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Nuclear Techniques in Food and Agriculture

Insect Pest Control Newsletter

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To Our Readers

Sterile Aedes aegypti *males inside a bucket ready for release on Captiva Island, Lee County, Florida, USA. The Lee County Mosquito Control District (LCMCD) managed to significantly reduce the* Aedes *population in 2020 and to completely suppress this species in 2021 and 2022 by integrating the sterile insect technique (SIT) in an area-wide integrated pest management (AW-IPM) strategy. A key aspect of the successful campaign was the collection of the necessary baseline data for three years before the start of the releases (Source: LCMCD, USA).*

The Insect Pest Control (IPC) Subprogramme of the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture provided and continues to provide technical assistance to the Lee County Mosquito Control District (LCMCD) in Florida, USA, on the development and implementation of a pilot *Aedes aegypti* suppression project by using the sterile insect technique (SIT) integrated with other suppression methods. The results show a significant reduction of the wild mosquito population in the second semester of 2020 and complete suppression in 2021 and 2022. Unfortunately, hurricane Ian destroyed the island completely in September 2022. Access by car was not possible anymore and the SIT activities had to stop.

A key aspect of this success was a three-year-long pre-release period of baseline data collection based on entomological surveillance. The study aimed to compare ecological indexes between Sanibel Island (control area) and Captiva Island (SIT area) and the population dynamics of *Ae. aegypti* during high and low rainy seasons. The *Ae. aegypti* population fluctuated significantly on both islands between high and low rainy seasons, but there was no significant difference between Captiva and Sanibel Island for both seasons. The study emphasizes the importance of entomological data collection to understand the population dynamics of *Ae. aegypti* mosquitoes, including the impact of environmental factors such as temperature and precipitation.

Another pilot mosquito project has been successful in Valencia, Spain. Since 2017, sterile male *Ae. albopictus* have been released in Valencia's Ribera Baixa region, leading to a 75 per cent decrease in *Ae. albopictus* mosquito population. In 2022, eight million sterile male mosquitoes were released in the Ribera Baixa pilot area.

More detailed information on both mosquito projects can be found in specific articles in this Newsletter (as well as information in the previous Newsletter on pilot trials in Brazil, China, Cuba, and Sri Lanka). All those pilot trials have benefited from the considerable progress that has been made with the development of the SIT package for *Aedes* mosquitoes at the Insect Pest Control Laboratory (IPCL), mainly after 2016. Further R&D activities at the IPCL and in the Member States are required to allow the up scaling of these pilot trials to larger operational programmes.

I also would like to raise the attention to a recently published web article where nuclear applications for insect pest control by the IPC Subprogramme are presented. Besides the SIT, that most of our readers are familiar with, the article also covers inherited sterility and biocontrol.

The Mediterranean fruit fly, Ceratitis capitata*, one of the most destructive fruit pests in the world has been successfully managed by using sterile insect technique (SIT).*

Inherited sterility, also known as F1 sterility, is a derivative of the SIT and it equally involves rearing, irradiation, and release of semi-sterile male insects into a target area to reduce the mating of their fertile wild counterparts. Females are fully sterile after irradiation, as female moths are more sensitive to radiation. This technique is applied to moths that have a higher tolerance to radiation than Diptera and other insects. The released male insects have a certain degree of fertility, but all their offspring are sterile.

Biological control is a method that uses mass-production and release of the pest's natural enemies, such as predatory insects who feed on the pest's eggs and larvae, or parasites (known as parasitoids) that lay eggs into the host insect, thus killing it. Unlike the SIT and inherited sterility methods, which are used for pest control through the induction of sterility to the wild insect population, in biological control, nuclear techniques are only used for the efficient, cost-effective and safe mass production, handling and release of parasitoids. You can read the full article on the IPC website: https://www.iaea.org/newscenter/news/how-to-control-insect-pests-using-radiation.

Finally, I am pleased to inform you that a simulation of the rapid response to an outbreak of *Bactrocera dorsalis*, was successfully conducted under the framework of an IAEA Regional Technical Cooperation Project in Latin America (Strengthening Food Security through Efficient Pest Management Schemes Implementing the Sterile Insect Technique as a Control Method) in El Salvador. This exercise was jointly organized by the Organismo Internacional Regional de Sanidad Agropecuaria (OIRSA), the IAEA through its Joint FAO/IAEA Centre and Department of Technical Cooperation, and the Ministry of Agriculture of El Salvador.

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Forthcoming Events (2023–2024)

I. Research Coordination Meetings (RCMs) of FAO/IAEA Coordinated Research Projects (CRPs)

First RCM on Mosquito Male Performance. 3–7 July 2023, Vienna, Austria.

Third RCM on Mosquito Irradiation, Sterilization and Quality Control. 6–10 November 2023 (virtual).

Fourth RCM on Assessment of Simultaneous Application of SIT and MAT to Enhance *Bactrocera* Fruit Fly Management, 19–23 April 2024, Reduit, Mauritius.

Fourth RCM on Improvement of Colony Management in Insect Mass-rearing for SIT Applications, 13–17 May 2024, Patras, Greece.

Second RCM on Improve the Mass-rearing of Lepidoptera Pests for SIT Programmes. 10–14 June 2024, Kelowna, Canada.

First RCM on Improvement of *Drosophila suzukii* Mass-Rearing and Released Methods for SIT Programmes, 8–12 July 2024, Vienna, Austria.

Fourth RCM on Generic Approach for the Development of Genetic Sexing Strains for SIT Applications, 2–6 November 2024, Reduit, Mauritius.

Third RCM on Improving Rearing, Handling, and Field Components for Fruit Fly SIT Application, 11–15 November 2024, Pretoria, South Africa.

II. Consultants and Expert Meetings

Consultancy Meeting on Tsetse Population Genetics. 24–28 June 2024, Vienna, Austria.

III. Other Meetings/Events

FAO/IAEA Regional Training Course on Fruit Fly Surveillance and Identification (under Regional TC Project RAS5097). 10–14 July 2023, Kuala Lumpur, Malaysia.

FAO/IAEA Regional Training Course on Collection of Entomological Baseline Data, and Data Management Tools to Support SIT Projects for Mosquito Control (under Regional TC Project RLA5083) 10–21 July 2023, Juazeiro, Bahia, Brazil.

International Congresses of Dipterology (ICDX). 16–21 July 2023, Reno, Nevada, USA.

FAO/IAEA Regional Workshop on Public Information and Outreach on New World Screwworm Surveillance, Prevention and Eradication Programmes (under TC Project RLA5088). 24–28 July 2023, Guatemala City, Guatemala.

FAO/IAEA Regional Training Course on Socio-economic Assessment (under Regional TC Project RAF5087). 28 August–1 September 2023, Dakar, Senegal.

FAO/IAEA Interregional Training Course on Dosimetry and Irradiation Procedures to Support SIT Field Projects for Vector Control (under Regional TC Projects RLA5083, RER5026, RAS5095, RAF5087). 2–6 October 2023, Vienna, Austria.

Horizon 2020 Project, Controlling and Progressively Minimizing the Burden of Animal Trypanosomosis (COMBAT) Second Annual Meeting. 10–12 October 2023, Rome, Italy.

FAO/IAEA Regional Training Course on Area-wide Fruit Fly Integrated Pest Management Including Sterile Insect Technique (SIT) and Male Annihilation Technology (MAT) (under Regional TC project RAS5097). 6–10 November 2023, Bangkok, Thailand.

Fifth TEAM (Tephritid Workers of Europe, Africa and the Middle East) Meeting. 15–18 April 2024, Belle Mare, Mauritius.

Second TAAO (Tephritid Workers of Asia, Australia and Oceania) Meeting. 6–10 May 2024, Beijing China.

11th TWWH (Tephritids Workers of Western Hemisphere) Meeting. 26–31 May 2024, Montego Bay, Jamaica.

Past Events (2023)

I. Research Coordination Meetings (RCMs) of FAO/IAEA Coordinated Research Projects (CRPs)

Third RCM on Improvement of Colony Management in Insect Mass-rearing for SIT Applications. 27 February–3 March 2023 (virtual).

Third RCM on Generic Approach for the Development of Genetic Sexing Strains for SIT Applications. 24–28 April 2023 (virtual).

Second RCM on Improving Rearing, Handling, and Field Components for Fruit Fly SIT Application. 15–19 May 2023, Vienna, Austria.

II. Consultants and Expert Meetings

Consultancy Meeting on Thematic Plan for Lepidoptera Sterile Insect Technique. 6–10 February 2023, Vienna, Austria.

Consultancy Meeting on *Drosophila suzukii*–New Other Species for SIT. 20–24 March 2023, Vienna, Austria.

Consultancy Meeting on Thematic Plan for tsetse area-wide integrated pest management programmes involving the Sterile Insect Technique. 29 May–2 June 2023, Vienna, Austria.

III. Other Meetings/Events

FAO/IAEA Workshop on Genetic Diversity Analysis and Colony Management. 23–25 February 2023, Patras, Greece.

FAO/IAEA Regional Group Scientific Visit on Area-Wide Eradication Programmes of the New World Screwworm (under Regional TC Project RLA5088). 3–7 March 2023, Pecora, Panama.

FAO/IAEA Regional Meeting on Genetics, Breeding Procedures and Other Characteristics of the New Genetic Sexing Strain of *Anastrepha fraterculus* (Wiedmann) (under Regional TC Project RLA5087). 27–31 March 2023, Mendoza, Argentina.

FAO/IAEA Regional Training Course on Applying State of the Art Dosimetry and Quality Control Tests for South American fruit fly *Anastrepha fraterculus* Wied. (under Regional TC Project RLA5087). 8–12 May 2023, Siebersdorf, Austria.

FAO/IAEA and OIRSA Regional Workshop on Emergency Response to Outbreaks of the Invasive Bactrocera spp. Fruit Flies (under Regional TC Project RLA5082). 8–12 May 2023, San Salvador, El Salvador.

FAO/IAEA Regional Training Course on Genetic Population Studies to Support Tsetse Field Projects (under Regional TC Project RAF5087). 8–19 May 2023, Nairobi, Kenya.

FAO/IAEA Coordination Meeting on Enhancing Capacity for the Use of the Sterile Insect Technique as a Component of Mosquito Control Programs (under Regional TC Project RLA5083). 19–23 June 2023, Havana, Cuba.

5th WHO Meeting of Stakeholders on Elimination of Human African Trypanosomiasis (Gambiense and Rhodesiense). 7–9 June 2023, Geneva, Switzerland.

Technical Cooperation Projects

The Insect Pest Control Subprogramme currently has technical responsibilities for the following technical cooperation projects that are managed by the IAEA's Department of Technical Cooperation. They can be classed under four major topics, namely:

- Biocontrol using radiation
- Human disease vectors
- Livestock pests
- Plant pests

Country	Project Number	Ongoing National Projects	Technical Officer
Bangladesh	BGD5035	Validating the Sterile Insect Technique as a Key Component of an Area-Wide Integrated Pest Management Programme Against *Aedes aegypti* in Dhaka	Maylen Gómez
Bolivia	BOL5023	Fruit Fly Control in Bolivia Using Integrated Pest Management Including the Sterile Insect Technique	Walther Enkerlin
Brazil	BRA5061	Using the Sterile Insect Technique to Apply a Local Strain in the Control of *Aedes aegypti* (Phase II)	Rui Cardoso Pereira
Burkina Faso	BKF5023	Implementing the Sterile Insect Technique to Reduce Wild Populations of *Aedes aegypti* and Tsetse	Adly Abdalla Maylen Gómez
Cameroon	CMR5026	Supporting the National Fruit Fly Management Programme	Daguang Lu
Cambodia	KAM5006	Implementing Fruit Fly Surveillance and Control Using Area-wide Integrated Pest Management	Daguang Lu
Chad	CHD5011	Implementing the Sterile Insect Technique to Control *Glossina fuscipes fuscipes* — Phase II	Adly Abdalla Chantel de Beer
Chile	CHI5051	Implementing Pilot Level of Sterile Insect Technique for Control of *Lobesia botrana* in Urban Areas	Walther Enkerlin
China	CPR5026	Applying the Sterile Insect Technique as Part of an Area-wide Integrated Pest Management Approach to Control Two Fruit Flies	Daguang Lu
China	CPR5027	Demonstrating Feasibility of the Sterile Insect Technique in the Control of the Codling Moth, *Cydia pomonella*	Walther Enkerlin
Cuba	CUB5021	Demonstrating the Feasibility of the Sterile Insect Technique in the Control of Vectors and Pests	Rui Cardoso Pereira
Cyprus	CYP5020	Developing a National Rapid Response Strategy for the Prevention of the Establishment of the Asian Tiger Mosquito	Jeremy Bouyer
Dominican Republic	DOM0006	Building and Strengthening the National Capacities and Providing General Support in Nuclear Science and Technology	Walther Enkerlin
Ecuador	ECU5031	Enhancing the Application of the Sterile Insect Technique as Part of an Integrated Pest Management Approach to Maintain and Expand Fruit Fly Low Prevalence and Free Areas	Walther Enkerlin

Ecuador	ECU5032	Building Capacity for Mass Rearing, Sterilization and Pilot Release of *Aedes aegypti* and *Philornis downsi* Males	Maylen Gómez Walther Enkerlin
Ethiopia	ETH5023	Enhancing Livestock and Crop Production through Consolidated and Sustainable Control of Tsetse and Trypanosomosis to Contribute to Food Security	Chantel de Beer
El Salvador	ELS5015	Integrated Management of Fruit Flies using the Sterile Insect Technique to Establish Areas of Low Prevalence of Fruit Flies	Walther Enkerlin
Fiji	FIJ5003	Implementing Pesticide-Free Suppression and Management of Fruit Flies for Sustainable Fruit Production	Daguang Lu
Grenada	GRN0001	Building National Capacity through the Applications of Nuclear Technology	Rui Cardoso Pereira
Guatemala	GUA5021	Strengthening National Capabilities for the Control of Agricultural Pests Using Nuclear Technologies	Walther Enkerlin
Israel	ISR5021	Assisting in the Development of a Strategy to Counteract *Bactrocera zonata*	Walther Enkerlin
Israel	ISR5022	Establishing the Sterile Insect Technique Methodology for the Management of the False Codling Moth, *Thaumatotibia leucotreta*, and Enhancing Integrated Pest Management Against the Peach Fruit Fly, *Bactrocera zonata*	Walther Enkerlin
Jamaica	JAM5014	Establishing a Self-Contained Gamma Irradiation Facility for the Introduction of Sterile Insect Technique and Experimental Mutagenesis and Diagnostic Technologies	Rui Cardoso Pereira
Libya	LIB5014	Supporting Control of Fruit Flies by Establishing a Low Fruit Fly Prevalence Zone	Daguang Lu
Mauritius	MAR5028	Enhancing National Capabilities on the Suppression of *Aedes albopictus* in an Urban Locality Using the Sterile Insect Technique as Part of an Integrated Vector Management Strategy	Maylen Gómez
Mexico	MEX5032	Scaling Up the Sterile Insect Technique to Control Dengue Vectors	Kostas Bourtzis
Morocco	MOR5038	Strengthening the Use of the Sterile Insect Technique	Walther Enkerlin Carlos Cáceres
Myanmar	MYA5029	Improving Fruit Yield and Quality by Using Sterile Insect Techniques as Part of Area-Wide Integrated Pest Management of Fruit Flies in the Mandalay Region	Daguang Lu
Palau	PLW5003	Facilitating Sustainability and Ensuring Continuity of Area-wide Pest Management — Phase III	Daguang Lu
Portugal	POR5006	Integrating the Sterile Insect Technique in the Control of the Invasive Vector Mosquito *Aedes albopictus*	Maylen Gómez
Senegal	SEN5040	Strengthening National Capacities to Create a Tsetse-Free Zone Using the Sterile Insect Technique	Marc Vreysen

