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

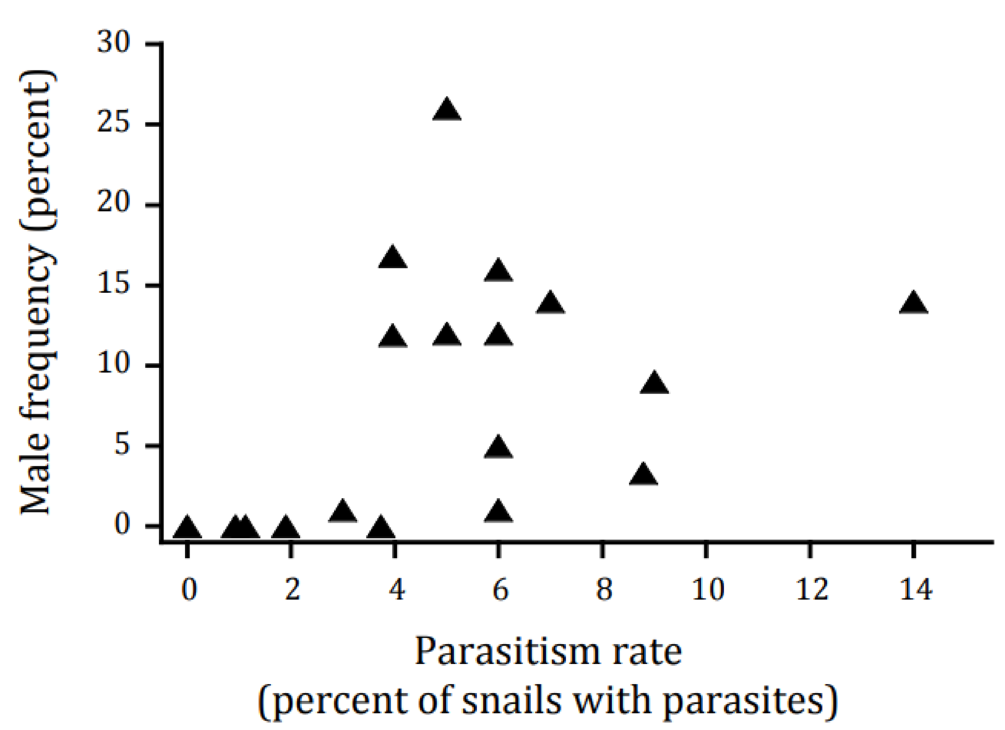

Figure 1: Parasitism rate is positively correlated with male frequency [1].

- 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 [2]
- prevalence of sex should be **positively correlated** with prevalence of infection [3]
- unable to detect any correlation in a similar snail-trematode system [4]

