Natural selection in dispersal-structured populations

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The influence of the dispersal of the individuals on the outcome of the competition has been debated for a long time. In some works it has been concluded that it is more advantageous to diffuse faster while in other ones the opposite conclusion has been drawn. The picture emerging is that the temporal fluctuations, including the stochasticity induced by demographic events, tend to give the competition advantage to species diffusing faster. Instead, the spatial heterogeneities, due to the patch formation of organisms or non-homogeneous distribution of nutrients, give the advantage to less motile species, or, in the case of the species described by different types of diffusion, to the one forming stronger clusters.

In most investigations various explicit assumptions are made, e.g., about the mutations, Allee effect, fitness, the distribution of resources, carrying capacities of different space regions, costs for faster dispersal etc. Instead, we address a simple model where the spatial distribution of organisms as well as the temporal fluctuations are generated solely by the individuals themselves, and the diffusivities leading to the competition advantage are selected by this self-created environment.

In the case of the competition between two species it is straightforward to draw the conclusions: either the species diffusing faster or slower wins, or the coexistence can occur. However, it is known that the dispersal ability can vary as much within a species as among species, indicating that the investigation of dispersal-structured populations is highly relevant. As we will demonstrate, in the dispersal-structured populations in which the organisms are characterized by a wide range of diffusivities the situation is more complex.

In accordance with other works, we observe that the general propensity is that the spatial heterogeneities tend to favor the smaller diffusivities while the increase of temporal fluctuations enhances the competition success of the individuals diffusing faster. However, beside this general trend, we observe that, instead of the utmost values, for a wide range of parameters the intermediate values of diffusion coefficient enhance the competition advantage. The optimal range of diffusion coefficients giving the competition advantage is determined by the interplay between various factors such as patch formation, temporal fluctuations, initial conditions, and carrying capacity of the system. The results of this study are particularly relevant in the problems of the motion of micro-organisms such as bacteria when the ability of an organism to move is determined by various factors such as its size, shape etc., but give useful references also for the behavior of the systems consisting of macro-organisms.