Some analytical and numerical approaches to understanding trap counts resulting from pest insect immigration

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Abstract

Monitoring of pest insects is an important part of the integrated pest management. Insect monitoring aims to provide information about pest insect abundance at a given location. This includes data collection, usually using traps, and their subsequent analysis and/or interpretation. However interpretation of trap counts (number of insects caught over a fixed time) remains a challenging problem. Firstly, an increase in either the population density or insects activity can result in a similar increase in the number of insects trapped (the so called "activity-density" paradigm). Secondly, a genuine increase of the local population density can be attributed to qualitatively different ecological mechanisms such as multiplication or immigration. Identification of the true factor causing an increase in trap counts is important as different mechanisms require different control strategies. In this paper, we consider a mean-field mathematical model of insect trapping based on the diffusion equation. We first show that, although the diffusion equation is a well-studied model, its analytical solution in a closed form is actually available only for a few special cases, whilst in a more general case the problem has to be solved numerically. We then choose finite differences as the baseline numerical method and show that numerical solution of the problem, especially in the realistic 2D case, is not at all straightforward as it requires a sufficiently accurate approximation of the diffusion fluxes. Once the numerical method is justified and tested, we apply it to the corresponding boundary problem where different types of boundary forcing describe different scenarios of pest insect immigration and reveal the corresponding patterns in the trap counts growth.

Keywords: Pest monitoring; Insect trapping; Random walk; Diffusion; Finite differences;

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