South Africa	SAF5015	Supporting the Control of Nagana in South Africa Using an Area-wide Integrated Pest Management Approach with a Sterile Insect Technique Component - Phase I	Marc Vreysen
South Africa	SAF5017	Assessing the Sterile Insect Technique for Malaria Mosquitoes — Phase III	Hanano Yamada
Seychelles	SEY5012	Establishing Area-wide Integrated Pest Management by Using the Sterile Insect Technique in Combination with Other Control Methods on the Suppression of the Melon Fly	Rui Cardoso Pereira
Sudan	SUD5042	Implementing the Sterile Insect Technique for Integrated Control of *Anopheles arabiensis* — Phase III	Adly Abdalla
Turkey	TUR5026	Conducting a Pilot Program on Integrated Management of *Aedes aegypti* Including Sterile Insect Technique	Maylen Gómez
Turkey	TUR5027	Implementation of SIT for Suppression and Eradication of Medfly in Turkey	Daguang Lu
United Republic of Tanzania	URT5034	Implementing Pre-Operational Activities for the Elimination of *Glossina swynnertoni* through Area-wide Integrated Pest Management with a Sterile Insect Technique Component	Chantel de Beer
United Republic of Tanzania	URT5035	Implementing the Sterile Insect Technique as Part of Area-wide Integrated Pest Management for Controlling Invasive Fruit Fly Populations	Daguang Lu
		Ongoing Regional Projects	
Regional Africa	RAF5074	Enhancing Capacity for Detection, Surveillance and Suppression of Exotic and Established Fruit Fly Species through Integration of Sterile Insect Technique with Other Suppression Methods	Daguang Lu
Regional Africa	RAF5087	Enhancing Regional Capacity for the Implementation of the Sterile Insect Technique as a Component for Area-Wide Tsetse and Trypanosomosis Management (AFRA)	Maylen Gómez
Regional Asia & the Pacific	RAS5086	Assessing the Efficiency of the Sterile Insect Technique for the Control of the Cocoa Pod Borer	Marc Vreysen
Regional Asia & the Pacific	RAS5090	Advancing and Expanding Area-wide Integrated Management of Invasive Pests, Using Innovative Methodologies Including Atomic Energy Tools	Walther Enkerlin
Regional Asia & the Pacific	RAS5095	Enhancing the Capacity and the Utilization of the Sterile Insect Technique for *Aedes* Mosquito Control	Marc Vreysen
Regional Asia & the Pacific	RAS5097	Strengthening and Harmonizing Surveillance and Suppression of Fruit Flies	Daguang Lu Rui Cardoso Pereira
Regional Europe	RER5026	Enhancing the Capacity to Integrate Sterile Insect Technique in the Effective Management of Invasive *Aedes* Mosquitoes	Wadaka Mamai Jeremy Bouyer
Regional Latin America	RLA5082	Strengthening Food Security through Efficient Pest Management Schemes Implementing the Sterile Insect Technique as a Control Method	Walther Enkerlin

Regional Latin America	RLA5083	Enhancing Capacity for the Use of the Sterile Insect Technique as a Component of Mosquito Control Programmes	Maylen Gómez
Regional Latin America	RLA5084	Developing Human Resources and Building Capacity of Member States in the Application of Nuclear Technology to Agriculture	Walther Enkerlin Rui Cardoso Pereira
Regional Latin America	RLA5087	Validating the Sterile Insect Technique for the Control of the South American Fruit Fly (ARCAL)	Walther Enkerlin
Regional Latin America	RLA5088	Advancing Surveillance and Progressive Control of the New World Screwworm Using the Sterile Insect Technique	Walther Enkerlin

Highlights of Technical Cooperation Projects

Strengthening Food Security through Efficient Pest Management Schemes Implementing the Sterile Insect Technique as a Control Method (RLA5082)

Regional Workshop on the Execution of an Emergency Plan Drill for Eradication of Outbreaks of Invasive Regulated Species of the Genus *Bactrocera spp.*

The regional workshop was organised within the framework of a Practical Arrangement between the International Regional Plant and Animal Health Organisation (OIRSA) of Central America and the IAEA. The event was hosted and coordinated by OIRSA with the support from the IAEA through its Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture and its Department of Technical Cooperation. It was held from 8–12 May 2023 in the city of San Salvador, El Salvador.

Participants to the regional workshop (San Salvador, El Salvador).

Thirty-two participants from El Salvador, Guatemala, Honduras, Mexico, and Panama attended the workshop. The IAEA supported the meeting with the scientific programme and by facilitating an international expert, Mr. Cesar Paredes. Participants were exposed to 40 hours of theory and practical hands-on training including: 1) Background of fruit fly species of the genus *Bactrocera* spp. Including the most important regulated species, 2) Principles of the Male Annihilation Technique (MAT), 3) Available tools for detection and eradication of *Bactrocera spp.* Outbreaks, 4) Strategy for the implementation of the contingency plan, 5) Control and eradication actions, and 6) Completion of the FAO/IAEA virtual course entitled "Action Plan in Case of the Detection of Regulated Fruit Flies of the *Bactrocera* Genus in Latin America and the Caribbean".

Validating the Sterile Insect Technique for the Control of the South American Fruit Fly (RLA5087)

Regional Meeting on Genetics, Artificial Rearing and other Characteristics of the New Genetic Sexing Strain of the South American Fruit Fly *Anastrepha fraterculus*

The meeting was hosted and coordinated by the Argentina Servicio Nacional de Sanidad y Calidad Agroalimentaria (SENASA) with support of the IAEA through its Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture and Department of Technical Cooperation and held from 27–31 March 2023 in the City of Mendoza, Argentina. Thirty-seven participants from Argentina, Brazil, Chile, Ecuador, Paraguay, Peru, Uruguay, and Venezuela attended the meeting. The IAEA supported the meeting by facilitating the participation of two international experts, Mr Gerardo Ortiz Moreno and Mr Vicente Hernandez Ortiz.

Participants to the regional meeting on Genetics, Artificial Rearing and other Characteristics of the New Genetic Sexing Strain of the South American Fruit Fly. (Mendoza, Argentina).

The objectives of the meeting were: (1) to present and discuss the *status quo* on the *A. fraterculus* morphotypes that are prevalent in South America; (2) to draft a regional strategic plan for the control of *A. fraterculus* using area-wide sterile insect technique (AW-SIT) strategy and (3) to draft a regional master plan to guide the Member States on the necessary milestones for implementation of national programmes for the control of *A. fraterculus* at national and regional levels.

The most relevant results obtained were: (1) Confirmation of the presence of at least eight morphotypes of *A. fraterculus* in the region, including: Andean, Brazilian -1, -2 and -3, Ecuadorian, Mexican, Peruvian, and Venezuelan. The morphotypes have shown to have different host range. The families of hosts more frequently affected include Myrtaceae (27.1%), Rosaceae (11.9%) and Rutaceae

(8.5%). Among these, guava (Myrtaceae) is the only common host being infested by *A. fraterculus* across the different tropical and subtropical regions in Central and South America. The number of the hosts has been recorded in Brazil (121), Argentina (40), Ecuador (40), Colombia (38), Venezuela (24) and Mexico (19); (2) In most cases there is a lack of hard data on the level of damage in different fruit hosts and corresponding losses from the pest in the countries as well as on control costs including insecticides and other control practices; (3) Argentina, Brazil and Peru have made significant progress in the research and development of the SIT for control of *A. fraterculus*, whereas, in the case of Ecuador, Paraguay, Uruguay and Venezuela are in the initial stages including the characterisation of the *A. fraterculus* problem and in some cases the application of basic IPM (integrated pest management) practices and (4) The main strategic activities that should be implemented in each country to embark on an AW-SIT control programme were identified as well as the main elements to be considered in each country to formulate a Master Plan.

Recommendations to the Member States include the following priorities: (1) to define the prevalent *A. fraterculus* morphotypes that occur in Ecuador, Paraguay, Uruguay and Venezuela; 2) to conduct baseline data collection including population fluctuation, host sequence and damage levels by host; (3) to conduct technical and economic feasibility studies as a basic tool for decision making; (4) to exchange information on the *A. fraterculus* situation among the Member States and (5) to continue the efforts towards validation of SIT against *A. fraterculus* within the framework of the Regional TC Project RLA5087.

Regional Training Course on Applying State of the Art Dosimetry and Quality Control Tests for the South American Fruit Fly *Anastrepha fraterculus*

Participants to the regional training course (Seibersdorf, Austria).

The regional training course was held from 8–12 May 2023 at the Insect Pest Control Laboratory (IPCL), Seibersdorf, Austria. Eight participants from Argentina, Brazil, Ecuador, Peru attended 40 hours of theory and practical hands-on training, which included: 1) Principles of irradiation and dosimetry for insect sterilization, 2) Theory and practice on Gafchromic dosimetry, 3) Practical exercise of irradiation and dosimetry with Gamma and X-ray, 4) Analysis of films and creating a dose map and calibration, and 5) Theory and practice of quality control.

This training course is part of the capacity building activities under the regional technical cooperation project RLA5087 and aims to validate the sterile insect technique (SIT) against *Anastrepha fraterculus* in South America.

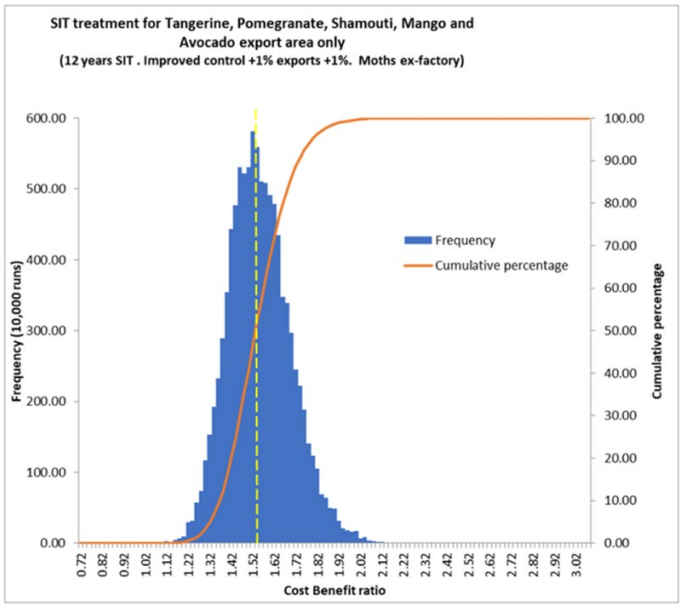
Establishing the Sterile Insect Technique Methodology for the Management of the False Codling Moth, *Thaumatotibia leucotreta*, And Enhancing Integrated Pest Management Against the Peach Fruit Fly, *Bactrocera zonata* (ISR5022)

Feasibility Assessment Estimating the Returns on Investment of False Codling Moth Control in Israel Using an IPM-SIT Based Approach

The False Codling Moth (FCM) is a non-native invasive species having first been discovered in Israel in 1984 and as a result, it would be a appropriate exercise to suppress or eradicate the moth from areas within the country or from the entire country, were economically viable. The FCM has subsequently spread to large areas of the fruit growing regions in the country although some more geographically isolated are certified as pest-free areas (PFA). It should therefore be possible to establish other such zones through the application of an integrated pest management (IPM) scheme that incorporates area-wide sterile insect technique (AW-SIT).

The export of fruit, especially citrus tangerines, pomegranate, mango and avocado, to the European Union (EU) and elsewhere is a significant industry and would benefit from better protection to ensure continued access to these markets. The current ‘systems approach’ to ensuring moth free fruit for export to the EU is resource heavy and adds significant costs to the process. There may be future opportunities to grow the export market through improved control or eradication, but currently the primary objective of the project is to protect the existing exports by ensuring the FCM is absent or undetected in exported fruit. Establishing moth free areas, that can subsequently be certified, would remove the costs of running the systems approach. It may also be possible in the longer term to eradicate the FCM from Israel completely, but this would necessitate the treatment of all host areas including the significant areas of Castor Bean plant, back yard fruit and all other orchards or wild host areas which is likely to be prohibitively expensive unless exports can be increased significantly alongside this activity.

Control of FCM using SIT is technically and economically feasible and offers a way of reducing both insecticides use in the crop and costs of meeting the systems approach. In isolated areas it is likely to be possible to eradicate the FCM population and establish PFA. There are, however, significant areas of wild hosts, especially castor bean plant but, with little detailed spatial data available, it is hard to assess the viability of a country-wide eradication.



Distribution of cost benefit ratio obtained when all export fruit areas are treated with the sterile insect technique (SIT).

The model of inputs, costs and benefits developed for this assessment by Jon Knight from the United Kingdom, was used to derive benefit indices for a feasible suppression plan for the major affected fruit crops. The outcomes were, in most cases, likely to have a positive result in terms of returns on investment.

Advancing Surveillance and Progressive Control of the New World Screwworm Using the Sterile Insect Technique (RLA5088)

FAO/IAEA Regional Training Course on New World Screwworm (*Cochlyiomya hominivorax*) Diagnostics

A regional training course on New World Screwworm (*Cochlyiomya hominivorax,* Coquerel) (or NWS) diagnostics was held in Montevideo, Uruguay, from 5 to 9 December 2022. The training course was hosted and coordinated by the Ministry of Livestock, Agriculture, and Fisheries (MGAP) of Uruguay, with support of the IAEA and FAO through its Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture and Technical Cooperation. Nineteen participants from 11 Member States attended the course (Bolivia, Brazil, Chile, Dominican Republic, Ecuador, Guatemala, Honduras, Panamá, Paraguay, Peru, and Uruguay).

The objectives of the training course were: (1) To learn about morphological identification of adults and larvae of the NWS through theory and practical sessions, (2) To learn about the monitoring of NWS using traps for adults and through larvae collections from affected livestock, and (3) To conduct genitalia dissections of female ovaries to learn about the age of females and of spermatheca for interpretation of mating which is relevant in the application of the sterile insect technique (SIT).

Series of lectures, laboratory and field practices were held covering the topics on: (1) Biological and structural characteristics of the NWS, (2) Differential diagnostic between the NWS and associated species that cause myiasis including *Cochliomyia macellaria*, *Chrysomyia bezziana*, *C. megacephala*, *C. rufifacies*, *Lucilia s*p, *Musca domestica*, *Fannia scalaris*, *Dermatobia hominis*, *Oestrus ovis* and Sarcophagidae, and (3) Taxonomic keys and how to use them.

*Participants to the regional training course on New World Screwworm (*Cochlyiomya hominivorax*) Diagnostics, (Montevideo, Uruguay).*

The training is part of the capacity building for NWS management including, in some cases, eradication using the SIT within the framework of the Regional TC project RLA5088.

Enhancing Regional Capacity for the Implementation of the Sterile Insect Technique as a Component for Area-Wide Tsetse and Trypanosomosis Management (RAF5087)

FAO/IAEA Regional Training Course on Genetic Population Studies to Support Tsetse Field Projects

The regional training course was hosted by the International Centre of Insect Physiology and Ecology (ICIPE) and was officially opened by Mr Daniel Masiga, the Head of Animal

and Human Health, ICIPE. The training course was attended by 15 participants from Ethiopia, Ghana, Kenya, Mozambique, Nigeria, South Africa, Uganda, United Republic of Tanzania, Zambia, Zimbabwe and two local participants from ICIPE as well.

Participants to the FAO/IAEA Regional Training Course on Genetic Population Studies to Support Tsetse Field Projects (Nairobi, Kenya).

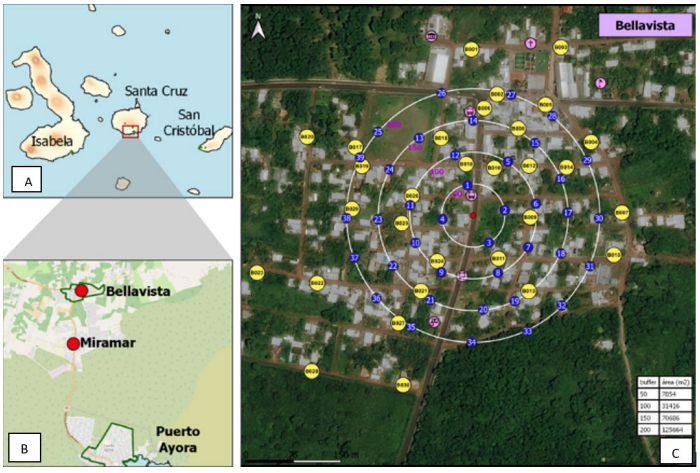
The training was well organized and most of the objectives were covered, despite the time limits to cover all the planned data analysis. The analysis was done on the data generated during the first week of the training and the first two and half days in the second week were devoted to conduct the quality control checks for the data. The analysis of the genetic variation between population, the effective population size, the isolation by distance, the dispersal and number of immigrant and the migration rates were calculated.

Building Capacity for Mass-rearing, Sterilization and Pilot Release of *Aedes aegypti* and *Philornis downsi* Males (ECU5032)

In the last decade, Ecuador has reported an increase in the number of cases of relevant diseases for public health such as dengue, chikungunya, and Zika. The primary local vector of the arboviruses causing the above-mentioned diseases in Ecuador is the mosquito, *Aedes aegypti,* with its control strategy mainly restricted to the intensive use of chemical insecticides which had a negative impact on the environment and has also increased the selection of mosquito population resistant to insecticides.

