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Original article

Modelling and qualitative analysis of a predator–prey system with state-dependent impulsive effects☆

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Abstract

In this work, according to integrated pest management principles, a class of predator–prey system with state-dependent impulsive effects is put forward. In this model, the control strategies by releasing natural enemies and spraying pesticide at different thresholds are considered. The sufficient conditions for the existence and stability of the semi-trivial periodic solution and the positive order-1 periodic solution are given by the Poincaré map and the properties of the Lambert W function. In addition, to verify the feasibility of our main results, the numerical simulations are carried out.

Keywords: Impulsive differential equations; Periodic solution; Predator–prey system; Stability; State-dependent

1. Introduction

In the recent decades, considerable work on the permanence, the extinction and the global asymptotic stability of epidemic models and Lotka–Volterra type systems have been studied extensively, for example [3–5,8,9,13,17,21–23]. In population dynamics, the effect of pest control has become an increasingly complex issue. In pest management, insecticides are useful because they quickly kill a significant proportion of an insect population and they sometimes provide the only feasible method for preventing economic loss. However, there are many deleterious effects associated with the use of chemicals that need to be reduced or eliminated. Another important method for pest control is biological control, which is a manipulation of existing natural enemies to increase their effectiveness. This can be achieved by mass production and periodic release of natural enemies of the pest, and by genetic enhancement of the enemies to increase their effectiveness at control. However, researches on augmentation as a biological control method have shown that some practices are cost-effective and others are not. Integrated pest management (involves combining biological, mechanical, and chemical tactics) has been proved to be more effective than the classic methods (such as biological control or chemical control) both experimentally (e.g. [16,19,20]) and theoretically (e.g., [1,23]).

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