2022_52_DoLS_Windbichler: CRISPR/Cas9 gene drives for the genetic control of agricultural pests

Supervisors: Nikolai Windbichler (mailto:nikolai.windbichler@imperial.ac.uk); Angela Meccariello

Department: Department of Life Sciences

An estimated 25% of global crop production is lost to arthropods annually. A changing climate will likely exacerbate this threat. The growing global human population requires raising agricultural productivity further, ideally without intensifying land usage. Crop losses due to pests must be reduced by not degrading agroecosystems for instance by the over-use of synthetic insecticides. The rise of insecticide resistance and a dearth in new pesticide classes renders this issue even more pressing.

Genetic control offers a species-specific approach to tackle this problem by delivering novel traits into target populations via the release of modified insects.Suppressive CRISPR/Cas9 gene drives, designed to reduce the population size of harmful pest organisms, are a promising strategy. They have now been under development for nearly a decade. Targeting medically relevant mosquito species has remained the prime application and here the technology has reached a stage where caged mosquito populations can be eliminated.

Agricultural pests have long been seen as a potential field of application for gene drives, but the genomic resources required were lacking behind those in mosquitoes. This has now changed with the availability of chromosome-level assemblies in some species including the medfly Ceratitis capitata. The medfly offers a unique opportunity for the development of suppressive gene drives. Not only do global economic costs due to crop damage, export controls and prevention of medfly infestation amount to &gt;US$ 1 billion annually but, importantly, its sex-determination mechanism allows generation of XX fertile males and XY fertile females. This demonstrates the feasibility of genetic control by way of true genetic sex conversion, an impossibility in many other insects, due to the role of the Y chromosome for male fertility. Since in most pest species the number and productivity of females determines population size and crop damage occurs solely through the activities of females, such approaches are highly effective.

We have already established a toolbox for the endogenous use of CRISPR/Cas9 in the medfly. In this project we intend to demonstrate the feasibility of a novel gene drive approach for the genetic control of the medfly based on complete female-to-male sex conversion paired with a mechanism for female sterility. Modelling predicts that this strategy triggers rapid population suppression a highly attractive feature for genetic control in agriculture and is robust with regards to target site resistance. Using Ceratitis capitata, the student will work towards completing the CRISPR/Cas9 toolset and establish the parameters for enabling efficient gene drive. They will characterize female fertility targets for gene drive and test the proposed sexconversion mechanism. They will use agent-based mathematical modelling to predict the behaviour of this system and demonstrate the power of this approach in eliminating caged medfly populations.

For more information on how to apply to us please visit: https://www.imperial.ac.uk/grantham/education