Currently, *Ae. aegypti* is widely distributed in continental Ecuador from the lowlands of the Pacific Coast and the Amazon basin to the highlands up to 1 650 meters above sea level, and is also present in Galapagos Archipelago. Since 2020, the Ecuadorian Instituto Nacional de Salud Pública (INSPI - National Public Health Institute) in collaboration with the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture and the Ecuadorian Agencia de Bioseguridad de Galapagos (ABG-Galapagos Biosafety Agency), initiated a project aiming to evaluate the feasibility to use the sterile insect technique (SIT) to suppress the mosquito population from Bellavista (SIT area) having Miramar as control area, two small villages located at Santa Cruz Island (Galapagos). During the study period, INSPI has made good progress in capacity building at national level including monitoring activities which started on May 2021 in both areas to collect baseline entomological data and characterize the mosquito population profile.

Likewise, a collaborative field laboratory was setup between INSPI and ABG in Santa Cruz Island to receive the shipments of sterile males, and support handling procedures and field activities. The INSPI's insectary in mainland Quito, has also been upgraded with new equipment and materials with the support of the Joint FAO/IAEA Centre to ensure local and basic mosquito rearing activities. Laboratory mosquito colonies were also successfully established, and mosquito mass-production was recently scaled-up to support the sterile male demand to conduct the first mark-release-recapture (MRR) study in Bellavista village. For the MRR study, around 90 000 sterile males were released in Bellavista village at Santa Cruz Island. This number required two shipments by airplane of chilled sterile mosquitoes on 8 and 11 March 2023 from the INSPI's insectary. Two external experts, Ms Aline Macedo (Moscamed Brazil) and Mr Danilo Carvalho (external consultant) supported the conduction of first MRR. Experts trained the local staff on rearing, marking, handling, releasing mosquitoes and basic field procedures and analysis.



Map of Galapagos Islands, Ecuador (A), illustrating the research areas Bellavista and Miramar (B). Geographic location and trapping network in the mark-release-recapture area (Bellavista), using ovitraps (blue points) to collect eggs, and BG-Sentinel adult trap (yellow points) (C).

In addition, the counterpart has developed a strong commitment with the health ministry and a solid collaboration with local authorities from Santa Cruz Island, which will be crucial for the project implementation and to support the upcoming phase; the systematic releases of sterile male in the field are planned to start in early 2024.

Coordinated Research Projects (CRPs)

Project Number	Ongoing CRPs	Project Officer
D4.30.03	Integration of the SIT with Biocontrol for Greenhouse Insect Pest Management (2017–2022)	Carlos Cáceres
D4.20.17	Improvement of Colony Management in Insect Mass-rearing for SIT Applications (2018–2023)	Adly Abd Alla
D4.10.27	Assessment of Simultaneous Application of SIT and MAT to Enhance *Bactrocera* Fruit Fly Management (2019–2024)	Rui Cardoso Pereira
D4.40.03	Generic Approach for the Development of Genetic Sexing Strains for SIT Applications (2019–2024)	Kostas Bourtzis
D4.40.04	Mosquito Radiation, Sterilization and Quality Control (2020–2025)	Hanano Yamada
D4.10.29	Improving Rearing, Handling, and Field Components for Fruit Fly SIT Application (2021–2026)	Walther Enkerlin
D4.10.28	Improve the Mass-Rearing of Lepidoptera Pests for SIT Programmes (2022–2027)	Daguang Lu
D4.40.05	Reproductive Biology of Male Aedes Mosquitoes for SIT Applications (2023–2028)	Maylen Gomez

Third RCM on Improvement of Colony Management in Insect Mass-rearing for SIT Applications 27 February–3 March 2023 (virtual)

The RCM was held virtually with twenty-three participants and thirty-one observers from eighteen Member States including Australia, Argentina, Brazil, Burkina Faso, Cameroon, Canada, Greece, Germany, Guatemala, Israel, Italy, Kenya, France, Mexico, Netherlands, Spain, United Republic of Tanzania, and United States of America. The first two days of the meeting were devoted to the presentations focused on the research progress achieved during the past 18 months whereas during the remainder of the meeting the participants discussed the major achievements and the recommendations in three working groups on tsetse, fruit flies and insect pathogens.

During the discussion it was concluded that the CRP made important progress in developing new GSS of the Mediterranean fruit fly to facilitate the refreshment of the colony with wild materials as well as developing and evaluating bi-environmental cage.

In addition, the discovery of new viruses in fruit flies and tsetse was highlighted. Moreover, the complete genomes of several gut bacteria have been advanced. The population genetics of several insect species was conducted and the impact of *Spiroplasma* infection in tsetse colony was studied. The issue of publishing a special issue in a scientific peer-reviewed journal was discussed.

Assessment of the mating compatibility of tsetse fly Glossina f. fuscipes.

Third RCM on Generic Approach for the Development of Genetic Sexing Strains for SIT Applications, 24–28 April 2023 (virtual)

The RCM was held virtually and attended by 22 research contract and agreement holders, and as well as 32 observers from Argentina, Australia, Cameroon, Canada, China, Czech Republic, Germany, Greece, Guatemala, Israel, Italy, Mexico, South Africa, Switzerland, Thailand, United Kingdom, and United States of America.

Research progress on identification and characterization of genes that can be used as selectable markers for construction of genetic sexing strains (GSS) for SIT target insect pest and vector species were presented by 23 participants. Emphasis was given on genes involved on pupal, eye and body coloration as well as on temperature sensitivity. There were reports on how novel genetic and molecular biology methods can be exploited for linking the wild type allele of these genes to male determining regions which will allow the development and use of a new generation of genetic sexing strains for SIT applications against insect pests and disease vectors.

Novel medfly white pupae strains developed in the frame of this CRP (Photo credit: Maria Eleni Grigoriou).

The CRP has been quite successful in respect to the identification and characterization of key genes, including *temperature sensitive lethal* (*tsl*) genes, and the use of novel methods for producing mutant strains as well as genetic sexing strains. Future efforts should focus on the development of an efficient way of linking the rescue alleles close to the male determining regions and the quality control analysis of the newly developed strains.

Second RCM on Improving Rearing, Handling, and Field Components for Fruit Fly SIT Application. 15–19 May 2023, Vienna, Austria

The RCM was held in Vienna and attended by 25 scientists from Argentina, Australia, Brazil, Burkina Faso, Guatemala, Israel, Mauritius, Mexico, Spain, South Africa, United States of America, and Viet Nam.

The scope of the research work done during the past 18 months included various topics related to fruit fly production, post-production, and field operations research.

Participants of the Second RCM on Improving Rearing, Handling, and Field Components for Fruit Fly SIT Application, (Vienna, Austria).

Relevant findings included: possibility of partially replacing diet ingredients such as Torula Yeast by Soybean, identification of genetic markers potentially linked to phenotypes of interest such as male specific genes and male mating success, identification of two individual volatile compounds capable of stimulating the calling behaviour of *Anastrepha fraterculus* males, assessment and modification of smart-trap prototypes based on image recognition for the detection of *Ceratitis capitata, Bactrocera zonata* and *Bactrocera dorsalis*, and parameter analysis for TrapGrid model focused on the pest movement. The relevance of focusing on applied research to find cost-effective solutions to problems being faced by fruit fly SIT operational programmes was highlighted.

Developments at the Insect Pest Control Laboratory (IPCL)

Genetics and Molecular Biology

Evaluation of An *Aedes aegypti* White Eye-based Genetic Sexing Strain with and without Inversion

Genetic sexing strains (GSS) of *Aedes aegypti* have already been developed in the IPCL by exploiting eye colour mutations, resulting in the Red-eye GSS (RGSS) and the White-eye GSS (WGSS). The *white eye (we)* gene is located on chromosome 1 and the inheritance of the mutant phenotype is controlled by a sex-linked, recessive gene. The WGSS was constructed using classical genetic approaches and its males are heterozygous with a normal "wild-type" phenotype (black eye) while the females are homozygous for the recessive allele of the selectable marker (white eye). The quality control analysis of the RGSS and the WGSS involved evaluation of the sex ratio, duration of the larval development, productivity, and lifespan. Significant differences were detected in productivity and lifespan which clearly demonstrated the prominence of the RGSS in terms of biological quality and genetic stability compared to the WGSS.

Genetic recombination phenomena can affect the stability of a GSS, and therefore, chromosomal inversions have been proposed as genetic stability enhancers. A chromosomal inversion (Inv35) was developed on chromosome 1 of *Ae. aegypti* and has been used successfully to reduce recombination rate and increase the genetic stability of the RGSS. Having been encouraged by this result, the long-term genetic stability and biological quality of WGSS, with and without the Inv35, was evaluated recently in the IPCL.

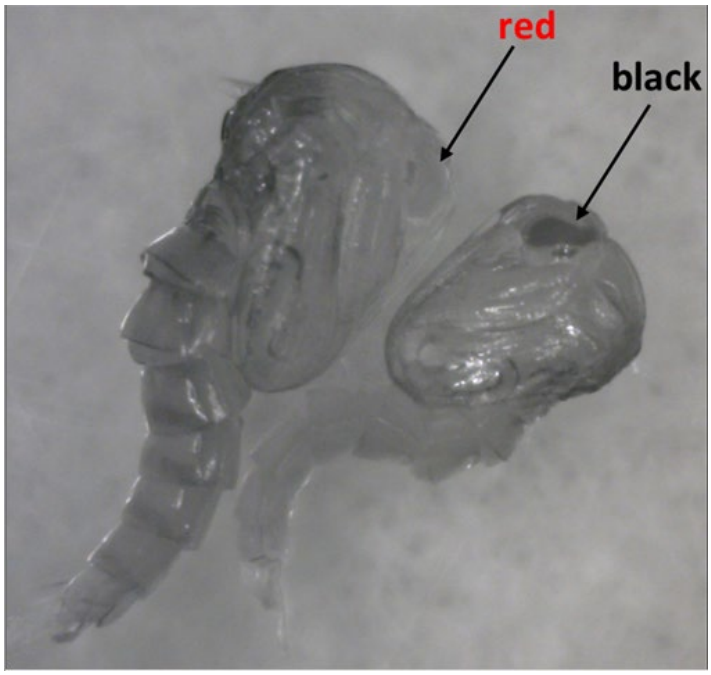
The recombination rate of the WGSS/Inv35, under filtering and non-filtering conditions was assessed for up to 16 generations to evaluate its genetic stability. The results suggested that WGSS/Inv35 presents a low recombination rate and long-term genetic stability when recombinants are removed from the colony (filtering) and a slow accumulation of recombinants when they are not removed from the colony (non-filtering).

The quality control analysis involved the assessment of female fecundity, fertility, pupal weight, pupation time, recovery rates during development, adult sex ratio, survival rate and flight ability. WGSS and WGSS/Inv35 strains were similar with respect to fecundity, pupal and adult recovery rates, pupation time, and pupal weight. However, the quality parameters of fertility, survival rate of females, and flight ability of males showed significant differences between the two strains. Lower fertility, higher survival rate of females, and better flight ability of males was demonstrated by the WGSS/Inv35 compared to the WGSS.

Even though WGSS and WGSS/Inv35 do not present major differences in terms of biological quality and the presence of Inv35 enhances genetic stability, they still remain inferior to RGSS and RGSS/Inv35, as reported in the past. The initially constructed RGSS and WGSS were comparatively assessed, and it was shown that the RGSS was a better performing strain in several quality control parameters. RGSS and RGSS/Inv35 were also introgressed into different genomic backgrounds, their sexing properties remained fully functional, while the recombination-suppressing activity of Inv35 was not affected for a long sequence of generations. Accordingly, the RGSS remains a front-runner when it comes to SIT applications aiming to suppress *Ae. aegypti* populations.

Near Infrared Imaging of *Aedes aegypti* Red-eye GSS

The Red-eye GSS (RGSS) of *Aedes aegypti* with and without Inv35 has been thoroughly assessed for its biological quality, genetic stability, and the ability of its irradiated males to suppress a target population in laboratory cage experiments.



Black and red eye as seen under the infrared light (Photo credit: Katerina Nikolouli).

The encouraging results of the quality tests, the great potential to fully suppress a target laboratory cage population within six weeks and the significant reduction of female contamination after the incorporation of Inv35 has raised the RGSS into a first-line candidate for SIT applications. However, use of RGSS at an operational level

requires a sex separation system that will not be time-consuming, labour-intensive, and prone to human errors. The eye colour can be distinguished when exposed in near-infrared light. Under this light, which is invisible to the human eye, the black eye is visible while the red eye is transparent.

Infrared cameras at several wavelengths were tested with the *Ae. aegypti* RGSS and it was shown that the eye can be distinguished at all developmental stages, from early larvae to pupae and adults. Thus, the development of a sorting system based on infrared cameras bears great potential and can support *Ae. aegypti* operational SIT suppression programmes.

Plant Pests

New Generation of Genetic Sexing Strains Facilitate Colony Refreshment for SIT Applications: Proof-of-principle in the Mediterranean Fruit Fly

The refreshment of the colonies of genetic sexing strains (GSS), such as the *Ceratitis capitata* (Mediterranean fruit fly or medfly) VIENNA 8 strain, with wild material is frequently needed, as laboratory domestication causes significant genetic changes in insect colonies, including GSS, which may affect their sexual behaviour.

However, this is a time-consuming and challenging process because wild males do not carry the translocation and wild females are not easily adapted to the artificial oviposition behaviour. To overcome these challenges, we have developed a new generation of GSS which facilitates the refreshment with wild genetic material, and hence increase genetic variability and potentially improve the sexual compatibility with the target population in the field.

Mr Gustavo Taret performing comparative quality control test to assess the quality of the new medfly genetic sexing lines.

Males from the mutant strain were irradiated to produce the new type of translocation T(X; A). Irradiated males were mass-crossed with wild-type females. Single pairs were then set up between F1 females and wild-type males. The established families were screened to select those that produced males with the wild-type phenotype and females with the mutant phenotype in subsequent generations. An additional selection step was applied to identify families in which the females could be eliminated thus establishing a novel GSS for further evaluation.

Ms Evelin Vazquez performing screening experiments for the isolation of new genetic sexing lines of Medfly.

Novel medfly GSS were constructed, which have similar characteristics with the T(Y;A)-based VIENNA 8 GSS. Their unique advantage is that they enable the smooth and controlled introduction of fresh genetic material into mass-reared colonies, potentially improving the quality of mass-produced males and the efficacy of medfly SIT action programs.

Mr Gustavo Taret, a consultant from Argentina, has been evaluating the strains under larger rearing conditions to assess its genetic stability and production and quality control profile before and after introgression in the genetic background from Guatemala. Ms Evelin Vázquez Romero, an intern from Mexico, has been assigned to help with the isolation of new lines for further evaluation.

Production and Quality Control Parameters of the New Black Pupae Genetic Sexing Lines of *Anastrepha fraterculus*

Recently, the Plant Pest Group of the IPCL developed a GSS of the South American fruit fly *Anastrepha fraterculus* based on a black pupae marker. The GSS was named Af IPCL-89 and the strain will allow separation of sexes at the pupal stage. The strain has been transferred to the University of Sao Paulo, Brazil, and the Instituto Nacional de Tecnologia Agropecuaria (INTA), Buenos Aires, Argentina for further characterization. To assess the possibility to have a GSS with a better production and quality profile, another set of translocations were induced by exposing males to sub-sterilization radiation doses and subjecting the treated males to proper GSS isolation schemes. Six new lines have been isolated and evaluated at a small scale using 1 000 eggs during 5 replications. Line Af IPCL –172 and Line Af IPCL – 9 have shown acceptable production and quality control profiles in comparison to the first line Af IPCL-89. Therefore, their evaluation at mass-rearing level should be

performed to determine the production and quality control profile in comparison with the Af IPCL-89 GSS line.

