eco-evolutionary models

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```
library(deSolve)
library(reshape2)
library(ggplot2)
theme_set(theme_bw())
```

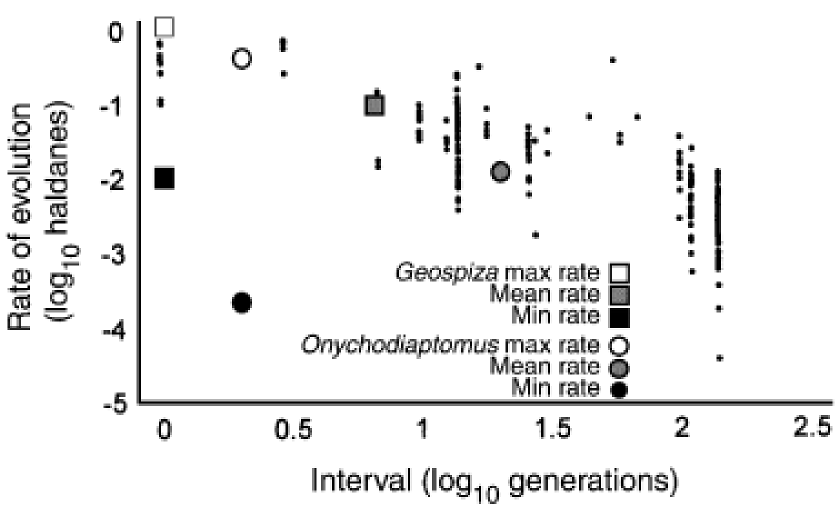
what are eco-evolutionary models?

- Slobodkin/Hutchinson: evolutionary theater, ecological play (i.e. ecological rates $\gg$ evolutionary rates)
- what if the rates are similar?
  - ecological dynamics (e.g. logistic equation)
  - evolutionary dynamics (changes in traits)
- alternatively, population genetics plus population dynamics

why aren't all models like this?

- eco/evo time scales are often different
- it's hard!
  - most population genetic models assume constant population size
  - most ecological models assume constant traits

(Ellner, Geber, and Hairston 2011)



(1 Haldane = change by a factor of 1 standard deviation/generation)

endpoints

- ecology only: e.g. Lotka-Volterra predator-prey or competition; Rosenzweig-MacArthur model ...
- evolution (population genetics); e.g. see Lande, Lande and Arnold ... (discrete-time matrix models)

how do we do it?

- range of realism/complexity
- individual or agent-based models
  - each individual has a genotype and a phenotype
  - rules for life history and interactions
- models for the distribution of a continuous trait
  - partial differential equations
  - reaction-diffusion equations
  - includes demography, mutation
- moment equations
  - simplify PDEs to equations for the means and variances of traits, plus population densities
- Price equations:
  - further simplify to equations for the means of traits (assume constant variance)

individual-based models

- maximum detail, realism
- slow
- in R: try to be clever
- also: Python/Cython, C, NetLogo

distribution models

- write equations to follow the fractions of the population in each bin
- i.e. write out $dN(\alpha)/dt$ for $\alpha = 0.01, 0.02, ...$
- move between bins via *mutation kernel*, e.g. $m(-1 + C\sum_{i \neq j} \exp(-((\alpha_i - \alpha_j)/\sigma^2))$ where C is a *normalization constant*, i.e. make sure the sum is 1/ population is balanced
- boundary conditions!