Sterile Insect Technique (SIT): Perspectives for the management of *Aedes* mosquitoes in the region of the Americas

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Outline

1. Joint FAO/IAEA Division
2. SIT projects in the Americas for insects other than mosquitoes
3. Mosquitoes research and development
4. Mosquitoes projects in the Americas (present and future plans)

The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture

Mandate of FAO (Rome - Italy)

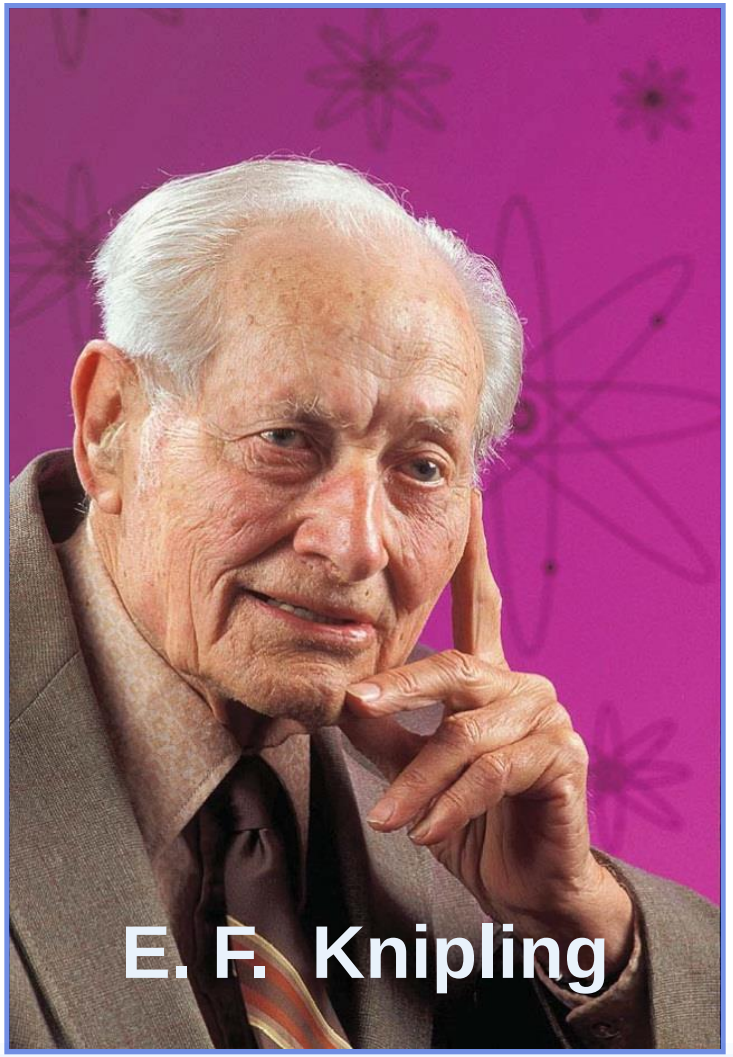
to build a world without hunger through technical cooperation and assistance and having three main objectives: eliminating hunger, fighting poverty and caring for the Earth

Mandate of IAEA (Vienna – Austria)

to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world

Sterile Insect Technique (SIT)

The concept was developed by Knipling, in the 1940's against screwworm (*Cochliomyia hominivorax*)



Sterile Insect Technique (SIT)

