Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Insect Pest Control Newsletter

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To Our Readers

Argentina and Chile are piloting the implementation of a preventive SIT approach against the Mediterranean fruit fly in their pest free areas. The picture shows the fruit production valleys in Patagonia, Argentina (Source: PROCEM-SENASA Argentina).

Argentina and Chile are piloting a preventive SIT approach against the Mediterranean fruit fly in their areas that are free of this pest, i.e., Mendoza province and Patagonia region in Argentina and Santiago Metropolitan Region in Chile. Both countries are adopting a preventive release strategy, similar to the one in California and Florida (USA) that has been in place since 1994.

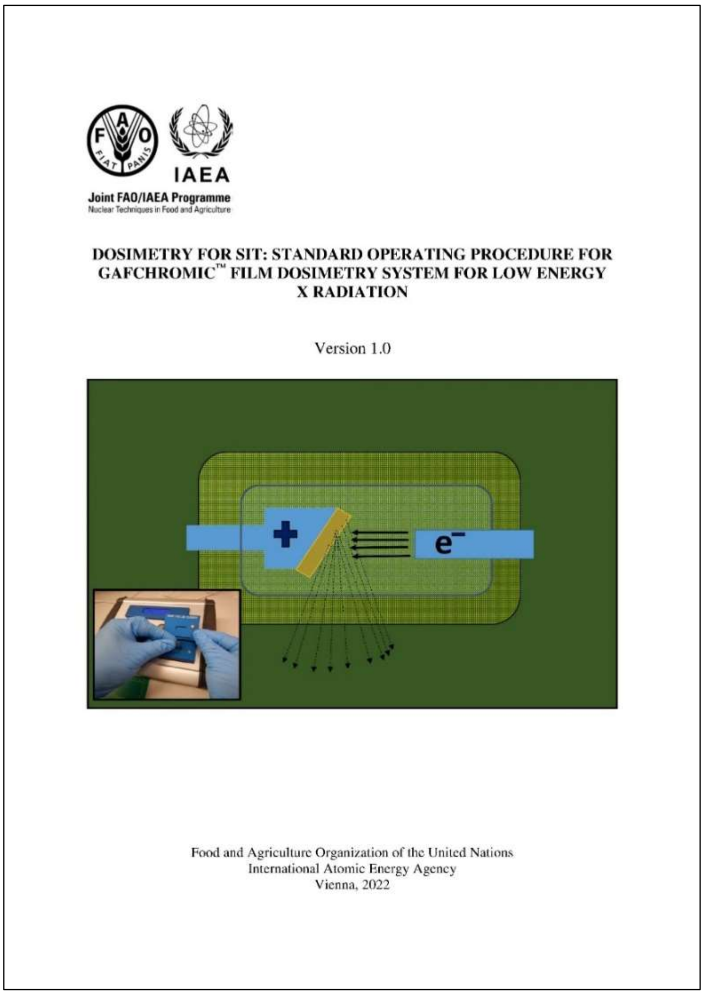
In the last newsletter, details were provided on this programme in Chile and in this newsletter, we would like to highlight the application of preventive releases in Argentina (see more details later in this newsletter). The National Fruit Fly Control and Eradication Programme (PROCEM) of the National Service for Food Health and Quality (SENASA) in Argentina, with the support of the FAO and IAEA, established fruit fly pest free areas in the Province of Mendoza and in the region of Patagonia using an area-wide integrated pest management (AW-IPM) approach with a sterile insect technique component. This allowed the diversification of fruit production and access to export markets that were previously excluded because of the presence of the fruit fly pest.

Since mid-2020, a Mediterranean fruit fly preventive sterile male release programme was adopted and successfully implemented as part of an AW-IPM scheme to protect the free areas established in the central and southern part of Mendoza and in the region of Patagonia. There is a distinctive difference between a traditional SIT control strategy and a preventive approach, i.e., the first one is implemented in infested areas to suppress or eradicate a pest, whereas the second strategy is applied in pest free areas to prevent the introduction of the pest.

An emergency action plan to deal with an outbreak of the Mediterranean fruit fly is being implemented in the state of Colima, Mexico, and the SIT is the main component of the programme. The fly was detected in Colima in April 2021, which is about 1 300 kilometres north from the closest wild populations located in the State of Chiapas, at the border area between Mexico and Guatemala. The Colima operation is on track and currently the outbreak is well under control (see more details later in this newsletter).

Furthermore, we would like to announce that the sweet potato weevil has successfully been eradicated from Tsuken Island, in Okinawa, Japan by integrating the SIT with other control methods. This is the second success on sweet potato weevil in the world, following the eradication achieved on Kume Island, also in Okinawa in 2012. Despite the small size of both Kume and Tsuken Islands (63.65 and 1.88 km2 respectively), it took 19 and 13 years, respectively to confirm the success of eradication.

Another achievement of our Subprogramme was the development of two Standard Operating Procedures (SOPs) for gamma radiation (Standard Operating Procedures for Gafchromic™ Film Dosimetry System for Gamma Radiation) and low energy X radiation (Standard Operating Procedures for Gafchromic™ Film Dosimetry System for Low Energy X Radiation). Both are available in English and Spanish and can be downloaded at the Insect Pest Control website of the IAEA. The SOPs keep everything related to the components of the Gafchromic™ dosimetry system in one place.



Finally, I am pleased to inform our readers that the IAEA has also re-designated the *Centro Agricoltura Ambiente (CAA) 'G. Nicoli'* in Bologna, Italy as an IAEA Collaborating Centre to develop the SIT for the management of *Aedes* mosquitoes. During the last designation period the CAA improved several aspects of the mosquito SIT package, such as the development of new methods for packaging mosquitoes to reduce the volume of the delivered parcel without affecting the survival rate of the mosquitoes during long-distance shipment. The CAA is expected to continue its leading role on the improvement of the SIT for *Aedes* mosquitoes.

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Forthcoming Events (2022–2023)

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

Second RCM on Mosquito Irradiation, Sterilization and Quality Control. 18–22 July 2022, Vienna, Austria.

First RCM on Improve the Mass-Rearing of Lepidoptera Pests for SIT Programmes. 5–9 September 2022, Vienna, Austria.

Fourth RCM on Integration of the SIT with Biocontrol for Greenhouse Insect Pest Management. 8–12 November 2022, Sydney, Australia.

Third RCM on Assessment of Simultaneous Application of SIT and MAT to Enhance *Bactrocera* Fruit Fly Management. 20–24 November 2022, Sydney, Australia.

Third RCM on Improvement of Colony Management in Insect Mass-rearing for SIT Applications. 27 February–3 March 2023, Patras, Greece.

Third RCM on Generic Approach for the Development of Genetic Sexing Strains for SIT Applications. 24–28 April 2023, La Reunion, France.

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

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, Athens, Greece.

II. Consultants and Expert Meetings

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

III. Other Meetings/Events

FAO/IAEA Workshop on Irradiation and Dosimetry. 14–15 July 2022, Vienna, Austria.

XXVI International Congress of Entomology. 17–22 July 2022, Helsinki, Finland.

FAO/IAEA Regional Training Course on Mark-Release-Recapture and Field Data Management (under Reginal TC Project RAS5095). 22–26 August 2022, Vienna, Austria.

Meeting of the Technical Panel on Phytosanitary Treatments (TPPT), International Plant Protection Convention FAO. 12–16 September 2022, Rome, Italy.

First International Plant Health Conference 21–23 September 2022, London, UK.

FAO/IAEA Regional Training Course on SIT Components: Handling, Shipping and Releasing Procedures Applied in SIT Projects (under Regional TC Project RLA5083). 07– 11 November 2022, Juazeiro, Brazil.

11th International Symposium on Fruit Flies of Economic Importance. 14–18 November 2022, Sydney, Australia.

FAO/IAEA Regional Training Course on Methods for the Mass-Rearing, Irradiation and Release of Sterile Male *Aedes* spp. (under Reginal TC Project RAS5095). 21–25 November 2022, Singapore.

FAO/IAEA Mid-term Review Meeting on Enhancing the Capacity to Integrate Sterile Insect Technique in the Effective Management of Invasive *Aedes* mosquitoes (under Regional TC Project RER5026). 28 November–02 December 2022, Pula, Croatia.

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

FAO/IAEA Regional Training Course on Fruit Fly Surveillance and Identification (under Reginal TC Project RAS5097). 27 February–3 March 2023, Kuala Lumpur, Malaysia.

Past Events (2021–2022)

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

Fourth RCM on Improved Field Performance of Sterile Male Lepidoptera to Ensure Success in SIT Programmes. 18–21 May 2021 (virtual).

First RCM on Mosquito Radiation, Sterilization and Quality Control. 31 May–4 June 2021 (virtual).

Third RCM on Integration of the SIT with Biocontrol for Greenhouse Insect Pest Management. 21–25 June 2021 (virtual).

Second RCM on Assessment of Simultaneous Application of SIT and MAT to Enhance *Bactrocera* Fruit Fly Management. 28 June–2 July 2021 (virtual).