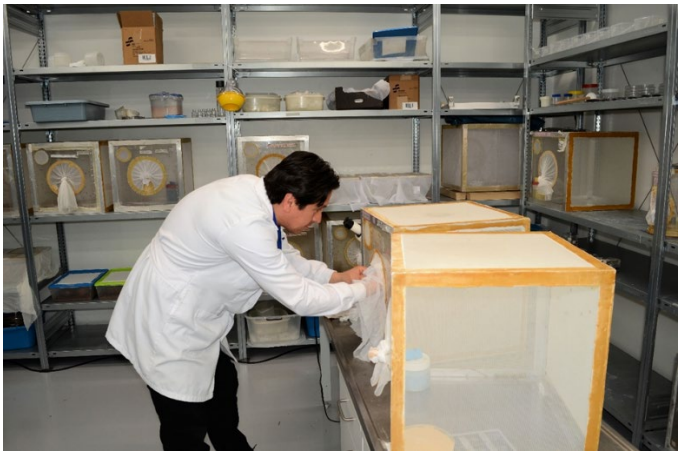
Construction of a Black Pupae Genetic Sexing Strain (GSS 89) of *Anstrepha fraterculus* with a Genetic Background from Ecuador

It is commonly accepted that the nominal species *Anastrepha fraterculus* is a cryptic species complex and previous studies have demonstrated the existence of high levels of mating isolation between populations from South Brazil, the coastal areas of Peru and hence, most probably also Ecuador. These results have indicated that these two populations belong to different biological entities within the *A. fraterculus* cryptic species complex. Consequently, any fly colony that would be used for a SIT programme should be derived from the target population.

Before the newly developed *Anastrepha fraterculus* (Af) black pupae GSS is transferred to Ecuador, it is mandatory to carry out a series of crosses and backcrosses to introgress the genetic background from Ecuador into the AF black pupae GSS.

Henry Fabian Troya Armijos from Ecuador is on a 6 month's fellowship, supported by TC project RLA5087, and has been conducting backcrosses and crosses between wild males from Ecuador and females from the black GSS Af-IPCL-89, as well as translocated males from Af-IPCL-89 and wild females from Ecuador.

To overcome the sexual incompatibility between Equatorian flies and GSS Af-IPCL-89, which was originally derived from wild flies collected in the south of Brazil and the north of Argentina, we will complete a series of six introgressions of genetic background from Ecuador into the GSS Af-IPCL-89. That will allow us to use the same male translocation and the black pupae phenotypic marker to create a new GSS from Ecuador.



Mr Henry Fabian Troya Armijos, a TC fellow from Ecuador sexing mature adults of Anastrepha fraterculus *for mating compatibility tests.*

Mr Troya intends to conduct a mating compatibility test following the three series of introgressions to assess the sexual compatibility of the strain.

FAO/IAEA/USDA Phytosanitary Treatment Project

Research has been initiated to evaluate the potential synergetic effects of low oxygen conditioning, chilling, and ionizing radiation on phytosanitary irradiation efficacy against *Drosophila suzukii*. A paper summarizing the validation of a phytosanitary irradiation treatment for *D. suzukii* and its effectiveness under modified atmospheres has been submitted for publication. The publication of our research findings, combined with previous studies, will support the submission of a phytosanitary irradiation treatment for *D. suzukii* to International Plant Protection Convention (IPPC) as an annex to International Standards for Phytosanitary Measures (ISPMs) 28.

Mr Vasilis Rodovitis assessing the thermal limits of Anastrepha ludens.

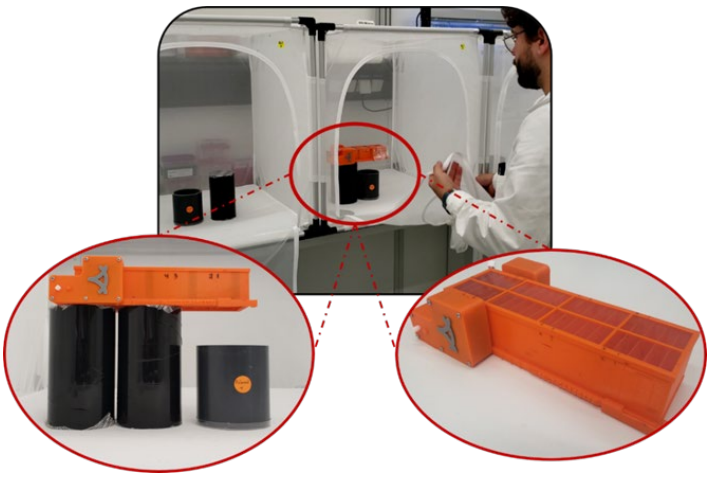
The most tolerant stage of *Bactrocera dorsalis* to vapor heat treatment is currently being evaluated. We aim to compare the response of the most tolerant stage of wild-collected and laboratory-maintained *B. dorsalis* strains from Mauritius to vapor heat treatment. This project will contribute to our understanding of the extent to which the domestication process of tephritid fruit flies affects their tolerance to vapor heat treatment.

A new research project evaluating the thermal limits of *Anastrepha ludens* has been initiated with the participation of IPCL's scientists, Vasilis Rodovitis – a Ph.D. student from Greece, and researchers from the USA. The main objective of this project is to determine whether thermal tolerance under acclimation and non-acclimation differs among *A. ludens* populations. Thermal tolerance will be assessed by measuring the critical thermal minimum, critical thermal maximum, and chill coma recovery time for adults from *A. ludens* populations. Information on thermal tolerance should enable us to understand better the potential for *A. ludens* to extend its geographical distribution to temperate areas.

Livestock Pests

Laboratory Assessment of a Release System for Adult Tsetse Flies for Use with Drones

As part of the tsetse *Glossina palpalis gambiensis* eradication program in the Niayes region of Senegal using the sterile insect technique (SIT), laboratory-reared tsetse males are sterilized using radiation and released to compete against wild fertile males for wild females. Tsetse sterile males are commonly released from the ground and by air. Although ground releases may require less costs and expertise for small surface areas when compared to aerial releases, aerial methods (fixed-wing aircrafts and gyrocopters) expedite the releases, cover larger areas, and allow access to hard-to-reach places.



Mr Anibal E. Morales-Zambrana assessing flight-propensity of Glossina palpalis gambiensis *males that were released with a new release system.*

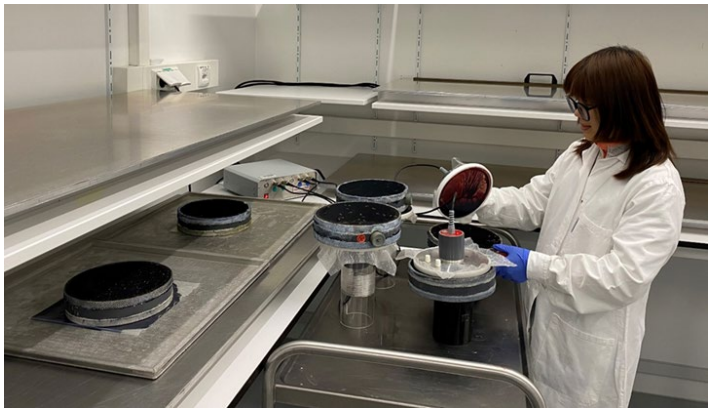
However, the high costs related to the use of manned aerial vehicles for the release of sterile males can be a limiting factor, especially for smaller programmes. To this end, Mr Anibal E. Morales-Zambrana, a Junior Professional Officer (JPO) from USA, assessed a novel adult release device for the aerial release of *G. p. gambiensis* using drones. The release device is a 3D-printed insect cassette cartridge manufactured by Birdview DroneBioControl from São Paulo, Brazil. The release device can hold approximately 6 800 *G. p. gambiensis* sterile males and weighs approximately 575g at full capacity.

The flight propensity of adult males released by this device was evaluated under laboratory conditions. Three locations in the insect cassette were chosen to simulate the release at three different timepoints, and each release was performed in a cleared flight cage over a flight quality control tube coated with unscented talcum powder to prevent released flies crawling out. Flies for the test and control groups were chilled at 4°C and placed at the three locations or directly in the flight quality control tube in the case of the control. The number of tsetse released vs. non-released from the release system and, within those that were released, the number of flyers vs. non-flyers were recorded. When compared to the control group, the release device did not significantly affect the flight propensity of the experimental groups as 81% of the released tsetse were able to fly. The next step would be the evaluation of this adult release device under field conditions.

An Artificial *in vitro* Membrane Feeding Systems Evaluated for Tsetse Flies

For the implementation of the sterile insect technique (SIT) mass-rearing of the target insects is needed. One of the main obstacles is the requirement of a continuous supply of high-quality feeding medium and this is even more so for tsetse fly rearing as the feeding medium is blood. Tsetse flies are obligate blood feeders, and they reproduce by adenotrophic viviparity, making adult and larval stages dependent on the same source of food. Insufficient nutrition will lead to severe production losses. The maintenance of live animals for tsetse feeding has become unethical and is too costly and labour intensive.

The development of appropriate *in vitro* feeding systems is essential for mass-rearing of tsetse flies. The current *in vitro* feeding systems in many tsetse rearing units has the following elements: a heating plate that can warm up the blood to an appropriate temperature between 35-36°C, a metal tray for holding the blood and a silicon membrane. The current system also has many advantages, i.e., the system is relatively easy to use and clean, it is made from durable materials and can be used to feed large quantities of flies. The system does however have some disadvantages as well, the biggest being that if the feeding protocol is not managed appropriately the refeeding of many flies can lead to increase virus infections such as the Tsetse Salivary Gland Hypertrophy Virus.



Ms Qian Li feeding Glossina palpalis gambiensis *with the standard and Hemotek feeding systems fitted with both silicon and collagen membranes.*

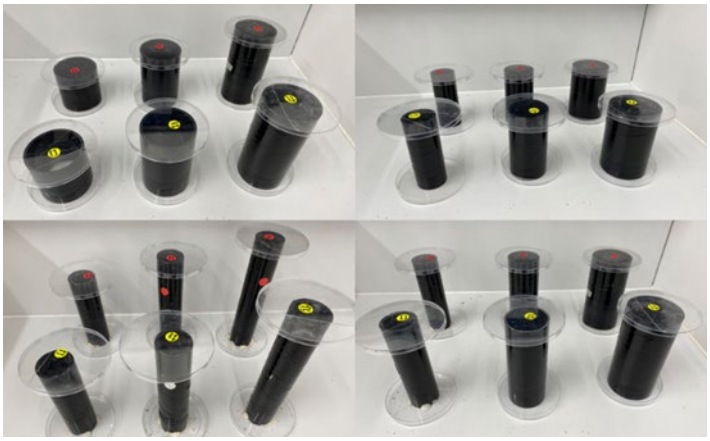
Investigation into the development of a low cost, single use feeding membrane for feeding of tsetse flies has started at the IPCL. In the first assessment, the Hemotek feeding system (commonly used for the feeding of female mosquitoes) and a collagen membrane were compared with the standard silicon membrane feeding system used at the IPCL following the standard 25-day bioassay feeding test. This test has a simple numerical system, the quality factor

(QF), that adequately summarizes and combines the various data obtained from survival, pupal production, and dissections. QF value > 1 is considered acceptable and indicates that the blood diet is suitable for colony maintenance. Additionally, the orientation of the fly during feeding was also evaluated in the Hemotek system.

A feeding temperature between 35-36°C was reached fairly quickly for both the silicon and collagen membranes on the standard feeding system. For the Hemotek system, the silicon membrane reached the required temperature only after 50 min. The QF value > 1 was obtained for the flies that fed on the standard (QF of 1.2) and Hemotek feeding system fitted with the silicon membrane (QF of 1.0). The orientation of the feeding device appeared important, as the flies that had to feed in the upward direction (the feeding device was on top of the cage) had a QF value of only 0.8 (the average was 0.835, or > 20% lower than the standard). The collagen membrane in both the standard and Hemotek feeding system and for both feeding orientations were unsuitable for feeding as all the QF values were below 0.7. Further investigations of alternative feeding membranes are continuing.

Tsetse Flight Quality Control Test Re-evaluated

The ability of sterile males to disperse and compete with wild males for mating with wild females is vital for the success of the sterile insect technique (SIT). The accurate estimation of the number of emerged sterile males that can actually fly from a batch of pupae delivered to a release facility can assist in the planning of field releases. Thus, an appropriate tsetse flight quality control test is required.



Flight tubes with various heights (10, 15, 20 cm) and diameters (5, 7.3, and 9 cm) that were used to evaluate the flight propensity for two tsetse species, Glossina palpalis gambiensis *and* Glossina brevipalpis.

Flight quality control protocols for SIT programs were initially developed for fruit flies, especially the Mediterranean fruit fly, and later developed and validated for tsetse flies such as *Glossina palpalis gambiensis*. In the current protocol, tsetse pupae are placed in a flight quality control tube/cylinder with a height of 10 cm and a diameter of 8.4 cm. The inner wall of the tube is coated with unscented talcum powder to prevent the emerging flies crawling out. The number of flies that can escape the flight tube is then classed as "flyers".

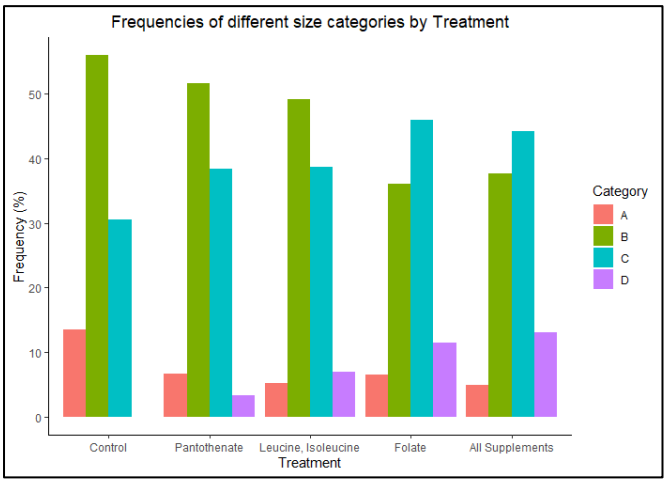
For this re-evaluation, flight tubes that were 10, 15, or 20 cm tall and that had a diameter of 5, 7.3, or 9 cm were evaluated for two tsetse species, *G. p. gambiensis* and *G. brevipalpis*. For each replicate, the pupae were divided in a control and treatment group. For the treatment group, pupae were exposed to radiation with a dose of 200 Gy for *G. p. gambiensis* and 120 Gy for *G. brevipalpis*. Both the doses for the two species were much larger than the dose that induces 99% sterility and hence, are expected to degrade the quality of the insects.

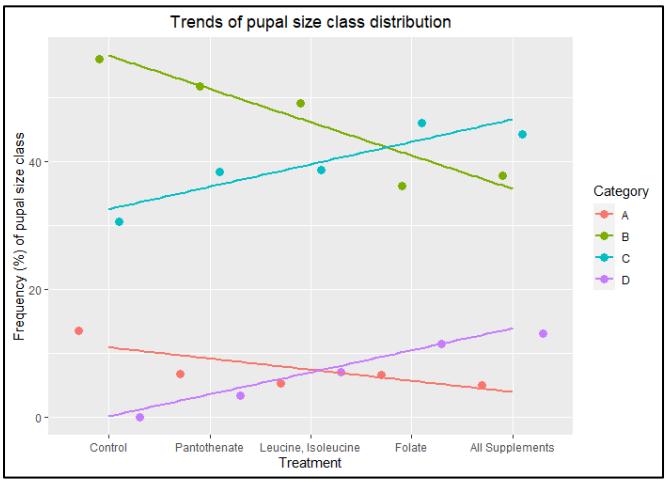
In the first evaluation the tube height with a fixed diameter of 9 cm was assessed. A significant difference in the flight propensity of *G. p. gambiensis* between the treatment (69%) and control (85%) groups could be observed for all three heights. Additionally, for the control groups, significantly less males escaped the 20 cm (83%) tall flight tube compared to the 15 (85%) and 10 cm (86%) tube. In contrast, no significant difference in the flight propensity between the treatment and control groups could be observed for *G. brevipalpis* as 90% of the males escaped all three heights. For the second evaluation, tube diameters with a fixed height of 15 cm for *G. p. gambiensis* and 20 cm for *G. brevipalpis* were assessed. A significant difference in the flight propensity of *G. p. gambiensis* was observed between the treatment (61%) and control (81%) groups for all three flight tube diameters. For *G. p. gambiensis,* it is recommended to use a flight tube with a height of 10-15 cm and a diameter between 7 and 9 cm. For *G. brevipalpis,* similar to the first evaluation, no significant difference in the flight propensity between the treatment and control groups could be observed for all three diameters. A third evaluation is currently ongoing to assess tube heights of 20, 25 and 30 cm with a fixed diameter of 5 cm. The preliminary data indicates that a significant difference in the flight propensity is observed between the treatment and control groups for the tube heights of 25 and 30 cm. However, a recommendation will be made when the evaluation has been completed.

