Stability of two-species communities: drift, environmental stochasticity, storage effect and selection

N.M. Shnerb, D.A. Kessler, M. Danino

Department of Physics, Bar-Ilan University, Ramat-Gan Israel

The dynamics of two competing species in a finite size community is one of the most studied problems in population genetics and community ecology. Stochastic fluctuations lead, inevitably, to the extinction of one of the species, but the relevant timescale depends on the underlying dynamics. The persistence time of the community has been calculated for neutral models, where the only drive of the system is drift (demographic stochasticity) and for models with strong selection. Following recent analyses [1-2] that stress the importance of environmental stochasticity in empirical systems, we present a general theory of persistence time of two-species community with N individuals where drift, environmental variations and time independent selective advantage are all taken into account.

Our analysis implements the backward Kolmogorov Equation, together (numerically inspired) dominant balance argument. It allows us to extend the scaling theory suggested recently by Hidalgo et al. [3] in the following senses:

1. An explicit, closed form for the scaling functions (in terms of a single or a double integral) is derived, so the answer covers all the range of parameters. In particular our formulas converge to the pure demographic limit when the environmental stochasticity vanishes.

2. The expressions suggested in Hidalgo et al. for the large N limit are recovered, but we can calculate also subleading terms in this asymptotic series. This allows us to identify the parameter region where the asymptotic is accurate, and to suggest simple analytic approximations that cover a much wider region of parameters.

3. We can calculate the persistence time for a single mutant. This is an important quantity, as it sets the threshold for clonal interference and may be relevant to the small island effect in island biogeography.

Moreover [3], we have extended the work of Hidalgo et al. to include the case where one species has a time independent selective advantage with respect to the other species, superimposed on the environmental variations.

[l] Kalyuzhny, Kadmon and Shnerb, Ecol. Lett. **18**, 572 (2015).

[2] Danino et al, JTB **409**, 155 (2016).

[3] Hidalgo, Suweis and Maritan, JTB **413**, 1 (2017).