GENETICALLY ENGINEERED PEST MANAGEMENT

UAB Universitat Autònoma de Barcelona

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OBJECTIVES

- To study, from an historical perspective, different **genetic strategies applied in insect pest management**.
- To describe the methodology of different pest control strategies ⟶

① **Self-limiting** genetic systems (SIT, IIT and RIDL).

② **Self-sustaining** pest management methods that implied **genetic modification** of individuals (HEGs and CRISPR/Cas).

INTRODUCTION

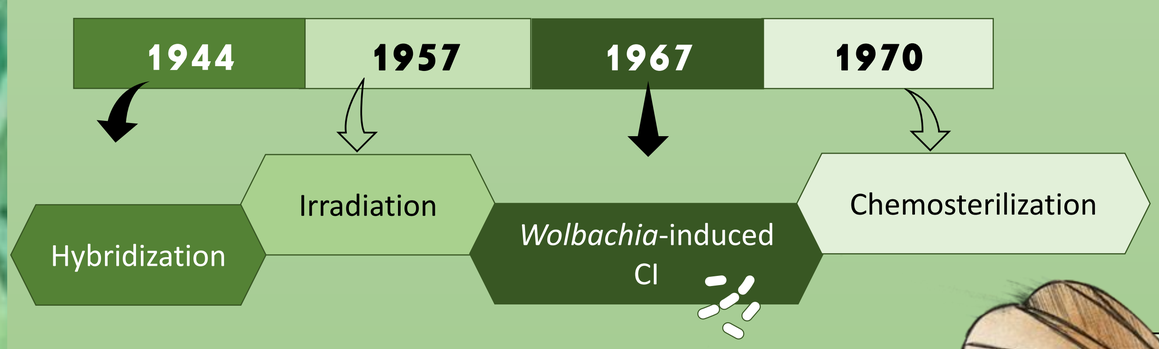
Insect pests entail a major problematic, due to the amount of **damage** produced to **agriculture** and because of its involvement in **vectorial disease transmission**.

In these last years, conventional **chemical control** methods applied to pest management have been **restricted** due to the appearance of **antimicrobial resistance** and the **environmental impact** caused.

There are currently several **alternatives based on genetic control strategies** that are able to **suppress and eradicate populations**, reducing their reproductive potential and producing genetically modified insect strains.

Sterile Insect Technique (SIT)

Multiple and abundant **releases** of **sterile/cytoplasmic incompatible (CI) insects** from the target species in a defined area. **Mating** between released males and wild type females will **not produce offspring.**



Incompatible Insect Technique (IIT)

Homing endonuclease genes (HEGs)

Heterozygous individual

Homozygous individual

Inheritance **higher** than the **Mendelian 50%.**

HOMING

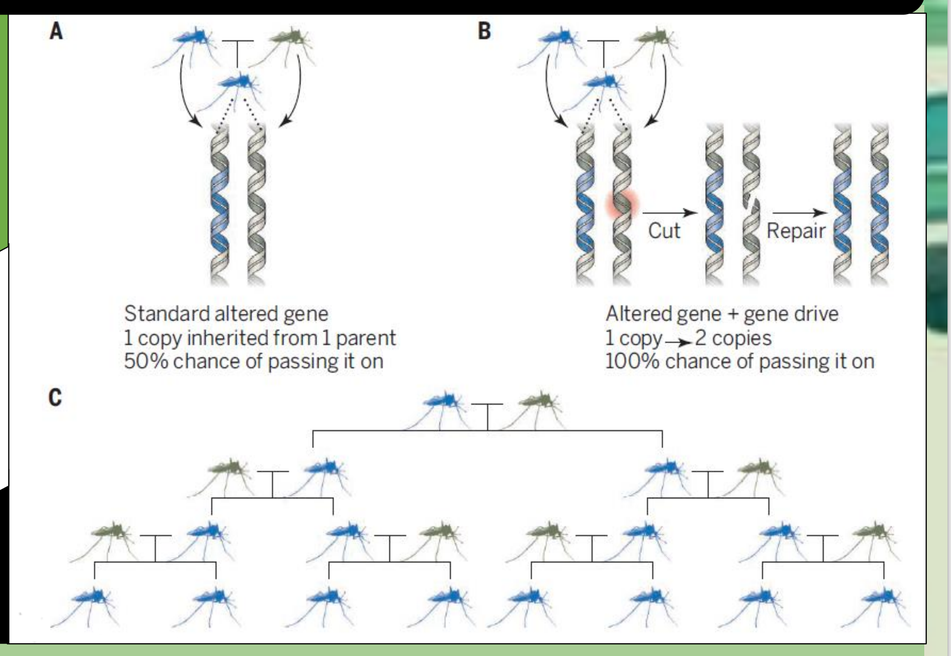


Figure 2. How endonuclease gene drives spread altered genes through populations (Oye *et al.* 2014)

1. HEGs **induce DNA breaks** on the homologous chromosome.
2. Use of **HEG+ homologous chromosome** as a **repair template.**
3. **Copy** of the HEG gene to the other chromosome.

