Title: Dynamics of Emerald ash borer influenced by maturation time delays

Summary: Emerald Ash Borer (EAB: *Agrilus planipennis* Fairmaire) is an invasive species which was introduced to the North America around the year 2002. We assume that the temperature drops will significantly increase the maturation time of EAB. A mathematical model will be constructed to study the effects of temperature variations in the population densities of EAB. The outcome predictions of this study will be compared with those of previous studies.

Background: EAB is highly destructive to ash trees and it has major economic consequences [4] [15]. An underlying difference between EAB and many other single species is that the immature individuals are immobile with respect to the spatial domain. The adult female lays eggs in ash bark, the larvae remain under the tree bark and feed from the inner bark until they are adult. Then they leave the tree and spread up to 9.48km within five days [5]. The maturation time of most insects may change by fluctuation in the ambient temperature. For instance, laboratory experiments on blowflies suggest that maturation time $\tau$ increases as the temperature drops [6], [7]. This could also be the case for EAB [8], [9]. Under laboratory conditions, $\tau$ for *Phaenicia sericata* increases from 12.3 to 54.4 days when the temperature changes from 35 to 19$^\circ$C. Similarly, for *Phaenicia pallescens*, $\tau$ increases from 10.9 to 30.8 days under the same temperature changes. Also, $\tau$ for *Lucilia cuprina* in the temperatures 20-22$^\circ$C varies between 14 to 17 days ([6], [7], also, see Table 1 of [10]). There are several studies of blowfly *Lucilia cuprina* [1], [2], [3], [11], [12] and the related models can be a guide to construct a biologically meaningful model of EAB population.

Objectives: The goals of this study are: (1) construct a mathematical model of EAB; (2) provide quantitative estimates of fluctuations and reductions in the population density as a result of temperature drops (3) provide a stability analysis of the equilibria.

Method: (1) Considering the previous modeling approaches [1], [2], [3], [12], a delay differential equation will be used to model the changes in the population density of EAB. (2) A linear stability analysis will be performed to obtain the stability conditions for the trivial and positive Equilibria. (3) Using the Matlab dde23, we will numerically explore the constructed model.

Anticipated result: seasonal changes of the ambient temperature may substantially affect the dynamics of EAB population in the invaded areas. In particular, the stability of the positive equilibrium would be lost when the temperature falls below a threshold value. Therefore, oscillatory solutions may bifurcate from the positive equilibrium as a result of decreases in the temperature. This corresponds to significant fluctuation in the population densities of EAB. In an extreme case, If the stability of the positive equilibrium is lost and the trivial solution becomes stable, then it implies that the population will go extinct as a result of a sharp temperature drop. Nevertheless, the adult EAB is resistant to temperature drops [13],[14] and and oscillations in the population density seems to be more biologically relevant than the extinction.
Significance: To this date, there is hardly any effective way of controlling the spread of EAB in the North America. This study employs a mathematical modeling approach to quantify the impacts of temperature drops on the population dynamics of EAB. Specifically, cold weather during the egg-laying season may significantly delay the offspring and lower the population density to a manageable level.

Key Articles for modeling:


References:


