

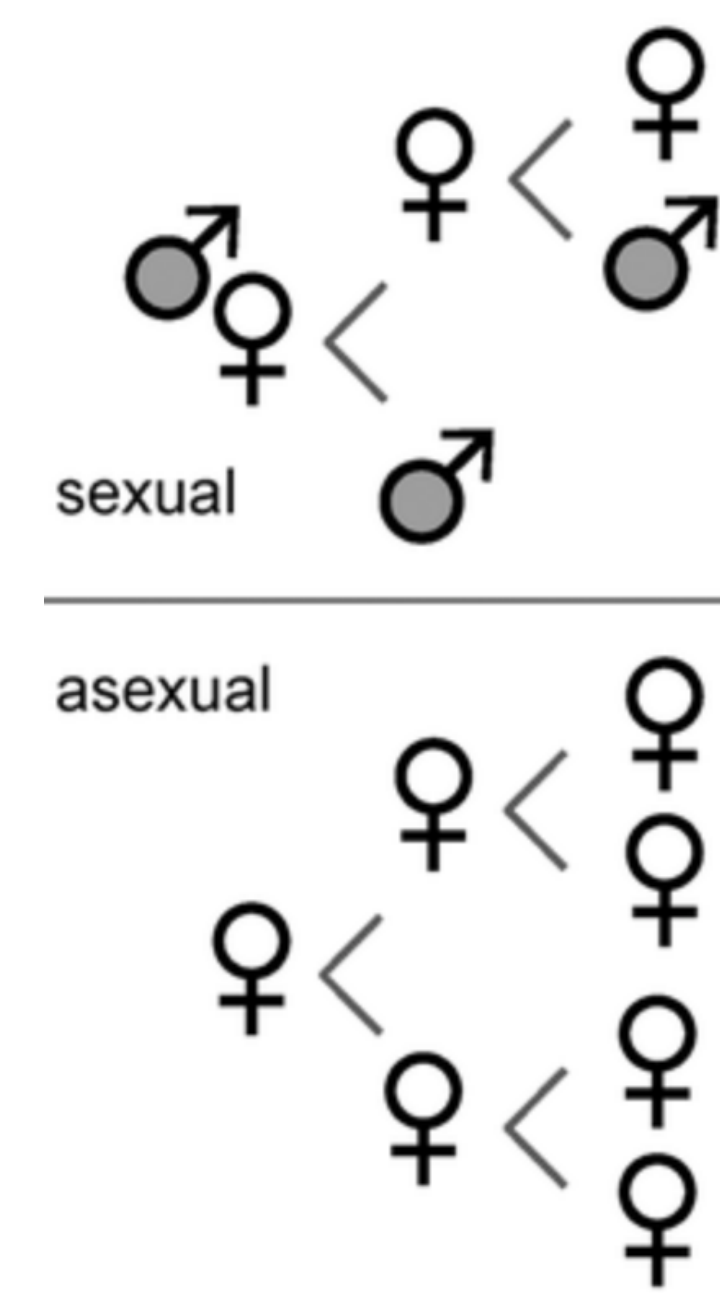
Quantifying the effects of parasites on the maintenance of sex

Sang Woo Park and Ben Bolker
McMaster University, Hamilton, Ontario, Canada

Evolution of sex

two modes of reproduction:

- asexual organisms can produce an offspring alone
- sexual organisms require a male partner to produce an offspring
- sexual population grows slower than asexual population because males cannot give birth; why do organisms reproduce sexually?



Gibson *et al.* [1]

