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Habitat quality and the velocity of spatial population expansion

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An important prediction of several spatio-temporal models of population dynamics is that habitat quality, defined here as the carrying capacity (K) of the environment, should have no influence on the velocity (v) of a population expansion. This is for instance the case with the Fisher-KPP model, where the asymptotic speed of propagation, starting from a compactly supported initial population, is entirely determined by the intrinsic population growth rate and the diffusion coefficient. Using different modelling frameworks, ranging from reaction-diffusion equations to stochastic individual based models (IBM), we show that this prediction is far from being generic.

First, we review known results on theoretical diffusion models, regarding the dependence between K and v for the most classical types of growth functions (logistic-like growth) and we derive some additional results for other less standard growth functions (growth affected by weak or strong Allee effects). We also report some results for other classes of equations describing density-dependent dispersal. Second, using discrete space stochastic (stepping-stone) models on a one-dimensional infinite grid, we investigate the dependence between K and v under four different assumptions: no Allee effect, weak and strong Allee effects, and positive density-dependent dispersal (with no Allee effect).

We show that both the theoretical diffusion models and the stochastic IBMs lead to an increasing relationship between v and K in the presence of an Allee effect or of positive density-dependent dispersal. This increasing relationship between v and K still holds in the stochastic IBMs even when there is no Allee effect or positive density-dependant dispersal. This effect of K on v is especially strong when K is small (or close to the Allee threshold in the presence of a strong Allee effect), and tends to become less powerful or negligible when K becomes large.

Experiments that we have conducted on minute size wasps *Trichogramma chilonis* in laboratory microcosms confirm the existence of a positive relationship between habitat quality and the speed at which populations spread.

To conclude, we discuss how the property of dependence of the expansion velocity with respect to the habitat quality is related to the pulled/pushed nature of the expansion process.