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Mathematics of a single-locus model for assessing the impacts of pyrethroid resistance and temperature on population abundance of malaria mosquitoes

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Mathematics of a single-locus model for assessing the impacts of pyrethroid resistance and temperature on population abundance of malaria mosquitoes

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Abstract

In this study, we developed a novel genetic population deterministic model of nonlinear ordinary differential equations for the temporal dynamics of the immature and adult anopheles mosquito population with sex structure. The deployment of larvicides, pupacides, and adulticides are incorporated into the model. Furthermore, the fitness costs associated with resistance are accounted for, including heterogeneities in fecundity, development rates, and natural mortality rates. The model is used to investigate the spread and management of insecticide resistance in mosquitoes. A threshold for the stability of the insecticide-sensitive-only and insecticide-resistant-only boundary equilibria is derived. Moreover, a conjecture has been established for the stability of the co-existence equilibrium where mosquitoes of all genotypes exist. Furthermore,we show that stratifying the mosquito population by genotype induces a bistability phenomenon. The impact of varying temperatures and insecticide coverage on the mosquito population by genotype in the context of the moderate and high fitness cost scenarios have been explored numerically.