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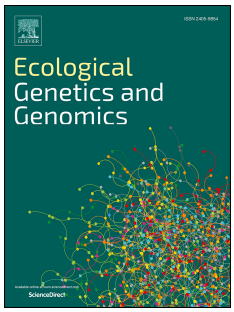

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ACCEPTED MANUSCRIPT

Dynamical Behavior of Three Species Predator–Prey System with Mutual Support Between Non Refuge Prey

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Abstract: In this paper, we study the effect of refuge and harvesting in a three species model of two prey and one predator, where the two prey refuge groups are helping each other and shielding from the predator group. The stability theory of nonlinear differential equations is used to analyze the model. Our study exhibits that, both the refuge and harvesting play a significant role on the stability of the system. Along with the local stability of the system, the global stability is also studied. Finally, numerical simulations are given to support the analytical conclusion.

Keywords: Prey-Predator; Harvesting; Refuge; Stability; Mutualism.

1 Introduction

In population dynamics, the relationship between prey-predator plays an importance for universal existence. Lotka [1] and Volterra [2] first studied the relationship between prey and predator. During the last few decades, several research articles have been published on the prey-predator system incorporating refuge concept and mutualism. The study of stability and harvesting of species including refuge is growing in importance. Due to the mutual support between the species, the study of harvesting of the prey-predator system is enhanced based on the study of refuge and mutualness of prey-predator system, as per the diverse nature of our ecological system. Recently, several researchers (Ding et. al. [3], Pal et al. ([4]-[6]), Pal and Mahapatra [7], Gupta and Chandra [8], Murphy and Smith [9], Palma and Olivares [10], Luo et al. [11]) concentrated their research work in the field of harvesting management of renewable resources.

We have studied the refuge and harvesting of two prey and one predator model. Rai et al. [12] analyzed the model of mutualism in predator-prey and competitive systems in three species environment. Ruxton [13] studied the stability of prey-predator model using short term refuge. Huang et. al. [14] presented a prey–predator model with Holling type III response function incorporating a prey refuge. Frisvold and Reeves [15] studied the costs and benefits of refuge requirements. Ma et al. [16] discussed the effects of prey refuges on a prey-predator model. Ross and J´ozsef [17] studied a predator–prey refuge system. Chen et al. [18] studied qualitative analysis of a predator-prey model with Holling type II functional response incorporating a constant prey refuge. Ji and Wu [19] presented qualitative analysis of a prey-predator model with constant rate of prey harvesting incorporating a constant prey refuge. Tao et al.[20] discussed the effects of prey refuge on a harvested predator–prey model with generalized functional response. Wu et al. [21] derived a sufficient condition for the existence of at least one positive periodic solution of a generalized prey–predator model with harvesting term. Mostafa and Mahmoud [22] presented periodic solutions of a prey-predator system with Beddington–DeAngelis functional response [23] on time scales. Jia et al. [24] studied the existence of positive solutions for a prey-predator model with refuge and diffusion. Leard and Rebaza [25] presented a prey-predator model with continuous threshold harvesting and formulated an alternative form of threshold harvesting. Chen et al. [26] studied the stability property for the predator-free equilibrium point of prey-predator systems with a class of functional response [27] and prey refuges.

In this paper, we consider a model which consists of two prey groups and one predator group. Prey groups help each other against the predator and few prey of each prey groups are the refuge. Here we consider an interesting situation, i.e., when a predator attacks the 1st prey group then some prey of the 1st prey group will be refuge, but the total population of 2nd prey group help 1st prey group against the predator and when a predator attacks the

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