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PERMANENCE OF AN IMPULSIVE PREDATOR-PREY SYSTEM WITH MUTUAL INTERFERENCE AND CROWLEY-MARTIN RESPONSE FUNCTION*†

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Abstract

In this paper, we investigated an impulsive predator-prey model with mutual interference and Crowley-Martin response function. By the comparison theorem and the analysis technique of [12,14], sufficient conditions for the permanence of the impulsive model are obtained, which generalizes one of main results of [4].

Keywords predator-prey; mutual interference; Crowley-Martin; impulsive; permanence

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1 Introduction

In 1989, Crowley and Martin [1] proposed a functional response which can accommodate interference among predators, for high predator density and handling or searching of prey by predator individual. The per capita feeding rate in this formulation can be written as follows:

$$\varphi(x_1, x_2) = \frac{cx_1}{1 + ex_1 + fx_2 + efx_1x_2},$$

where c, e, f can be interpreted as the effects of capture rate, handing time, the magnitude of interference among predators respectively, on the feeding rate. All

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the coefficients c, e, f are positive constants. We can easily obtain that $\varphi(x_1, x_2)$ is positively correlated with x_1 and varies inversely with respect to x_2.

The following autonomous predator-prey system with Crowley-Martin response functional was proposed and studied:

$$\begin{aligned}\dot{x}_1(t) &= x_1(t)\Big(a_1 - b_1x_1(t) - \frac{c_1x_2(t)}{d + ex_1(t) + fx_2(t) + gx_1(t)x_2(t)}\Big),\\ \dot{x}_2(t) &= x_2(t)\Big(-a_2 + \frac{c_2x_1(t)}{d + ex_1(t) + fx_2(t) + gx_1(t)x_2(t)}\Big),\end{aligned} \tag{1.1}$$

in [2], where the local stability of the equilibria, global asymptotic stability of the positive equilibrium and permanence were carried out in system (1.1). [3] discussed a predator-prey model with Crowley-Martin functional response and density dependent predator:

$$\begin{aligned}\dot{x}_1(t) &= x_1(t)\Big(a_1 - b_1x_1(t) - \frac{c_1x_2}{d + ex_1(t) + fx_2(t) + gx_1(t)x_2(t)}\Big),\\ \dot{x}_2(t) &= x_2(t)\Big(-a_2 - b_2x_2(t) + \frac{c_2x_1(t)}{d + ex_1(t) + fx_2(t) + gx_1(t)x_2(t)}\Big).\end{aligned} \tag{1.2}$$

They considered the permanence, non-permanence, local asymptotic stability behavior of various equilibrium points and global asymptotic stability of positive equilibrium to understand the dynamics of both delayed and non-delayed model systems.

On account of the fluctuation in many biological or environmental parameters as time goes on. And the prey has the tendency to leave each other when they meet, which interferes with predators capture effects. Recently, Tripathi [4] considered and explored the almost periodic solution and global attractivity of the following two dimensional non-autonomous, density dependent predator-prey model with mutual interference and Crowley-Martin response function:

$$\begin{aligned}\dot{x}_1(t) &= x_1(t)\Big(a_1(t) - b_1(t)x_1(t) - \frac{c_1(t)x_2^{\beta}(t)}{d(t) + e(t)x_1(t) + f(t)x_2(t) + g(t)x_1(t)x_2(t)}\Big),\\ \dot{x}_2(t) &= x_2(t)\Big(-a_2(t) - b_2(t)x_2(t) + \frac{c_2(t)x_1(t)x_2^{\beta-1}(t)}{d(t) + e(t)x_1(t) + f(t)x_2(t) + g(t)x_1(t)x_2(t)}\Big),\end{aligned} \tag{1.3}$$

However, the ecosystem is often deeply perturbed by nature and human exploit activities such as drought, fire, flooding deforestation, hunting, harvesting, breeding and so forth. For the sake of accurately describing the real-world phenomena, impulsive differential equations may be a better candidate than ordinary differential equations or difference equations. Motivated by these facts, we propose the following impulsive predator-prey model with mutual interference and Crowley-Martin