Invasion and persistence in heterogeneous environments

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Soil systems exhibit a high degree of spatial and temporal heterogeneity at different spatial and temporal scales. Models of soil biodiversity, whether based on the food-web concept [2] or on competition [1] have often ignored spatial and/or temporal dynamics.

A coupled map lattice is used to describe dynamics of a microbial population, in the absence and presence of environmental variability, competition and dispersal. The dynamic within a single patch is assumed to be deterministic, but the environmental influence is modelled by varying parameters among patches (quenched disorder). Each patch represents a single microsite in which the input of nutrients (carbon, water, nitrogen) is either periodic or aperiodic, but concentrated in time. This approach attempts to account for rather sporadic availability of nutrients at the micro-scale.

Survival of microorganisms in the between-pulse period is shown to be the main factor determining the mean dynamics and variability of microbial populations. It is shown analytically that in the uncoupled case a wide class of random distributions of parameters of individual patches leads to long–tail distributions (power-law of a type of $1/y^{s+1}$, $s > 1$) of microbial densities in a single patch ([3]). This in turn results in high levels of variability between micro-sites. Dispersal between patches, but not competition within patches, destroy these long tails partially (nearest–neighbor interaction and 'small-world' interaction; local dispersal only) or completely (mean field interactions; global dispersal). Environmental heterogeneity assists species survival even in the case of high competition, by creating spatial heterogeneity in species distribution, partially reflecting the underlying environmental heterogeneity. There exists an optimal level of dispersal leading to the highest diversity of species.

An application to saprotrophic and parasitic colonization of roots and plants is also discussed.

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