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A differential delay model for ticks

Abstract: Ticks play a critical role as vectors in the transmission and spread of Lyme disease, an emerging infectious disease which can cause severe illness in humans or animals. To understand the transmission dynamics of Lyme disease, it is therefore necessary to investigate the population dynamics of ticks. Here, we formulate a system of delay differential equations which models the stage structure of the tick population. Temperature can alter the length of time delays in each developmental stages, and so the time delays can vary geographically (and seasonally which we do not consider). We define the basic reproduction number R_0 of stage structured tick populations. The tick population is uniformly persistent if $R_0 > 1$ and dies out if $R_0 < 1$. We present sufficient conditions under which the unique positive equilibrium point is globally asymptotically stable. In general, the positive equilibrium can be unstable and the system show oscillatory behavior. These oscillations are primarily due to negative feedback within the tick system, but can be enhanced by the time delays of the different developmental stages.

Joint work with Horst Thieme (Arizona State University) & Huaiping Zhu (York University)