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Mathematical Modeling of Metapopulation Dynamics: Revisiting Its Meaning

The following 2-state metapopoulation dynamics model is well known as Levins model [2,3]:

$$\frac{dE}{dt} = e_{\mathrm{P}}P - cPE$$
$$\frac{dP}{dt} = cPE - e_{\mathrm{P}}P$$

In a patchy habitat, E and P mean the frequency (or the probability of existence) of patches with 'vacant' state and that with 'occupied' state, respectively. Since E and P satisfy the condition that $E + P = 1$ independently of time, this model can be described in a mathematically equivalent form by the following single ordinary differential equation as known well:

$$\frac{dP}{dt} = cP(1-P) - e_{\mathrm{P}}P$$

The parameter e_{P} means the coefficient for the occurrence of transition from the state 'occupied' to 'vacant' which is due to the extinction of population in the 'occupied' patch, and c means the coefficient for the transition of vacant patch to the 'occupied' state due to the successful settlement of some immigrants from the 'occupied' patches.

Interesting and valued point of mathematical modeling by Levins [2, 3] is its treatment of dynamics in terms of 'state' transition of each patch without considering the temporal variation of population size itself in each patch [1]. However, the frequency of migration, that is, the strength of migration effect on the state transition is significant in the modeling since it takes the effect of immigrants into account for the cause of state transition, and the strength of migration effect necessarily depends on the size of migrating population. Therefore it requires a rational combination of patch states and population size for the modeling by the idea of Levins [2, 3] to aggregate the population dynamics in a patchy habitat into a dynamics of patch state transition.

In the work [4], we will discuss a mathematical modeling, focusing on how the strength of migration could be involved in it to construct a metapopulation dynamics model, with the same idea with Levins'. Although the similar problem has been discussed in some previous papers, we will independently consider the mathematical modeling of Levins' idea, and try to discuss the problem about the rationality of its modeling typical with the mass-action terms.

REFERENCES

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