Mathematical model

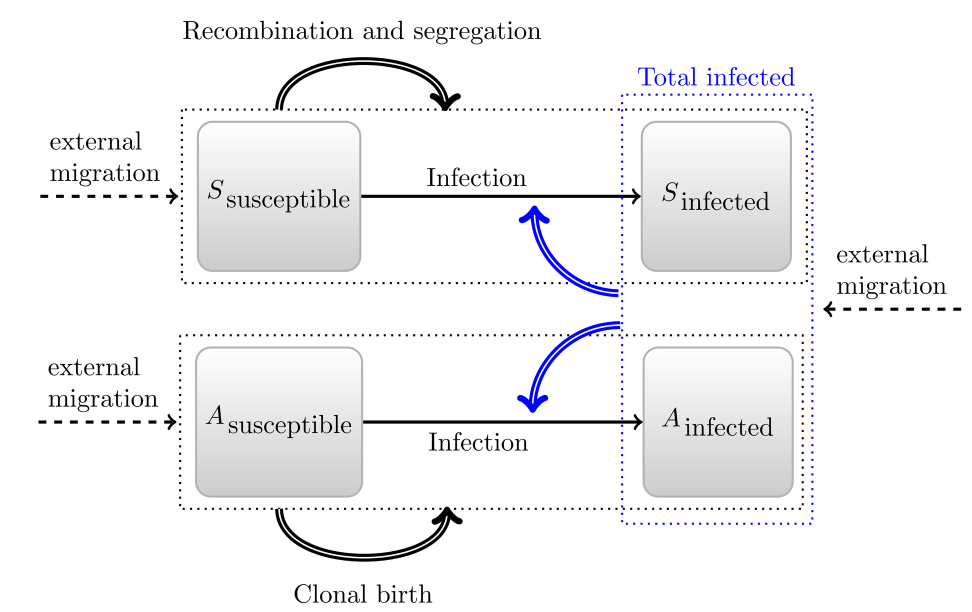

Figure 2: Graphical representation of simulated events that occur in a habitat at each time step. Double lined arrows represent dynamics that are affected by mixing betwee habitats.

- competition between obligate sexual (S) and clonal (A) population under parasite selection is represented by a mathematical model [5]
- hosts stay within their habitats and can mix with hosts in different habitats
- relies on stochastic computer simulations

Approximate Bayesian Computation (ABC)

- a random sample of parameters is drawn
- a data simulated from the sample parameter is compared to the actual data using summary statistics (mean proportion of sex and infected and variation in mean across time/space)
- if the difference is small enough, the parameter sample that generated the data is *accepted*
- the process is repeated but parameters are sampled from deviates of the acepted parameters and lower acceptance rate is used

Results

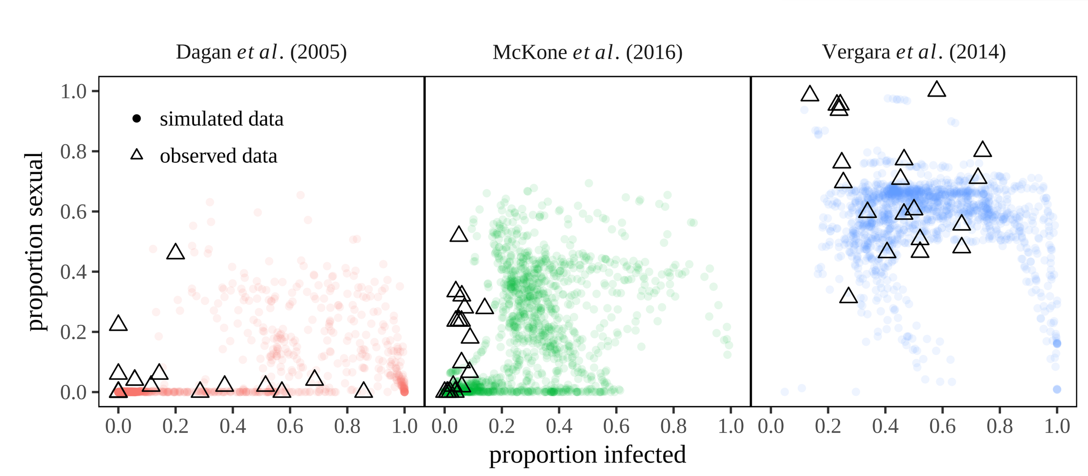

Figure 3: Simulated data v.s. observed data. Each point represents mean proportion infected and sexual at each site.

- fitted result does not appear to match Dagan *et al.* [4]
- overestimates proportion infected when fitted to McKone *et al.* [1]
- spatial structure allow shigh level of infection to be maintained even at high virulence (middle panel)
- initially increasing prevalence of sexual reproduction pulls back infection (consistent with [3]) and causes prevalence of infection to decrease; quadratic overall?