Red Queen Hypothesis

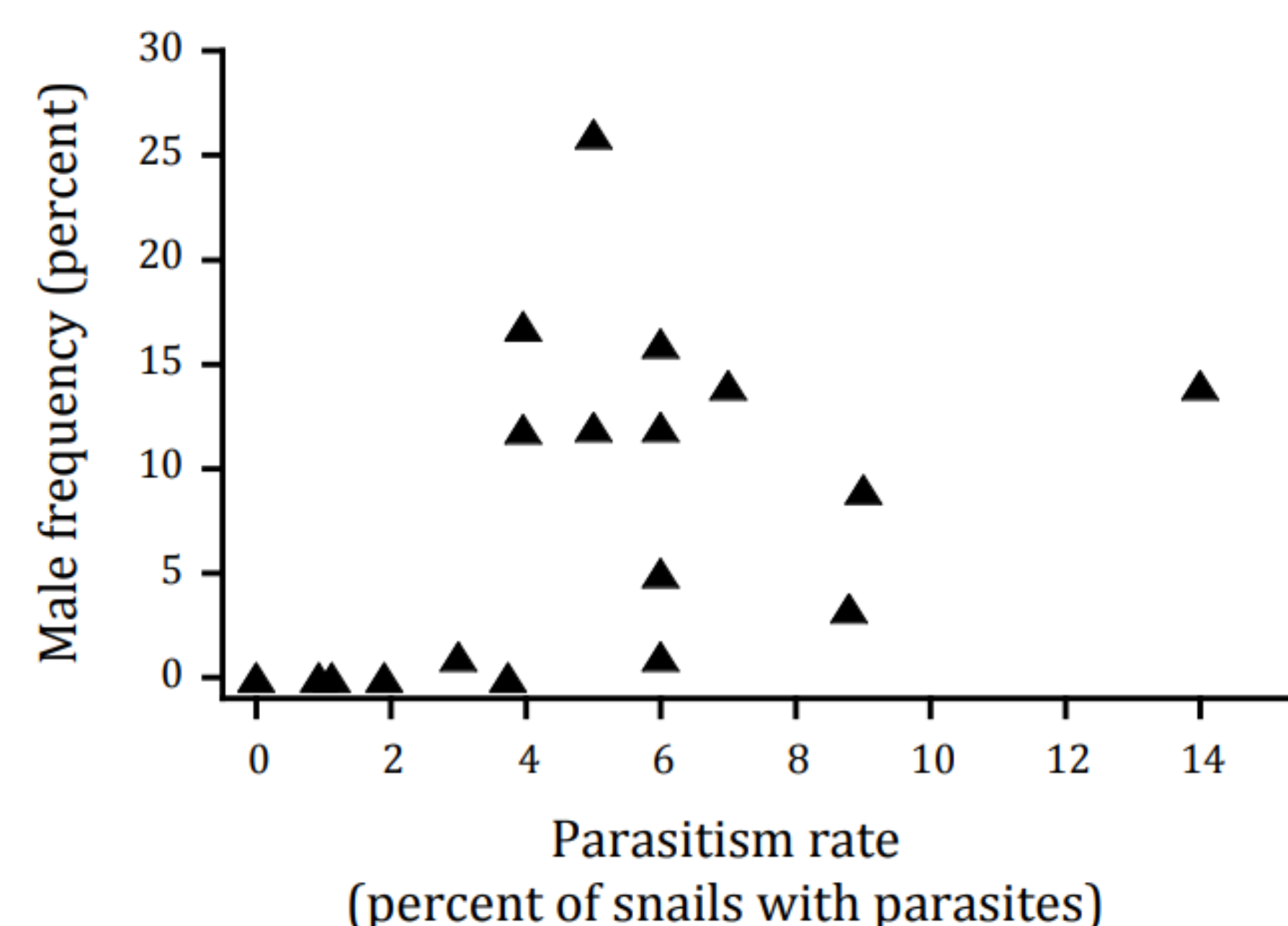


Figure: The snail population in a New Zealand lake [2] follows the prediction made by Lively [3]. Proportion of male snails is used as a measure of proportion of sexual snails in a population.

- snail population living in lakes in New Zealand coexist in both sexual and asexual forms
- the snail population serve as an important host for parasites called trematodes
- hypothesis: sexually reproducing snails can produce snails with rare genes that are resistant to trematode infection [4] (**Red Queen Hypothesis**)
- Lively [3] predicted that population with more infected snails will have higher proportion of sexual snails; **how likely is it to observe this trend in nature?**

Methods

- developed a mathematical model that represent the evolution of the snail population
- the model can be simulated to generate data
- found parameters of the model that made simulated data similar to the observed data
- compared our model to three different snail-trematode systems; one from Israel [5] and two from New Zealand [2, 4]