Quality control protocols such as the flight test produces valuable data on the propensity of sterile male flyers and quality each week that can be used for crucial feedback information to the rearing facility and to better plan the operational phase of the SIT component of AW-IPM programmes.

Improvement of Tsetse Mass-rearing Through Blood Supplements

The reproductive cycle of tsetse flies is remarkably slow and poses a limiting factor to the efficiency of mass-rearing activities that are needed to support SIT programs. A recent study on metabolic profiles of tsetse flies indicates that several amino acids required for fatty acid synthesis were enriched in virgin tsetse fly females.





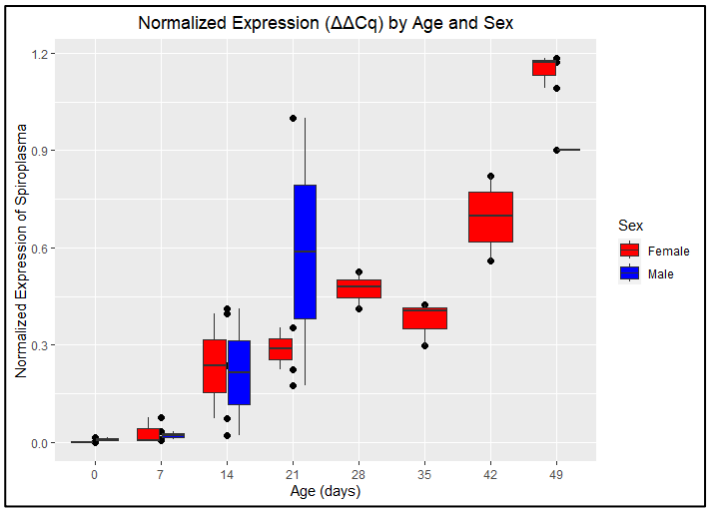
Effects of blood supplements on the pupal size class distribution. The addition of amino acids required for fatty acid synthesis causes a shift of pupal size classes towards bigger pupae. A = smallest class; D = biggest class.

Currently, experiments are being conducted at the IPCL to test whether the blood that is used for tsetse fly feeding and supplemented with these amino acids, can accelerate the reproductive cycle, enhance the performance, and potentially lead to higher quality insects for SIT applications. Several parameters were recorded, such as the quality factor (QF, which is routinely used to assess blood quality), mortality, productivity, pupal size distribution and emergence time of the offspring. Preliminary results indicate that the supplements had no negative impact on fly survival and showed comparable numbers of pupae produced. However, the pupal size distribution in flies fed with supplemented blood shows a shift towards bigger pupae as compared with the control, which might indicate a better health of the produced pupae.

This work is carried out by Fabian Gstöttenmayer, a PhD student from Austria, in collaboration with Dr Geoffrey Attardo from the University of California, Davis, USA. The outcomes of this study may guide tsetse mass-rearing facilities to improve the rearing conditions and consequently produce tsetse flies of high quality for insect management programs using SIT.

Host Range of *Spiroplasma* in Tsetse Species

Spiroplasma is a bacterial symbiont of *Glossina fuscipes fuscipes* (Gff) and *G. tachinoides* (*palpalis* group) and has so far not been found in any other tsetse species. To study the host range and impact of *Spiroplasma* in a yet uninfected host, *G. p. gambiensis* (Gpg), flies were artificially infected with *Spiroplasma* by injection of the infected haemolymph of Gff. Preliminary results indicate that *Spiroplasma* can replicate and increase its titter in Gpg injected flies over the course of 7 weeks, as tested with quantitative PCR. However, the symbiont was not transmitted from the infected Gpg flies to the F1 generation in a detectable density, suggesting that it might not infect the reproductive tissues and thus no transmission to the offspring occurred. Further experiments can give more insights on the localization of *Spiroplasma* in different tissues, potential barriers to transmission, fitness costs and the *Spiroplasma* dynamics in further tsetse host species outside of the *palpalis* group.



Normalized expression of Spiroplasma *in injected* Glossina palpalis gambiensis *over the course of 7 weeks as measured with relative expression of* Spiroplasma *normalized to Tubulin.*

Prevalence and Genetic Diversity of Negeviruses in Different Tsetse Species

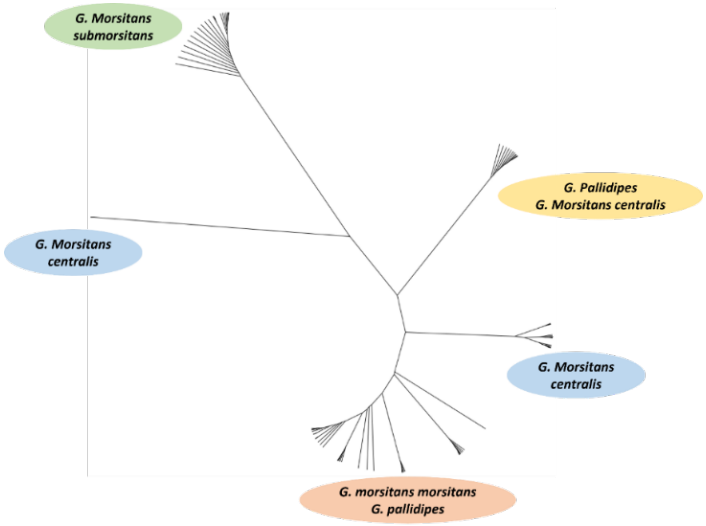
Glossina morsitans morsitans Negevirus (GmmNegev) and *Glossina morsitans morsitans* Iflavirus (GmmIV) are two recently discovered viruses that infect tsetse flies. A host range distribution study of GmmNegeV and GmmIV is being conducted at the IPCL to determine the prevalence of these virus infection in our mass-reared colonies.

Teneral males and females from *Glossina morsitans morsitans* (Gmm), *Glossina morsitans submorsitans* (Gmsm), *Glossina morsitans centralis* (Gmc), *Glossina palpalis gambiensis* (Gpg), *Glossina pallidipes* (Gp), *Glossina fuscipes fuscipes* (Gff), *Glossina brevipalpis* (Gb) and *Glossina austeni* (Ga) were tested for viral infections. So far, no Negevirus infection was found in Gpg, Gff, Gb and Ga. Both Gmm and Gmsm had 100% of flies infected

with Negevirus, while Gmc and Gp had a 91% and 90% infection prevalence respectively.

Mr Giovanni Petrucci conducting quantitative PCR analysis to detect Negevirus infections in tsetse samples.

Sequencing of positive PCR products revealed an interesting host species-dependant genetic diversity of Negevirus sequences, possibly suggesting new species or strains. The sequences from Gmsm and Gmm are clustered in two divergent clades. Negevirus sequences from Gp clustered either with Gmm or on a different clade. Gmc had the highest Negevirus sequence variability, clustering either with Gp or on two species specific clades.



Phylogenetic tree representing the observed Negevirus sequence diversity in different tsetse fly species.

Full genome sequencing of these viruses will reveal whether these are new species of negeviruses. This work is conducted by Mr Giovanni Petrucci, an intern from Italy, in collaboration with Prof. Monique van Oers from Wageningen University in the Netherlands.

Human Disease Vectors

Efficiency Assessment of a Novel Automatic Mosquito Pupae Separation System (Orino Technology Pte Ltd)

When the sterile insect technique (SIT) is considered in a mosquito vector control program, the elimination of females or separation from the males is an essential requirement. Over the past decades, interest has turned to SIT as a sustainable method to control *Aedes* mosquitoes, vectors of several pathogens causing human and animal diseases. However, sex separation is still one of the major challenges to be addressed before its implementation at a large scale and for its success. Available methods such as metal sieving plates and the Fay-Morlan glass separator are time-consuming or have so far failed to eliminate all the females to achieve male-only releases for SIT or other related applications. Therefore, new tools, which are both effective and scalable, are needed now more than ever.

The Orino Technology Pte Ltd has developed an automatic mosquito pupae separation system based on pupal size dimorphism, which is currently being used in a sterile insect technique - incompatible insect technique (SIT-IIT) program in Singapore to separate the sexes of a Wolbachia-infected *Ae. aegypti* strain.

The two automatic pupae sex sorters that were assessed at the IPCL for Aedes *mosquitoes.*

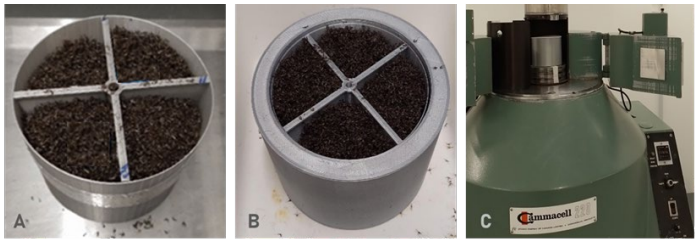
Studies were initiated at the IPCL to assess its efficiency by using a comparative approach against another automatic mosquito pupae separation system developed by Wolbaki Biotech™.

Suitability of the Blood X-ray Irradiator Raycell MK2 for the Irradiation of Three Target Pests of the Sterile Insect Technique: Dose Response in Fruit Flies, Tsetse Flies and Mosquitoes

The sterile insect technique (SIT) is based on the inundatory field release of a target pest following their reproductive sterilization via exposure to radiation. Until recently, gamma irradiation from isotopic sources has been the most widely used in SIT programmes. As isotopic sources are becoming increasingly expensive and regulations surrounding their procurement and shipment increasingly strict, irradiation capacity is one of the limiting factors in smaller or newly developing SIT projects. For this reason, the possibility of using X-ray irradiators has been evaluated in the recent decade. The availability of "off the shelf" blood X-ray irradiators that meet the technical requirements for insect irradiation can provide irradiation capacity for those SIT projects in which the acquisition of gamma-ray irradiators is not feasible. Following the recent technical characterization of the Raycell MK2 X-ray blood irradiator, a series of irradiation experiments were performed on fruit flies, tsetse flies and two species of mosquitoes (*Anopheles arabiensis* and *Aedes aegypti*). It was found that the MK2 is suitable for the sterilization of males of these groups of insects, resulting in comparable, even slightly higher sterility levels as compared to those achieved by gamma-ray irradiation. This together with its estimated processing efficiency shows that the MK2 is suitable for small to mid-size SIT programmes.

Design Protocols and Dedicated Equipment for Effective Irradiation of Adult Mosquitoes

A plastic container made of PLA (polylactic acid) with 3D printing technique was developed and tested at the IPCL for sterilization of adult mosquitoes. The container consists of two overlapping compartments that can be introduced inside a plastic ring. This ring can be filled with phase change materials (PCM) packs and once conditioned at 5 degrees for 24 hours, can guarantee an effective cooling of the entire container between 10 and 13°C for about 4 hours. When used in some radiation models, the container can be interposed between the radiation field and attenuate the dose received by the sample of about 3-4%.



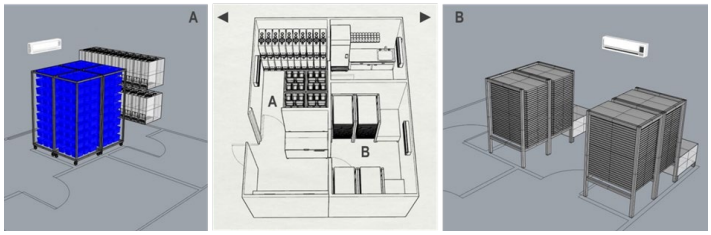
Irradiation container with (A) and without (B) the cooling ring added during the radiation procedure using a gamma cell radiator (C).

During the validation tests, the effect of handling, cooling, compaction and radiation on the survival, fertility, and flight ability of adult males of 2 days of age was investigated. Untreated samples (control) and cold anesthetised samples (C5) were compared with cold anesthetized and compacted samples maintained inside the container with (CW) and without (CN) the cooling ring and subjected (RW) or not (RN) to effective sterilizing doses (50 to 60 Gy).

Preliminary results indicate that, *Ae. albopictus* males show greater sensitivity to cold treatment and radiation doses with a more noticeable drop in the quality parameters observed in comparison to *Ae. Aegypti.* The use of the irradiation container seems to improve the quality of the adult males processed, reducing the negative impact of handling and sterilization procedures. Further tests and different conformations are ongoing to adapt the container to different radiation sources to minimize excessive shaking on the adults and the shielding effects of the cooling system.

Planning and Organization of New *Aedes* Mass-rearing Modular Unit

A modular *Aedes* mosquito mass rearing unit has been designed using standard mass-rearing equipment validated and/or designed by the Human Disease Vectors (HDVs) group of the IPCL. This design has been optimised by using 20 feet shipping containers, to provide Member States (MSs) with an effective rearing unit for initial SIT field feasibility studies.



Modular Aedes *mosquito mass-rearing unit (center) with details of the adult (A) and larval (B) rearing areas.*

The internal space of the available container structure is very limited and include an area for adult mass-rearing and emergence, sex separation procedures, larval rearing and laboratory and quality control procedures. This rearing container does not provide dedicated space and equipment for sterilization, cooling and packaging procedures which need to be ensured by adequate connected facilities.

Based on the available rearing areas and the use of non-mechanized technology, this concept targets a maximum production of 100 000 to 150 000 mosquito males per week with the involvement of two to three operators for the management of the entire rearing system. This production capacity can be increased with up to 30% once the rearing procedures are streamlined and the staff gets used to the mass-rearing equipment and procedures.

Due to the limited space and low structural isolation, it is important to underline that this module cannot guarantee effective confinement of insects and therefore the rearing of invasive species not yet established in the region is to be avoided.

Reports

Consultancy Meeting on Thematic Plan for the Use of the Sterile Insect Technique for Lepidoptera. 6–10 February 2023, Vienna, Austria

Lepidoptera are key pests that require control to avoid significant losses in many cropping systems worldwide. Failure to control key species can result in crop losses and jeopardise the economics of production. Many lepidopteran pests are undergoing geographical range expansion. Control options exist for these pests, but most have issues of cost or efficacy, e.g., insecticides have non-target impact, mating disruption is comparatively expensive, classical biological control is usually inadequate alone, and biopesticides have issues of cost, efficacy, and resistance development.

The sterile insect technique (SIT) has been used successfully against many moth species and bears great potential. It was therefore considered opportune to develop a thematic plan for the use of SIT against Lepidoptera.

Thematic plans aim at identifying the end users for the SIT for Lepidoptera and to develop a strategic vision for improving the technology through research (in house and Coordinated Research Projects) and transferring the technology through the TC mechanism to produce tangible socio-economic benefits for the end users. In the past, thematic plans have been developed for other key insect pests, such as screwworms, fruit flies and tsetse flies.

Participants to the Consultancy Meeting on Thematic Plan for the Use of the Sterile Insect Technique for Lepidoptera (Vienna, Austria).

A consultancy meeting to develop the thematic plan for Lepidoptera was held at the IAEA headquarters in Vienna from 6–10 February 2023. The meeting was attended by 8 experts from Canada, Indonesia, Malaysia, Papua New Guinea, Philippines, South Africa, USA and Viet Nam, in addition to staff of the IPC Subprogramme.

The following items were discussed during the meeting and are developed in the report: 1) Importance of Lepidoptera as a crop pest in the world, 2) Available control tactics: advantages and limitations, 3) SIT and Lepidoptera: success stories, 4) Lepidoptera: the ideal insect target for SIT? 5) Challenges in operational SIT programmes against Lepidoptera, 6) Recent advances in R&D for Lepidoptera SIT, 7) Potential future role of the Joint FAO/IAEA Centre, 8) Research priorities for the future, 9) Benefit-cost and economics of Lepidoptera SIT, 10) Partnerships and collaborations, 11) Recommendations.

The Thematic Plan will be available soon at IPC website.

Workshop on the Sterile Insect Technique (SIT) Against *Aedes* Vectors, to Control *Aedes*-borne Diseases. 2–6 May 2023, Tahiti, French Polynesia

The workshop was organized by TDR (the Special Programme for Research and Training in Tropical Diseases) and the Institute Louis Malardé of French Polynesia to launch a research project entitled "Pacific Islands Consortium for the Evaluation of *Aedes* SIT" (PAC-SIT) testing the sterile insect technique (SIT) in Tahiti and Cook Islands, where the impact of the SIT on dengue transmission will be measured. This is part of a global research initiative supported by TDR, the World Health Organization, the International Atomic Energy Agency, and the U.S. Centers for Disease Control and Prevention.