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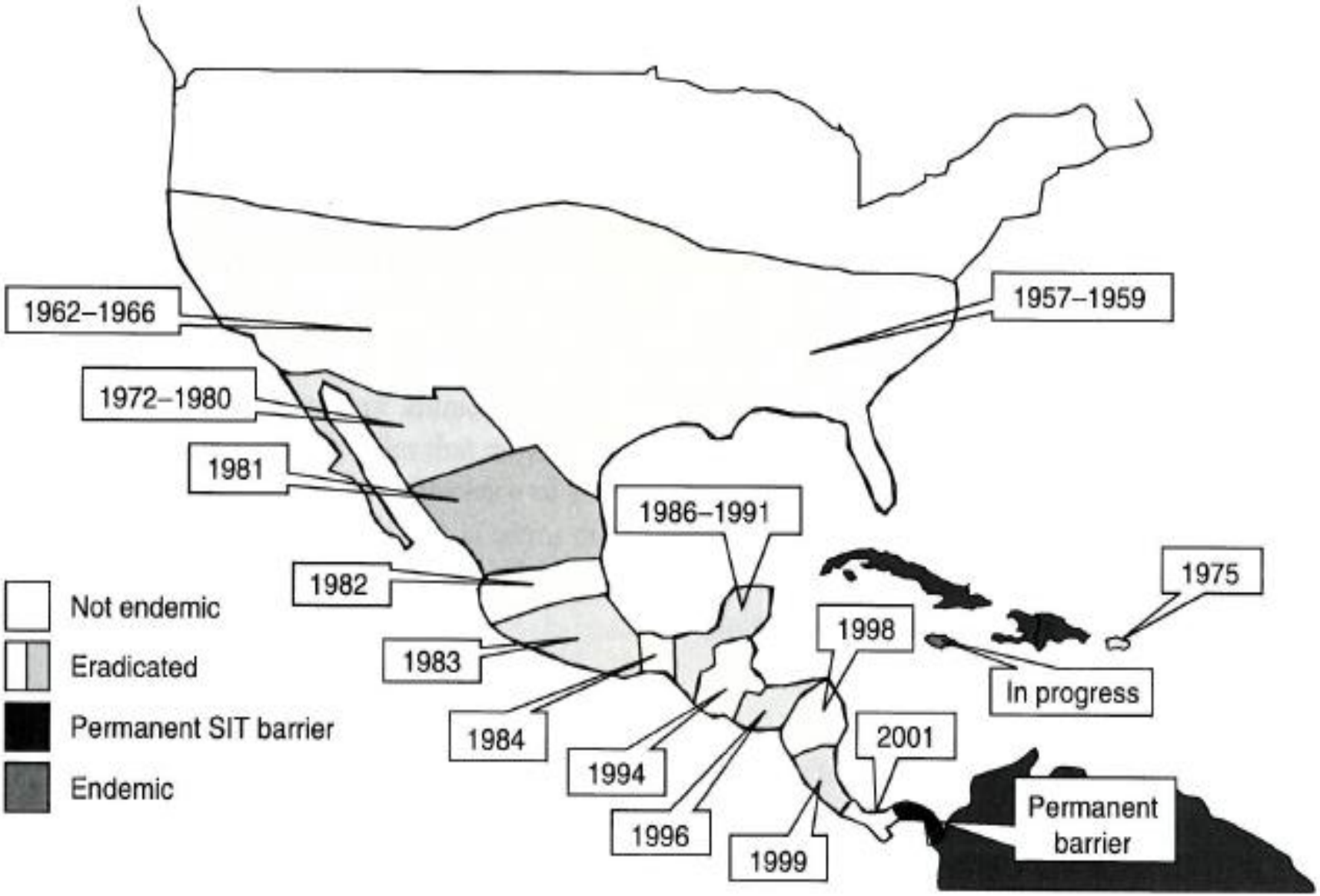


Sterile Insect Technique (SIT)

1. Plant pests
    a. Fruit flies
    b. Moths
2. Pests of medical and veterinary importance
    a. Mosquitoes
    b. Screwworm
    c. Tsetse flies





SIT is only one more AW-IPM tool

It relies on:

- **mass production of the target species**
- **sterilization and packing**
- **inundative releases by air**
- **matings result in no offspring**

The Sterile Insect Technique is an industrial process, and its area-wide application is logistically and managerially complex

Guatemala, ¨El Pino¨
Medfly facility

Containment

Preventive Release Program over Los Angeles Basin, California

(Ca. 400 million sterile males / week since 1994)

Dominican Republic Medfly Eradication

Dominican Republic Medfly Eradication

- The outbreak was detected in March 2015 and the ban of fruit export caused the reduction of US$ 40 million in exports
- Last Fertile Adult was detected on January 2017
- Control technology and a reliable trapping network is in place for early detection and eradication of potential outbreaks.

