Simulation of genetics-based strategies for mosquito control and implications of density-dependence

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The advent of CRISPR-based gene editing has reignited interest in the application of genetics-based strategies for the control mosquitoes and the diseases they transmit. The versatility of this technology has also enabled a wide range of gene drive architectures and population suppression technologies to be realized, creating a need for their population-level and spatial dynamics to be explored. To this end, we present MGDrivE (Mosquito Gene Drive Explorer): a simulation framework designed to investigate the population dynamics of a variety of gene drive and genetics-based control systems, and their spread through spatially-explicit mosquito populations. MGDrivE is based on a tensor algebraic generalization of the lumped age-class model of mosquito ecology. Treating the population dynamic equations in a variable-dimension tensor form allows them to be left unchanged while modifying the dimensionality of the tensor describing inheritance patterns, as required by the genetic system. We present simulation results for the use of: a) reciprocal chromosomal translocations, as a confineable and reversible gene drive system, and b) precision guided sterile insect technique (pgSIT), as a self-limiting strategy for population suppression. We describe the sensitivity of these results to density dependence, and discuss alternative approaches to modeling density-dependence within this modeling framework.

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