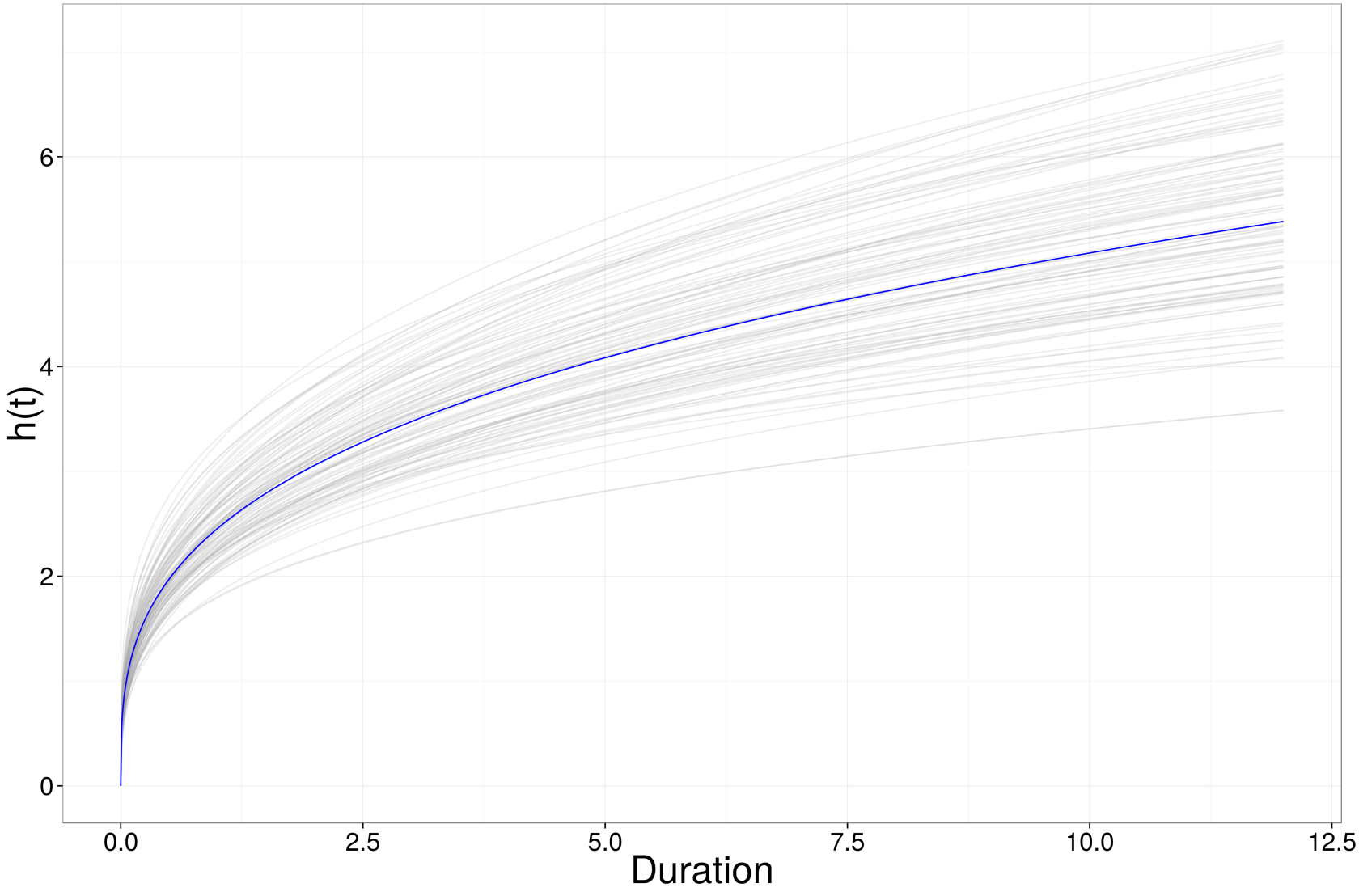


Variance partion coefficient



- Because GLMM, VPC approximated via simulation modified from Goldstein *et al.* '02 *Understanding Statistics*
- phylogenetic heritability, *sensu* Lynch '91 *Am. Nat.*, is a special case of VPC.

Hazard curvature



Meaning

Results

- model generally fits; no systematic biases in residuals
- comparable probabilistic statements of trait, temporal, and historical effects
  - individual level is major source of variance
  - phylogenetic effect $>$ cohort
- decreasing cohort survival risk over Cenozoic
- $h(t)$ not constant over t, increases slowly

Interpretation

- older lineages out-competed by younger (Wagner and Estabrook '14 *PNAS*)
  - hard to pin to any organismal traits, but weak phylogenetic heritability
- increasing extinction with group age (Quental and Marshall '13 *Science*)
  - temporally non-constant selective pressures
- background extinction; no single mode of extinction
- relative effect of universality of covariate, levels of selection(?)

