A nonlinear continuous-time model for a semelparous species

Amy Veprauskas[1]

[1] *University of Louisiana at Lafayette, Lafayette, LA, US, 70504*
aveprauskas@louisiana.edu

Synchronization of age classes is a common feature of periodical semelparous species such as cicadas and May beetles. This synchronization leads to "outbreaks" when the adults of these species reach maturity around the same time. For discrete-time matrix models, it has been shown that synchronous cycles may occur as a results of model structure. In particular, greater between-class competition relative to within-class competition may lead to stable synchronous cycles in which age classes are temporally separated. This leads to the question: are similar dynamics possible when a semelparous species is modeled using continuous-time? Here we develop a continuous-time model for a semelparous species. We start with a nonlinear McKendrick partial differential equation model where semelparity is represented by a birth function whose age distribution can be made arbitrarily narrow. We apply a technique called the linear chain trick to convert this model into a finite system of ordinary differential equations. For this new system, we show that a Hopf bifurcation may occur as a result of competition between reproducing and non-reproducing classes. This bifurcation leads to stable cycles in which the two classes are out of phase, thus providing a continuous- time counterpart to the synchronous cycles that occur in discrete-time models.

References

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