Population dynamics in a bounded habitat: impact of nonlinearities

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The collective behavior of living organisms in an heterogeneous environment is a central issue in population ecology. In particular, it is relevant to know whether a population will survive long term or go extinct. In a recent article, we address this question for a single species population in a bounded one-dimensional habitat of length L.

We assume that the evolution of the population density distribution ρ is governed by elementary processes such as growth and dispersal. In standard models, these processes are typically described by a constant per capita growth rate and normal diffusion, respectively, however, feedbacks in the regulatory mechanisms and external factors can produce density-dependent rates. The role of these plausible nonlinearities has been overlooked in previous studies. Then, we analyze a generalization of the standard evolution equation, with diffusion coefficient $\rho^{\nu-1}$ and per capita growth rate $\rho^{\mu-1}$, which depend on ρ when $\nu,\mu\neq1$. This equation is complemented by absorbing boundaries, mimicking a nonviable neighborhood. For this nonlinear problem, we obtain, analytically, exact expressions of the critical habitat size L_c for population survival, as a function of the exponents and initial conditions. We find that depending on the kind of nonlinearities present, population survival occurs for $L \geq L_c$, $L \leq L_c$ or for any L. This result generalizes the usual statement that L_c represents the minimum habitat size. Additionally, nonlinearities introduce sensitivity to the initial conditions, affecting L_c.

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