Current Topics on Mathematics and Computer Science

Vol. 7

India ▪ United Kingdom

B P International

Editor(s)

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FIRST EDITION 2021

ISBN 978-93-91595-24-1 (Print)
ISBN 978-93-91595-32-6 (eBook)
DOI: 10.9734/bpi/ctmcs/v7

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Print ISBN: 978-93-91595-24-1, eBook ISBN: 978-93-91595-32-6

Study on Single Species One Sex Age-structured Fish Population Model with Restricted Harvesting

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DOI: 10.9734/bpi/ctmcs/v7/10528D

Abstract

A discrete age-structured Bernardelli, Lewis and Leslie (BLL) population model for a single species is formulated under age dependent harvesting condition. Here, after an initial period during which the growth of the species is not much, harvesting is performed. Its rate is proportional to the available bio-mass (number of species) of different age group population and decreases with the age of the species by considering monotonic decreasing catch per unit effort parameter. The modified Leslie matrix for the present models is derived. Stability of the system is studied from the ratio of the population densities with respect to times. This kind of study is very important in population biology as to get an idea about the future biomass and sustainability of the species.

Keywords: Age-structured model; BLL- model; age-dependent harvesting; modified Leslie matrix.

1 Introduction

In reality every natural biological biomass are subjected to complex dynamic processes that cannot be described and analysed by simple continuous time models. In fish population, for example, recruitment to the fishable stock may only occur with a significant time lag after spawning of the existing adult population. Furthermore the entire life history of fish and other organism is generally subjected to strong seasonal, environmental and periodic influence. Single species discrete insect population model was developed by Nicholson and Baily [1] and after that another single species discrete population was studied by Maynard Smith [2, 3], May [4] etc. Single species discrete fish population dynamics were also discussed by Cushing [5], Ricker [6,7], Berverton and Holt [8], Larkin et al. [9] and Nikolskii [10] etc. The number of individuals within a population is often kept under control changes in the maternity function of the females. These changes may occur in response to the values of some demographic parameters like total size of the population, birth rate, cohort density, the ratio of older and younger females, the ratio of males to females and so forth. Another factor is also due to the change in the mortality of the population for different natural and man-made situations. So discrete age structure model is very much important to discuss the real phenomena. Researchers may refer to Eather et al. [11], Tahvonen et al. [12], Giordano et al. [13], Nicholson et al.[14], Gurtin & Maccamy [15], De Angelis [16], Dekker [17], Landel and Hersen [18]. Kapur [19], Sadhukhan et al. [20] also developed discrete age structure fish population model using Bernardelli, Lewis and Leslie (BLL) model and discussed the stability of the model. He also presented model with constant harvesting as a particular case. After that In this paper, a discrete age-structured BLL population model for a single species is formulated under age dependent harvesting condition of mature species. In this formulation, some realistic conditions are incorporated. In some countries, governments impose restriction on the harvesting of immature population of some species such as fishes. Generally fishermen throw the smaller fishes back into the water. It is fact that withdrawal of a species decreases with the age of the species. Hence, in the present model, the species of age group 0 to 1 is not considered for harvesting and after that harvesting is performed. Its rate is directly proportional to the available biomass of different age group population and decreases with the age of the species. The modified Leslie matrix for the model is derived. Stability of the system is discussed from the ratio of population densities at different times. The model is illustrated through numerical experiments.

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