Optimal impulsive release of insects for population replacement

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Insects are vectors that transmit various diseases to humans. At the same time, they are part of the food chain of several species that depend on them for their subsistence. Consequently, it is important to analyze how to reduce their vectorial capacity and simultaneously keep their population under control. In this work, we analyze the replacement of a population of resident insects with vector potential by another population of the same species, with limited vector capacity, that is introduced in an impulsive manner. This scenario involves substituting a population of mosquitoes (e.g., Aedes aegypti) with another similar species containing Wolbachia, which reduces its vector capacity. Based on the interaction model of two insect populations (S_1, a local population of females, and S_2, an invasive population), we analyze the local insertion of the invasive species, conducted through releases (or assault waves) with a particular frequency and magnitude. We model this phenomenon using impulsive releases, which allows for a more realistic representation of how these releases occur in practice while also enabling us to examine the conditions for success and failure that may arise from the combination of model parameters and external conditions. We present criteria for the existence, positivity, and uniqueness of solutions, as well as conditions for the invasive population to become established, meaning that the equilibrium point is locally and globally asymptotically stable within the analysis region. This leads us to a sufficient condition for the release of females that ensures the establishment of the invasive population (convergence to $S_1 = 0$ and $S_2 \neq 0$). Additionally, we present optimal solutions regarding the frequency and magnitude of releases. We will also present advances in the modeling and classification of mosquitoes with vector potential and in the adjustment of models for the prediction of dengue. This

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