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Comparing the Eco-Coevolutionary Dynamics and the Eco-Evolutionary Dynamics of Predator-Prey Systems Using Fast-Slow Dynamical Systems Theory

Ecologically important traits can evolve at the same rate as changes in species' ecological dynamics (e.g. population densities or spatial distributions). This interaction between ecological and evolutionary processes with comparable time scales can potentially alter the ecological dynamics of the system or lead to coevolutionary dynamics that would be unexpected based on the evolutionary dynamics of a single species. In this talk, we will focus on the consequences of the interactions between ecological and evolutionary processes in predator-prey systems. In particular, we focus on the question 'how do coevolutionary dynamics differ from evolutionary dynamics with a single evolving species in their effects on the populations dynamics of predator-prey systems?'

To address this question we consider a general predator-prey model where the two species are evolving nearly instantaneously. Our model is an extension the model in Cortez and Ellner (2010) where a single species evolves. While evolutionary processes are not nearly instantaneous in natural systems, there are two main advantages of considering the fast evolution limit. First, via fast-slow dynamical systems (or Fenichel) theory, the dimension of the system can be reduced from four to two. This facilitates the analytical analysis of the system and allows one to derive biological and mathematical conditions that characterize when and what kinds of effects evolutionary processes have on the ecological dynamics of the system. Second, the results and conclusions derived in the fast evolutionary limit yield insight into the effects coevolutionary dynamics have on the ecological dynamics of the system when evolution is not as fast.

Based on comparisons between the current model and the model in Cortez and Ellner (2010), our analysis yields biological and mathematical conditions under which the eco-coevolutionary dynamics of the systems can be accurately predicted by the subsystems that have a single evolving species. However, we also find conditions under which the single evolving species subsystems do not accurately predict the eco-coevolutionary dynamics. In these cases, the interaction between the evolutionary dynamics of the two species yield unexpected coevolutionary dynamics, e.g. one species can become trapped at a fitness minimum or the fitness maximum of both species can become evolutionarily unstable. Some of these dynamics have been observed previously in the literature (e.g. Abrams and Matsuda 1997) and our analysis reveals the general biological and mathematical mechanisms driving those phenomena. This analysis suggests how some of these different cases can be identified from experimental data and what (sometimes unexpected) effects rapid coevolutionary dynamics can have on ecological dynamics.

References

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