Second RCM on Improvement of Colony Management in Insect Mass-rearing for SIT Applications. 30 August–3 September 2021 (virtual).

Second RCM on Generic Approach for the Development of Genetic Sexing Strains for SIT Applications. 18–22 October 2021, Vienna, Austria (hybrid).

First RCM on Improving SIT Fruit Fly Field Programmes. 1–5 November 2021 (virtual).

II. Consultants and Expert Meetings

FAO/IAEA Consultancy Meeting on Improving SIT Fruit Fly Field Programmes. 7–11 June 2021 (virtual).

FAO/IAEA Consultancy Meeting on Rearing of Lepidoptera for SIT Application. 8–12 November 2021 (virtual).

FAO/IAEA Consultancy Meeting on Mosquito Male Performance. 23–27 May 2022, Vienna, Austria.

FAO/IAEA Consultancy Meeting on *Aedes* Mosquito Sterile Insect Technique Package: Review and Future Perspectives. 30 May–1 June 2022, Vienna, Austria.

FAO/IAEA Consultancy Meeting on Guideline on Transboundary Shipments of Sterile Insects. 13–17 June 2022, Vienna, Austria.

III. Other Meetings/Events

FAO/IAEA First Coordination Meeting on Enhancing the Capacity to Integrate Sterile Insect Technique in the Effective Management of Invasive *Aedes* Mosquitoes (under Regional TC Project RER5026). 15–19 February 2021 (virtual).

FAO/IAEA First Coordination Meeting on Enhancing Capacity for the Use of the Sterile Insect Technique as a Component of Mosquito Control Programmes (under Regional TC Project RLA5083). 22–24 February 2021 (virtual).

Fifteenth Session of the Commission on Phytosanitary Measures (CPM-15), International Plant Protection Convention, FAO. 16, 18 March and 1 April 2021 (virtual).

FAO/IAEA Regional Training Course on Pest Risk Analysis (under regional TC Project RLA5090). 23–29 March 2022 (virtual).

FAO/IAEA Second Regional Coordination Meeting on Strengthening Food Security Through Efficient Pest Management Schemes Implementing the Sterile Insect Technique as a Control Method (under Regional TC Project RLA5082). 7 April 2021 (virtual).

FAO/IAEA Second Regional Coordination Meeting on Strengthening the Regional Capacities in the Prevention and Progressive Control of Screwworm (under Regional TC Project RLA5075). 8 April 2021 (virtual).

FAO/IAEA Regional Workshop on State-of-the-Art Sterile Fruit Fly Shipping, Packing and Release Systems (under Regional TC Project RLA5082). 16 April 2021 (virtual).

FAO/IAEA Second Regional Coordination Meeting on Advancing and Expanding Area-Wide Integrated Management of Invasive Pests, Using Innovative Methodologies Including Atomic Energy Tools (under Regional TC Project RAS5090). 19 May 2021 (virtual).

FAO/IAEA First Coordination Meting on Validating the Sterile Insect Technique for the Control of the South American Fruit Fly (under regional TC Project RLA5087). 23–25 May 2022 (virtual).

FAO/IAEA First Coordination Meting on Advancing Surveillance and Progressive Control of the New World Screwworm Using the Sterile Insect Technique (under regional TC Project RLA5088). 1–3 June 2022 (virtual).

FAO/IAEA Regional Training Course on SIT Components: 'Methods for Mass-Rearing and Irradiation of *Aedes* Mosquitoes' (Module I) (under Regional TC Project RLA5083). 15–18 June 2021 (virtual).

FAO/IAEA High-Level Group Scientific Visit for Uruguay on Area-Wide Integrated Pest Management Programmes for the Control of the New World Screwworm (under regional TC Project RLA5088). 27 June–1 July 2022, Pecora, Panama.

FAO/IAEA Regional Workshop on Phytosanitary Schemes to Enable Fruit Exports Under the Framework of the WTO and the SPS Agreement (under Regional TC Project RLA5082). 21 June–2 July 2021 (virtual).

FAO/IAEA Regional Workshop on MEDNIP Database (under Regional TC Project RAS5090). 26–28 July 2021 (virtual).

FAO/IAEA Regional Training Course on SIT Components: Mosquito Monitoring, Data Collection and Data Management (Module II) (under Regional TC Project RLA5083). 27–30 July 2021 (virtual).

FAO/IAEA Regional Workshop on Managing Fruit Fly Surveillance Networks Based on Risk Factors (under Regional TC Project RLA5082). 26 July–6 August 2021 (virtual).

FAO/IAEA Regional Workshop on Communication Strategies for the Use of the Sterile Insect Technique as a Component of Mosquito Control (under Regional TC Project RLA5083). 3–5 and 9–11 November 2021 (virtual).

FAO/IAEA Regional Training Course on Management and Statistical Analysis of Data Collected from Mark-Release-Recapture Studies for *Aedes* Mosquitoes in Preparation of SIT Pilot Trials (under Regional TC Project RER5026). 6–10 December 2021 (virtual).

FAO/IAEA Regional Workshop on Challenges and Solutions in the Implementation of SIT based Technologies against *Aedes* Vectors (under Regional TC Project RAS5082), co-organized with the National Environment Agency, Singapore. 12–19 January 2022 (virtual).

FAO/IAEA Second Coordination Meeting on Enhancing Capacity for the Use of the Sterile Insect Technique as a Component of Mosquito Control Programmes (under Regional TC Project RLA5083). 1–3 February 2022 (virtual).

FAO/IAEA Regional Stakeholder Engagement Meeting to Achieve Early Support to Sterile Insect Technique Pilot Trials against *Aedes* Mosquitoes (under Regional TC Project RER5026). 4–6 April 2022, Bologna, Italy.

FAO/IAEA Regional Training Course on Vector Control Needs Assessment, Co-organized with the World Health Organization Regional Office for Europe (under Regional TC Project RER5026). 9–13 May 2022, Limassol, Cyprus.

FAO/IAEA First Coordination Meeting on Enhancing Regional Capacity for the Implementation of the Sterile Insect Technique as a Component for Area-Wide Tsetse and Trypanosomosis Management (under Regional TC Project RAF5087). 20–24 June 2022, Vienna, Austria.

FAO/IAEA First Regional Coordination Meeting on Strengthening and Harmonizing Surveillance and Suppression of Fruit Flies (under Regional TC Project RAS5097). 21–23 June 2022 (virtual).

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	BKF5020	Strengthening the Insectarium to Create Agropastoral Areas Permanently Liberated from Tsetse Flies and Trypanosomiasis	Adly Abdalla
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	RAS5082	Managing and Controlling *Aedes* Vector Populations Using the Sterile Insect Technique	Marc Vreysen Hamidou Maiga
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 Hamidou Maiga
Regional Asia & the Pacific	RAS5097	Strengthening and Harmonizing Surveillance and Suppression of Fruit Flies	Daguang Lu Rui Cardoso Pereira

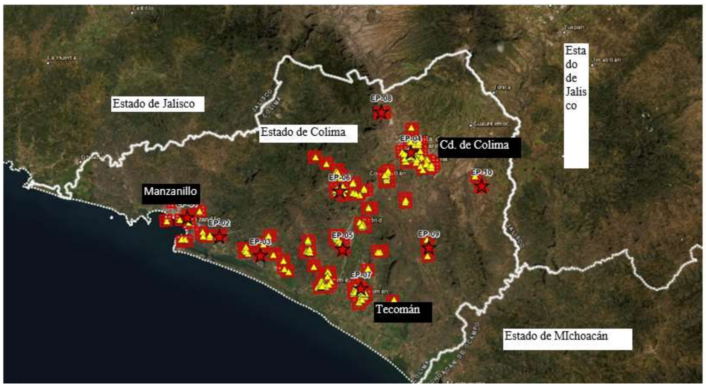
Regional Europe	RER5026	Enhancing the Capacity to Integrate Sterile Insect Technique in the Effective Management of Invasive *Aedes* Mosquitoes	Wadaka Mamai Jeremy Bouyer
Regional Latin America	RLA5082	Strengthening Food Security through Efficient Pest Management Schemes Implementing the Sterile Insect 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)

Eradication of the Mediterranean Fruit Fly from the State of Colima, Mexico

The Mediterranean fruit fly (or medfly) *Ceratitis capitata*, Wied., is considered among the most devastating insect pests worldwide due to the direct damage it inflicts to a wide range of fruit and vegetable crops, as well as due to quarantine restrictions to fruit trade imposed by countries which are free from this pest. In 1977, the Governments of Guatemala, Mexico and the USA joined forces against this pest by establishing the Moscamed Regional Programme for the prevention and eradication of the pest, which, by that year, had invaded Guatemala and Chiapas in the southern part of Mexico bordering Guatemala. Through the actions of the Moscamed Programme, the medfly was eradicated from Mexico in 1982 using an area-wide integrated pest management (AW-IPM) scheme based on the sterile insect technique (SIT). Since then, an effective containment barrier has been kept preventing introduction of the pest to northern Guatemala, Mexico, and the USA.



