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The Stability and Bifurcation of Food Chain Model; Holling Type II

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Abstract

Food chains in the environment can be modeled by systems of differential equations, that approximate species with functional responses. In this paper, an ecological model with Holling type-II functional response in order to describe the dynamical behavior of a three-species food chain is investigated. The local stability and the existence of Hopf bifurcations are established. Finally, numerical simulations are carried out to illustrate the theoretical results.

Keywords: Stability, Bifurcation, Food chain.
Mathematics Subject Classification [2010]: 34D20, 34C23

1 Introduction

Food chains in the environment are very important systems in many different fields such ecological science, applied mathematics, and etc. Food chains can be modeled by systems of differential equations which approximate species with different functional responses. In the history of population ecology, both mathematicians and ecologists have a great interest in the Holling type predator-prey models including Holling types I-III. The Hastings-Powells food chain was analyzed in two different ways [2]. First, the asymptotic states were obtained by direct numerical integration of the dynamical system, varying a key parameter. Second, some relevant features of the whole system were identified by using the delay coordinate embedding from a time series [5].

2 Main Results

We will describe three species Hastings-Powells food chain model revisited given by,

$$\begin{aligned} \frac{dx}{dt} &= x(1-x) - \frac{a_1 x}{1+b_1 x} y \\ \frac{dy}{dt} &= \frac{a_1 x}{1+b_1 x} y - \frac{a_2 y}{1+b_2 y} z - d_1 y \\ \frac{dz}{dt} &= \frac{a_2 y}{1+b_2 y} z - d_2 z. \end{aligned} \tag{1}$$

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