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Ratio-dependent functional response predator-prey model with threshold harvesting

Razie Shafei*
Hashtgerd branch, Islamic Azad University, Alborz, Iran

Dariush Behmardi Sharifabad
Alzahra University

Abstract

This paper deals with a ratio-dependent functional response predator-prey model, with a threshold harvesting in the predator equation. We study the equilibria of the system before and after the threshold. Furthermore, we show that the threshold harvesting can improve the undesirable behavior, such as nonexistence of interior equilibria. Finally, some numerical simulations are performed to support our analytic results.

Keywords: Predator-prey model, functional response, threshold harvesting
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1 Introduction

Classically a predator-prey model is defined as the following system

$$\begin{cases} \dot{x} &= rx(1-\frac{x}{k}) - F(x,y)y \\ \dot{y} &= \beta\, F(x,y)y - \delta y, \end{cases} \tag{1}$$

where x and y are the number of prey and predator, respectively. In this model, in the prey equation, the parameter $r > 0$ is the prey intrinsic growth rate and k represents the environmental carrying capacity. The function $F(x,y)$ describes predation and is called the *functional response*. In the predator equation, the parameter β accounts for conversion rate to change prey biomass into predator reproduction, and δ is the predator's death rate. Moreover, from the point of view of human needs, it is necessary to consider the harvesting of populations in some models [5]. An important harvesting policy for the predator-prey model is the threshold harvesting function. It works as follows:

when population is above of certain level or threshold T, harvesting occurs; when the population falls below that level, harvesting stops. The policy was first studied by Collie and Spencer [2], and additional analysis has been done since then [1]. So the continuous threshold function proposed as the following

$$H(z) = \begin{cases} 0 & z \le T \\ \frac{h(z-T)}{h+z-T} & z > T, \end{cases} \tag{2}$$

*Speaker