*Mediterranean fruit fly (*Ceratitis capitata*, Wied.) detections and outbreaks in the State of Colima Mexico, June 2021.*

In Mexico, this has paved the way for the country's development and diversification of the horticultural industry, becoming the seventh producer and exporter of fresh fruits and vegetables in the world, including avocado, mango, papaya, guava, citrus, tomato, and others, valued at tens of billions of US dollars per annum in the local and export markets and generating millions of jobs and demand for services in the rural areas of the country.

In April 2021, an outbreak of Mediterranean fruit fly occurred along the Pacific Coast in the State of Colima, Mexico, about 1 300 km north from where the medfly containment barrier is kept in the State of Chiapas and Guatemala. The establishment of the pest in the state of Colima would jeopardize the success of the Moscamed Programme and would put at high risk the production and exports of fruits and vegetables from Colima and from the entire country as well as greatly increasing the risk of the pest introduction into the USA.

Ground release of sterile male Mediterranean fruit flies, Colima, Mexico.

The medfly outbreak was detected in the vicinity of the Port of Manzanillo with several male adult flies caught in a Jackson trap baited with the specific male attractant, Trimedlure. This port handles over 2.5 million containers per year, being the largest port in Mexico. The goods being imported to the country include horticultural products from Central and South America, Asia, and the Mediterranean Basin, many of which are fruit fly hosts.

After confirming the medfly outbreak, the Mexico Plant Protection General Directorate (DGSV), National Service for Plant and Animal Health, Food Safety and Quality (SENASICA), immediately implemented an emergency response which included the delimitation of the outbreak as well as suppression and eradication measures. A surveillance programme composed of 4 436 traps was implemented throughout the whole state for pest delimitation purposes. It soon became clear that the pest was widespread in the state with the main populations present in the urban areas infesting fruits of the tropical almond (*Terminalia cattapa*) which is used by the households as shade trees. Without an immediate intervention, the risk of the pest spreading into the commercial fruit and vegetable production areas would have been extremely high.

In June 2021, an FAO/IAEA expert reviewed the emergency response plan and provided advise on the implementation of the surveillance system and the eradication strategy. In October, the same expert provided follow-up to the emergency plan and gave specific recommendations to adjust the emergency response. After seven months of intensive and extensive suppression and eradication activities including the weekly aerial releases of 1 170 million sterile male flies, the pest population was substantially reduced to low prevalence levels. So far, seven biological cycles (about seven months) of the pest have been completed with no further detections since the last one that occurred on 26 October 2021.

FAO/IAEA Technical Advisory Panel (TAP) visiting the Port of Manzanillo in Colima, Mexico, April 2022.

Given the favourable progress made in the eradication of the pest, in April 2022 an FAO/IAEA Technical Advisory Panel (TAP) visited the State of Colima to evaluate the results obtained so far onsite, to confirm the status of the pest and to provide further recommendations.

The TAP confirmed that the pest population is close to being eradicated and recommended to continue the sterile fly releases until June 2022 in order to eliminate the remaining fly population pockets. It also recommended the implementation of a specific survey to verify absence of the pest for at least one biological cycle once sterile fly releases have stopped.

The results of the verification survey will be used as technical criteria to officially declare eradication and to reinstate the fruit fly free area status.

Advancing and Expanding Area-Wide Integrated Management of Invasive Pests, Using Innovative Methodologies Including Atomic Energy Tools (RAS5090)

Workshop on Pest Risk Analysis (PRA). 23–30 March 2022 (virtual)

Globalization has increased travel of people worldwide as well as international trade of goods including agricultural products. With this, also the risk of introducing invasive quarantine pests capable of inflicting devastating damage to food security worldwide has significantly increased.

Climate change (in particular global warming) plays also an important role in increasing the risk of survival and establishment of quarantine pests in places where they could not previously survive. Countries and regions in the world are exposed to this increasing threat, including FAO and IAEA Member States in the Middle East.

Participants of the virtual workshop on Pest Risk Analysis (PRA).

Under this context, a virtual workshop on PRA was conducted within the framework of regional technical cooperation project RAS5090. The PRA is a unique tool for assessing the risk of introduction of regulated pests and provides phytosanitary measures to manage the pest risk.

A total of 25 participants from Israel, Jordan and Territories Under the Jurisdiction of the Palestinian Authority attended the workshop, including the regional project counterparts and staff from their plant protection organizations.

A total of 20 hours of lectures including theory and practical exercises were offered. The topics included: 1) introduction to PRA, 2) the World Trade Organization agreement on sanitary and phytosanitary measures (WTO-SPS) and the International Plant Protection Convention (IPPC) framework, 3) relevant International Standards for Phytosanitary Measures (ISPMs) including ISPM 11 'Pest risk analysis for quarantine pests', 4) resources available to conduct PRAs, and 5) case studies on application of PRAs to facilitate opening of trade. The workshop was delivered by the international expert Mr Manuel Mejia, Technical Director of Risk Analysis, Colombian Agricultural Institute, ICA, Colombia.

The plant protection organizations of Israel, Jordan and Territories Under the Jurisdiction of the Palestinian Authority have been trained in conducting PRA and are now better equipped to mitigate the risk of quarantine pests while facilitating international trade.

Capacity Building for Mass Rearing, Sterilization and Pilot Release of *Aedes aegypti* and *Philornis downsi* males in Ecuador (ECU5032)

Philornis downsi

Twenty-one bird species in the Galapagos Islands, including 12 species of Darwin's finches, are under threat from an invasive parasitic fly, *Philornis downsi*. Commonly known as the Avian Vampire Fly, this fly was accidentally introduced in the Galapagos Islands and is now seriously affecting the survival of at least seven of these Galapagos bird species. One of these species is the critically endangered Mangrove Finch, with only about 100 individuals left in the wild. The flies are adept at locating bird nests to lay their eggs. Once larvae hatch, they feed on the blood of hatchlings, sometimes causing all of the chicks in a nest to die.

Avian Vampire Fly larvae collected from a Galapagos Mockingbird nest. These larvae feed on the blood of bird hatchlings (Photo: Paola Lahuatte).

The Galapagos National Park Directorate (GNPD) with the Charles Darwin Foundation (CDF) are coordinating a multi-institutional collaborative effort to find effective and environment-friendly control methods for the Avian Vampire Fly. The Food and Agriculture Organization of the United Nations (FAO) and the International Atomic Energy Agency (IAEA) through the IAEA Technical Cooperation (TC) project is supporting the studies in Galapagos to pave the way for using the Sterile Insect Technique (SIT) as a control tool. The first steps include: (1) developing techniques to mass-rear this parasitic fly; (2) improving trapping techniques for estimating fly populations in the field; and (3) training personnel on using these techniques.

Considerable progress has been made towards meeting these goals. With the help of an IAEA expert mission and new laboratory equipment, an essential component missing from the lab-reared flies' diet - brewer's yeast - was identified. This addition to the diet, and improvements made to the rearing methods by CDF scientists, has enabled on-demand production of flies for the first time, with up to 500 flies produced per week. Analyses conducted through IAEA subcontracts with State University of New York College of Environmental Science and Forestry have identified some chemical compounds in the odours produced by the flies and birds that could be used as attractants in traps in the field. These will be tested in 2022. Lastly, six Galapagos residents have been receiving ongoing training in the rearing and trapping methods *in situ*.

Laboratory assistants Andrea Cahuana (left), Joselyn Yar (center) and Magally Infante (right) tending to the Avian Vampire Fly colonies in the laboratory at the Charles Darwin Research Station (Photo: Paola Lahuatte).

Further studies are needed to build on the information collected to date about this little-known fly species. One of the most pressing needs is to find a way to standardize the blood diets given to the larvae; blood from free-range chickens is currently used. Also, so far, lab-rearing is dependent on collecting eggs from female flies caught in the wild. A full understanding of the factors that trigger mating is needed to get flies to mate in captivity. So far, the CDF team has discovered that dusk is an important factor. Once flies mate and lay fertile eggs consistently, studies will be needed to produce enough males, since male sterile flies are the key component of the SIT. Tests will also be needed to determine the correct doses of irradiation required to render the flies sterile.

The progress made on this project to date has allowed GNPD and CDF to move forward with studies necessary to evaluate the efficacy of SIT, as well as to make progress on developing complementary control techniques. Reduction in Avian Vampire Fly numbers through an integrated management approach will help protect bird hatchlings from fly parasitism and ensure the long-term conservation of Darwin's finches and other land birds endemic to this UNESCO World Heritage Site.

