Evolutionarily stable ecological equilibrium: Evolutionary stability in Lotka-Volterra models

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The Lotka-Volterra model of population ecology is combined with the behavioral evolution model of evolutionary game theory. Both models have similar underlying assumptions. For instance, in the separate models, individual fitness is linearly dependent on the population densities and on the phenotype frequencies, respectively. Moreover, both models ignore spatial and genetic effects, assuming that interactions are pair-wise and random and the whole system is totally mixed. In a monomorphic situation, conditions for the stability of the resident Lotka-Volterra system are analyzed, under the perturbation of a mutant phenotype in each species. We develop an evolutionary ecology stability concept, called a monomorphic evolutionarily stable ecological equilibrium which, as a special case, contains the original definition of an evolutionarily stable strategy given by Maynard Smith for a single species. Heuristically, evolutionary ecological stability here refers to a resident ecosystem in which (i) there are equilibrium densities where no species is extinct and this equilibrium is stable in the underlying ecological model when there are no mutant phenotypes, and (ii) this equilibrium remains stable when a rare mutant phenotype is introduced in each species and subsequently eliminated. Technically, the paper follows the "dynamic approach" since stability refers to (local) asymptotic stability.

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