Parasite-mediated eco-evolutionary dynamics in evolving communities

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"Nothing in evolution or ecology makes sense, except in the light of the other."
(Pelletier et al. 2009)

Background

- Eco-evolutionary dynamics are the reciprocal impact between ecological and evolutionary processes. These feedbacks shape ecosystems' structures and functions[1].
- Parasites influence host-mediated trophic cascades[1]. They are also important consumers[2].
- Parasites are, however, often ignored in food web studies.

Objective

To explore the role of host-parasite coevolution in community structure and dynamics.

Methods

1. **Individual based model** of a predator-prey-parasite system[3] **(Fig 1)**, where demographic and evolutionary variation in the system emerge from the properties of individual organisms.

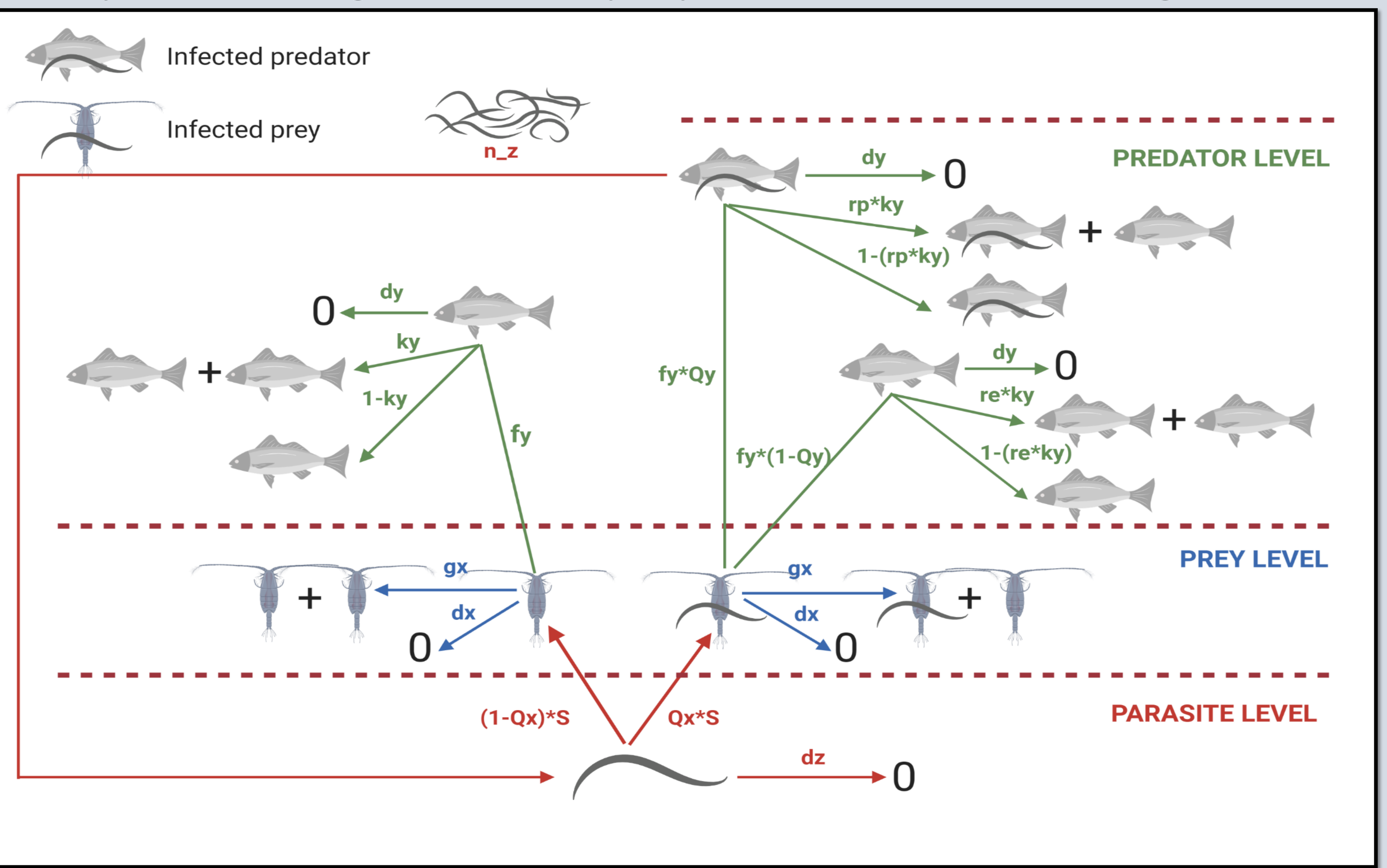

Fig 1. Predator-prey-parasite system with trophically transmitted parasites. The red dashed lines indicate different trophic levels, and the colored arrows indicate all the ecological interactions (created with BioRender.com).

