Notes on (pathogen) evolution

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Evolution

- Rice (2004) (fundamentals)
- Smith (1982) (evolutionary game theory)
- Hamilton (1998) (evolution of behaviour, dispersal ...)

(ask me about other topics!)

population genetics models

- generally discrete-time, often stochastic
- Mendelian or **infinite alleles model** (continuous traits)
- usual simplifying assumptions:
  - non-overlapping generations
  - fixed population size
  - unconditional fitness
- Hardy-Weinberg

invasion analysis

- can species/type A *invade* a *monomorphic* equilibrium of type B? (evaluate Jacobian at $\{0, B^*\}$)
- can measure in terms of *fitness* r (eigenvalue) or R (fitness scaled by generation time)

evolutionary game theory

- competing strategies; "payoff" (fitness) dependent on coexisting strategies
- evolutionary stable state/strategy (non-invadable) (vs. convergent stable strategy: Apaloo, Brown, and Vincent (2009))

adaptive dynamics

- *pairwise invasibility plots*
- separation of time scales: mutation $\ll$ population dynamics

- typically looking for *evolutionary branching points*

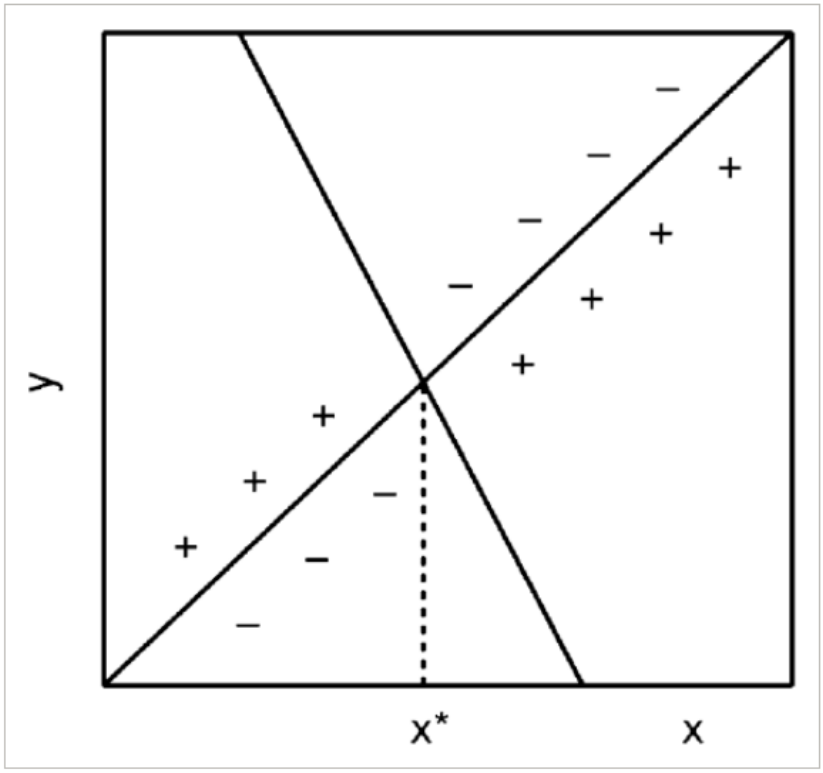


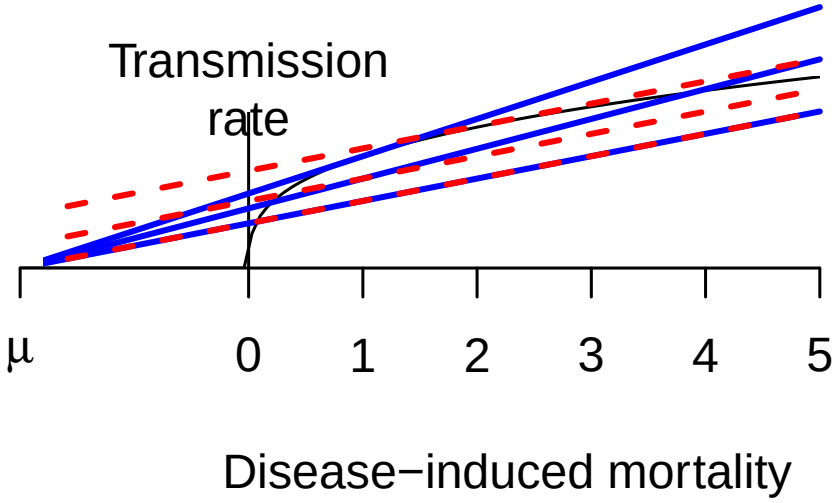
Figure 1: pairwise invasion plot

eco-evolutionary dynamics

- keep track of population dynamics *and* trait distribution
- full model: PDEs (distribution), *or* mean and variance, *or* just mean
- *Price equation* (Day and Proulx 2004)

evolution of virulence

- *Very* broadly, maximizing $\mathcal{R}_0$ is an ESS
- What is ESS if transmission rate β is a *decelerating* function of disease-induced mortality (α)?
  - $d\beta/d\alpha > 0$, $d^2\beta/d\alpha^2 < 0$
  - $\to \mathcal{R}_0 = \beta(\alpha)/(\alpha + \mu)$
- more generally *clearance rate* $\alpha + \gamma$ (recovery plus virulence)
- what value of β maximizes $\mathcal{R}_0$?
- $\to \beta' = \beta/(\alpha + \mu)$



Invasion of VOCs

$$I_1 = \exp(r_1 t)$$
$$I_2 = \exp(r_2 t)$$

References

Apaloo, Joseph, Joel S. Brown, and Thomas L. Vincent. 2009. "Evolutionary Game Theory: ESS, Convergence Stability, and NIS." *Evolutionary Ecology Research* 11 (4): 489–515. http://www.evolutionary-ecology.com/abstracts/v11/2445.html.

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