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Dynamics of multi-species competition–predator system with impulsive perturbations and Holling type III functional responses

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ABSTRACT

We investigate the dynamics of a class of multi-species predator–prey interaction models with Holling type III functional responses based on systems of nonautonomous differential equations with impulsive perturbations. Sufficient conditions for existence of a positive periodic solution are investigated by using a continuation theorem in coincidence degree theory, which have been extensively applied in studying existence problems in differential equations and difference equations. In addition, sufficient criteria are established for the global stability and the globally exponential stability of the system by using the comparison principle and the Lyapunov method.

1. Introduction

Ecological predator–prey systems have been studied extensively by many authors [1–8]. In the real world, any biological or environmental parameters are naturally subject to fluctuation in time, so it is reasonable to study the corresponding nonautonomous system. Considering the biological and environmental periodicity (e.g. seasonal effects of weather, food supplies, mating habits), we focus on the existence of a periodic solution with strictly positive components of (1.1).

Differential equations with impulsive effects form a wide set of different problems. During the last three decades those problems were intensively studied. Some authors devote themselves to the study of impulsive differential equations [9–13]. The main definitions and results of the theory of systems of ordinary differential equations with impulse effects were given in [9]. Similarity and differentiality of such problems of applied mathematics with corresponding problems of ordinary differential equations (and without the conditions of impulsive effects) were demonstrated and general characteristics of these systems were described. Periodic and almost-periodic solutions of differential equations with impulsive effects were studied in [14].

Some impulsive factors have also great impact on the growth of a population. For example, we notice that the births of many species are not continuous but happen at some regular time. (For instance, the births of some wildlife are seasonal.) Moreover, human beings have been harvesting or stocking species at some time, then the species is affected by another type of impulse. If we incorporate these impulsive factors into the models of population interactions, the models must be governed by impulsive ordinary differential equations. The first author investigated the existence of positive periodic solutions of a nonautonomous competitive Lotka–Volterra system with impulse and Beddington–DeAngelis functional

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