Quantifying the effects of parasites on the maintenance of sex

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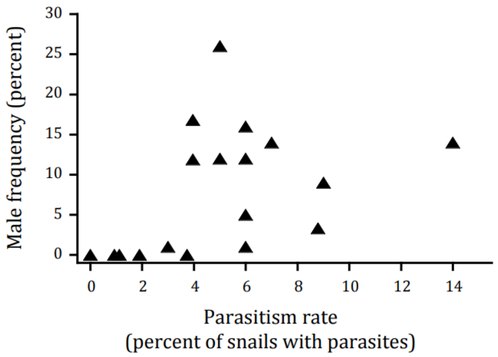
Summary

Why must **sexual reproduction** persist in nature given its **twofold cost**? The **Red Queen Hypothesis** predicts sexually reproducing individuals to overcome the cost of sex by escaping infection more easily under strong parasite selection. Here, we tried to quantify the effect of the Red Queen and perform a power analysis.

Evolution of sex

- **Two fold cost of sex**: (1) cost of producing males and (2) cost of meiosis
- the two fold cost of cost of sex asumes that **all else is equal**
- only 0.01% eukaryotes conform to purely asexual reproduction. How?

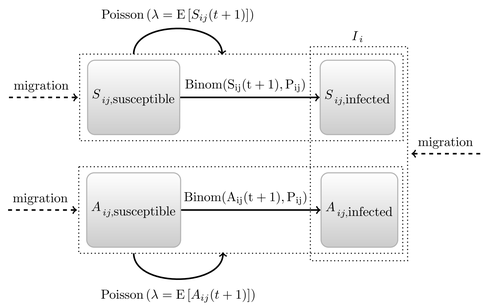
Red Queen Hypothesis



McKone *et al.* [5]

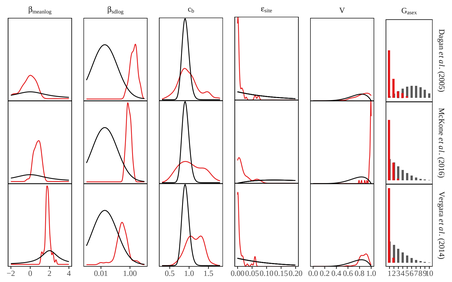
- sexual reproduction creates rare genotypes that can escape infection (**negative frequncy dependence**)
- snail population in New Zealand (host for sterilizing trematode infection) is believed to support the hypothesis [7]
- prevalence of sex should be **positively correlated** with prevalence of infection [3]
- unable to detect any correlation in a similar snail-trematode system [2]

Mathematical model



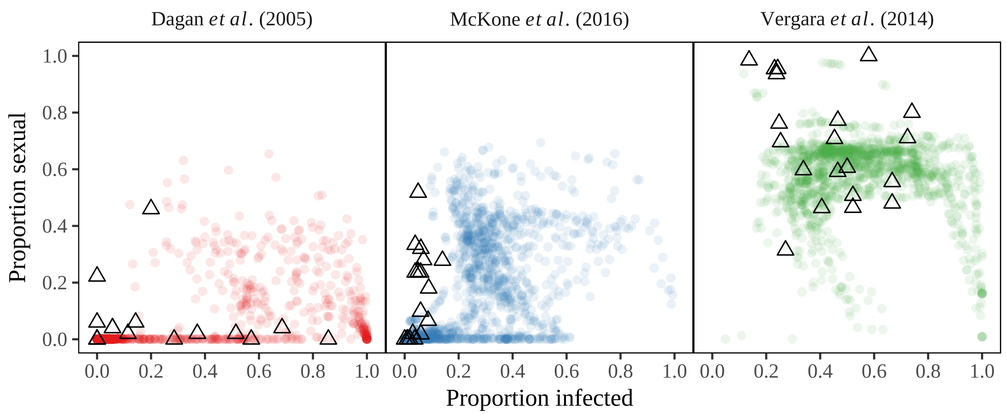
- extension of [4]; the figure represents a dynamic of a single site at each generation
- solid lines represent dynamics with spatial feature (i.e., mixing between sites)
- dashed lines represent stochastic migration from an external source
- transmission rate varies across site

Approximate Bayesian Computation (ABC)

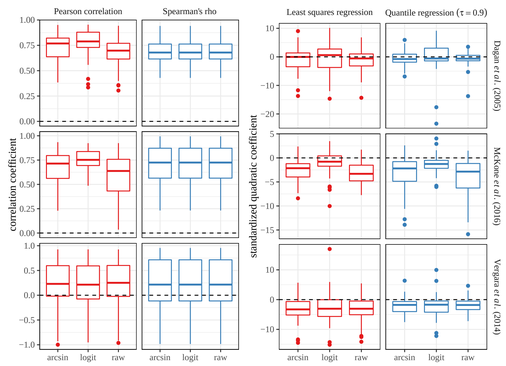


- Bayes' theorem: $p(\theta|X) \propto p(X|\theta)p(\theta)$
- relies on difference between observed and simulated data rather than explicit likelihood
- **Sequential Monte Carlo** method allows for efficient approximation of the posterior [6]
- summary statistics: mean proportion infection/sexual and variation in mean proportion across generation/site

Simulated data v.s. observed data



- spatial structure allows high level of infection to be maintained even at high virulence
- initially increasing prevalence of sexual reproduction pulls back infection (consistent with [3]) and causes prevalence of infection to decrease; quadratic overall
- fitted result does not appear to match Dagan *et al.* [2].



Cycles and spatial structure

- Insert a figure

Discussion and further questions

- High asexual diversity [2] and different environment (e.g., seasonal flood [1] and highly interconnected sites [2]) may not be appropriate for the Red Queen Hypothesis?
- Detecting a positive correlation is not easy; [CITE] used a simple model. What about [CITE]?
- expected relationship may be masked by different cycles but may be recovered with high spatial mixing
- test for risk rather than

Reference

[1] Frida Ben-Ami and Joseph Heller. Temporal patterns of geographic parthenogenesis in a freshwater snail. *Biological journal of the Linnean Society*, 91(4):711–718, 2007.

[2] Y Dagan, K Liljeroos, J Jokela, and F Ben-Ami. Clonal diversity driven by parasitism in a freshwater snail. *Journal of evolutionary biology*, 26(11):2509–2519, 2013.

[3] Curtis M Lively. Trematode infection and the distribution and dynamics of parthenogenetic snail populations. *Parasitology*, 123(07):19–26, 2001.

[4] Curtis M Lively. An epidemiological model of host–parasite coevolution and sex. *Journal of evolutionary biology*, 23(7):1490–1497, 2010.

[5] Mark J McKone, Amanda K Gibson, Dan Cook, Laura A Freymiller, Darcy Mishkind, Anna Quinlan, Jocelyn M York, Curtis M Lively, and Maurine Neiman. Fine-scale association between parasites and sex in potamopyrgus antipodarum within a new zealand lake. *New Zealand Journal of Ecology*, 40(3):1, 2016.

[6] Brandon M Turner and Trisha Van Zandt. A tutorial on approximate bayesian computation. *Journal of Mathematical Psychology*, 56(2):69–85, 2012.

[7] Daniela Vergara, Jukka Jokela, and Curtis M Lively. Infection dynamics in coexisting sexual and asexual host populations: support for the red queen hypothesis. *The American naturalist*, 184(S1):S22–S30, 2014.