Networks of networks: biodiversity in connected habitats

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Metacommunity models describe ecological systems consisting of several patches or habitats in which several populations interact with each other as competitors or via predator-prey relationships in form a food webs. Those food webs are interconnected by migration corridors. As such metacommunities can be considered as networks of networks. Competition among species for resources is in most ecological models determined only by one limiting resource. We study metacommunities in which multiple resource limitation is taken into account leading to non-equilibrium coexistence of species.
In many studies of competition models Liebig,s law of the minimum is used to account for the fact that the least available nutrient will determine the growth rate of the plankton species. However this would require that the organisms can instantaneously switch their physiological regulation system, which is problematic. It is more natural to assume that there is a co-limitation for all resources, so that all resources contribute to the growth rate. Therefore we study models which use the concept of a synthezising unit developed in the framework of energy budget theory [1]. This concept is based on the mechanisms of enzyme kinetics and considers all resources as complementary. Using this model we study the dynamics of the competing species which can exhibit competitive exclusion, heteroclinic cycles, stable coexistence in a fixed point and periodic solutions.
Furthermore we show, how general competition theory can be explained in terms of bifurcation theory to account for a much larger class of systems then originally studied by Tilman [2]. This mathematical approach complements and extends the graphical methods developed by Tilman [2] to include models with co-limitation and with a larger number of species.
Moreover, we find the coexistence of more species than resources in parameter regions where periodic and chaotic solutions are possible. Hence we can show that supersaturation is possible in a model with a more realistic approach to the uptake of resources. It is important to note that this model exhibits supersaturation in parameter ranges which are realistic. Our study reveals the dynamical mechanism how supersaturation can occur: it is due to a transcritical bifurcation of limit cycles [3].
Furthermore we demonstrate the consequences of supersaturation for the functioning of the ecosystem by analyzing the impact of an invading species on the resident community. To this end we focus on the study of the relation between resource use efficiency and the level of biodiversity.
Finally, we study the interplay between the resource conditions in the patches and the dispersal structure. Specifically, we analyze to what extent dispersal, i.e. coupling in the network of habitats, can support supersaturation in the network of networks even in the case when not all patches provide resource conditions in which more species than limiting resources can survive.

References

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