2. **Gene-for-gene principle**[4] for simulating host-parasite interactions within the food web:

- Genotypes are simulated as binary numbers.
- Effective resistance is the sum of resistant alleles ('1') in the host genotype matching the position of non-infective ('0') alleles in the parasite genotype (**Fig 2**). These allelic states can change with mutations.
- Infection rate values are exponentially distributed with resistance, according to a parameter σ, which is a value [0,1]. This is calculated as: $\textit{Infection rate} = \sigma^{resistance}$

HOST	0	0	0	1	1	0	1	0	0	0
PARASITE	0	0	0	1	0	0	0	1	0	0

Fig 2. Host-parasite interaction. In this example, two resistant alleles in the host genotype match the position of non-infective alleles in the parasite genotype (i.e. effective resistance = 2; infection rate = σ^2).

Methods (Continuation)

3. **Identifying the parameter values** for a system's equilibrium that allows species coexistence, and potentially coevolution.

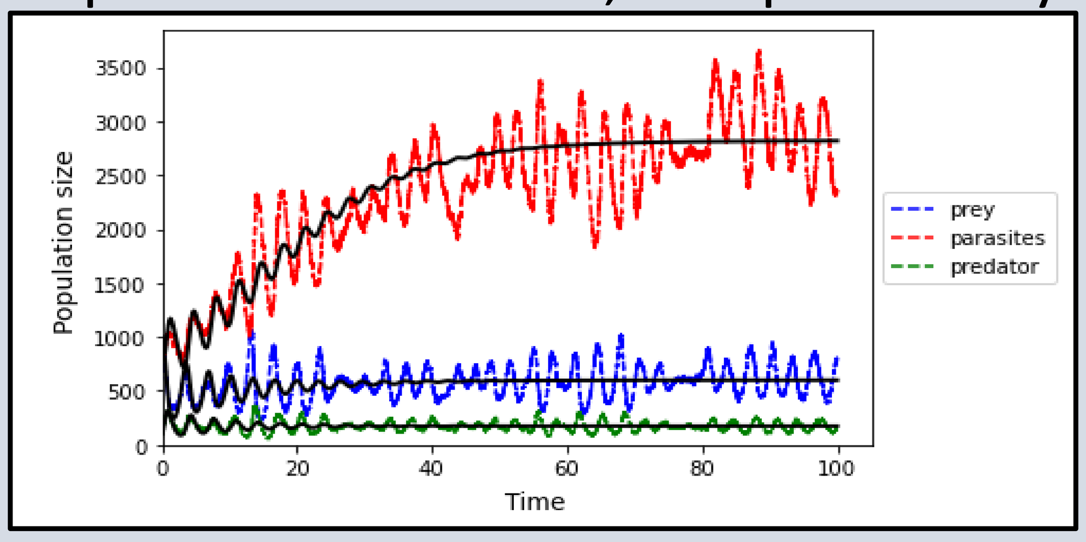

Fig 3. Predator-prey-parasite system at equilibrium, **without mutations**. The black solid lines show populations' average dynamics; coloured lines show stochastic fluctuations.

Preliminary results

- With high parasite impact, predator's partial resistance determines the population sizes at which predator and prey can coexist, i.e. populations' equilibrium points **(Fig 4)**.