Insect Pest Control Sub-programme

Normative

FAO-IAEA guidelines for standardised mass-rearing of *Anopheles* moquitoes

FAO-IAEA Guidelines for routine colony maintenance of *Aedes* mosquito species

Guidelines for *Aedes* mosquito colonisation (in preparation)

Guidelines for mass-rearing of *Aedes* mosquitoes (in preparation)

Guidelines for marking sterile male mosquitoes (in preparation)

A standard Mark-Release-Recapture protocol to measure dispersal, survival and field competitiveness of sterile male *Aedes albopictus* (in preparation)

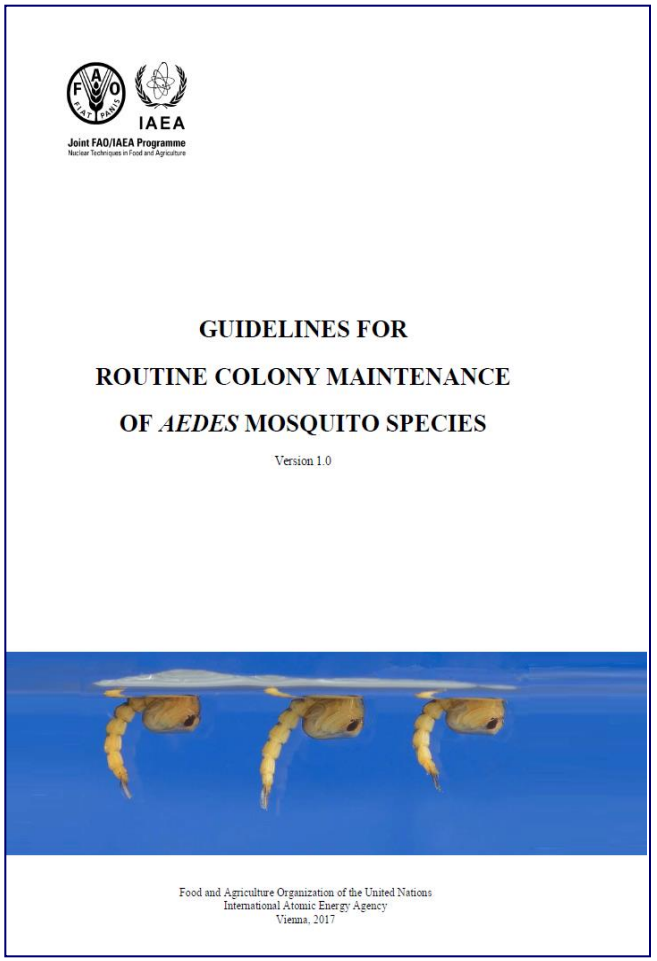
Research & Development

Coordinated Research Projects

Development of the SIT package for mosquitoes

Technology transfer

Technical Cooperation Projects



http://www-naweb.iaea.org/nafa/ipc/public/guidelines-for-routine-colony-maintenance-of-Aedes-mosquito-species-v1.0.pdf

Insect Pest Control Sub-programme

Coordinated Research Projects

Exploring Genetic, Molecular, Mechanical and Behavioural Methods of Sex Separation in Mosquitoes (2013-2018)

Mosquito Handling, Transport, Release and Male Trapping Methods (2015-2020)

Insect Pest Control Sub-programme

Increase the efficacy of the sterile insect and related techniques through development of

- innovative insect mass rearing techniques
- new insect strains (classical and modern genetics)
- management tools for pathogens
- handling, transport and release methods
- methods to study insect behaviour, mating compatibility and mating competitiveness
- insect quality management tools

SIT and IIT for mosquitoes

Lack of a 100% efficient sex separation system

No Genetic Sexing System available for *Ae. albopictus / Ae. aegypti*

→ Sexual dimorphism in pupae

→ Female contamination in male releases

SIT or transgenic = Risk of pathogen transmission

IIT = Risk of population replacement

SIT and IIT for mosquitoes

Wolbachia-infected strain (CI + pathogen protection)