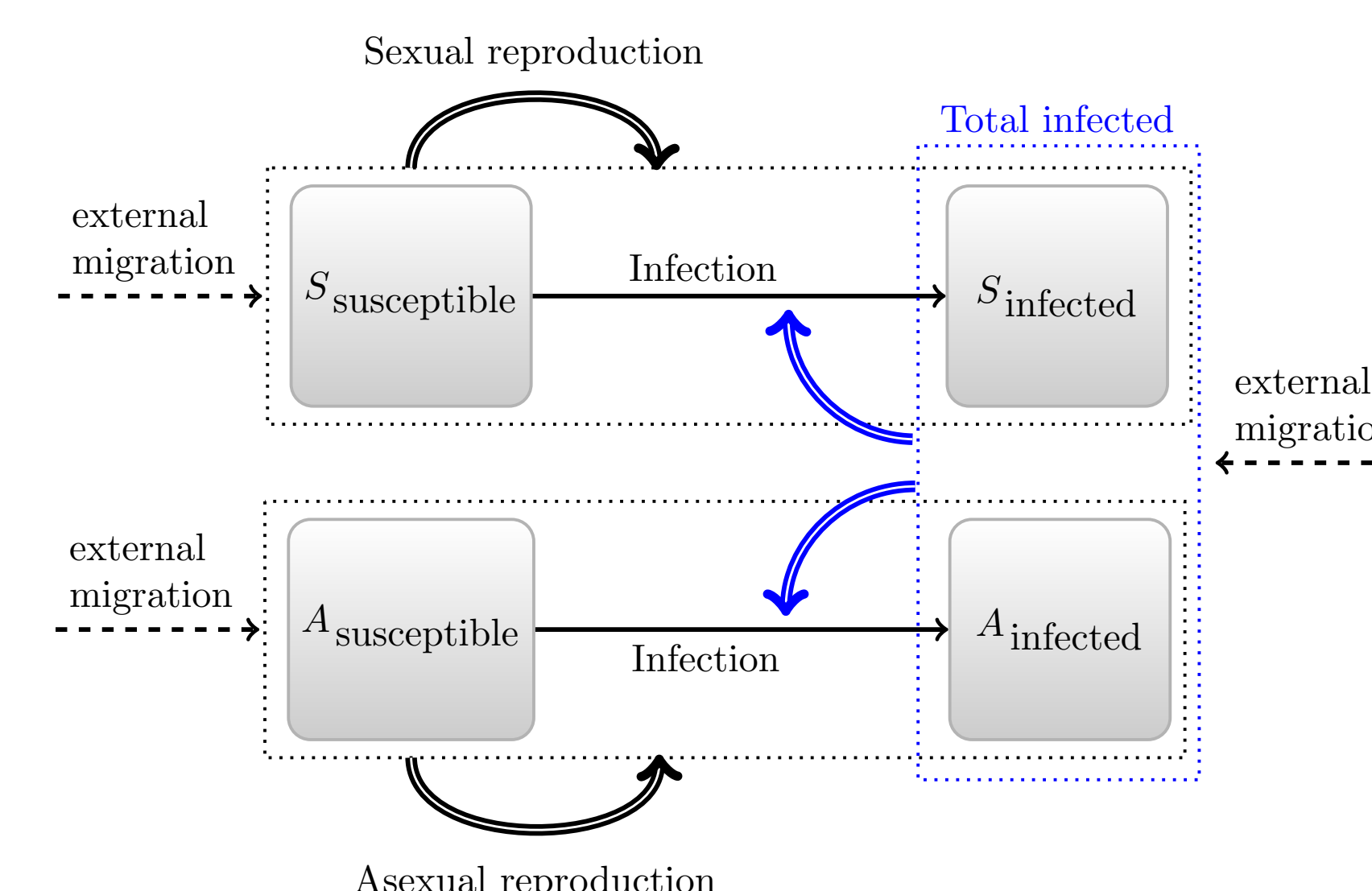


Figure: Graphical representation of the model. Each population is composed of both asexual (A) and sexual (S) hosts. An infected host can infect susceptible hosts if it carries a matching parasite. Hosts can move to other populations.

