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Thesis title: **Dynamical system modeling of nonlinear complex ecological systems**

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In this thesis, we proposed and analyzed mathematical models for the predator-prey dynamics through a coupled system of differential equations. At the beginning, we studied a simple predator-prey model with different types of functional response and model exhibits rich ecological dynamics. We introduced the effect of fear on the growth of prey due to predator population. Our theoretical analysis shows strong anti-predator responses that can stabilize the predator-prey interactions by ignoring the existence of periodic behaviour. Our model system undergoes Hopf bifurcation by considering the prey birth rate as a bifurcation parameter. We extend our study on the effect of fear in an eco-epidemiological system and obtained that the increasing level of fear cannot wipe out the diseases from the system but the amplitude of the infected prey decreases as the level of fear is increased. Then, we proposed and analyzed a mathematical model for the eco-epidemiological system by incorporating disease in prey population, with particular emphasis on the influence of weak Allee effect in the growth of the predator population and the effects of incubation time delay. This study shows high-periodic oscillations due to increasing the value of time delay parameter and the disease transmission rate. We modified the fear function and proposed a more realistic fear function based on the experimental findings. We investigate how behavioural modification in prey population due to fear for predators and mutual interference among predator species can create various spatiotemporal pattern formation in population distribution. Finally, we considered a carbon-phytoplankton-zooplankton model and studied the effect of global warming and our simulation shows shifts in plankton's seasonal dynamics. The spatially explicit carbon-phytoplankton-zooplankton model shows complex spatiotemporal dynamics and patchy pattern formation. Analytical findings are validated with extensive numerical simulations. The thesis ends with a potential future direction.

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