+

low radiation dose

SIT = ~~Risk of pathogen transmission~~

IIT = ~~Risk of population replacement~~

Advantages of the combined SIT / IIT approach

- Safe for humans and environment
  - No release of potentially disease-transmitting females
  - No establishment of species, strains, (trans)genes in nature
  - No use of antibiotics
  - No use of human blood
  - No potential for resistance development
- Responsible and sustainable approach
- Positive public perception for SIT

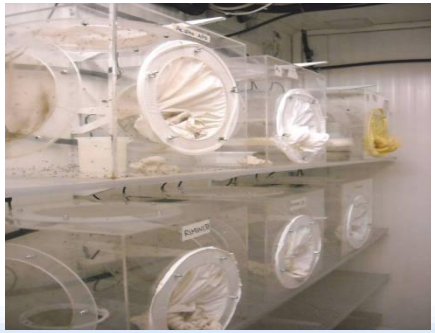
WHO Vector Control Advisory Group (VCAG)

Conclusions and recommendations
(http://apps.who.int/iris/bitstream/10665/255824/1/WHO-HTM-NTD-VEM-2017.02-eng.pdf):

- "*The combined SIT/IIT technology has potential for long-term control of Ae. aegypti and Ae. albopictus mosquitoes*" and

- "*VCAG strongly recommends further entomological and epidemiological field trials be conducted to validate the use of this intervention and its claims of efficacy against disease*"

Challenge: from research to operational programmes



R&D: recent developments SIT mosquitoes – adult feeding

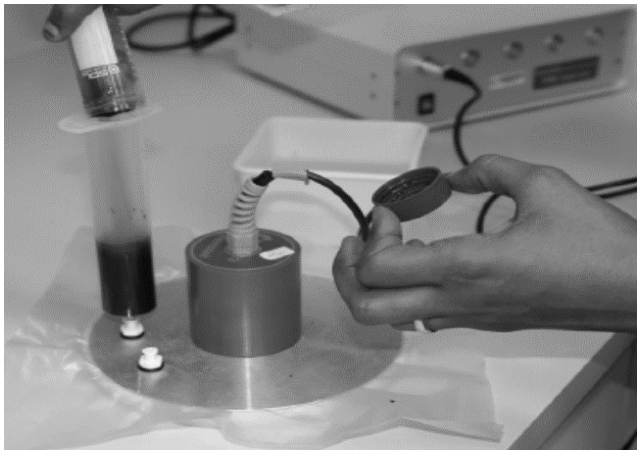
How to deliver the blood?