Results

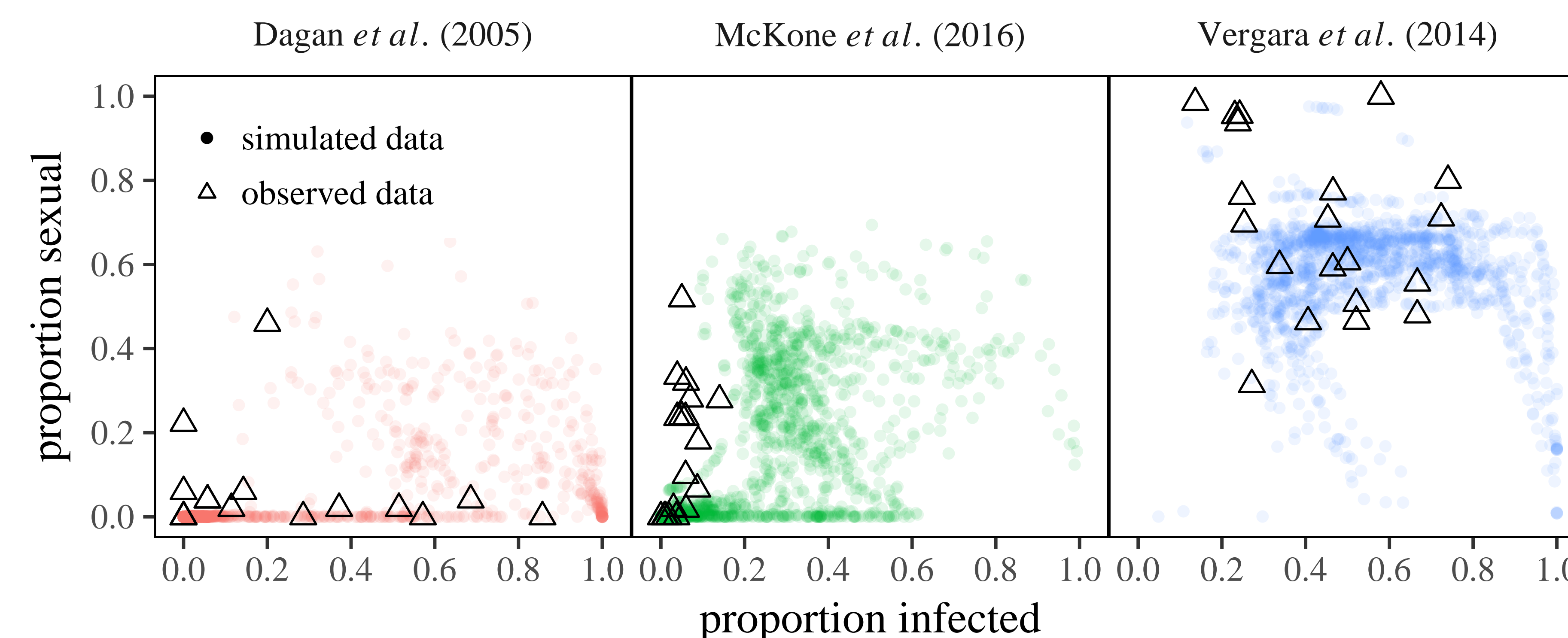


Figure: Simulated data v.s. observed data. (triangle) each point represents an observation from a study site in one year (circle) proportion of sexual hosts and proportion of infected hosts in a simulated population averaged over 100 generations. 50 simulations are plotted and each simulation consists of 30 populations.

- this model is not appropriate for studying the snail population in Israel (left panel: Dagan *et al.* [5]); need to consider other hypotheses for the maintenance of sex?
- when a population is dominated by asexual reproduction, stronger parasite infection leads to increase in sexual reproduction but decrease in proportion infected; opposite to Lively's prediction [3]
- even stronger infection leads to balance between sexual and asexual reproduction (hump in the intermediate zone) and eventually decrease in advantage of sexual reproduction

