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DYNAMICAL ANALYSIS OF A DENSITY DEPENDENT TWO PREY ONE PREDATOR MODEL WITH HELP

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Abstract. In this paper, we present a three dimensional continuous time dynamical system consisting of three teams, two of preys and one of predator. We assume that during predation the members of both the team of preys help each other and the rate of predation on both the teams are different. The prey consumption rate per individual of predator is considered as Holling type II. Different conditions for the coexistence of equilibrium solutions are determined analytically. Persistence and permanence of the system are established and the role of cooperation coefficient is investigated. We establish the local asymptotic stability of various equilibrium points to understand the dynamics of the model system. The global asymptotic stability of the positive equilibrium is also established by constructing suitable Lyapunov function. The Kolmogorov analysis of subsystems suggest the existence of a stable periodic solution. Existence of at least one limit cycle is discussed with eigenvalue approach. It is observed that stable equilibrium bifurcates to a periodic solution with large amplitude when the cooperation coefficient crosses a threshold value. At the end, numerical simulations are performed to substantiate our analytical findings.

Keywords. Bifurcation; Lyapunov function; Limit cycle; Help; Global stability.

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1 Introduction

Dynamical relationship between predator and their prey continues to draw interest from both applied mathematicians and ecologists due to its universal existence and importance [7, 29, 39]. A general two dimensional predator-prey model is given by

$$\frac{dX}{dt} = Xf(X) - g(X,Y)Y, \quad \frac{dY}{dt} = cg(X,Y)Y - dY, \tag{1}$$