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Hybrid systems modeling of ecological population dynamics

Abhyudai Singh[1], Brooks Emerick[2]

[1]Departments of Electrical and Computer Engineering, Mathematical Sciences, University of Delaware, Newark, DE 19716, USA
absingh@udel.edu

[2]Department of Mathematics,
Kutztown University, Kutztown, PA 19530, USA
bemerick@kutztown.edu

Discrete-time models are traditional for capturing the population dynamics of antagonistic interactions between two insect species – a host and its parasitoid [1].

These models are characterized by an update function that connects the population densities from one year to the next. While previously these update functions were chosen phenomenologically, here we introduce a hybrid approach for obtaining the update functions by solving ordinary differential equations that mechanistically capture the ecological interactions between the host and the parasitoid [2].

This hybrid approach is used to study the suppression of host density by a parasitoid. Our analysis shows that when the parasitoid attacks the host at a constant rate, then the host density cannot be suppressed beyond a certain point without making the population dynamics unstable. In contrast, when the parasitoid's attack rate increases with increasing host density, then the host population density can be suppressed to arbitrarily low levels [3].

These results have important implications for biological control where a natural enemy, such as a parasitoid wasp, is introduced to eliminate a pest that is the host species for the parasitoid. Finally, we further generalize these hybrid models to consider multi-species interactions, where multiple parasitoids attack a common host, or a single parasitoid attacks multiple host species [4].

Keywords: ecological modeling, host-parasitoid interactions, population dynamics, hybrid systems, discrete-time models

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