Sterility on the rocks

Marine A. Courtois*[1], Taha Belkhayate[1], Crésus Kounoudji[1], Frédéric Grognard[2], Suzanne Touzeau[1,2], Ludovic Mailleret[1,2], and Louise Van Oudenhove[1]

[1]Université Côte d'Azur, INRAE, CNRS, ISA, France – Université Côte d'Azur, INRAE, CNRS, ISA, France – France

[2]Université Côte d'Azur, Inria, INRAE, CNRS, MACBES, France – Université Côte d'Azur, Inria, INRAE, CNRS, MACBES, France – France

Résumé

The Sterile Insect Technique (SIT) is more and more used in agriculture to manage crop pests. It entails the large-scale breeding, sterilization, and subsequent release of the targeted insects into crops. This approach lowers the population reproductive output and reduces associated damages. Despite its apparent simplicity in theory, each step of this technique poses practical hurdles to its effective implementation. Several challenges, such as residual fertility in sterile insect releases and the tendency of females to re-mate, can significantly impede SIT success.
To assess whether SIT efficiency is influenced by: (1) residual fertility and (2) multiple matings, we devise a population dynamics model using ordinary differential equations. This model is structured into larvae, wild males, sterile males, fertilized females (mated with wild males), and sterilized females (mated with sterile males). Sterile males are released continuously into the population. Only fertilized females have the ability to lay eggs. We assume that fertility is determined by the last mating. Females can thus change status whether and when they re-mate.

(1) We determine the residual fertility threshold below which eradication can be achieved. This threshold depends on the offspring number of the targeted pest and fitness costs on released males. Moreover, pest control remains feasible even when this threshold is overshot. In this case, SIT allows to maintain pest population under an acceptable level.

(2) We compare scenarios where females undergo single mating with multiple matings separated by a refractory period. We investigate the impact of this refractory period, which can vary depending on whether it follows a mating with a fertile or sterile male.
Our study highlights the crucial role of reproductive mechanisms in shaping the efficiency of SIT control strategies, emphasizing the necessity of a thorough comprehension of the ecology and biology of the targeted pest. This understanding is essential not only for optimizing SIT but also for enhancing pest management practices overall.

Mots-Clés: Modelling, biological control, sterile insect technique, crop protection, bifurcation analysis, ordinary differential equations, stability analysis

*Intervenant