A model of biological, spatial, and phylogenic effects on Cenozoic mammal co-occurrence

Biogeographic network

Define a bipartite network between species and their occurrences on a equal area grid.

Species adjacency

One mode. Species now connected to species they co-occurred with.

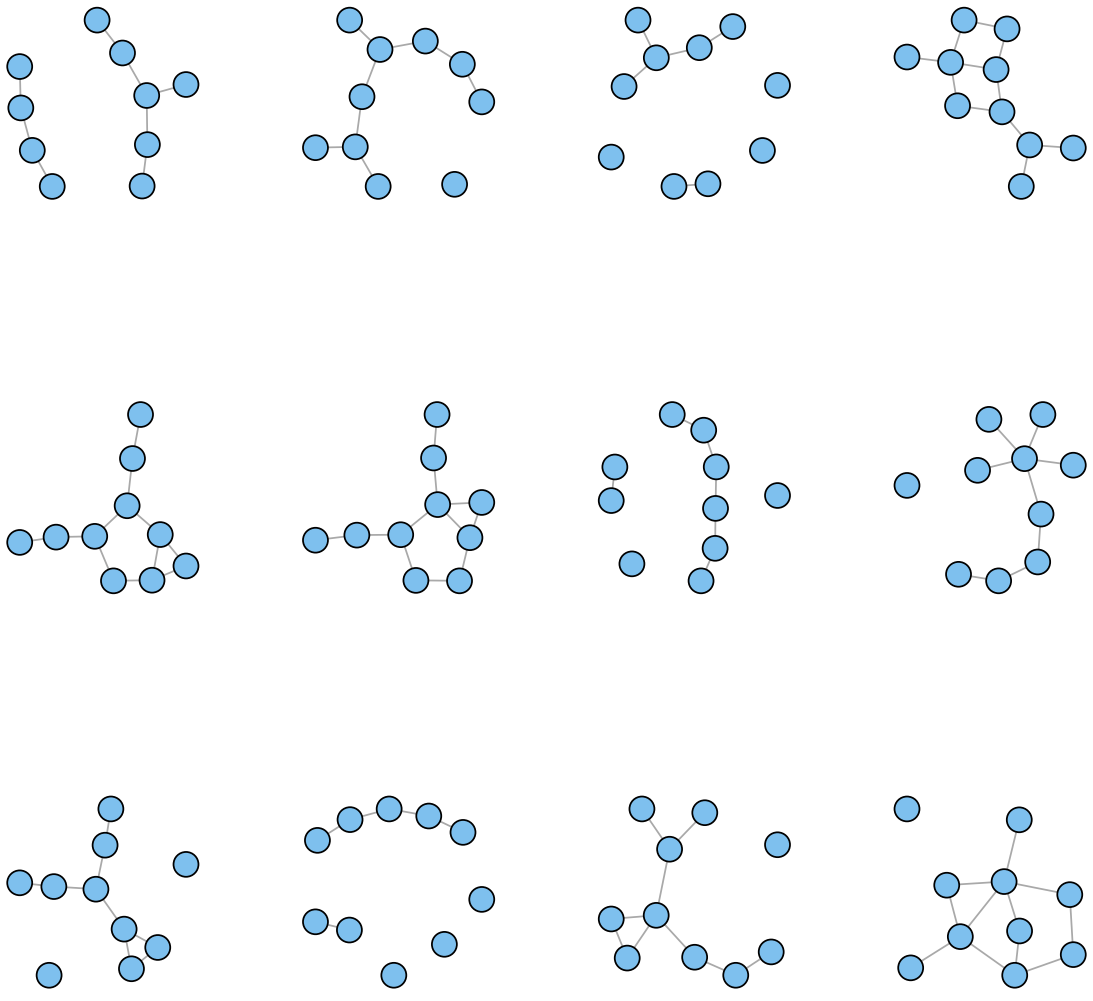
For every species, count degree.

Autoregressive model

Adjacency is also a symmetric n by n matrix, A, with ones on the off-diagonals if the species co-occur.

