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A predator-prey system with digest delay and anti-predation strategy

Predator-prey system is one of the most fundamental topics in ecology and evolutionary biology. Classic point of view focuses on direct predation only. With theoretical and experimental studies focusing on indirect effect such as cost of fear, researchers proposed that indirect effect may even have stronger impact than direct killing. Recent works by Wang, Zanette and Zou (2016,2017) have proposed some mathematical models to discuss the influence of such kind of effect. In this project, we consider indirect effect represented by anti-predation strategy. The anti-predation strategy such as group defense and avoiding detection can help prey survive from hunting by predator. Meanwhile, as a cost of these anti-predation strategies, the reproduction rate decreases due to the lack of time, space and energy. We adopt differential equation models to describe the dynamics between two species. At the same time, we take digest delay of predator into account. That is, after consuming the prey, predators need time τ to convert the biomass to their own. By applying stability analysis for delay differential equations, we find that for specialist predator, if the prey species use high level anti-predation strategy, the predator will become extinct and the prey will survive after suffering from the cost of this kind of strategy. A mild anti-predation strategy can guarantee coexistence of two species. Periodic change of population is possible for low level anti-predation strategy and sufficient large delay. Numerical simulations are given to verify our theoretical results.