- better to increase number of sites than number of samples
- spearman's rank correlation has higher power for detecting a positive correlation than Pearson correlation
- a negative correlation is observed from simulated data fitted to vergara *et al.*
- very low power for detecting a negative quadratic curvature

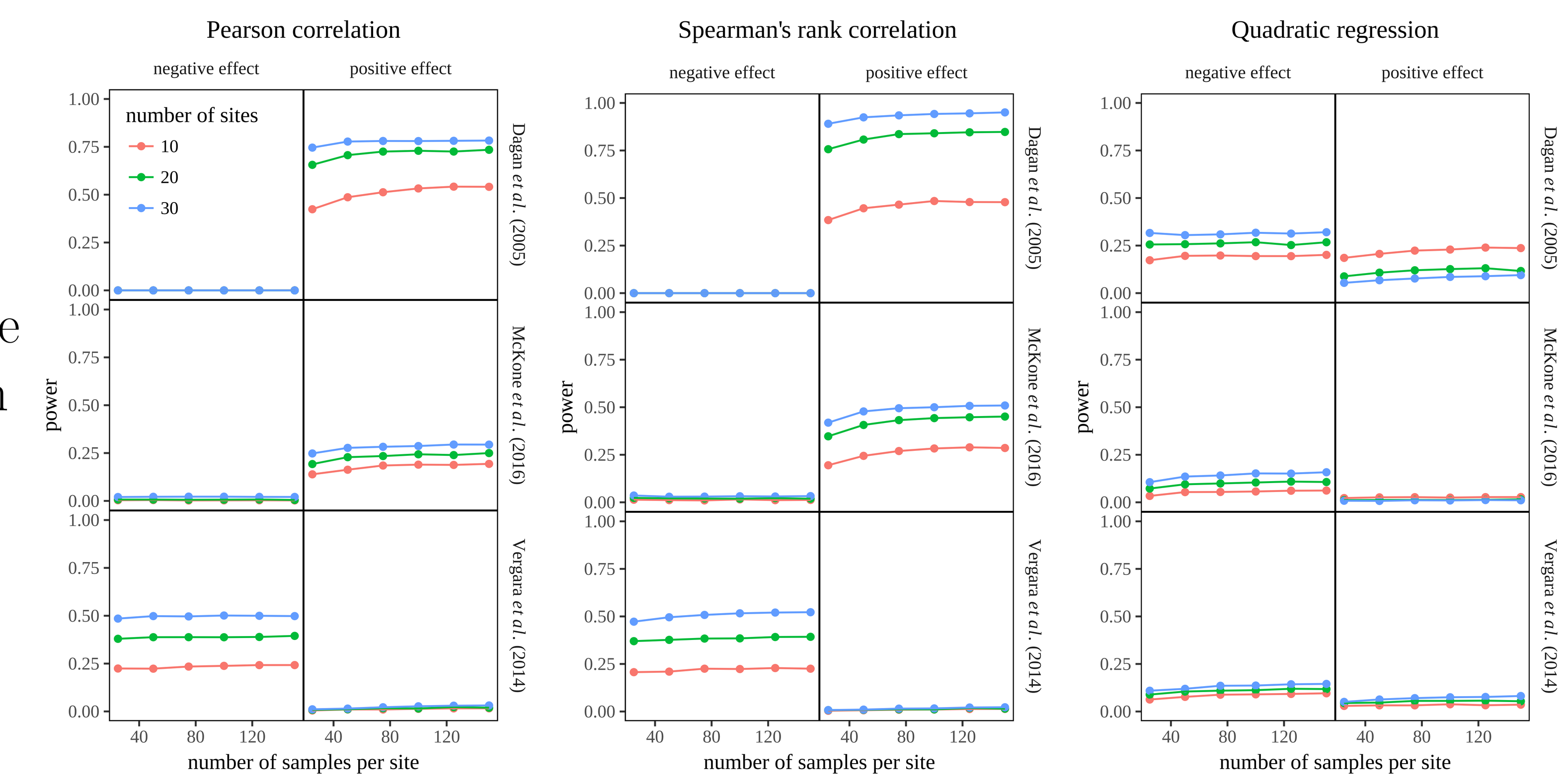

Figure 4: Power analysis for detecting a correlation and negative quadratic curvature.

Cycles and spatial structure

- Insert a figure

Discussion and further questions

- High asexual diversity [4] and different environment (e.g., seasonal flood [6] and highly interconnected sites [4]) 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
- try test for risk rather than looking at prevalence?

Reference

[1] 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.

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

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