Application of matrix population models

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Matrix population model is a difference equation to describe the dynamics of stage-structured populations in population ecology and conservation biology. Since the model is a useful tool to understand the mechanism of population subsistence and to predict the dynamics of animal and plan populations, field ecologists use the models and publish a bunch of papers in these thirty years (Caswell 2001). The matrix adopted by field ecologists is composed of constant elements and the model is the simplest and linear difference equation. I firstly introduce how to use the model and the information we can derive from it, explaining the concept of population growth rate, stable stage structure and sensitivity analysis.

Secondly, I introduce an analysis of density-dependent matrix model as an application of matrix population models to obtain the optimal life history strategy. Several theoretical results on life history evolution are obtained. The first one concerns the invadable condition of mutant types when the density is considered as the weighted sum of population densities at each stage. In the second result, it is shown that the invadability is equivalent to the increase of the weighted sum at equilibrium. It is also shown that the sensitivity for the dominant eigenvalue is proportional to that for the weighted sum at equilibrium. We show some examples to apply the general result to a specific life history evolution.

As the advanced study of stage-structured populations, I thirdly introduce a multi-layer model to describe the dynamics of a tree population. Population of a tree species often occupies the different layers as they grow up from seedlings or saplings to mature trees. They transit from lower layer to middle and top layer during their lifetime. We examined the local stability of the equilibrium of the system. From our result, we discussed about the relationship between local stability and the pattern of interaction among individuals at different layers. It is shown that one-sided interaction (or asymmetric competition) through light resource promotes the stability of tree populations.