

Article

Bifurcation analysis and chaos control in a discrete-time predator-prey system with Crowley-Martin functional response

S. M. Sohel Rana

University of Dhaka, Dhaka-1000, Bangladesh

E-mail: srana.mthdu@gmail.com

Received 29 December 2018; Accepted 5 February 2019; Published 1 June 2019



Abstract

In this paper, the dynamics of a discrete-time predator-prey system with Crowley-Martin functional response is examined. Via application of the center manifold theorem and bifurcation theorems, we algebraically show that the system undergoes a bifurcation (flip or Neimark-Sacker) in the interior of \mathbb{R}_+^2 . Numerical simulations are presented not only to validate analytical results but also to reveal new dynamical behaviors which include bifurcations, phase portraits, period- 5, 6, 7, 10, 11, 15, 16, 17, 21, 28, and period- 51 orbits, invariant closed cycle, sudden disappearance of chaotic dynamics and abrupt emergence of chaos, and attracting chaotic sets. Furthermore, maximum Lyapunov exponents and fractal dimension are computed numerically to justify the chaotic behaviors of the system. Finally, we apply a strategy of feedback control to control chaos exists in the system.

Keywords predator-prey system with Crowley-Martin functional response; bifurcations; chaos; Lyapunov exponents; feedback control.

Computational Ecology and Software
ISSN 2220-721X
URL: <http://www.iaees.org/publications/journals/ces/online-version.asp>
RSS: <http://www.iaees.org/publications/journals/ces/rss.xml>
E-mail: ces@iaees.org
Editor-in-Chief: WenJun Zhang
Publisher: International Academy of Ecology and Environmental Sciences

1 Introduction

Predator-prey interactions have long been studied and have become one of the dominant themes in both biology and mathematical biology due to their universal existence and importance, such as resource-consumer, plant-herbivore, and phytoplankton-zooplankton forms. In recent decades, mathematical models have been established to analyze various complex dynamics of the predator-prey systems in various circumstances. The research on the Crowley-Martin functional response has now drawn great attention (Dong et al., 2015; Li et al., 2015; Tripathi et al., 2016).

Despite plenty and extensive results on dynamics of continuous predator-prey system, studies on discrete predator-prey model are relatively rare. In fact discrete predator-prey model is not a simple parallel promotion of continuous system. Sometimes it shows richer and more complex dynamics than the corresponding continuous model. Besides, for insects with non-overlapping generations, predator-prey system can be

- Zhang H, Ma S, Huang T, Cong X, Gao Z, Zhang F. 2018. Complex dynamics on the routes to chaos in a discrete predator-prey system with Crowley-Martin type functional response. *Discrete Dynamics in Nature and Society*, 2386954
- Zhao M, Xuan Z, Li C. 2016. Dynamics of a discrete-time predator-prey system. *Advances in Difference Equations*, 191
- Zhao M, Li C, Wang J. 2017. Complex dynamic behaviors of a discrete-time predator-prey system. *Journal of Applied Analysis and Computation*, 7: 478-500