Release of insects carrying a dominant lethal (RIDL)

✓ Female-specific RIDL →

Msl2-NOPU gene
yp1/yp3 enhancers

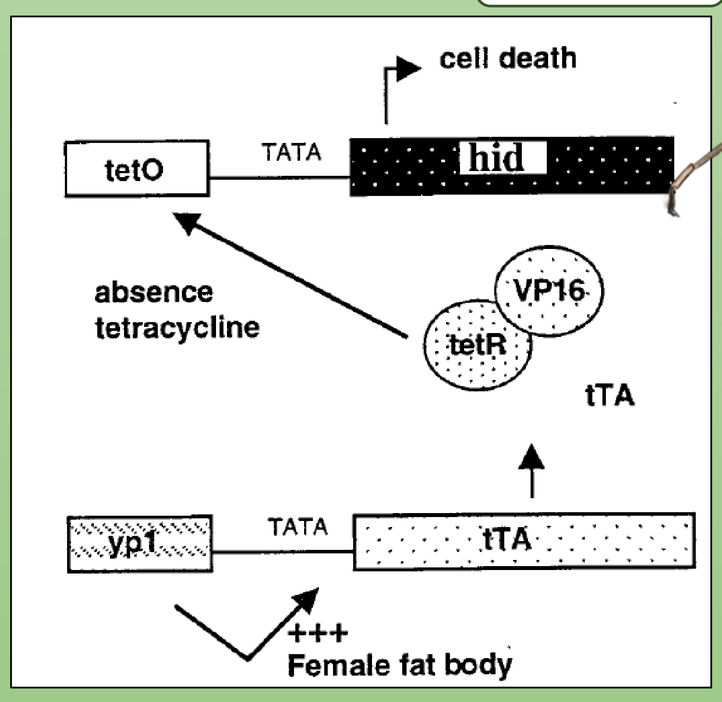


Figure 1. The tetracycline-regulated female-killing system (Heinrich i Scott 2000)

CRISPR/Cas

Nucleases (Cas) + guide RNA (gRNA) based system. Designed to induce double-stranded DNA breaks at specific sites in the genome.

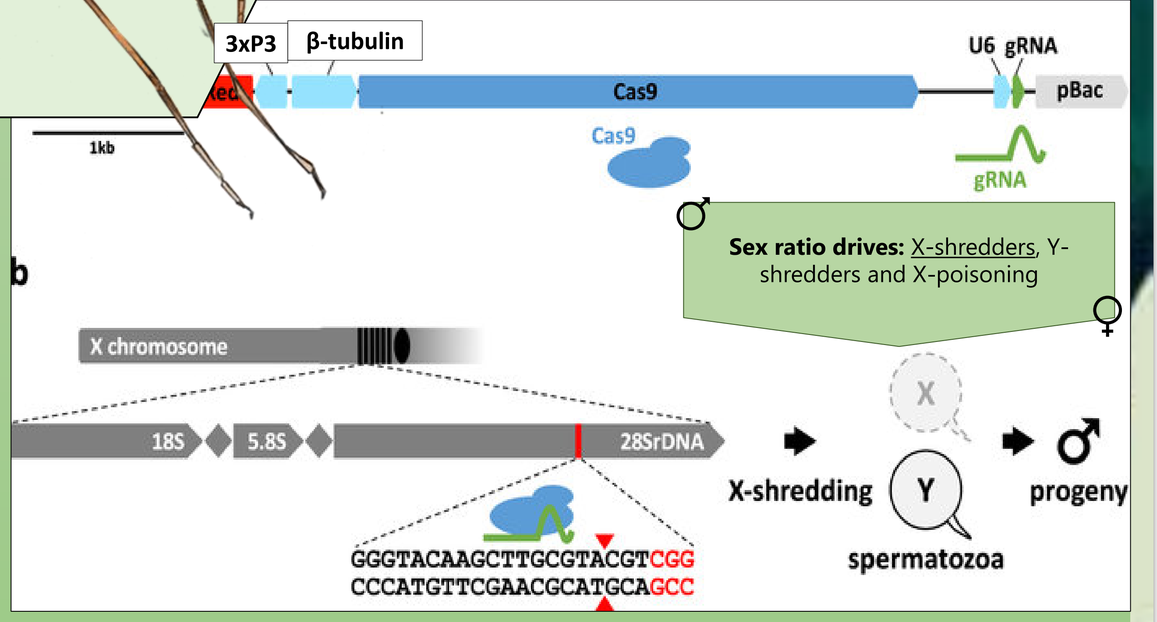


Figure 3. Generation of a CRISPR-Cas9 sex-ratio distortion system (Galizi *et al.* 2016)

CONCLUSIONS

Genetic control strategies signify a **great alternative** to conventional chemical methods. Initially, multiple genetic control strategies based on **massive and constant releases** of sterile or incompatible specimens were proposed and implemented. In the new world, **genetically engineered populations** involving **reduced releases** of individuals and **indefinite persistence** of modified traits are predominant. Many genetic pest control strategies are still under development.

Heinrich, J. C., & Scott, M. J. (2000). A repressible female-specific lethal genetic system for making transgenic insect strains suitable for a sterile-release program. *Proceedings of the National Academy of Sciences of the United States of America*, 97(15). https://doi.org/10.1073/pnas.140142697

Windbichler, N., Menichelli, M., Papathanos, P. A., Thyme, S. B., Li, H., Ulge, U. Y., Hovde, B. T., Baker, D., Monnat, R. J., Burt, A., & Crisanti, A. (2011). A synthetic homing endonuclease-based gene drive system in the human malaria mosquito. *Nature*, 473(7346). https://doi.org/10.1038/nature09937

Meccariello, A., Krsticevic, F., Colonna, R., del Corsano, G., Fasulo, B., Papathanos, P. A., & Windbichler, N. (2021). Engineered sex ratio distortion by X-shredding in the global agricultural pest Ceratitis capitata. *BMC Biology*, 19(1). https://doi.org/10.1186/s12915-021-01010-7