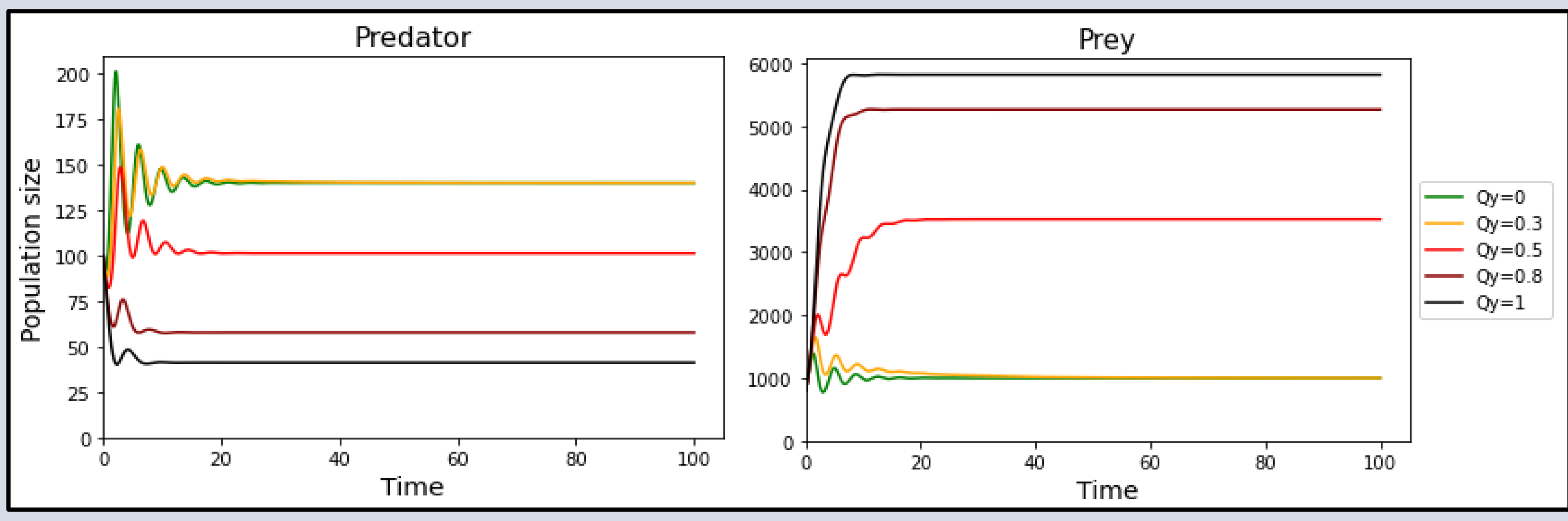

Fig 4. Predator and prey population equilibrium points with increasing infection rates.

- When σ value is small, only the parasite genotypes that have infective alleles matching the position of resistant alleles in the host genotypes, persist **(Fig 5).**

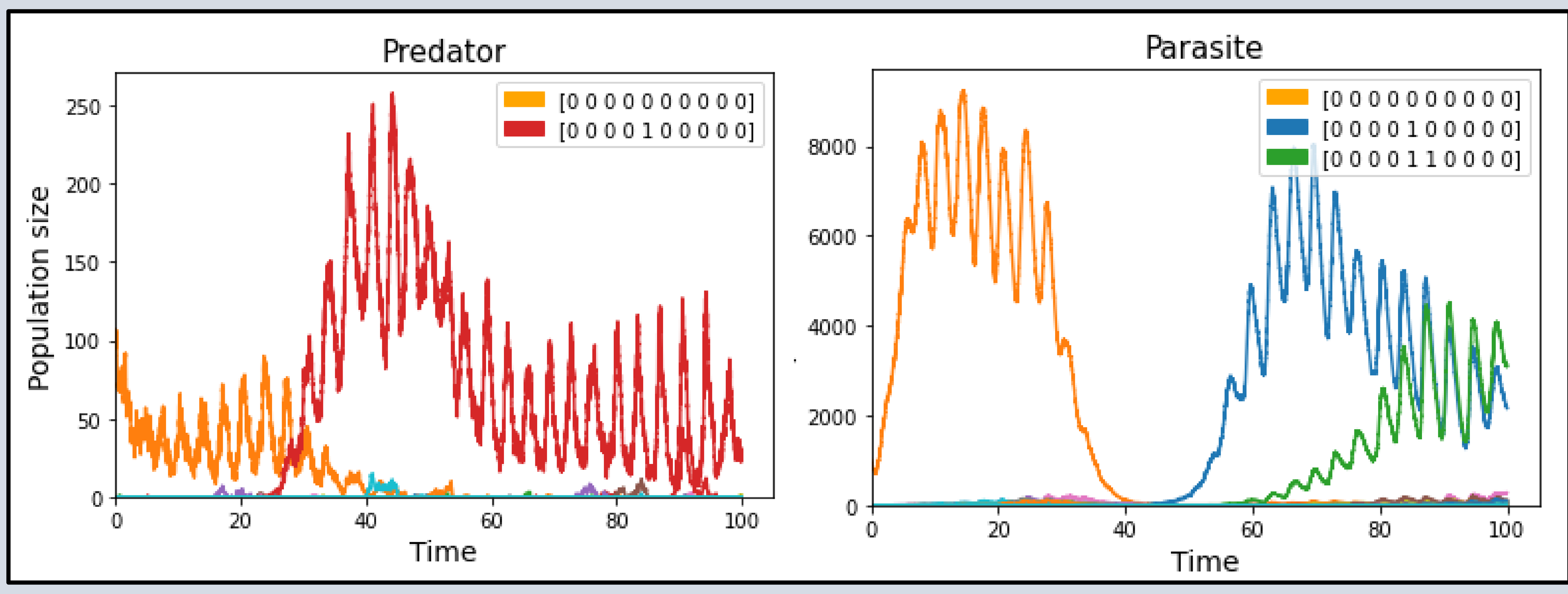

Fig 5. Predator and parasite population dynamics **with mutations**; **σ = 0.25**.

Conclusions

Parasites play a key role in food web structure and dynamics due to their relative high abundance and effects on the host fitness. Thus, the evolution of resistance determines trophic interactions, which highlights the relevance of eco-evolutionary feedbacks shaping complex systems such as food webs.

Future work

- Correlation between predator's resistance and prey community diversity.
- Impact of active vs. trophically transmitted parasites.
- Invasion ecology of host and parasite genotypes.

References:

1. Brunner, F. S., et al. (2017). *Proc Nat Acad Sci*.
2. Kuris, A. M. *et al.* (2008) *Nature*, 454(7203)
3. Huang, W., et al. (2017). *Nat Comms*, *8*(1), 1–8.
4. Sasaki, A. (2000) *Proc Royal Sci Bio*, 267(1458), pp. 2183–2188

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