Haemotek system

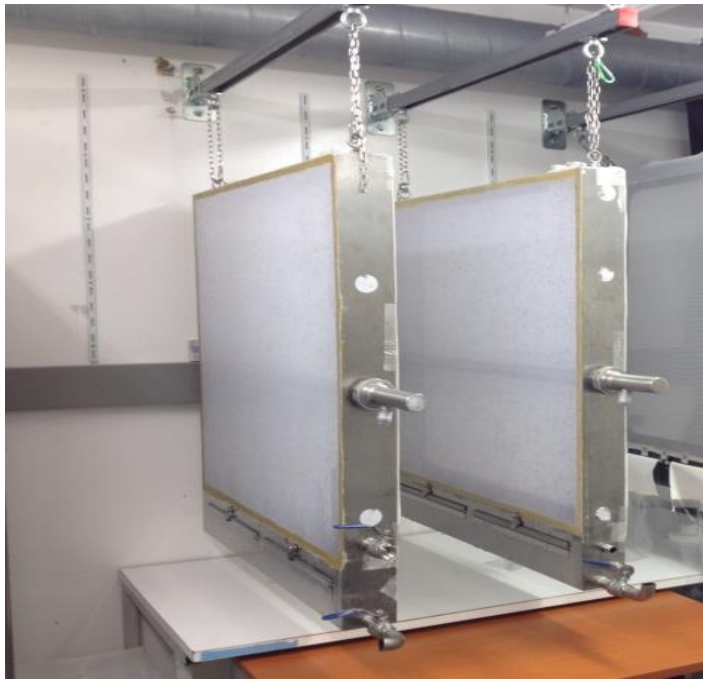
- Heating plate
- Membrane

Sausages

- In warm water bath
- Hung in adult cages



R&D: recent developments SIT mosquitoes – adult rearing



16,000 *Aedes* per cage

200,000 - 500,000 eggs per week

1500 €

Very space efficient

Easy handling

R&D: recent developments SIT mosquitoes – larvae rearing

18,000 larvae/tray

900,000 larvae/rack

100,000 *Aedes* male pupae/week

40 - 70 €/tray

Unit of 4 racks of 5 m^2

R&D: recent developments SIT mosquitoes – larvae counter

To maintain consistent larval density

- Larvae dispenser
- Electronic counting unit
- PC and software

5000 larvae in 1 minute per channel

120 channels

R&D: recent developments SIT mosquitoes – sex separation

Mechanical separation – size dimorphism

Aedes: 0.2-0,5% Female contamination

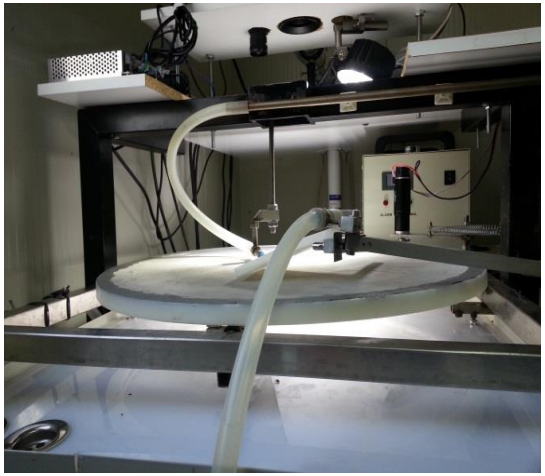
Labour intensive

Tragsa Laser Sex Separator

Algorithm: size and morphology

Laser to kill the females

<0.1% Female contamination

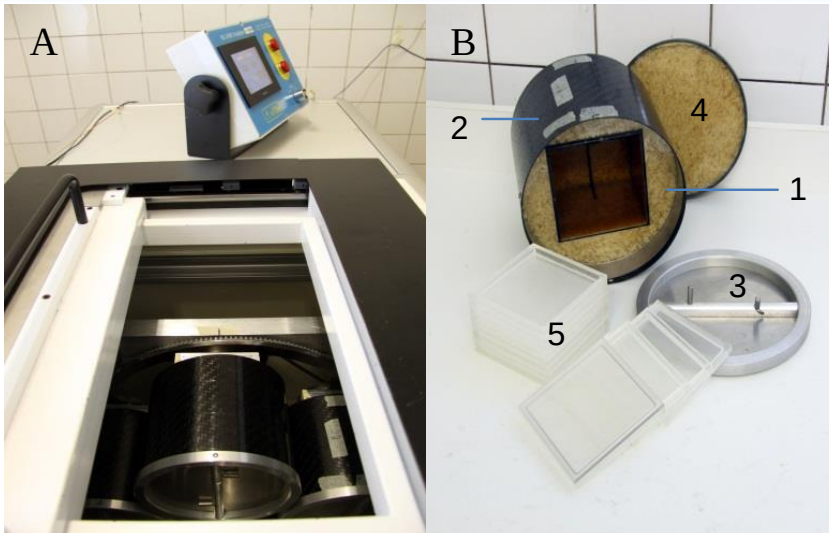


Development of Genetic Sexing Strains

- 1st generation GSS for *Ae. aegypti*: currently testing for genetic stability
- Working to increase genetic stability to better link the mutation(s) to the M locus
- Using classical genetic approaches: low-dose irradiation to induce chromosomal inversions
- Promising strains also for *Ae. albopictus* and *An. arabiensis*
- Addition of *Wolbachia* to GSS (*de novo*)

Irradiation methods

Gamma-Ray Irradiator (^{137}Cs / ^{60}Co)



