New Mathematics and Natural Computation
(2028) 1–31

DOI: 10.1142/S1793005728500160

World Scientific
www.worldscientific.com

Effect of a Fear Response Time Delay on a Prey–Predator Model with Disease in Predator and Linear Harvesting of Predator

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Received 6 September 2025
Accepted 30 December 2025
Published

The predator–prey connection is an occurrence of nature which, according to fundamental ecosystems, greatly influences the formation of practically all groups and preserves biodiversity. In almost all ecological models, the range of the prey species is restricted by direct assaults by predator species; however, new findings indicate that predators not only cause physical death to their prey but also instil fear in them, so slowing down the rate of procreation of prey species and causing them to exhibit anti-predator behavior. This study proposes and analyzes a three-dimensional eco-epidemiological model including prey, a vulnerable predator, and a diseased predator. It has been proposed that fear in prey results from predators and anti-predator actions taken by prey against predators that cause a delay in the fear reaction. Additionally, it is hypothesized that the susceptible predator uses the simplified Holling type II functional reaction to consume food, while the infected predator uses the simpler Holling type IV functional response to swallow prey. The answers to the proposed system's boundedness and positive invariance have been made clear. We evaluate each point of equilibrium and explain the reason for their existence. Furthermore, an investigation is conducted into the local stability of every possible equilibrium point. Our numerical simulations indicate that the predator–prey connection is capable of being regulated by fear. The Hopf bifurcation of the system has been investigated with respect to certain parameters. Furthermore, it is demonstrated through the application of Hopf bifurcation that time delay has periodic solutions and that it is essential for managing the system's behavior. To provide more insight into the potential impact of fear on the delayed prey–predator model, we investigated the connections between fear effects and other characteristics using computational models. To determine the trajectory of the Hopf bifurcation and the stability of the bifurcating periodic solution, precise expressions are provided that utilize the normal form theory and the center manifold theorem. Finally, the outcome of the theoretical inquiry is validated using simulation using computers.

Keywords: Fear effect; predator harvesting; Hopf bifurcation; fear response time delay; numerical simulations.

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