Enhancing Capacity for the Use of the Sterile Insect Technique as a Component of Mosquito Control Programs (RLA5083)

Second Coordination Meeting, 1–3 February 2022 (virtual)

After the 2016 Zika outbreak in many American countries, the International Atomic Energy Agency (IAEA) in collaborating with the Food and Agriculture Organization of United Nations (FAO) endeavoured to help Member States to build capacities in Latin America and the Caribbean Region to evaluate and validate the SIT in open field conditions as a complementary tool for mosquito population control. In this context, the IAEA technical cooperation project RLA5083 aims to provide technical support for the participating Member States to develop their capacity for gathering entomological data through monitoring the mosquito population and, also, to further develop the SIT components, by building capacities to mass-rearing, irradiation, handling, transporting, and releasing *Aedes* spp. sterile males. Besides, the project supports aspects from an ethical and regulatory perspective, along with strategies for an effective engagement with communities and stakeholders during the SIT evaluation. From this perspective, the region builds and strengthens the capacities and the networks harmonizing the SIT package information among the participants.

Participants of the Second Coordination Meeting on Enhancing Capacity for the Use of the Sterile Insect Technique as a Component of Mosquito Control Programmes (held virtually).

The second coordination meeting of the RLA5083 project was held virtually and was attended by counterparts from participating MSs of the Latin America and Caribbean Region. The meeting reviewed the project's status and the progress achieved in 2021. During the meeting, all challenges faced by the MSs with respect to the implementation of the SIT package targeting *Aedes* species were discussed at both national and regional level. Technical discussions took place and focused on the 'Phase Conditional Approach' since this is essential during the preparation and implementation of SIT field trials. Based on the Phase Conditional Approach: 1) two MSs have implemented field projects with additional support of their respective TC National Project, and they showed an effective *Aedes aegypti* population reduction. The next step is to scale up and incorporate new areas; 2) eight MSs are at the pre-intervention phase groups identifying and engaging key stakeholders for a strong commitment prior to the pilot trial; 3) eight MSs are building capacities, and actively collecting relevant baseline data, a prerequisite to perform an appropriate intervention strategy to reduce the mosquito population using SIT.

During the meeting, advanced MSs, such as Brazil, shared with all participants lessons learned, bottlenecks, and challenges faced during the implementation phase of the SIT pilot project in Recife, Brazil which had a complex logistic and entomological scenario towards the suppression of the target mosquito population.

In summary, the MSs discussed the implementation activities in 2021 and the work plan proposed for 2022. All participating MSs discussed and agreed with the upcoming priorities according to the Phase Conditional Approach aiming to enhance capacities, networking, and harmonizing procedures at the regional level for the adoption of the SIT package for mosquito control which are the vectors of diseases such as dengue, chikungunya and Zika in the Latin America and Caribbean region.

Managing and Controlling *Aedes* Vector Populations Using the Sterile Insect Technique (RAS5082)

Workshop on Challenges and Solutions in the Implementation of SIT based Technologies against *Aedes* vectors. 12–19 January 2022 (virtual)

This IAEA TC project aims to equip participants with the skills to use sterile insect technique (SIT) based approaches to suppress *Aedes aegypti* and *Aedes albopictus* populations. To achieve this objective, the project provides assistance to the participating Member States to develop capacities in mass-rearing, irradiation and release methods of *Aedes* spp., as components of the SIT package. A virtual workshop was held and aimed to identify the challenges and the solutions in the implementation of SIT based technologies against *Aedes* vectors. The workshop consisted of (i) country presentations on the status of their SIT project, (ii) expert presentations on the challenges and the solutions in the application of SIT based technologies, including epidemiological pilot trials, and (iii) discussion on individual case studies by 19 participants from 11 Member States including Bangladesh, Cambodia, China, Indonesia, Malaysia, Myanmar, Pakistan, Philippines, Singapore, Sri Lanka, and Thailand.

The knowledge of challenges, potential pitfalls and innovative solutions gained by each participant will help to accelerate the development of SIT based technologies in respective Member States.

Enhancing the Capacity and the Utilization of the Sterile Insect Technique for *Aedes* Mosquito Control (RAS5095)

First Coordination Meeting. 20 April 2022 (virtual)

As part of an area-wide integrated pest management (AW-IPM) approach to manage insect pest populations, the FAO/IAEA has been supporting the integration of the SIT into existing national pest control strategies by equipping participants with the skills to use SIT based approaches to suppress *Aedes aegypti* and *Aedes albopictus* mosquito vector populations. To continue building on the experience gained under project RAS5082, a new regional TC project RAS5095 was approved for the years 2022–2025, to support Member States in the development of the required capacities to effectively implement SIT within their integrated mosquito control strategies. The meeting was attended by two participants from each of 13 participating Member States, i.e., Bangladesh, China, Indonesia, Iran, Jordan, Malaysia, Mongolia, Pakistan, Philippines, Singapore, Sri Lanka, Thailand and Viet Nam.

The meeting reviewed the project workplan and future activities, the status of each participating Member State within the Phased Conditional Approach, and areas that require support.

Enhancing the Capacity to Integrate the Sterile Insect Technique in the Effective Management of Invasive *Aedes* Mosquitoes (RER5026)

Regional Training Course on Data Management of Mark-Release-Recapture studies for *Aedes* Mosquitoes in Preparation of SIT Pilot Trials. 6–10 December 2021 (virtual)

Mark-Release Recapture (MRR) studies are essential and a prerequisite for effectively planning and implementing SIT programmes. The appropriate collection, management, and analysis of the data is important to warrant proper implementation of sterile insect releases in the field. The training provided the participants with the basic knowledge on the use of a spreadsheet for MRR studies. The virtual training course covered basic knowledge on MRR principles for SIT, organizing and handling data using the spreadsheet and the R package to infer the main parameters of sterile males such as survival and dispersal. The training was conducted with ten participants from seven Member States (Albania, Cyprus, Greece, Montenegro, Portugal, Serbia, Turkey) as well as two experts from France (La Reunion and Montpelier) who presented their experience in MRR studies. The training was of great importance for capacity building in preparation of SIT programmes.

Regional Stakeholder Engagement Meeting on Early Support to Sterile Insect Technique Pilot Trials against *Aedes* Mosquitoes. 4–6 April 2022. Bologna, Italy

Mosquito species are a considerable threat to both humans and animals for their role as vectors of diseases and nuisance. Over the past decades, *Aedes*-borne diseases are of growing concern globally and particularly in Europe, and new effective control technologies are urgently needed, including the SIT. Under the regional TC project RER5026, IAEA is supporting European Member States with respect to the transfer and application of the SIT against invasive mosquito species, including cooperation and networking among the countries already affected, or at high risk for invasive disease-transmitting mosquito species. Stakeholder engagement and early support is critical in area-wide integrated control of mosquitoes with an SIT component.

Participants of the Regional Stakeholder Engagement Meeting on Early Support to Sterile Insect Technique Pilot Trials against Aedes *Mosquitoes visiting the CAA mosquito mass-rearing module in Crevalcore, Italy.*

Therefore, this meeting was organized to raise awareness of local and regional stakeholders involved in mosquito control, health policy authorities and national or regional funding organizations to mobilize the necessary support and investment for SIT pilot trials. Nineteen participants from 6 countries (Albania, Croatia, Cyprus, Greece, Portugal, Serbia) as well as local participants and experts from France, Germany, Italy, and Switzerland attended the meeting. The principles of the application of SIT as a component of area-wide integrated pest management was presented, current SIT pilot trials reviewed, and examples provided of relevant stakeholder's supports on policy and funding mechanisms. The progress of each participating Member State was assessed, and the way in which stakeholder engagement could be enhanced. Participants also attended the release of sterile male *Aedes albopictus* in a 100ha area of Bologna, Italy and visited the new mosquito mass-rearing module with a production capacity of 1 million sterile males per week at the Centro Agricoltura Ambiente 'G. Nicoli' (CAA), that is an

IAEA Collaborating Center on the ‘Development and implementation of the SIT package for the suppression of *Aedes* mosquitoes’, located in Crevalcore, Italy.

Regional Training Course on National Vector Control Needs Assessment in Preparation of Integrated Vector Management including the Sterile Insect Technique. 09–13 May 2022, Limassol, Cyprus

In collaboration with World Health Organization (WHO) Regional Office for Europe and the European Centre for Disease Prevention and Control (ECDC), FAO and IAEA organized this workshop to build Member State’s capacity to assess the situation of vectors, vector-borne diseases, and control methods at different levels, as well as to strengthen their capacity for a comprehensive identification of the problems/gaps, intervention methods, opportunities and needs based on a situation analysis. Participants were provided with practical guidance on the framework to conduct a National Vector Control Needs Assessment including specific questions on SIT.

The training allowed participants to identify and assess all major requirements (milestones) such as political commitment, stakeholders, structures, human resources, legislations etc. for the completion of the baseline data collection and pre-intervention phases of the Phased Conditional Approach for testing the SIT against *Aedes* mosquitoes.

Participants of the training on National Vector Control Needs Assessment in Preparation of Integrated Vector Management including the Sterile Insect Technique, 9–13 May 2022, Limassol, Cyprus.

Twenty participants including counterparts and stakeholders from 11 countries (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Georgia, Greece, Montenegro, North Macedonia, Portugal and Serbia) as well as local participants and experts from Sweden, Germany, Netherland, and Switzerland attended the training.