CAR prior. Estimate spatial correlation (p) and hierarchical variance variance (sigmasq) as a multivariate normal effect with mean vector all 0 and covariance matrix = sigmasq * (I - p * A)

Erdos-Renyi graph $G(n, p)$



Overdispersion model

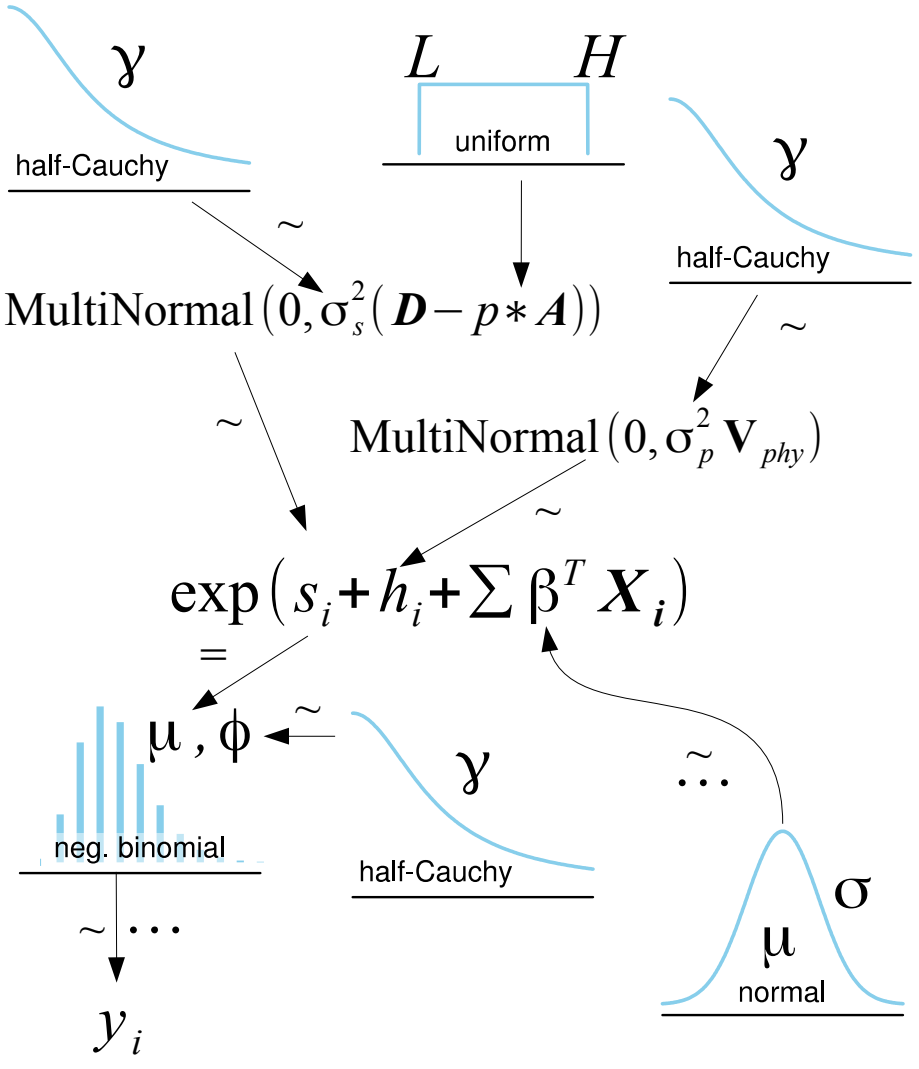
Negative Binomial

$$\text{NegBinom}(y|\alpha,\beta) = \binom{y+\alpha-1}{\alpha-1}\left(\frac{\beta}{\beta+1}\right)^{2}\left(\frac{1}{\beta+1}\right)^{y}$$

reparameterized

$$\text{NegBinom}(y|\mu,\phi) = \binom{y+\phi-1}{y}\left(\frac{\mu}{\mu+\phi}\right)^{y}\left(\frac{\phi}{\mu+\phi}\right)^{\phi}$$

Model diagram



$$y_i \sim \text{NegBinom}(\mu, \phi)$$
$$\phi \sim \text{half-Cauchy}(2.5)$$
$$s_i \sim \text{MultiNormal}(0, \Sigma_s)$$
$$\Sigma_s = \sigma_s^2(\boldsymbol{D} - p * \boldsymbol{A})$$
$$\sigma_s \sim \text{half-Cauchy}(2.5)$$
$$p \sim \text{Uniform}(0, 1)$$
$$h_i \sim \text{MultiNormal}(0, \Sigma_p)$$
$$\Sigma_p = \sigma_p^2 \mathbf{V}_{phy}$$
$$\sigma_p^2 \sim \text{half-Cauchy}(2.5)$$
$$\beta \sim \text{Normal}(0, 10)$$