

## **COOPERATIVE HUNTING AND PREY REFUGE IN THE DYNAMICS OF PREDATOR-PREY INTERACTION**

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Prey refuge and predator cooperation play pivotal roles in shaping predator-prey interactions. In this study, a discrete-time predator-prey model based on Ricker-type dynamics was developed, integrating cooperative hunting behaviour among predators and incorporating the prey refuge effect. Their effects on stability, persistence, and long-term dynamics were analysed. A detailed mathematical analysis identifies fixed points and assesses their stability using Jacobian matrices. To examine the transition to oscillatory dynamics, Neimark-Sacker bifurcation conditions are derived analytically. The analytical findings are subsequently validated through numerical simulations conducted under varying levels of prey refuge and predator cooperation. Ecologically, this bifurcation corresponds to the onset of quasiperiodic oscillations in population densities, reflecting recurrent fluctuations in the abundance of both predators and prey. The results show that the system stabilises at a positive equilibrium in the absence of prey refuge and predator cooperation. In contrast, low prey refuge combined with slight cooperation causes destabilisation and oscillation. Under high refuge conditions, predator persistence requires both strong cooperation and high conversion efficiency. Quantitatively, it is found that, when prey growth is sufficiently large, a predator-free equilibrium emerges and remains stable if the effective predation rate is below a critical threshold. These findings provide novel insight that cooperative hunting can counteract the destabilising effects of prey refuge. They also reveal a threshold mechanism that determines the persistence of predators and ecological balance. This study contributes to the theoretical understanding of predator-prey interaction and provides theoretical insights relevant to biodiversity conservation and the management of predator-prey ecosystems.

**Keywords:** Discrete-time predator-prey system, Neimark-Sacker bifurcation, Predator cooperation, Prey refuge, Ricker model