Participants to the workshop on the sterile insect technique (SIT) against Aedes *vectors, to control* Aedes*-borne diseases (Tahiti, French Polynesia).*

Twenty-two participants and experts from Australia, Brazil, Burkina Faso, Cook Islands, France, Indonesia, Kenya, Malaysia, Singapore, Sri Lanka, Switzerland and the USA. The meeting included presentations of the ongoing SIT trials against mosquitoes world-wide as well as working sessions to define entomological and epidemiological endpoints to be measured to assess the entomological and epidemiological impacts of SIT against arboviral diseases, such as dengue.

The actions necessary to ensure community participation to the trials were also discussed. Finally, the participants visited the new mass-rearing facility of Institut Louis Malardé that has the capacity to produce 8 million sterile male mosquitoes per week, which will be used to provide the sterile male mosquitoes necessary to organize the field trials planned within the PAC-SIT project.

Joint ICTP-IAEA Workshop on Accounting for Climate in Vector-borne Disease Intervention Planning Including the Sterile Insect Technique (SIT). 22–25 May 2023, Trieste, Italy

Dengue has huge socio-economic and direct health impacts world-wide, and those impacts have been on the rise over the past decades. The sterile insect technique (SIT) against its *Aedes* vectors is being developed at the Insect Pest Control (IPC) Subprogramme of the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture and several pilot trials and field projects have been initiated in the world. However, currently there is no information concerning how to account for climate in planning sterile males' release. The use of dynamical models of vector life cycles coupled with machine learning technique may allow developing more cost-effective strategies.

The International Center for Theoretical Physics (ICTP) and IAEA thus initiated a collaboration in 2021 to extend the VECTRI model (VECtor borne disease community model of ICTP, TRIeste) in order to account for climate in disease intervention planning with an SIT component.

Participants to the joint ICTP/IAEA workshop on accounting for climate in vector-borne disease intervention planning including the sterile insect technique (Trieste, Italy).

The workshop consisted of a series of lectures that present the SIT, the latest observational evidence of its effectiveness, and introduced the basics of dynamical disease modelling and the role of climate in vector-borne disease transmission. The afternoon hands-on classes introduced participants to the methods to access and manipulate latest state-of-the-art climate information, as well as parallel classes in the use of VECTRI, the dynamical climate-driven vector mathematical model developed at ICTP, which includes a SIT component.

The workshop included 20 participants from Austria, Cameroon, Cyprus, Greece, Indonesia, Italy, Mexico, Nigeria, Pakistan, Senegal, Serbia, South Africa, South Korea, and Switzerland.

Consultancy Meeting on Thematic Plan for the Development and Application of Sterile Insect Technique for Tsetse Area-wide Integrated Pest Management Programmes. 29 May–2 June 2023, Vienna, Austria

A Thematic Plan for establishing tsetse-free zones through area-wide tsetse control interventions involving the sterile insect technique (SIT) was developed in 2001 based on the discussions, observations and conclusions reached during an expert meeting aimed at providing a strategic guidance and direction on how and where the SIT technology could be most efficiently and effectively applied to control and ultimately eradicate the tsetse fly. Following the recommendations in the thematic plan, the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture, particularly its Insect Pest Control (IPC) Sub-programme, in collaboration with Member States, has improved the SIT technology as a tool for controlling tsetse populations as a component of Area-Wide Integrated Pest Management (AW-IPM) strategy during the last two decades.

Participants to the Consultancy Meeting on Thematic Plan for the Development and Application of Sterile Insect Technique for Tsetse Area-wide Integrated Pest Management Programmes (Vienna, Austria.)

Extrabudgetary contributions have been instrumental to support the transfer of the SIT technology from the laboratory to the field. The technology has been evaluated in the field and success has been recently demonstrated in Senegal with the eradication of *Glossina palpalis gambiensis* from the highly productive agricultural region of Niayes using an AW-IPM approach with an SIT component. The creation of a zone free of the tsetse fly and the disease trypanosomosis has resulted in significant increase in milk yields, and a ten-fold increase in the number of imported, more productive cattle with a very positive overall return on investment. Other successful examples include the operational programme with an SIT component

implemented in the Unguja island, Zanzibar from 1994 to 1997 for the eradication of *Glossina austeni*. The eradication of tsetse fly from Unguja in 1997 followed by the disappearance of African animal trypanosomosis (AAT) thereafter enabled farmers to integrate livestock keeping with crop production in areas where this had been impossible before. The increased livestock and crop productivity and the use of animals for transport and traction significantly contributed to an increase in the quality of people's lives.

In light of these successful results and considering new technological challenges regarding efficient and economical delivery of SIT package for tsetse species, a consultancy meeting to review and update the existing Thematic Plan on tsetse was organized by the Joint FAO/IAEA Centre. The meeting was held at the IAEA headquarters in Vienna, Austria from 29 May to 2 June 2023, with the participation of 11 experts from Burkina Faso, France, Italy, Kenya, Senegal, South Africa, Zimbabwe, and United of Republic of Tanzania, in addition to the staff of Programme Against African Trypanosomosis (PAAT), FAO and IPC sub-programme. During the meeting, special consideration was given to the advantages, constraints, gaps, and challenges for the implementation of field operational programmes with the SIT component targeting tsetse species. Technical discussion also took place about upcoming priorities on research and development activities for developing and fine-tuning components of the SIT for tsetse. As outcome of meeting, a report was produced with key recommendations from the MSs to the IAEA to continue supporting the control of tsetse and trypanosomosis following the Phase Conditional Approach in an AW-IPM strategy.

How to Control Insect Pests Using Radiation

Insect pests spread diseases. Mosquitoes, for example, are responsible for the spread of malaria, which affected 247 million people in 2021 alone and caused over 600 000 deaths. Parasitic insect pests, such as parasitic flies, can threaten whole ecosystems, putting at risk long-term conservation of animals and biodiversity. Other insect pests, such as fruit flies, moths, tsetse flies and screwworms destroy crops and livestock, threatening farmers' livelihoods, harming international trade, and undermining global food security. According to official estimates, pests destroyed up to 40 per cent of global crops and caused $220 billion in losses in 2021.

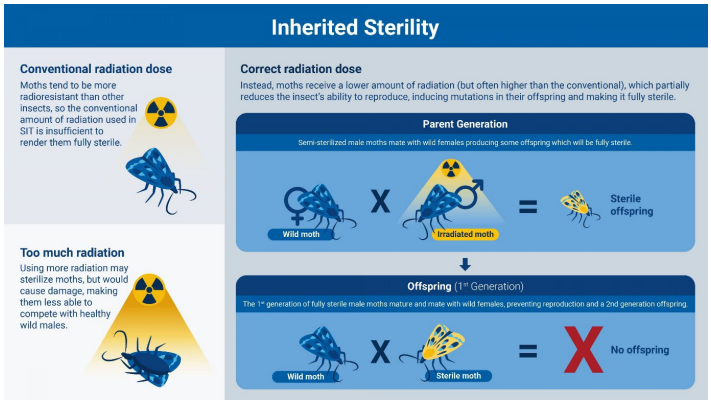
The use of radiation can help in the regulation or management of pests — known as pest control — effectively preventing insect-related risks to human and animal health, the ecosystems and food security (including crop and livestock production). Methods using radiation for pest control include the sterile insect technique (SIT), inherited sterility and biological control.

What is the Sterile Insect Technique (SIT)?

The sterile insect technique is a method that uses ionizing radiation to sterilize large numbers of insects reared in a laboratory, which are then released over infested areas to mate with the wild pest population. As these sterilized insects are incapable of producing any offspring, the insect population declines over time. For details, please watch the 3 minutes animated infographic at https://www.iaea.org/newscenter/multimedia/videos/using-nuclear-science-to-control-pests.

The SIT is one of the safest and most eco-friendly insect birth control methods available, which ensures environmental protection through a reduced use of insecticides. In addition, since sterile insects cannot self-replicate, this creates a long-term solution for the pest problem without running the risk of introducing non-native species into the ecosystem.

What is Inherited Sterility?



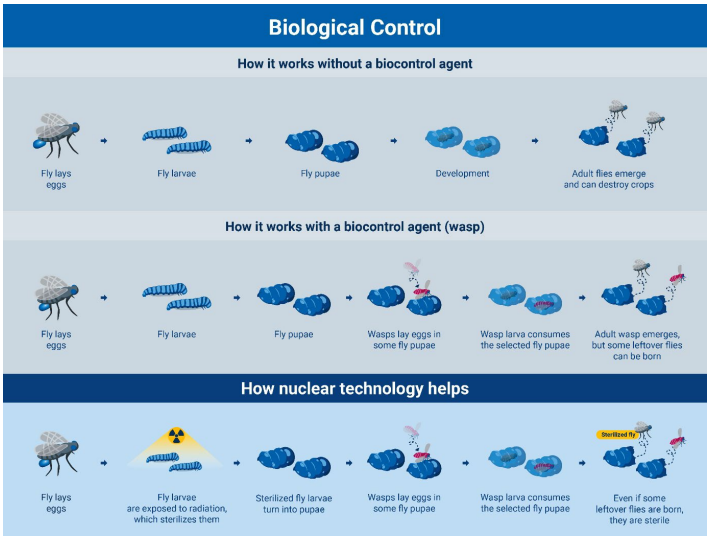
Moth pests can be rendered sterile; however, they require higher doses of radiation, which tend to weaken the insect's ability to compete with wild males. Instead, less debilitating semi-sterilizing doses are used to induce full sterility in the moths' offspring. This is known as inherited sterility (Infographic: Adriana Vargas/IAEA).

Inherited sterility, also known as F1 sterility, is another type of SIT, very similar to the traditional method, as it involves rearing, irradiation, and release of semi-sterile male insects into a target area to reduce the mating of their fertile counterparts. In this technique, however, the reared and released male insects have a certain degree of fertility, but all their offspring is born sterile. However, the females are fully sterile after irradiation since female moths are more sensitive to radiation.

This technique is used when males of certain types of pests, such as moths, cannot be fully sterilized unless very high doses of radiation are used. A high dose, however, may weaken the insect and hinder its ability to compete with wild moths for reproduction. Therefore, this technique involves using much lower and less debilitating doses, which do not hinder the insects' opportunities to reproduce, but which induce inherited sterility in the moths' offspring.

What is Biological Control?

Biological control is a method that uses mass-production and release of the pest's natural enemies, such as predatory insects who feed off the pest's eggs and larvae, or parasites (known as parasitoids) that lay eggs into their host insect, killing the insect.



Biological control helps to control insect pests, while by irradiating the host of the biological control agent no new pests are accidentally introduced into the environment. (Infographic: Adriana Vargas/IAEA).

Unlike the SIT and inherited sterility methods, which are based on the use of nuclear techniques, in biological control nuclear techniques are only used for particular purposes. Radiation can be used to increase the applicability, cost-effectiveness and safety of rearing, shipping, and deploying these natural pest enemies. It can also improve the results of the method and alleviate several constraints associated with it. For example, radiation can be used to reduce the cost of production of biological control agents. In case of parasitoids, for example, radiation can lower the host insect's natural defences (i.e. immune response) to increase the productivity and survival rate of parasitoids. Moreover, radiation helps to prevent development of the host insects, assuring that only parasitoids emerge from the pupae. In cases where some host insects do survive, the use of radiation ensures they are sterile in order to eliminate the risk of releasing fertile host insects, which can become pests in the new environment (see infographic below). In appropriate contexts, low doses of radiation can also stimulate the reproduction of some predators, which could be used to improve the effectiveness of biological control in environments where these predators do not threaten non-target insect populations.

Full report is available at IPC website: https://www.iaea.org/newscenter/news/how-to-control-insect-pests-using-radiation.

Announcements

Call for Research Proposals on a New FAO/IAEA Coordinated Research Project (CRP) D41030: Improvement of *Drosophila suzukii* Mass-Rearing and Released Methods for SIT Programmes

Description

The invasive spotted wing drosophila (SWD, *Drosophila suzukii*), an insect pest that recently invaded most parts of the world, is a major pest of soft fruits. The application of an environmentally friendly method, such as the sterile insect technique (SIT), is especially important in greenhouses where the biocontrol methods in use are not compatible with the insecticide application. This CRP should focus on the improvement of the SIT package to support field implementation against *D. suzukii*. The objective is to identify and overcome constraints of implementing SIT with other complementary techniques. The background information required for SIT, such as mass-rearing and radiation biology, has been developed under a previous CRP. However, improvement of the technology for field implementation needs to be further developed to ensure the success of SIT programmes against *D. suzukii*.

A new Coordinated Research Project (CRP) entitled 'Improvement of *Drosophila suzukii* Mass-Rearing and Released Methods for SIT Programmes' will focus on the fine-tuning of rearing, quality control, and irradiation protocols for SIT application, the development of male-only genetic sexing strains, field release methods, and long-distance shipments of sterile insects. The overall expected outcome would be that the SIT and compatible control methods are being implemented and used by member states as appropriate, to reduce crop losses and pesticide residues in food.

Overall Objective:

The overall objective is to advance development and implementation of SIT and its integration with biocontrol agents in greenhouses and open field.

Specific Research Objectives:

- To implement SIT for *Drosophila suzukii*
- To develop genetic sexing strains and assess the efficiency of male only releases
- To combine the use of biocontrol agents with SIT for the control of *Drosophila suzukii*
- Investigate long distance and cross jurisdiction shipping of sterile *Drosophila suzukii.*

Duration:

The expected duration of the CRP is five years (2024–2029) and the first Research Coordination Meeting is planned to take place from 8–12 July 2024 in Vienna, Austria.

Applications:

Scientist and researchers who are interested in collaborating in this new CRP should contact Mr Rui Cardoso Pereira (r.cardoso-pereira@iaea.org). Information on the IAEA Coordinated Research Programme and how to apply for research contracts and research agreements can be found at:

https://www.iaea.org/services/coordinated-research-activities/how-to-participate.

Proposals should be submitted to the IAEA's Research Contracts Administration Section (E-mail: research.contracts@iaea.org) by **30 October 2023.**

Fruit Flies of Brazil: Basic and Applied Knowledge

The book "Fruit flies of Brazil: basic and applied knowledge", in Portuguese "Moscas-das-frutas no Brasil: conhecimento básico e aplicado", brings together research carried out over the last 20 years on the pests that most affect fruit production, with up-to-date and comprehensive information. It has a target to contribute to the academic public institutions (teachers and students, mainly in agronomy and postgraduate courses linked to the areas of entomology and plant protection), companies and phytosanitary inspectors. The edition was supported by the Luiz de Queiroz Agricultural Studies Foundation (Fealq).

With 54 chapters, divided into two volumes, the book began to be prepared in March 2018 with the collaboration of researchers, technicians and graduate students from universities and research institutes. In total, there are 125 authors from 66 institutions (62 Brazilians and four from abroad). The first volume focuses on basic aspects, from fruit fly surveillance to integrated management strategies,

including taxonomy (morphological and molecular), egg and larval morphology, biology, behaviour, parasitoids, control techniques, monitoring and phytosanitary treatments. The second volume addresses applied knowledge related to the economic importance and records of *Anastrepha* species, their host plants, and parasitoids for all the Brazilian States.

Source: Fealq, 3 March 2023. https://fealq.org.br/obra-unica-em-portugues-reune-conhecimento-das-moscas-das-frutas-no-brasil/.

Fifth TEAM (Tephritid Workers of Europe, Africa and the Middle East) Meeting (15–18 April 2024)

The 5th TEAM meeting will be held at the Maritim Crystals Beach Hotel, Belle Mare, Mauritius from 15–18 April 2024. The theme of the meeting is "Food Security- Securing our fruit for healthy consumption". In the meeting, information on the latest research in the TEAM region on basic and applied research on fruit fly biology, ecology, behaviour, physiology, genetics, and fruit fly management will be presented. The meeting will offer a great platform for collaboration between fruit fly workers in the region and beyond.

Contact persons of the Local Organising Committee: Preeaduth Sookar & Nausheen Patel, Ministry of Agro Industry and Food Security (psookar69@gmail.com &bnausheen04@gmail.com).

For more information visit the first announcement at: https://nucleus.iaea.org/sites/naipc/twd/Lists/News/Attachments/1571/TEAM%202024_First%20announcement.pdf.

