Mathematical Methods and Models in Biosciences
June 18-23, 2023, Pomorie, Bulgaria
https://biomath.math.bas.bg/biomath/index.php/bmcs
Biomath Forum

Optimal control approach for establishing *Wolbachia* in wild population of *Aedes aegypti* mosquitoes

Daiver Cardona-Salgado[1], Lilian Sofia Sepulveda-Salcedo[1],
Olga Vasilieva[2], Jose Luis Orozco-Gonzales[2]

[1]Universidad Autónoma de Occidente, Cali, Colombia
dcardona@uao.edu.co
lssepulveda@uao.edu.co

[3]Universidad del Valle, Cali, Colombia
olga.vasilieva@correounivalle.edu.co
jose.gonzales@correounivalle.edu.co

Replacements of wild *Aedes aegypti* mosquitoes with *Wolbachia*-infected insects are becoming more and more socially accepted for controlling and preventing arboviral diseases in various areas invaded by this vector species worldwide. The main characteristics of this environmentally friendly technique are [1, 2, 3, 4]: it reduces the vectorial capacity of female mosquitoes, shortens the vector life expectancy, and reduces the overall vectorial density. In particular, the presence of *Wolbachia* in the vector's cells impedes it from developing a viral load sufficient for infecting human individuals through mosquito bites.

Additionally, the maternal transmission of *Wolbachia*, combined with the effect of cytoplasmic incompatibility (CI), facilitates the spread of *Wolbachia* infection in wild *Aedes aegypti* populations. However, these two principal features (maternal transmission of *Wolbachia* and CI reproductive phenotype) are sensitive to thermal stress. The latter may cause a partial loss of *Wolbachia* infection, known as *imperfect* maternal transmission and *imperfect* CI.

This presentation is focused on the population dynamics model of *Wolbachia* invasion bearing the imperfections mentioned above. Under this setting, the goal of *Wolbachia*-based control of arboviral infections consists in achieving the coexistence equilibrium with a high density of *Wolbachia*-infected mosquitoes and a low density of wild mosquitoes. Our model can also be adapted to two major *Wolbachia* strains, *wMel* and *wMelPop*, which are being tested in field releases.

To ensure the evolution towards the desired coexistence equilibrium, we employ the optimal control approach to design the release strategies of Wolbachiacarrying insects. The control intervention aim is two-fold: minimizing the overall number of released *Wolbachia*-infected mosquitoes while reducing the total intervention time. Our numerical simulations with parameters for two *Wolbachia* strains will display different scenarios of the tradeoffs between these two objectives to offer alternatives for policymaking.

Acknowledgements
This work was supported by:

- National Fund for Science, Technology, and Innovation (Autonomous Heritage Fund *Francisco José de Caldas*), Project CI-71289 (Universidad del Valle and Universidad Autonoma de Occidente, Cali, Colombia), Contract No.: 80740-224-2021 issued by the Colombian Ministry of Science, Technology, and Innovation (Minciencias)
- STIC AmSud Program grant for regional scientific cooperation between Argentine, Chile, Colombia, Paraguay, and France, 2020-2021 (NEMBICA: 20-STIC-05)

References

[1] T. H. Ant, C. S. Herd, V. Geoghegan, A. A. Hoffmann, S. P. Sinkins, The *Wolbachia* strain *wAu* provides highly efficient virus transmission blocking in *Aedes aegypti*, *PLoS Pathogens* 14(1):e1006815, 2018.

[2] A. A. Hoffmann, P. A. Ross, G. Rašić, *Wolbachia* strains for disease control: ecological and evolutionary considerations. *Evolutionary applications* 8(8):751-768, 2015.

[3] S. T. Ogunlade, A. I. Adekunle, M. T. Meehan, D. P. Rojas, E. S. McBryde, Modeling the potential of *wAu-Wolbachia* strain invasion in mosquitoes to control *Aedes*-borne arboviral infections, *Scientific Reports* 10:16812, 2020.

[4] S. T. Ogunlade, M. T. Meehan, A. I. Adekunle, D. P. Rojas, O. A. Adegboye, E. S. McBryde, A Review: *Aedes*-borne Arboviral Infections, Controls and *Wolbachia*-Based Strategies, *Vaccines* 9(1):32, 2021.