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)	Jeremy Bouyer
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

CRP Success Story: Mosquito Handling, Transport, Release and Male Trapping Methods (D4.40.02)

A five-year FAO/IAEA coordinated research project (CRP) yielded new knowledge, tools and novel protocols for monitoring, marking, handling, transporting and releasing sterile males of the world's deadliest animal: the mosquito.

A drone that was designed under the IAEA coordinated research project and tested in pilot projects for aerial releases of sterile mosquitoes (Photo: Moscamed Brasil).

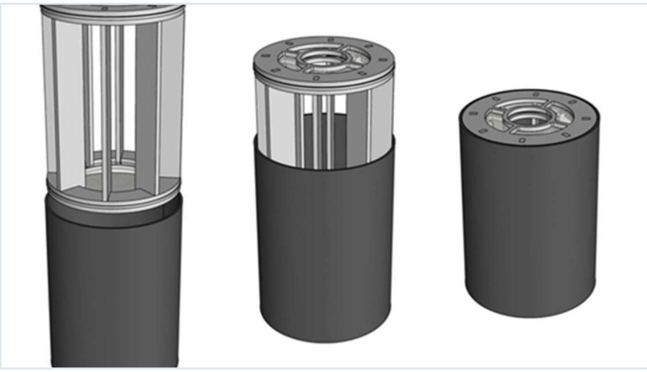
In recent years, mosquito-transmitted dengue has become a major international public health burden due to the increasing spread of invasive mosquito species of the genus *Aedes,* which transmit dengue, chikungunya, Zika, and yellow fever. The recent increase of dengue cases, the Zika outbreaks in the Americas in 2015 and 2016, and the low effectiveness of insecticides and the environmental issues associated with insecticide used for mosquito control have increased the demand to develop new environment-friendly and sustainable approaches. The sterile insect technique (SIT) is one such method that could be used, as a component of area-wide integrated pest management (AW-IPM) programmes, to control major disease-transmitting mosquito species and thus to improve human health.

The SIT is a component of area-wide integrated pest management (AW-IPM) programmes with the potential application for use against mosquitoes. The Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture has initiated the development of the SIT package as a tool for managing mosquito vector populations. The SIT requires of the mass production, sterilization and transportation of male mosquitoes to the release sites after having them first chilled for easy handling, with minimal detrimental impact on their quality and sexual competitiveness. Methods for population monitoring are also essential, so that the releases can target the wild population, assess the quality of sterile males, and evaluate the effectiveness of the SIT application on the suppression of wild populations.

Some of the critical issues for improving the SIT package for mosquitoes include the development and optimization of handling, transporting, and release procedures without having a significant impact on sterile male survival, dispersion, and sexual performance. Furthermore, affordable and efficient tools to monitor the mosquito population before and during the releases of sterile males are needed.

The main objective of this CRP was to provide the necessary advances in these techniques, to enable the SIT application against mosquitoes and help reduce vector populations in affected countries. The CRP that involved 22 scientists from 19 countries resulted in the following key achievements:

- Novel and efficient trapping methods were developed and assessed for mosquito surveillance of an AW-IPM programme with an SIT component. An important next step will be the upscaling of these methods in support of mosquito SIT pilot projects.
- A novel large-scale insect marking technique using Rhodamine-B was developed and evaluated. This technique has the advantage of marking all the tissues of the mosquitoes, including sperm that can be retrieved and identified in mated females, and thus with great potential to estimate the sexual competitiveness of sterile male mosquitoes under field conditions.
- The impact of temperature, time, and compaction levels, and their interactions was explored for the handling, shipment, and transport of chilled males. The effect of these conditions on male quality was also assessed. Based on these results, suitable environmental conditions for short and long-distance shipment were obtained for *Aedes aegypti, Aedes albopictus* and *Aedes polynesiensis*.
- Concerning the release of mosquitoes, methods for ground and aerial releases (using drones) were developed. A Remotely Piloted Aircraft System with an embedded mosquito release device was developed and evaluated under laboratory and field conditions for *Ae. Aegypti* and showed negligible impact on male quality. While aerial releases using drones is a powerful and cost-effective tool for mosquito releases, there are still several challenges to implement this approach in SIT pilot projects against mosquitoes.



All-in-one mosquito container developed under the FAO/IAEA coordinated research project for optimized handling, packing and ground release of Aedes albopictus *males (Photo: TRAGSA, Spain).*

The research carried out in the framework of this CRP generated 22 scientific publications in peer-reviewed journals and several presentations in international and national scientific meetings. The final CRP results will be published in a special issue of a peer-reviewed scientific journal. The next step is to transfer these new tools to the Member States to benefit their mosquito SIT pilot and operational projects worldwide.

Developments at the Insect Pest Control Laboratory (IPCL)

Genetics and Molecular Biology

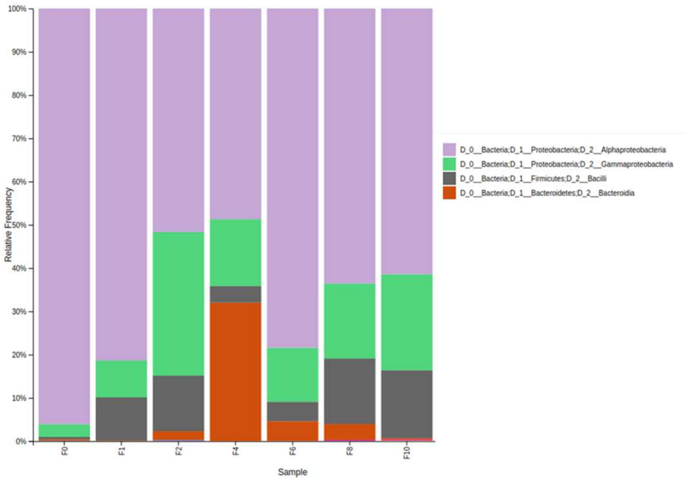
Drosophila suzukii: Laboratory Domestication, Genetics, and Microbiota

Insects reared in an artificial environment undergo evolutionary changes that lead to domesticated populations. Diet composition and availability, oviposition substrates, temperature and humidity levels, photoperiod, high numbers of mates and absence of any stress that insects would have to confront in the wild are all promoters of laboratory adaptation. Maintaining populations in the laboratory often requires dense rearing conditions both of the larval and adult stages, primarily due to space and resource limitations which can subsequently lead to changes in fitness traits. During a colonization process, the descendants of each generation are not mixed with the parental line and individuals that reproduce and develop faster are often selected and seed the next generation. However, the rate and extent of laboratory adaptation can vary substantially among species. For example, laboratory-adapted strains of Tephritidae showed a shorter lifespan and preoviposition period, but increased emission of male-produced volatiles. In addition, studies on various species showed a declining genetic variability and loss of heterozygosity with colonization.

Gut microbiota is part of the holobiont, a notion that considers the host and its microbiota as a biological unit of selection in evolution. Key host traits, such as development, fecundity, longevity, and mating behaviour are affected by gut bacteria. Laboratory colonization induces changes on gut microbial communities when a wild insect population is introduced to artificial rearing conditions, and therefore they should be properly monitored.

In a recent study we employed microsatellite markers and 16S *rRNA* gene sequencing to assess whether the genomic and microbial profiles are modified during domestication. A wild population of *Drosophila suzukii* was collected from infested fruits and domesticated at the Insect Pest Control Laboratory (IPCL) for 20 generations. Sixteen microsatellite loci were monitored over five generations and high throughput 16S *rRNA* gene sequencing was applied in nine generations. The microsatellite-based genetic analysis demonstrated a distinct cluster formation as domestication progresses. In addition, the 16S *rRNA* gene sequencing analysis showed that bacterial composition is affected by adaptation and relative abundances present substantial differences among the generations.

D. suzukii has been escalated to a scourge for worldwide fruit production. Area-wide integrated pest management (AW-IPM) approaches with a sterile insect technique (SIT) component have been suggested as a sustainable solution to manage populations of *D. suzukii* under certain confined conditions such as greenhouses. Development of an SIT programme requires a robust mass-rearing protocol that produces high-quality and competitive flies at a reduced cost. Laboratory adaptation plays a preponderant role in the development of viable mass-rearing protocols. Any change that occurs in the genetic and symbiotic structures should be recorded throughout adaptation and evaluated for potential reduction of the biological quality of the mass-produced flies to ensure the viability and success of the SIT programme.