Second TAAO (Tephritid Workers of Asia, Australia and Oceania) Meeting (6–10 May 2024)

The Tephritid Workers of Asia, Australia and Oceania (TAAO) Steering Committee is pleased to announce that the second TAAO meeting will be held at the Best Western OL Stadium Hotel, Beijing, China from 6–10 May 2024 under the support from China Agricultural University. The meeting will consist of 8 sessions including Survey and Monitoring, Risk Assessment, Management and Communication, Species Complex and Species Diagnosis, Population Tracing and Invasive Pathway, Phytosanitary Treatment and Eradication, Area-wide management and SIT, and Global Change and Invasion Mechanism. A training workshop on molecular identification of Tephritids and a field trip visit surrounding Beijing will be organised before and after the meeting.

11th TWWH (Tephritids Workers of Western Hemisphere) Meeting (26–31 May 2024)

The Jamaican Ministry of Agriculture, Fisheries and Mining and the Tephritids Workers of Western Hemisphere (TWWH) are pleased to announce that the 11th TWWH Meeting will be hosted by Jamaica in the city of Montego Bay from 26–31 May 2024.

The meeting aims to promote the exchange of knowledge and experiences between scientists and personnel in charge of executing programs for surveillance and control of fruit flies in the Western Hemisphere. The research needs and results will be shared among the participants and the dissemination of new technologies will be promoted.

Among the disciplines that are expected to be addressed during the event are investigations in biology, population ecology and chemical ecology, ethology, genetics, taxonomy, morphology, monitoring systems, control methods and pre- and post-harvest mitigation, and area-wide management.

In Memoriam

Issa Sidibe (1958–2023)

It is with great sadness that we have to announce the passing away of Mr Issa Sidibé, the former Director General of the 'Insectarium de Bobo-Dioulasso' – Tsetse and Trypanosomosis Eradication Campaign (IBD-CETT), Bobo-Dioulasso, Burkina Faso on 30 April 2023.

Issa Sidibé received his DEA (Master) degree in biological sciences at the University of Paul Sabatier III, Toulouse, France in 1992 and a PhD degree in Integrated Biology Systems, Agronomy and Ecology, University of Montpellier II, France in 1996.

Professionally, he dedicated his life to the control of tsetse flies and trypanosomosis in Burkina Faso, as Research Entomologist and scientific Director at the International Centre for Livestock Research and Development in Sub-humid Zones (CIRDES) and as national coordinator of the Pan African Tsetse and Trypanosomosis Eradication Campaign (PATTEC) of the African Union in Burkina Faso. He worked as a consultant for many international organizations including the International Atomic Energy Agency (IAEA) where he was a counterpart for several technical cooperation projects for Burkina Faso. Moreover, Mr Issa Sidibé worked in partnership with several other national and international organizations including the French Research Institute for Development (IRD), the French Agricultural Research Centre for International Development (CIRAD), the Liverpool School of Tropical Medicine, the University of Montpellier, the Pierre Richet Institute, the World Health Organization (WHO), the Food and Agriculture Organization of the United Nations (FAO), as well as the national Human African trypanosomiasis (HAT) control programmes in Burkina, Chad, Côte d'Ivoire and Guinea.

Issa Sidibé was an authority in West Africa with respect to the biology and the control of tsetse flies and trypanosomes and is the author or co-author of more than 100 scientific articles published in international peer-reviewed journals.

Issa's cheerful personality, and his desire to help and collaborate to solving the tsetse and trypanosomosis problem will be sorely missed.

Source: Soumaïla Pagabeleguem (IBD-CETT).

Ronald F.L. Mau (1943–2023)

With great sadness we must inform you that Ronald (Ron) Mau, professor of entomology (emeritus) at the University of Hawaii at Manoa (UH) passed away on 23 May 2023.

Ron was born and raised in Hawaii and attended the University of Hawaii where he received his PhD in economic entomology. Ron began his career as an extension agent in Hilo, HI and later relocated to Honolulu where he spent the remainder of his professional career at the Manoa campus. Ron's extension entomology experience was extensive, ranging from ornamental crops (flowers and foliage), to a variety of fruits and vegetable crops. Ron spent a good part of his career working on the control of diamondback moth and issues related to pesticide resistance in that pest. Ron was an excellent communicator and loved talking directly with farmers to help them deal with the problems they faced and had a keen sense for how adult learning was different from adolescent learning.

Ron had always been aware of the fruit fly issues but this really became apparent when we asked him to join our Hawaii Areawide Pest Management program (HAWPM), funded by the United States Department of Agriculture (USDA). The program was set up to demonstrate the various research-driven technologies developed by USDA Agricultural Research Service (ARS) in Hawaii and others in the fruit fly community. It was purposefully set up to be administered and run through a multi-organization partnership, and we were looking for a UH cooperator that could work with our other partners (USDA Animal and Plant Health Inspection Service (USDA-APHIS), Hawaii Department of Agriculture and the public). At that stage of his career it would have been easy for Ron to 'step-back' and concentrate on his diamondback moth resistance management research but to our delight he accepted our invitation and told me that the key to the program was applying the research to teach the farmers using adult education and 'hands-on' extension demonstrations. Ron became our 'go-to' person in transferring the technology to local farmers and in the process re-educated the ARS researchers and others on the importance of that effort in the program's overall success.

Through Ron's leadership in the extension arena and the hard work of the HAWPM team, our program was successful locally and eventually internationally with cooperators in Australia, China, Reunion Island, Thailand, and other locations. As a result of the success of the HAWPM program Ron was sought out by many fruit fly organizations to share his ideas on research, extension and outreach programs. Our program in Hawaii would have not succeeded if Ron had not joined our team and he will be missed by us and the fruit fly community.

Source: Eric Jang (retired USDA-ARS).

Björn Sigurbjörnsson (1931–2023)

It is with great sadness that we learnt today of the passing of Dr Björn Sigurbjörnsson, the second Director of the Joint FAO/IAEA Centre (at that time the Joint Division of Nuclear Techniques in Food and Agriculture).

In a distinguished career, Dr. Sigurbjörnsson led the Joint FAO/IAEA Programme from 1983–1995. He was a strong leader and tireless advocate of the FAO/IAEA partnership and greatly strengthened this longstanding cooperation between the two organizations and its ongoing contribution to agricultural development and global food security.

It is with our deepest respect for his achievements that we convey our heartfelt condolences to all colleagues for the loss of a great and charismatic leader.

Our thoughts are with his grieving family and friends in this difficult time.

Source: Office of the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture.

Other News

A Successful Pilot *Aedes aegypti* Suppression Project by Using the Sterile Insect Technique (SIT) in Captiva Island, Lee County Mosquito Control District (LCMCD), Florida, USA

The yellow fever mosquito *Aedes aegypti* is a dangerous mosquito species that has been spread around the world. They can be a vector for several viruses, such as yellow fever, dengue, chikungunya, and Zika, making them an extremely important public health threat. *Ae. aegypti* are diurnal mosquitoes that use cryptic breeding habitats so that larvae are difficult to find and remove. This, in combination with increasing pesticide resistance, makes *Ae. aegypti* a very challenging mosquito to suppress using traditional control techniques.

BG Sentinel 2 traps installed in Captiva Island, FL, USA to collect baseline data on mosquito adult abundance and distribution.

Lee County Mosquito Control District (LCMCD), located in southwest Florida, USA, has been working to mitigate the public health threat posed by mosquitoes since its inception in 1958. While the focus has historically been on the black salt marsh mosquito, *Aedes taeniorhynchus*, the increasing urbanization combined with increasing resistance to pesticides has led to a nearly ubiquitous spread of *Ae. aegypti* throughout the county. As Florida experienced local transmission of chikungunya, dengue and Zika, in recent years, LCMCD began looking for alternative ways to combat this challenging species to prevent the establishment of these diseases in Lee County.

In April 2017, LCMCD met with the International Atomic Energy Agency (IAEA) in Vienna, Austria to discuss the foundation of a sterile insect technique (SIT) programme focusing on *Ae. aegypti*. Experts with Insect Pest Control (IPC) Subprogamme of the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture provided invaluable guidance on the best practices and considerations that should be incorporated into an SIT programme. This meeting provided LCMCD personnel with a better idea of where the target area should be, how to remodel the laboratory and insectary, the establishment of an entomological baseline data, and future experiments.

Captiva Island was selected as the site for a pilot SIT project. It was an ideal location that was accessible via car but was separated from the mainland by Sanibel Island. This reduced the potential for *Ae. aegypti* to immigrate to the area and allowed LCMCD to focus on the population that was endemic to Captiva Island. Public engagement, an essential part of any successful SIT operation, began in this initial stage but would remain a key portion of the project, preparing the community for releases and updating the public of advancements that were made.

Mosquito quality control being conducted at the Lee County Mosquito Control District mass-rearing facility.

Background population sampling began in June 2017 with traps placed throughout Captiva Island and in the

westernmost neighborhood on Sanibel Island, an area that would serve as a non-intervention control. Those mosquito adult traps (pictured next) and ovitraps were instrumental on the collection of baseline data for 3 years.

Meanwhile, renovations were made to an existing building at LCMCD to improve the spaces for mass rearing mosquitoes up to 1 million sterile mosquitoes per week. Once these were completed, LCMCD was able to establish a colony of *Ae. aegypti* from Captiva and Sanibel Islands to prepare for future releases of sterile males. The LCMCD purchased an X-ray machine to sterilize mosquitoes, enabling the entire mass-rearing, irradiation, and release process to be conducted in-house.

Releases of sterile mosquitoes being conducted at the Captiva Island, FL, USA.

After several mark-release-recapture studies, operational releases of sterile male *Ae. aegypti* began on Captiva Island on 10 June 2020. With consistently occurring releases and increasing production capabilities over time, LCMCD was able to effectively suppress the population of *Ae. aegypti* found in the release area of Captiva Island. The initial release area covered approximately 72 hectares with an additional 47 hectares added as LCMCD's production capability expanded. At the peak of releases, approximately 400,000 sterile males were released per week (twice per week). The results show a significant reduction of the wild *Ae. aegypti* population in the second semester of 2020 and complete suppression in 2021 and 2022.

On 28 September 2022, Hurricane Ian struck southwest Florida and devastated Captiva and Sanibel Islands. The damage was so significant to the islands that LCMCD determined that the best course of action would be to move the release program to a new area on the mainland. After preliminary sampling in several potential sites throughout Lee County, an area near downtown Fort Myers was selected as the new operational SIT zone. Using lessons learned from the pilot project on Captiva Island, LCMCD has begun data collection in earnest to better inform their releases of sterile male *Ae. aegypti* in early spring 2024. Background population sampling has been ongoing since November 2022 and a mark-releases-recapture study has already been completed, with several more planned. The staff members implementing the SIT are taking advantage of this time to perform experiments that will enhance and improve mosquito mass-rearing, irradiation, and releases. While the move to Ft. Myers was sooner than initially planned, the pilot project on Captiva Island allowed LCMCD to validate SIT as a component of an integrated mosquito management operation. Using the profound amount of knowledge gained from mass-rearing, releases, and fieldwork, LCMCD is hopeful to have similar successful outcomes in Ft. Myers and provide relief and protection to local residents.

Source: Rachel Morreale, David Hoel, Aaron Lloyd and Danilo Carvalho (Lee County Mosquito Control District (LCMCD), Florida, USA).

REACT: Advancing SIT to combat *Bactrocera dorsalis* and *Bactrocera zonata*

The REACT project (Rapid Elimination of Invasive Insect Agricultural Pest Outbreaks by Tackling them with Sterile Insect Technique Programs), funded by the European Union under its Horizon Europe framework with 6.65 million Euro funding, is taking innovative strides to protect European agriculture from the growing threat of invasive fruit flies such as *Bactrocera dorsalis* and *Bactrocera zonata*. These pests, exacerbated by climate change and infested fruit imports, have posed significant challenges to European agricultural sectors, creating an urgent need for advanced and efficient control methods.

The REACT project began in November 2022, with an inaugural Kick-Off meeting in Giessen in January 2023. This four-year initiative is a multinational collaboration, uniting 17 research groups from Europe, Israel, Mauritius, South Africa, and the UK, with the objective of developing and testing a rapid, fresh, and dynamic approach to fend off pest infestations threatening European agriculture. The project is coordinated by Marc F. Schetelig, an expert in Insect Biotechnology in Plant Protection at the Justus-Liebig-University (JLU) Giessen in Germany. It is set to implement a groundbreaking strategy: the localized release of sterile insects, performed on newly detected outbreaks to combat quarantine pests. This novel concept signals a shift in our fight against these agricultural invaders, aiming for a more efficient and targeted solution to the pressing issue of invasive *Bactrocera* species.

A critical aspect of REACT's strategy involves the development of Genetic Sexing Strains (GSS) for *B. dorsalis* and *B. zonata* by using a novel approach. The new generation of GSS will not only enable the production and release of all-male offspring but they are also designed to bypass the semi-sterility usually observed with the classical GSS. This approach will enhance the genetic stability of the GSS as well as the efficiency and cost-effectiveness of large-scale sterile insect technique (SIT) programmes.

Participants of the REACT kick-off meeting, (Giessen, Germany).

Creating these strains is challenging, given the quarantine status of both fruit fly species. The Insect Pest Control Laboratory (IPCL) of the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture in Seibersdorf offers invaluable support to the project through data and technology transfer, and expert guidance on GSS development and radiation-based SIT technologies. During a recent visit to IPCL, Marc F. Schetelig emphasized the crucial role of the FAO/IAEA Insect Pest Control Subprogramme (IPCS) in the REACT project's success.

Fitness assessment setup: greenhouse enclosures utilized for performance trials in Bactrocera *species, with a focus on* Bactrocera dorsalis *and* Bactrocera zonata *(inlet) in REACT.*

The REACT's approach is holistic, integrating farmer insights and investigating ecological dynamics, such as native species competition and microbial interactions. Efforts are also underway to identify native European host fruits and analyze the population dynamics under various climate scenarios.

To curb the spread of these fruit flies, REACT is focused on developing a cost-effective, swift, and sensitive diagnostic tool suitable for pooled larval samples. A prototype interception kit utilizing the cutting-edge CRISPR/Cas12a technology combined with recombinase polymerase amplification (RPA) is in the pipeline. This innovative method surpasses existing techniques in sensitivity, enabling prompt detection of pests even in mixed samples.

By adapting the SIT for smaller-scale use and conducting first pilot releases using the novel strategy, the REACT project hopes to make this approach rapidly available for farmers in small farming settings that are invaded by agricultural quarantine pest insets. The collaboration between the IPCS, JLU Giessen, and the REACT consortium is a great example of how international teamwork can tackle common farming problems. It also shows the aligned goals, efforts, and commitment to multiple projects and initiatives to create the most environmentally friendly pest control strategies and applications.

For more information, please visit www.react-insect.eu.

Source: Marc F. Schetelig, Institute for Insect Biotechnology, Department of Insect Biotechnology in Plant Protection (IBPP), Justus-Liebig-University (JLU) Giessen, Germany.

Nine Million Sterile Males to be Released in the Valencian Community to Combat the Tiger Mosquito

The Ministry of Agriculture, Rural Development, Climate Emergency and Ecological Transition announced that it will increase the release of sterile male tiger mosquitoes (*Aedes albopictus*) in 2023 to nine million in Valencia, Spain.

This is part of a pilot project of biological control through the sterile insect technique (SIT) that the government department has been promoting since 2017 in the Ribera Baixa region of Valencia. In previous years, this technique has reportedly managed to reduce the population of tiger mosquitoes by up to 75 per cent. This figure is based on the monitoring that technicians conduct in the municipality where the releases are carried out.

Eight million insects were released in the Ribera Baixa in 2022. The release of sterile males was resumed at the end of February in this new season in order to anticipate the appearance of the first wild individuals, which usually occurs in springtime.

The SIT is a method of biological pest control that consists of the mass breeding of male insects of the same species that

are intended to be combated. They are sterilised by irradiation and subsequently released in the area of action. These sterile males mate with wild females, which causes the eggs they produce to be inviable. As a result, no offspring are produced, resulting in reduced levels of the pest.

This is the same technique that the department has used in the fight against the Mediterranean fly (*Ceratitis capitata*) in citrus fruits. In the case of the tiger mosquito, it is the female that causes the annoying bites, so the release of males has no impact on the members of the public.

Image of Aedes albopictus - *Tiger Mosquito. Credit: Wikipedia - By James Gathany, CDC (PHIL) Public Domain.*

Roger Llanes, the regional secretary for Agriculture, explained that as the capacity to produce sterile insects has improved, releases have also increased.

