Abstract

Intra- and inter-species interactions actively regulate the extinction, persistence and coexistence of species in a natural population. The impact of cooperative and competitive interactions on the evolution of a population is not instantaneous; it experiences some delay. Moreover, the evolution of self-defense in the prey population to restrict the exploitation followed by the predation-induced death is ubiquitous in the general resource-consumer systems.

This dissertation investigates the impact of delayed mutualistic, competitive and combative interactions on the species coexistence. To study the evolutionary dynamics of cooperative producers in the presence of defense against non-productive defectors and delayed public goods interactions, we consider the model community as microbial population. In the course of analysis of evolutionary population model in bacterial biofilms, we find that the policing to the defectors can maintain both the evolutionary stability of cooperation and the stable coexistence. The analysis further reveals that the asymmetry in two positive interaction delays can initiate chaotic concurrence.

Next, we analyze the ecological Allee dynamics of the prey–predator system to understand the impact of physiological-process-induced delay and the delayed interactions on the evolution of the integral populations, and we find that the presence of the Allee effect can introduce the capability to the intra-predator

competition-induced death rate of predator towards altering the stability and direction of Hopf-bifurcating periodic oscillations.

Lastly, in order to figure out the consequences of the interplay between ecology and evolution in the dynamics of prey–predator system, we consider the initially available free-space as an ecological variable and the degree of defensiveness as an evolutionary parameter, and we analyze the respective spatio-temporal eco-evolutionary population dynamics of undefended prey, defended (aposematic) prey and predator in the presence of delay in defense. The study unveils the significant impact of initial availability of free space on the species extinction and coexistence. We also find that the parameter space comprises of ecological and evolutionary parameters divulges all possible temporal dynamics. The analysis further shows that the presence of delay in aposematism can commence supercritical Hopf-bifurcation, leading to the period-doubling bifurcation.

Keywords: Bacterial biofilm; evolutionary dynamics; delayed interactions; policing effect; prey–predator system; ecological dynamics; eco-evolutionary dynamics; aposematism.