Relative abundance of Drosophila suzukii-*associated bacteria at the Class level in every generation.*

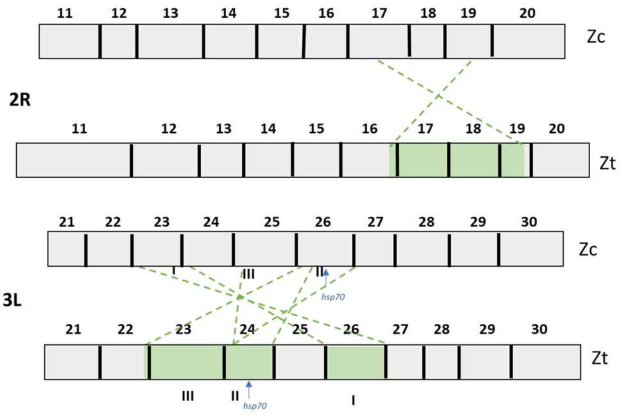
Cytogenetic Analysis of *Zeugodacus* Species

Cytogenetic studies have significantly contributed to the development and evaluation of tools, such as genetic sexing strains, in support of SIT applications against major tephritid pest species including the Mediterranean fruit fly *Ceratitis capitata*, the Oriental fruit fly *Bactrocera dorsalis*, the melon fly *Zeugodacus cucurbitae*, the Mexican fruit fly *Anastrepha ludens* and the South American fruit fly *A. fraterculus sp.1*. In addition, cytogenetic analysis has played a key role in integrative taxonomy approaches in species delimitation in the Tephritidae family.

In the frame of these studies, cytogenetic research efforts have focused on the construction of polytene chromosome maps, the detection and characterization of chromosomal rearrangements, chromosome evolution, the identification of translocation breakpoints in genetic sexing strains, as well as on *in situ* localization of gene markers on polytene chromosomes. We recently expanded these studies, in collaboration with the research groups of Prof. Antigoni Zacharopoulou from University of Patras and Prof. Elena Drosopoulou from Aristotle University of Thessaloniki (members of Coordinated Research Projects), to include another member of the

Zeugodacus genus, i.e., the pumpkin fly *Zeugodacus tau* in view of ongoing efforts for the development of a genetic sexing strain for SIT applications against this major pest.

Comparative cytogenetic analysis of *Z. tau* and *Z. cucurbitae* indicated that these two species are largely homosequential thus confirming that they are closely related. Even though the banding pattern of their polytene chromosomes presented extensive similarities, several characteristic inversions were identified, which allowed us to clearly distinguish specimens from the two species. One inversion was detected on the 2R polytene chromosome arm while the remaining inversions were on 3L.



Schematic presentation of the structure of the right arm of polytene chromosome 2 and the left arm of polytene chromosome 3 indicating the presence of chromosomal inversions (inverted areas in green colour) in the closely related species Zeugodacus cucurbitae (Zc) *and* Zeugodacus tau (Zt).

In addition, *in situ* hybridization experiments were performed to localize four gene markers on the polytene chromosomes of *Z. tau* and *Z. cucurbitae*: *white*, *scarlet*, *white pupae* and *hsp70*. All four of them gave a unique signal confirming they are single copy genes; they were also localized in the same position in both species. One of these four markers, *hsp70*, even allowed us to confirm the presence of an inversion on the 3L chromosome arm.

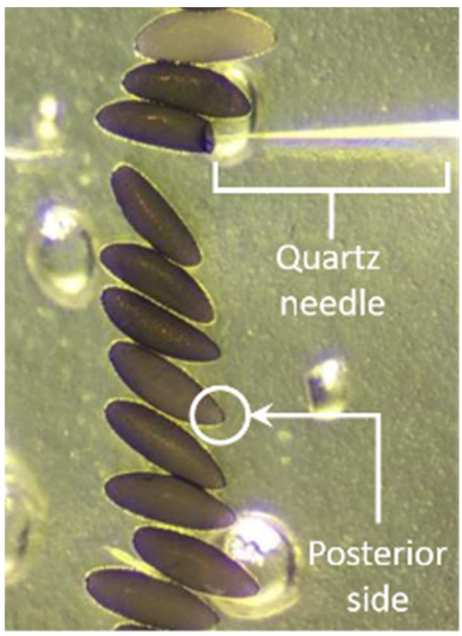
Microinjection Facility at the Insect Pest Control Laboratory

Microinjection is a method which aims to deliver liquid material into cells, tissues, or whole individuals using a micropipette. It has been applied in diverse fields of biology including physiology, functional genetics, molecular biology, microbiology, and developmental biology. During the last 40 to50 years, microinjection has played a fundamental role in applied entomology, including insect genetics and insect molecular biology studies, focusing, among others, on gene discovery and gene function, induction of mutations, host-symbiont and / or host-pathogen interactions.

Insect microinjections can be performed at any developmental stage including embryos. For example, for the induction of mutations, microinjections are carried out in early embryos at the syncytial blastoderm stage, close to the posterior pole where pole cells are localized, which will form the insect's germ line (testes or ovaries).

Mr. Germano Sollazzo (Italy) and Ms. Georgia Gouvi (Greece), both PhD consultants, performing microinjection experiments in the IPCL microinjection facility. The left photo shows the microinjection area, and the right photo shows the needle preparation area.

The IPCL microinjection facility has two main areas: (a) needle preparation and (b) injection area. The needle preparation area has a laser needle puller capable of pulling quartz capillary glass under precise conditions. A micropipette beveler is used to sand the pulled capillary glass's tip at the desired angle, forming a bevel. This is an important step as it facilitates the penetration of the needle into the embryo. The injection area contains the microinjector and an air compressor, as air is needed to be pumped inside the capillary needle to maintain constant pressure during the injections. Moreover, the microinjector has a micromanipulator which is used to move the needle around the eggs (on the X, Y, and Z-axis) using mechanical arms. The IPCL microinjection facility is used for in-house R&D activities, but it is also available to researchers from all Member States to support SIT related research projects.



Mosquito embryo microinjection. The embryos are aligned with the posterior side on the right. The quartz needle is touching the egg and ready to perform microinjection.

Plant Pests

Sexual Competitiveness of the Black Pupa Genetic Sexing Strain of *Anastrepha fraterculus* under Field Cage Conditions

Anastrepha fraterculus is a pest that has a significant economic impact in South America as it targets various economically important fruit crops. It not only damages fruit directly, but it also makes trade more difficult between infested and non-infested countries due to phytosanitary restrictions.

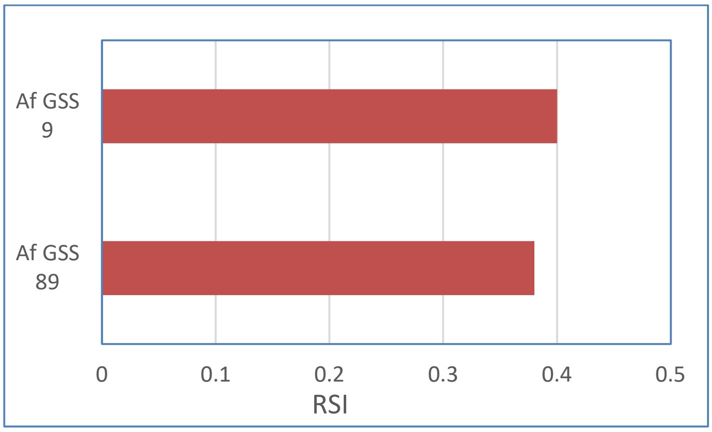
A sexing system was developed for *A. fraterculus* by the induction of a reciprocal translocation between the Y chromosome and the autosome carrying the wild-type locus of the *black pupae* (*bp*) gene.

The genetic sexing strain (GSS) was developed from a laboratory population of the Brazilian-1" morphotype (=*Anastrepha* sp.1 aff. *fraterculus*), which implies that the mass-reared strain could be used in area-wide integrated pest management (AW-IPM) programmes with an SIT component in an area that extends from southern Brazil to central Argentina. Two GSSs that have shown good productivity and quality control profile were selected and their sexual performance under field cage conditions assessed.

Field cage tests were carried out under controlled temperature (24 °C) and relative humidity (65%) conditions in the 250 m^2 Ecosphere of the IPCL. The mating and competitiveness tests were done in conventional circular cages of 3 m in diameter × 2 m tall. Inside each cage, a young citrus plant (*Citrus sinensis*) was enclosed. Natural illumination oscillated between 600 and 2 600 lux during the test period from 9.00 to 12.00 am.

Males from the GSS 89 and GSS 9 and wild-type males and females from Vacaria, Brazil were kept separate in plexiglass round cages (30 Ø × 40 cm long) for eight days until they reached sexual maturity. For the experiment, 50 males of each GSS were released in a field cage together with 50 wild-type males in order to compete for mating with 50 virgin wild fertile females. The experiment was replicated five times for each combination (a) GSS 89 males vs. wild-type males and (b) GSS 9 males vs. wild-type males. As there was only one kind of laboratory male in competition with wild-type males, the relative sterility index (RSI) was used as a measure for the competitiveness of the males from the two GSSs. The RSI values have a range from −1 to +1, with a value of −1 indicating that all matings were carried out by wild-type males, whereas a value of +1 indicates that all matings were carried out by the experimental males. Zero indicates that males from both populations participated equally in matings. Field tests were carried out as outlined in the USDA-FAO/IAEA quality control manual.

In the cages where males of the GSS 89 and wild-type males competed for wild-type females, 49% and 30% successful matings were recorded, respectively. In cages where males of the GSS 9 and wild-type males competed for wild-type females, 48% of the mating pairs were formed with males for the GSS 9 and 32% with wild-type males.