The problem generated by the expansion of the tiger mosquito led the Department of Agriculture to design a pilot project for biological control that began six years ago in the Ribera Baixa. These pests were first detected in the Valencian Community in 2005, in the town of Orihuela. Specifically, the technicians selected the towns of Polinyà de Xúquer and Albalat de la Ribera for this purpose. Initially, they carried out the release of sterilised males.

Good results were achieved from the outset due to the increase in the production capacity of sterile males. This was achieved thanks to the development of technology and equipment. That led to a fourfold increase in the area in which males were being released in recent years.

In addition to expanding the study area in the Ribera Baixa, the Ministry has also introduced the project to Vilavella in Castellón, and Paterna.

These field works to curb the expansion of the tiger mosquito include the evaluation of different control strategies in various urban environments. The aim is to determine the variables that influence the success of the SIT in controlling the pests as well as the effect of different complementary fighting methods.

Source: The Euro Weekly News. By Chris King, 17 April 2023. https://euroweeklynews.com/2023/04/17/nine-million-sterile-males-to-be-released-in-the-valencian-community-to-combat-the-tiger-mosquito/.

Port Augusta's fruit fly facility to double in size

The 3 million AUD expansion of the National sterile insect technique (SIT) facility at Port Augusta is now underway, helping to drive down fruit fly numbers in South Australia. The existing site, which opened in November 2016, has reached its capacity, producing up to 20 million sterile flies a week with most being released in the Riverland as part of the response to the current outbreaks in the region.

The programme aims to reduce fruit fly population by mating sterile flies with wild flies, resulting in no fertile offspring. The expansion is funded under the 30 million AUD Australian Government National Building Resilience to Manage Fruit Fly programme, with additional contributions from Department of Primary Industries and Regions, South Australia (PIRSA) and Citrus SA, and once completed will have twice the capacity of the original facility, doubling Queensland Fruit Fly (Q-fly) production.

The SIT facility will provide a critical service to help eradicate outbreaks in pest-free areas and reduce pest pressure in vulnerable production areas. The SIT contributes to reduced pest damage and costs to farmers who must treat their fruit before it goes to premium export market. Currently work on the Q-fly facility is on track to be completed by spring 2023 with additional flies expected to be ready for release later this year.

Production of sterile Q-flies will continue throughout the construction phase. The expansion will occur alongside the existing building and will then be joined at the end of the construction phase.

For more information on the Australian National SIT Facility and SIT operations visit www.fruitfly.sa.gov.au.

Source: Mirage.News, 30 May 2023. https://www.miragenews.com/port-augustas-fruit-fly-facility-to-double-in-1015970/.

Area-Wide Management of Mediterranean Fruit Fly with the Sterile Insect Technique in South Africa

In the late 1990s, a mass-rearing facility was established in South Africa to produce sterile male Mediterranean fruit flies, *Ceratitis capitata*, for a sterile insect technique (SIT) programme in the Hex River Valley in the Western Cape Province. After 30 years development, the mass-rearing facility is now operated by FruitFly Africa (FFA), an industry service company in South Africa, owned and managed by various fruit industry stakeholders, such as HORTGRO (Pome & Stone), Canning Fruit Producers Association, RaisinsSA, South African Table Grape Industry, the Agricultural Research Council (ARC) and the Department of Agriculture, Land Reform and Rural Development (DALRRD).

Nowadays, FFA executes a programme for the Area Wide Integrated Pest Management (AW-IPM) of fruit flies of economic importance by following critical practices to ensure the sustainable agriculture in South Africa.

Mass-rearing of Mediterranean fruit fly for SIT application

The FFA production facility in Stellenbosch produces around 65 million sterile males per week (in the warmer months, from October to May), and around 30 million sterile males per week (in the cooler months, from June to September).

Mediterranean mass-rearing facility at FruitFly Africa.

Field sterile release for Mediterranean fruit fly control

The sterile medflies are released in various of the major deciduous fruit and vine producing areas in South Africa. FFA contracts an aerial operator to release sterile flies via helicopter, each week from October to May, covering a total area about 41 700 hectares. Weekly ground releases of sterile medflies also take place, covering a total area around 4 790 hectares. These releases form an integral part of the overall AW-IPM strategy of FFA. Weekly wild and sterile medflies counts are communicated to the fruit producers and other role players.

Getting ready for lift-off to release sterile flies over the Grabouw and Elgin regions (Western Cape).

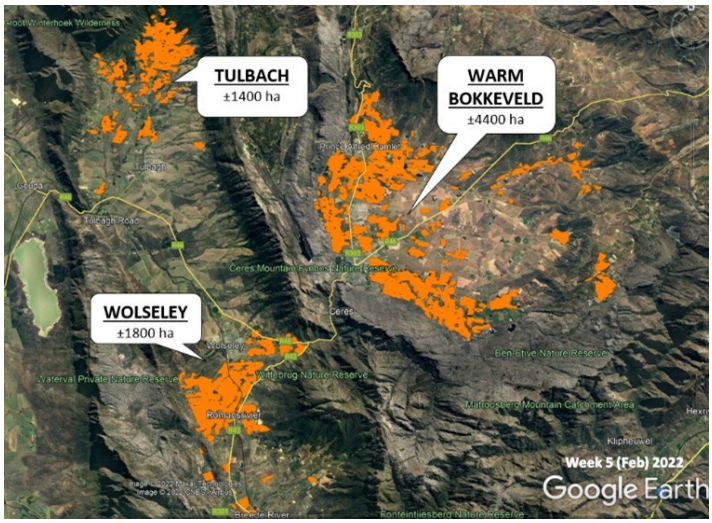
Monitoring ("scouting") for rapid response to major insect pests

The FFA has an extensive footprint to monitor the economic important fruit pests such as Mediterranean fruit fly, Cape fruit fly (*Ceratitis quilicii*), Oriental fruit fly (*Bactrocera dorsalis*) and False Codling Moth (*Thaumatotibia leucotreta*) on commercial orchards, and in towns. The network extends over three provinces in South Africa (Eastern Cape, Western Cape and the Northern Cape) and traps are serviced on a weekly basis, year-round. In total, around 7 400 traps spread over an area of about 60 000 hectares. This monitoring programme has successfully enabled the detection and rapid response to *B. dorsalis* invasion in those areas. In 2022, eight detections of *B. dorsalis* were reported immediately to DALRRD and FFA assisted DALRRD to distribute *B. dorsalis* control products for eradication.

Monitor Armand de Klerk (of the Langkloof region) servicing a fruit fly trap in an orchard.

Area-wide aerial baiting of attract and kill insecticide for SIT integration

The FFA coordinates the aerial baiting of an attract and kill insecticide over commercial fruit orchards, on behalf of producers, in regions like Elgin, Grabouw, Vyeboom, Hemel & Aarde, Ceres (Warm Bokkeveld, Wolseley, Tulbagh), Hex River Valley (including De Wet & Brandwag), Langkloof and Lower Orange River.



Aerial map of all the regions covered during an aerial baiting in Ceres, February 2022.

Other activities for AW-IPM

The FFA is also involved in related activities such as: hotspot management (including host plants and home gardens), ground baiting, including "attract and kill" bait stations, orchard sanitation and participation in international research projects.

Source: Mr Ghian du Toit, FruitFly Africa.

Tasmania Tests Sterile Insects to Combat Codling Moth

For the first time in Australia, a form of fertility control is being trialled to manage a major pest to the apple industry, codling moth. Researchers at the Tasmanian Institute of Agriculture (TIA), a joint venture of the University of Tasmania and the Tasmanian Government are partnering with local apple growers to pilot a controlled sterile insect release program.

Dr Sally Bound in apple orchard in the Huon Valley, Tasmania.

The program is importing sterilised moths from Canada for release in the test orchards. The research team rigorously monitor the moths' progress using specific pheromone traps.

The TIA Senior Research Fellow, Dr Sally Bound leads the pilot program which is taking place across three apple orchards in Tasmania's Huon Valley.

"The program works by flooding the wild population with large numbers of sterile males to substantially reduce the number of fertile eggs produced," Dr Bound said. "When this is repeated over a number of seasons, the population crashes and infestations drop below the threshold levels set for pesticide application, meaning growers no longer need to apply pesticides for codling moth, even for export markets that require pest free shipments."

The research team will assess sterile moth viability and competitiveness, determine the logistics of importation and release, and undertake an economic assessment of the release program, with the aim of developing recommendations for adoption and integration of sterile releases into an IPM program.

Current management strategies for codling moth include monitoring, mating disruption, biological control and chemical pesticide control. While these strategies can be effective, application of pesticides can disrupt beneficial insects, substantially affecting integrated pest management systems.

Mr Scott Price, Orchard Manager from R&R Smith said codling moth was a big issue for the apple industry. "Our area around Grove in the Huon is a real hotspot for both codling moth and light brown apple moth, I'm really excited about the sterile codling moth technology; I've seen the phenomenal results they have achieved in New Zealand. If this pilot program stacks up economically and logistically then I think it will be very good for the apple industry in Tasmania and Australia."

Dr Bound said the team will be repeating the program next season. "By the end of the second release season we hope to see a reduction in the numbers of wild moths. It can take a few seasons to see a significant drop off in the wild population."

The project runs for three years and has been funded by Hort Innovation, using the Apple & Pear research and development levy and contributions from the Australian Government. It is a partnership between TIA, the Tasmanian Government, Fruit Growers Tasmanian, The Department of Agriculture, Fisheries and Forestry, the South Australian Research and Development Institute and Lenswood Coop in South Australia.

Source: Miragenews.com, 1 March 2023. https://www.miragenews.com/tasmania-tests-sterile-insects-to-combat-956967/.

Relevant Published Articles

The Sex Pheromone Heptacosane Enhances the Mating Competitiveness of Sterile *Aedes aegypti* Males

Lin-Min Wang[1], Ni Li[1], Mao Zhang[1], Qi Tang[1], Hong-Zheng Lu[1], Qing-Ya Zhou[1], Jia-Xuan Niu[1], Liang Xiao[2], Zhe-Yu Peng[1], Chao Zhang[1], Miao Liu[1], Duo-Quan Wang[3] and Sheng-Qun Deng[1]

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[3] *Chinese Center for Disease Control and Prevention, National Institute of Parasitic Diseases, Shanghai, China.*

Abstract

Background *Aedes aegypti* is a vector that transmits various viral diseases, including dengue and Zika. The radiationbased sterile insect technique (SIT) has a limited effect on mosquito control because of the difficulty in irradiating males without reducing their mating competitiveness. In this study, the insect sex pheromone heptacosane was applied to *Ae. aegypti* males to investigate whether it could enhance the mating competitiveness of irradiated males.

Methods Heptacosane was smeared on the abdomens of *Ae. aegypti* males that were allowed to mate with untreated virgin females. The insemination rate was used to assess the attractiveness of heptacosane-treated males to females. The pupae were irradiated with different doses of X-rays and γ-rays, and the emergence, survival time, egg number, and hatch rate were detected to find the optimal dose of X-ray and γ-ray radiation. The males irradiated at the optimal dose were smeared with heptacosane, released in different ratios with untreated males, and mated with females. The effect of heptacosane on the mating competitiveness of irradiated mosquitoes was then evaluated by the hatch rate, induced sterility, and mating competitiveness index.

Results Applying heptacosane to *Ae. aegypti* males significantly increased the insemination rate of females by 20%. Pupal radiation did not affect egg number but significantly reduced survival time and hatch rate. The emergence of the pupae was not affected by X-ray radiation but was affected by γ-ray radiation. Pupae exposed to 60 Gy X-rays and 40 Gy γ-rays were selected for subsequent experiments. After 60 Gy X-ray irradiation or 40 Gy γ-ray irradiation, the average hatch rate was less than 0.1%, and the average survival time was more than 15 days. Moreover, at the same release ratio, the hatch rate of the irradiated group perfumed with heptacosane was lower than that of the group without heptacosane. Conversely, the male sterility and male mating competitiveness index were significantly increased due to the use of heptacosane.

Conclusions The sex pheromone heptacosane enhanced the interaction between *Ae. aegypti* males and females. Perfuming males irradiated by X-rays or γ-rays with heptacosane led to a significant increase in mating competitiveness. This study provided a new idea for improving the application effect of SIT.

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A Volatile Sex Attractant of Tsetse Flies

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Abstract

Tsetse flies transmit trypanosomes—parasites that cause devastating diseases in humans and livestock—across much of sub-Saharan Africa. Chemical communication through volatile pheromones is common among insects; however, it remains unknown if and how such chemical communication occurs in tsetse flies. We identified methyl palmitoleate (MPO), methyl oleate, and methyl palmitate as compounds that are produced by the tsetse fly *Glossina morsitans* and elicit strong behavioral responses. MPO evoked a behavioral response in male—but not virgin female—*G. morsitans*. *G. morsitans* males mounted females of another species, *Glossina fuscipes*, when they were treated with MPO. We further identified a subpopulation of olfactory neurons in *G. morsitans* that increase their firing rate in response to MPO and showed that infecting flies with African trypanosomes alters the flies' chemical profile and mating behavior. The identification of volatile attractants in tsetse flies may be useful for reducing disease spread.

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Jackson Trap Efficiency Capturing *Bactrocera* dorsalis and *Zeugodacus cucurbitae* with Male Lures with and without Insecticides

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Abstract

Jackson traps baited with male lures with or without insecticides are essential components of surveillance and monitoring programmes against pest tephritid fruit flies. The ability of a trap to capture a fly that enters, sometimes termed 'trap efficiency', is dependent on many factors including the trap/lure/toxicant combination. We tested the effects of three important components of Jackson traps on efficiency of capture of two important fruit fly species, using the 'standard' (i.e. as they are used in the state-wide surveillance programme in California) and alternative setups: Insecticide (Naled, DDVP or None), type of adhesive on the sticky panel (Seabright Laboratories Stickem Special Regular or Stickem Special HiTack) and use of a single or combination male lure (Methyl eugenol and/or cuelure). Experiments were conducted in large outdoor carousel olfactometers with known numbers of *Bactrocera dorsalis* and *Zeugodacus cucurbitae* and by trapping wild populations of the same two species. Lures were aged out to eight weeks to develop a comprehensive dataset on trap efficiency of the various combinations. Results indicate that the current liquid lure/naled combinations on cotton wicks used in California for surveillance of these flies can be effectively replaced by plastic polymer plugs for the lure and pre-packaged DDVP strips with no loss of trap efficiency for eight weeks of use or longer. The 'high tack' adhesive showed no advantage over the current standard against these flies, and both have low efficiency when used without an insecticide in the trap. Combination lure + DDVP varied when compared to the current standard liquid lure + naled: Olfactometer assays showed similar efficiency between them for *B. dorsalis*, but higher efficiency for the wafer against *Z. cucurbitae*. Field result showed similar or slightly higher performance of the wafer compared with the standard for B. dorsalis, but a much lower catch of Z. cucurbitae.

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Maternal and Host Effects Mediate the Adaptive Expansion and Contraction of the Microbiome During Ontogeny in A Holometabolous, Polyphagous Insect

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Abstract

Polyphagous, holometabolous insects adapt to rapid diet shifts imposed by their ecology and their life cycle. One shift is linked to development, as larvae and adults usually dwell and feed in different environments, using different resources. The second is caused by changes in larval hosts, often occurring at each generation. Studies show that the insect's microbiome also changes in relation to development and larval host. However, parental and larval host contributions to its structure and trans-generational dynamics remain uncharted.

We investigated the sources of variation of the microbiome of the highly polyphagous Mediterranean fruit fly by tracking microbiome structure and its potential functional impact in fly lineages over generations and fruit host shifts, using 16S rRNA gene amplicon single variant analysis.

Bacterial community alpha-diversity expanded and contracted cyclically in a life stage-dependent manner with the mothers' microbiome community 'resetting' to the same structure across generations. Expansion occurred at the larval stage, while alpha-diversity decreased in tenerals, and significantly in mothers. In contrast, richness was highest in mothers, with rare taxa expanding in larvae depending upon fruit type.

Metabolic predictions using PICRUSt pointed to increased metabolism of vitamins in mothers, and of aromatic compouds in larvae and tenerals, while indicator species analysis suggested fruit host composition-dependent potential functional adaptations.

Our data indicate lineage, fruit host and their interactions as the main sources of microbiome variation and provide examples of possible metabolic developmental and ecological adaptations. Taken together, these data support the hypothesis that microbiome diversity and microbiome-driven local adaptations act as a mechanism sustaining polyphagy.

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