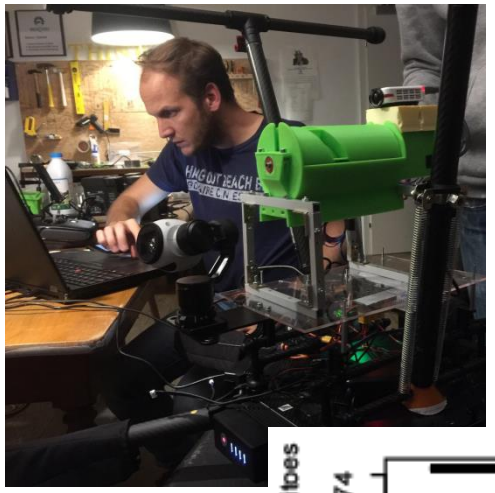
X-Ray Irradiator

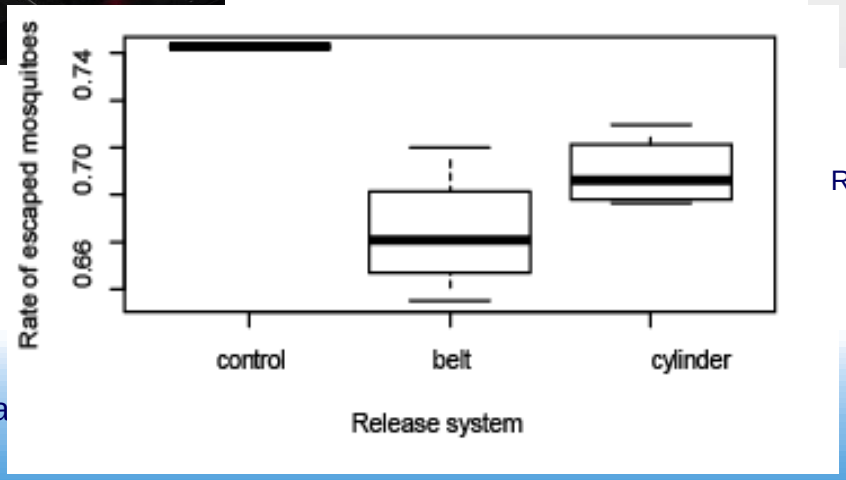
Sterilization procedures and handling methods tested for X-ray and Gamma-ray:

- Sterility curves (dose-response) for *Ae. aegypti*, *Ae. albopictus*, *An. arabiensis*, *etc.*
- Effects of handling methods on induced sterility
- Effects of handling and irradiation source on induced sterility and resulting male quality
- Development of efficient and standard holding containers
- Comparison of sensitivity/methods on different strains
- Optimization and harmonization of methods towards SOP development

Aerial release using drones

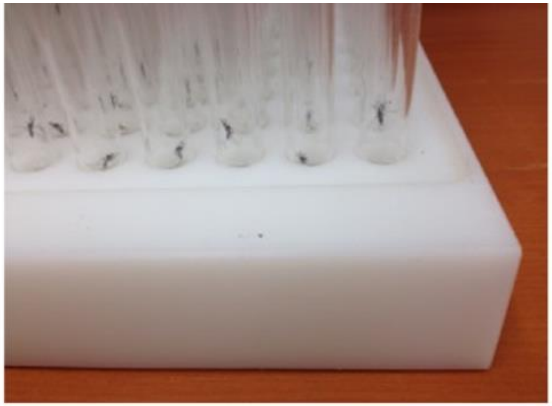
- USAID project - *Combatting Zika & Future Threats: A Grand Challenge for Development: "Fighting Future Threats Using Autonomous Aerial Robotics"*
  - Awarded $400,000 to develop an aerial release system for *Aedes* sterile male mosquitoes
  - Joint project between FAO/IAEA IPCL & WeRobotics (NGO)
  - Compatible with multiple UAV platforms