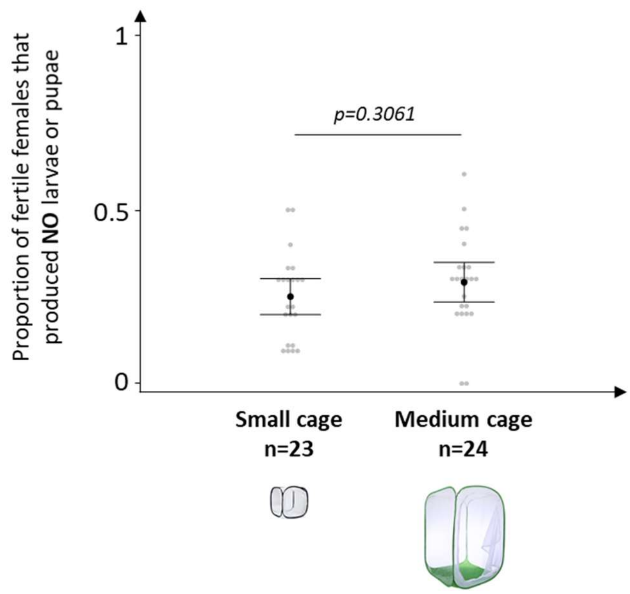


Relative sterility index (RSI) as a measure of competitiveness when males of the GSS 89 and GSS 9 of Anastrepha fraterculus *were competing for mating with wild-type males from Vacaria, Brazil under field cage settings. Positive RSI indicates that there were more matings with GSS males and wild-type females than with wild-type males.*

Therefore, it can be concluded that males of both black pupae strains were very competitive when compared to the wild-type males under field cage conditions of the IPCL. Therefore, both strains seem suitable for use in SIT programmes.

Methodology for the Evaluation of Male Competitiveness in *Drosophila suzukii*

The SIT is being evaluated as a tool to manage populations of the spotted wing Drosophila, *Drosophila suzukii* in greenhouses. Assessing the competitiveness of mass-reared males for release requires protocols calibrated to the sexual characteristics of the species.



Estimates of the competitiveness of Drosophila suzukii *sterile males in different-sized cages. Observed mean (black dot), CI 95 % (bars), raw data (grey dots). Comparison between the two cages: linear mixed model, α=0.05.*

Observation of mating pairs, an often-satisfactory method for larger Tephritidae fruit flies, could however be challenging for *D. suzukii* in field cage semi-natural settings due to its small size and elusive behaviour. A promising alternative protocol was successfully evaluated in 2021 in collaboration with researchers of the French National Research Institute for Agriculture, Food and Environment (INRAE). Sterile laboratory males and females as well as fertile wild-type males and females interact for 24 hours under ecologically realistic conditions (live plants, presence of fruits, high humidity level). The females are then collected and placed for an additional day individually in tubes containing half fruits. Thereafter, the females are removed and identified using a fluorescence microscope (laboratory or wild insects being marked with fluorescent dust depending on the replicates). The presence of pupae in the tubes that contained fertile females makes it possible to deduce the proportion of fertile females that mated with fertile wild-type males, while the absence of pupae indicates the proportion of fertile females that mated with sterile laboratory males (or did not mate, which was rare during our tests). Replicating the experiment using different sized cages did not influence the estimate of the competitiveness of sterile males, paving the way for the future use of limited sized cages. After several minor technical adjustments and further assessments in 2022, this protocol should be easily reproducible and usable by partners.

FAO/IAEA/USDA Phytosanitary Treatment Project

Confirmatory large-scale tests aimed at validating a phytosanitary irradiation dose for *Drosophila suzukii* were completed. The study was carried out considering all requirements and suggestions from the Technical Panel on Phytosanitary Treatments (TPPT) of the International Plant Protection Convention (IPPC) in its meeting report published in July 2019. A total of 30 824 late pupae were irradiated with 80 Gy. A few numbers of females that emerged from those irradiated pupae were able to survive and oviposited a total of 49 non-viable eggs, supporting prevention of F_1 generation as the endpoint for a phytosanitary irradiation treatment against *D. suzukii*. Dose response and survival tests have been conducted and are nearly completed. Egg laying and survival decreased after pupal irradiation with doses below 80 Gy. A manuscript summarizing our findings is currently being drafted for submission to a scientific journal. Our findings combined with previous studies have great potential to support the first harmonized phytosanitary irradiation treatment for *D. suzukii*.

Research evaluating the effect of low oxygen treatments on phytosanitary irradiation efficacy for *D. suzukii* has been initiated. Modified atmosphere storage is widely used to prolong the shelf life of several perishable commodities. Our research aims to proactively evaluate whether a radiation treatment with 80 Gy of fruit infested with *D. suzukii* under low oxygen conditions can rescue reproduction of the irradiated insects.

Inajara Viana and Jhonatan Aguilar irradiating blueberries infested with Drosophila suzukii *for phytosanitary irradiation research.*

Field cage studies were conducted to determine the host status of *Citrus sinensis* for *Zeugodacus tau* populations from Bangladesh, China, and India. Those tests were carried out because the host status of *C. sinensis* is yet undetermined for *Z. tau*. Our results suggest that *C. sinensis* can be considered a conditional host for *Z. tau*. This relevant information was included in a submitted manuscript focused on cold treatment of *Z. tau* in navel oranges.

Development of Microsatellite Markers for Population Genetics Studies of the Cocoa Pod Borer *Conopomorpha cramerella*.

The cocoa pod borer *Conopomorpha cramerella* (Snellen) (CPB) is one of the most devastating insect pests of cocoa throughout South-East Asia. The species is present in the Philippines, Malaysia, Indonesia, and Papua New Guinea.

The cocoa pod borer Conopomorpha cramerella *adults (top) and damage to cocoa pods (bottom). Image source: Saripah, B, Malaysian Cocoa Board.*

Although, there are various control measures that have been implemented to manage populations of this pest, the SIT is being considered as an additional control tactic for integration in an area-wide integrated pest management (AW-IPM) approach. There is little or no information available on the population structure of this pest in the infested countries and population genetics studies could help answer the important question whether it is the same strain that is infesting these countries or not.

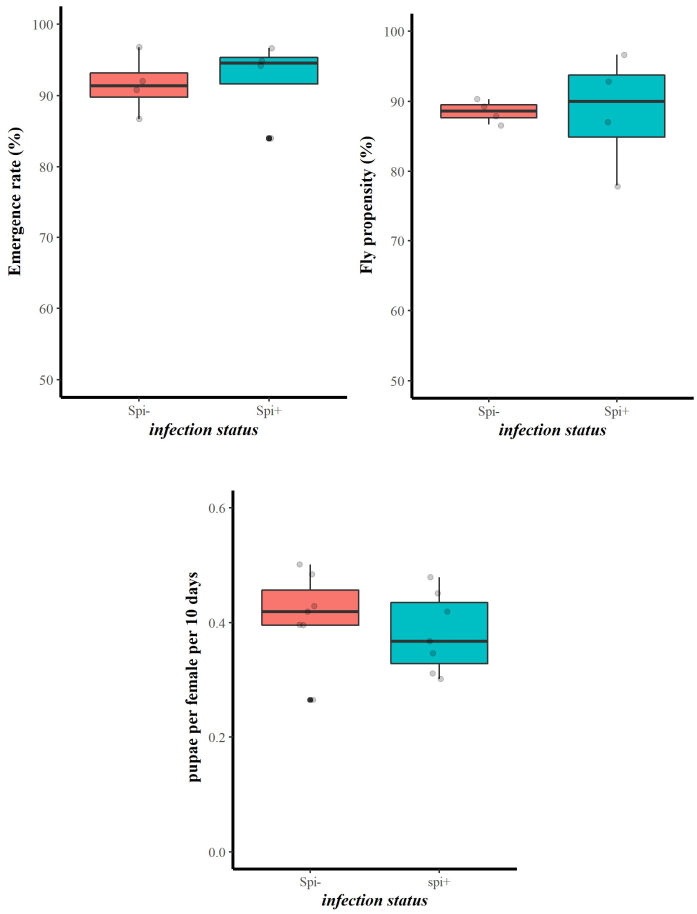
Ms Roslina Binti Mohd Shah preparing the CPB samples.

This information is important for SIT programmes to determine whether one mass-rearing facility could provide the required sterile males or whether mass-rearing of different strains will be required. In addition, it would offer the possibility to identify the level of gene flow and hence the level of isolation of the different populations. To this end, developing tools such as microsatellites to analyse the CPB population genetics is required. Staff of the IPCL have developed 12 microsatellites for CPB and their efficiency to explore the genetic diversity between and within populations is being assessed. This work is conducted by Ms Roslina Binti Mohd Shah, a TC fellow from Malaysia.