Discussion

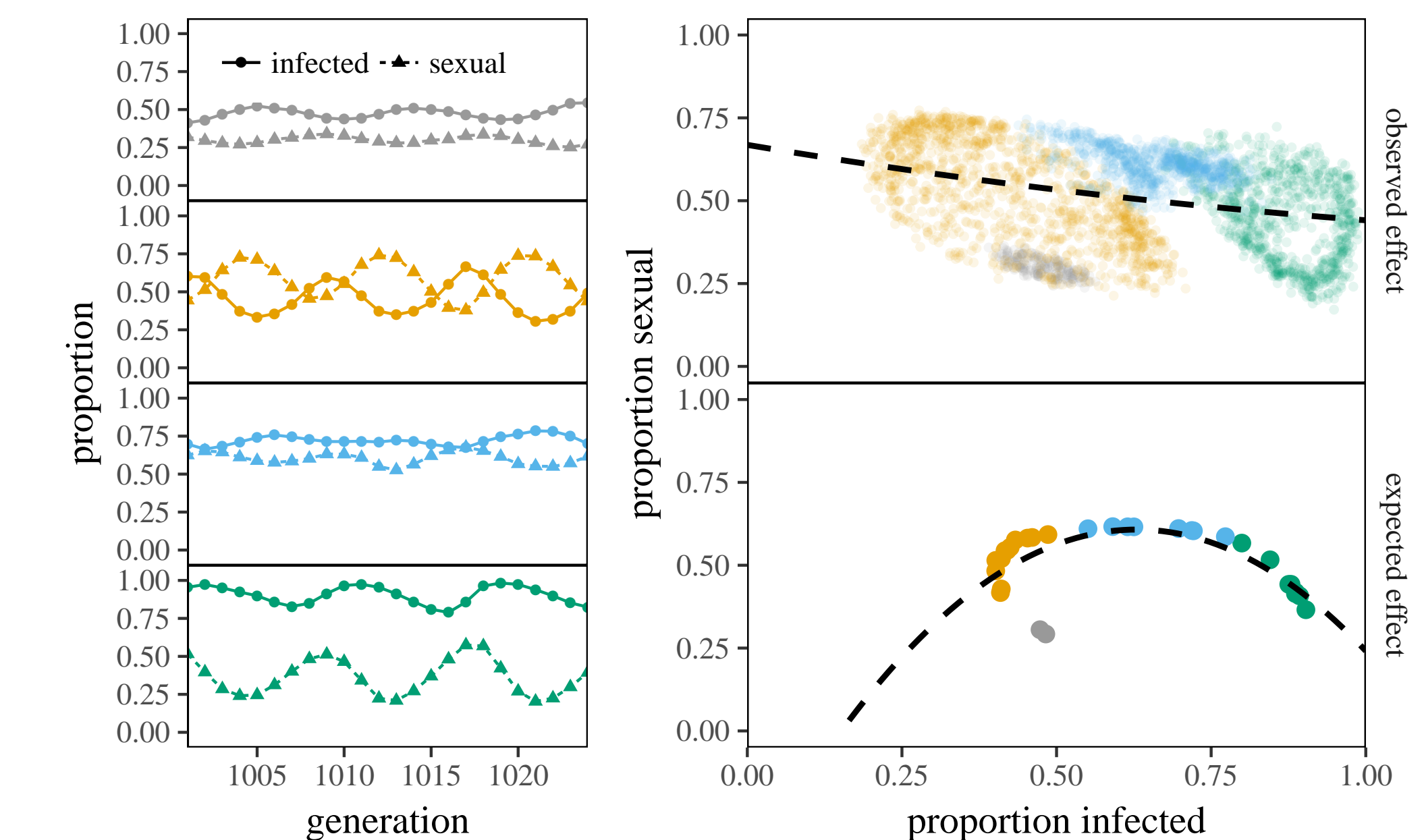


Figure: Closer look at Red Queen dynamics. (left) interaction between parasites and sexual hosts can create various oscillations. (right) we expect to see a downward curved trend but accounting for oscillations in each population predicts an oppsite trend

- eventually parasites evolves to infect resistant snail and sexual reproduction decrease in the population; creates **oscillation between parasite and sexual population** (left panel)

Conclusion and further questions

- sexual population "runs away" (to escape infection) from parasites but parasites "chase" (to infect more) sexual populations, creating an oscillation; depending on where the population is in the cycle, we can observe a wide range of trends
- what kind of data and tests are needed to detect oscillation in the population?

Reference

- Amanda K Gibson, Lynda F Delph, and Curtis M Lively. The two-fold cost of sex: Experimental evidence from a natural system. *Evolution Letters*, 1(1):6–15, 2017.
- 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 antipodorum* within a new zealand lake. *New Zealand Journal of Ecology*, 40(3):1, 2016.
- Curtis M Lively. Trematode infection and the distribution and dynamics of parthenogenetic snail populations. *Parasitology*, 123(07):19–26, 2001.
- 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.
- 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.