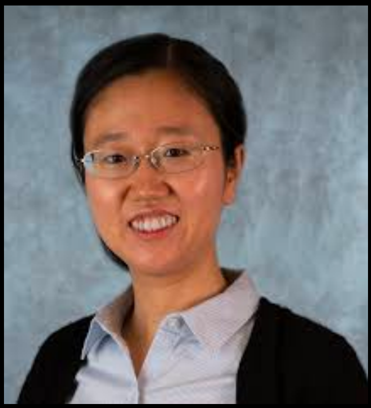
Biomathematics Seminar Series

Department of Mathematics and Statistics

Modeling the invasion wave of Wolbachia in mosquitoes for controlling mosquitoes-borne diseases



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We develop and analyze a partial differential equation (PDE) model to study the transmission and invasion dynamics of releasing Wolbachia-infected mosquitoes to establish infection among the wild uninfected mosquitoes. Wolbachia is a novel mitigation strategy to control mosquitoes-borne diseases, such as Zika, Chikungunya, and dengue fever. It is a natural bacterium that can infect mosquitoes and reduce their ability to transmit these diseases. A critical threshold condition that determines if a Wolbachia infection can be sustained in the wild is the ratio of infected to uninfected mosquitoes. Thus, accounting for the spatial heterogeneity in the distributions of the infected and uninfected mosquitoes is critical to accurately predict if a release can be sustained in the field. We create a reaction-diffusion type PDE model for the spread of a Wolbachia epidemic within the mosquito population. The model accounts for both the complex vertical transmission parameters (from different mosquito life-stages) and the horizontal transmission (spatial diffusion) of Wolbachia infection. We show that the proposed PDE model can give rise to the traveling waves of Wolbachia infection, and we compare the threshold condition for having a successful invasion to the level in the spatially homogenous setting. We also analyze how the magnitude of the diffusion coefficient can impact if a locally highly infection region will grow or collapse and the shape and velocity of the traveling front.

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