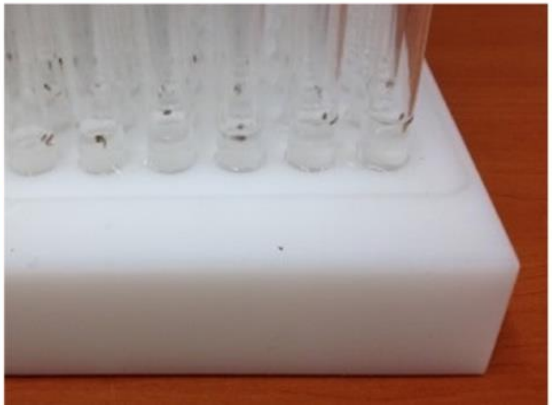


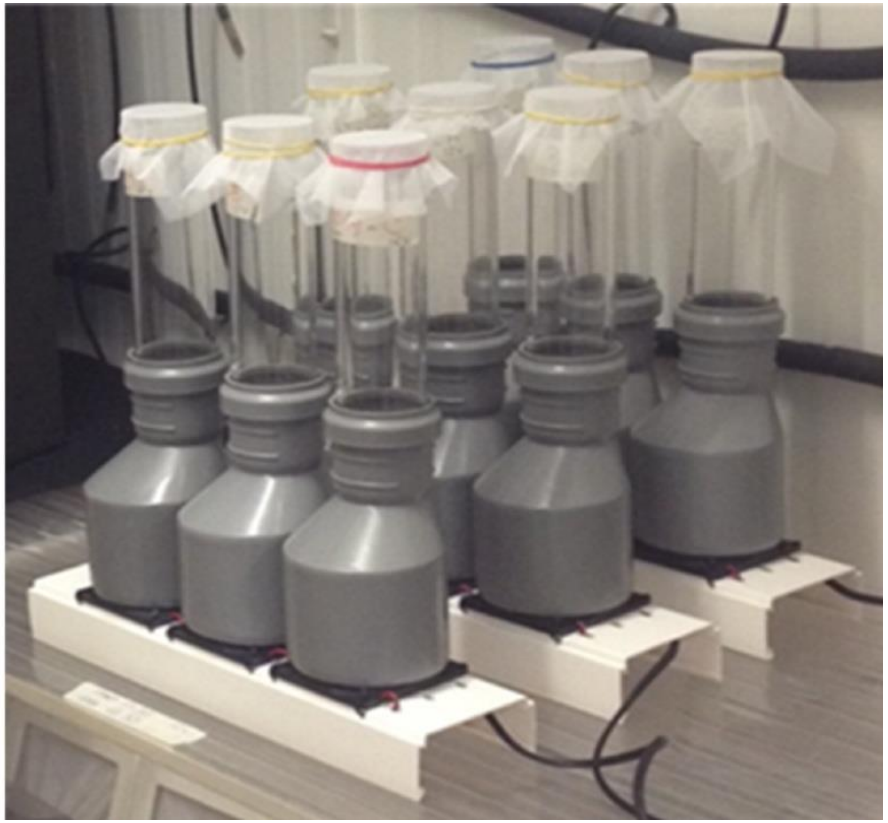


Rate of mosquitoes with unaffected flight ability after release by the mechanism

Development of Standardised Quality Control Protocols







Current Projects Supported by the IAEA (TC)

TC projects supported by IPC Sub-programme

- RLA5074: Strengthening Regional Capacity in **Latin America and the Caribbean** for Integrated Vector Management Approaches with a Sterile Insect Technique Component, to Control *Aedes* Mosquitoes as Vectors of Human Pathogens, particularly Zika Virus.

- INT5155: Sharing Knowledge on the Sterile Insect and Related Techniques for the Integrated Area-Wide Management of Insect Pests and Human Disease Vectors
- **BRA5060**: Using the Sterile Insect Technique to Evaluate a Local Strain in the Control of *Aedes aegypti*
- **CUB5021**: Demonstrating the Feasibility of the Sterile Insect Technique in the Control of Vectors and Pests
- MEX5031: Using the Sterile Insect Technique to Control Dengue Vectors

- More: RER5022, RAF5072, **RAS5082**, MAR5019, SRL5047, SAF5014, SUD5038, MHL5001, PHI5033

MEX5031: Using the Sterile Insect Technique to Control Dengue Vectors

Thank you!!