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Sensitivity of the Rosenzweig–MacArthur model to the form of the functional response: a bifurcation theory approach

The equations in the Rosenzweig–MacArthur predator-prey model have been shown to be sensitive to the mathematical form used to model the predator response function even if the forms used have the same basic shape: zero at zero, monotone increasing, concave down, and saturating. Here, we revisit this model to help explain this sensitivity in the case of Holling type II, Ivlev, and Trigonometric response functions. We consider both the local and global dynamics and determine the possible bifurcations with respect to variation of the carrying capacity of the prey, a measure of the enrichment of the environment. We give an analytic expression that determines the criticality of the Andronov-Hopf bifurcation, and prove that although all three forms can give rise to supercritical Andronov-Hopf bifurcations, only the Trigonometric form can also give rise to a subcritical Andronov-Hopf bifurcation and has a saddle node bifurcation of periodic orbits giving rise to two coexisting limit cycles, providing a counterexample to a conjecture of Kooij and Zegeling. We also revisit the ranking of the functional responses, according to their potential to destabilize the dynamics of the model and show that given data, not only the choice of the functional form, but the choice of the number or position of the data points can influence the dynamics predicted.

This is joint work with Gunog Seo, Colgate University.