

Impact of Fear, Allee Effects, and Harvesting on a Predator-Prey Delay Model with a Modified Beddington–DeAngelis Functional Response

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Abstract This paper studies the dynamics of a delayed predator-prey model with a modified Beddington-DeAngelis response function influenced by fear factors, Allee effects, and harvesting on the predator population. This paper analyzes the influence of parameters, namely fear factors (ω), Allee effects (m), and delay time (τ), on the stability of the model's equilibrium point. First, an analysis of the existence of the model's equilibrium point is carried out, then an analysis of the stability and the influence of changes in the model's parameter values and delay time that can affect the stability of the model's equilibrium point is carried out. The analysis indicates that the larger the parameters ω , m , and τ , the more unstable the coexistence equilibrium point tends to be. Several numerical simulation results are used to validate the analytical results obtained.

Keywords Predator-prey model, Beddington–DeAngelis, Fear effects, Allee effect, Harvesting, Stability

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1. Introduction

The study of predator-prey dynamics has become one of the main research topics in ecosystems, because it can provide a deep understanding of the influence of various ecological factors on ecosystem sustainability. In the ecosystem, the interaction between predators and prey is often influenced by external factors that can change the behavior of the predator-prey system dynamics as well as its stability and the sustainability of the ecosystem as a whole. The predator-prey model describes the dynamic interaction between two species with a pattern of relationships that influence each other and are often influenced by several factors, namely the fear experienced by the prey, the impact of the Allee effect on low populations, and hunting by the predator on the prey itself. To handle more realistic interactions in conditions of varying population densities, one of the functions that describes predator-prey interactions is the Beddington-DeAngelis function. This function describes the dynamics of predator-prey interactions in ecosystems that consider population density. Research on the combined effects of these factors is very important to understand how these elements interact with each other and affect the stability of the ecosystem in the long term.

Several researchers have studied these factors and the combination of these factors in the predator prey model. The fear effect, which reflects changes in prey behavior due to threats from predators, has been the focus of various studies. The importance of fear factors in prey populations has received special attention in several studies, where fear of predators can change prey behavior and significantly affect ecosystem structure. [1], [2] and [3] showed

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