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Dynamical Analysis of a Leslie-Gower Predator-Prey Model with Fear Effect and Prey Refuge

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Abstract

In this paper, we investigate a ratio-dependent predator–prey model incorporating both fear effect and prey refuge mechanisms. The model is formulated within the Leslie-Gower framework [1], where predator growth depends on the ratio between prey and predator populations. The fear effect is introduced through a nonlinear reduction in the prey reproduction rate, while the refuge mechanism assumes that a constant portion of the prey population is protected from predation.

We first establish the positivity and invariance of solutions in the biologically meaningful region. Then, the existence and uniqueness of positive equilibrium points are obtained for all considered submodels. Local stability of the equilibria is analyzed by means of the Jacobian matrix and eigenvalue criteria. In particular, conditions ensuring stable node and stable spiral behavior are derived explicitly in terms of the model parameters. Furthermore, global dynamical properties of the full system are investigated. Sufficient conditions guaranteeing global asymptotic stability of the positive equilibrium are established. The obtained results show that the combined effects of fear and refuge significantly influence the stability structure and long-term dynamics of the predator-prey interaction.

Keywords: Predator-prey model, ratio-dependent, fear effect, refuge, global stability.

References:

[1] P. H. Leslie, Some further notes on the use of matrices in population mathematics. Biometrika 35 (1948), no. 3-4, 213–245.