Livestock Pests

Impact of *Spiroplasma* Infection on the Performance of *Glossina fuscipes fuscipes* Colonies

As mentionned in NL96, some tsetse species such as *Glossina fuscipes fuscipes* of which a colony is maintained at the IPCL, and wild *Glossina tachinoides* are infected with *Spiroplasma* bacteria. To assess the impact of a *Spiroplasma* infection on the performance of tsetse fly colonies, Mr Kiswenda-Sida Mikhailou Dera, a consultant from Bobo Dioulasso, Burkina Faso screened *G. f. fucipes* teneral flies and established two colonies, i.e. one infected with *Spiroplasma* (Spi$^+$) and one with no or low *Spiroplasma* infection (Spi$^-$). The aim of the study was to assesss the impact of *Spiroplasma* infection on the emergence rate, flight propensity and female productivity and preleminary results indicate no significant difference between these parameters in Sp$^+$ and Sp$^-$ flies.

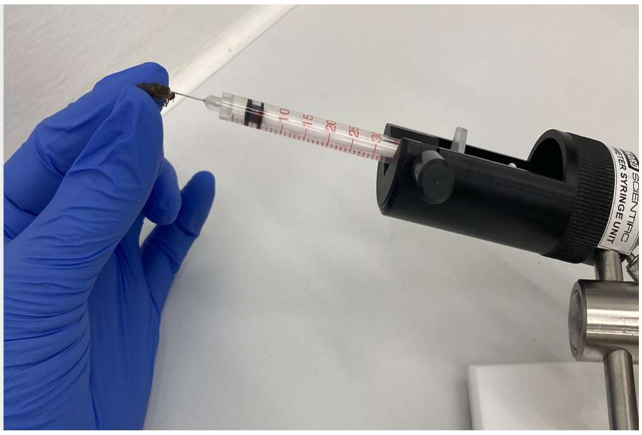


Impact of Spiroplsama *infection on fly emergence, flight propensity and female productivity.*

Assessing the impact of the *Spiroplasma* infection on the fly transcriptom is undertaken in collaboration with Prof. Serap Aksoy and Brian Weiss from Yale University, USA and Prof. Anna Malacrida from Pavia University, Italy.

Impact of *Glossina morsitans morsitans* Iflavirus and Negevirus on *Glossina pallidipes*

As reported in NL 98, Iflavirus and Negevirus are two recently discovered RNA viruses in the tsetse fly *Glossina morsitans morsitans* and were named *Glossina morsitans morsitans* Iflavirus (GmmIV) and *Glossina morsitans morsitans* Negevirus (GmmNegeV), respectively. The impact of these viruses on the productivity of tsetse colonies is currently being studied. So far, none of the infected flies show any symptoms that can be related to the presence of these viruses. Nevertheless, GmmIV and GmmNegeV could not be detected in the tsetse species *Glossina pallidipes.* This species is the most susceptible to the Salivary Gland Hypertrophy Virus (SGHV) that represents a major threat to the rearing of *G. pallidipes* as it can cause the collapse of an entire fly colony. Therefore, it is important to analyse the impact of the two newly identified GmmIV and GmmNegeV on the productivity of *G. pallidipes* and their possible interaction with SGHV. To this end, *G. pallidipes* flies were injected with GmmIV and GmmNegeV with the aim to obtain an artificial infection.



Injecting of Glossina morsitans morsitans *Iflavirus and* Glossina morsitans morsitans *Negevirus in* G. pallidipes.

Analysing the recorded data on the impact of these infections on the fly performance is undertaken by Ms Hannah Huditz, a cost-free consultant from Vienna, Austria in collaboration with Prof. Monique van Oers, Wageningen University, The Netherlands.

Using Gamma and X-ray Irradiators to Sterilise Tsetse Pupae

Self-contained gamma irradiators have been used extensively for the sterilisation of insects that are destined for release in tsetse SIT programmes. However, as the purchase and transport of gamma irradiators and transboundary shipment of radioisotopes are facing growing constraints and difficulties, new generation, high output X-ray irradiators have been suggested as a potential replacement.

The potential benefits of using X-ray irradiators for insect sterilisation for SIT has been demonstrated in insect groups such as mosquitoes and fruit flies and is now also being investigated for tsetse flies. *Glossina palpalis gambiensis* pupae, 23-24 day old, were exposed to X-rays in a Radsource 2400 at a dose rate of 14.30 Gy.min^{-1} or to γ-rays in a Foss Model 812 ^{60}Co self-contained gamma irradiator at a dose rate of 78.63 Gy.min^{-1}.

For both the X- and γ-rays, a dose of 110 Gy was needed to induce 97% sterility in females that mated with the males that were exposed to radiation in the pupal stage. Additionally, radiation source had no effect on other parameters such as fly emergence, flight propensity and male survival. Male performance as assessed in walk-in field cages was also similar for males exposed to a 110 Gy dose of X- and γ-rays. These assessments confirm that X-rays can be used to sufficiently sterilise tsetse males and that the males sterilised with X- and γ-rays had similar mating performance.

The Radsource 2400 X-ray irradiator is currently being used as an alternative source for the sterilisation of the *G. palpalis gambiensis* pupae that are biweekly shipped long distance to the tsetse eradication programme in Senegal, when the Foss Model 812 ^{60}Co gamma irradiator is unavailable.

Mr Aristide Kabore, Burkina Faso (right) and Mr Mahamat Hissene, Chad (left) during a field cage assessment of the mating performance of male Glossina palpalis gambiensis *that were sterilised as pupae with X- or γ-rays.*

Additionally, an X-ray irradiator has been transferred to Centre International de Recherche -Développement sur L'Elevage en zone Subhumide (CIRDES) in Burkina Faso and is ready to be utilised for tsetse sterilisation.

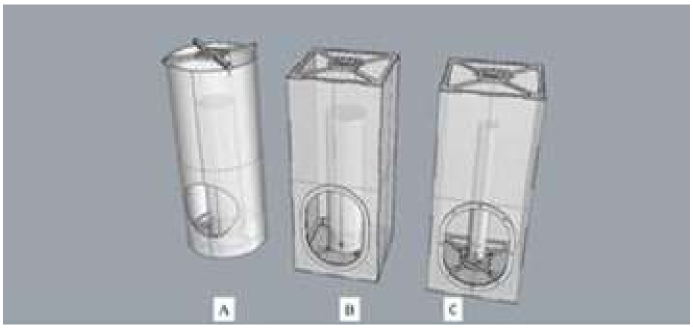
Human Disease Vectors

Laboratory Strain Selection for Improved Pupae Production, Egg Production and Sex-Separation Efficiency in *Aedes aegypti*

In mosquito sterile insect technique (SIT), two colonies can be considered in mass-rearing facilities: a mother colony for a continuous egg production and a male production colony for releases. However, the efficacy of such SIT programs depends on the ability of producing large numbers of both male and female pupae whilst reducing as much as possible the number tilting/sorting events. This implies the abolition/increase of protandry in the above-mentioned colonies. Protandry, defined as the earlier emergence of males as compared to con-specific females, is a phenomenon which exists naturally in *Aedes* mosquitoes. To collect the maximum number of female pupae in the mother colony and the maximum number of male/female pupae in one tilt/separation event, we initiated a long-term laboratory experiment to investigate the possibility to select a strain toward absence of protandry/synchronization of pupation and increased sexual size dimorphism for improved sex-separation. The selection experiment was designed (under laboratory rearing) and is being carried out on the mother colony to suppress protandry with the ultimate goal to collect male and female pupae in both colonies at one tilt event while improving sex-separation. The experiment consists of crossing males and females from the same batch of pupae that emerged the same day, and progeny were reared under more relaxed conditions than that of the male production colonies. After five generations, preliminary results showed a trend to protandry suppression with no reduced male recovery, sex-separation and male flight ability which is encouraging in terms of cost-efficiency. Further long-term studies are needed to explore in more detail the importance of strain selection in SIT mass-rearing facilities.

New Generation of Flight Test Devices for Quality Control of Sterile Mosquitoes

Affordable, rapid, and practical quality control tools that are based on the flight ability of the insect may contribute to maintaining a consistent release of high-quality sterile males for successful implementation of the SIT against *Aedes* mosquito species. A recent study at the IPCL therefore aimed to standardize the use of the original FAO/IAEA rapid quality control flight test device (FTD) (version 1.0), while also improving handling conditions and reducing the device's overall cost by assessing factors that could impact the subsequent flight ability of *Aedes* mosquitoes. A new FTD (version 1.1) proved easier to use.



3D designs of the original flight test device (FTD) (40-tube) (version 1.0) (A), the new FTD (40-tube) (version 1.1) (B), and the FTD with eight tubes (version 2.0) (C).

In addition, a cheaper version of the FTD (version 2.0) that contains eight individual tubes instead of 40 was designed and successfully validated against the previous version. It was sensitive enough to distinguish between the effects of cold stress and high irradiation dose. The new generations of FTDs (versions 1.1 and 2.0) may therefore be used to assess *Aedes* flight ability.

Importance of Dose Rate in Mosquito Irradiation

One of the key elements of the SIT is the irradiation-based reproductive sterilization of the male insects destined for release in the target area. Sterilizing mosquitoes using ionizing radiation is, however, not as straightforward as once thought. It has been shown that changes in dose rate of the irradiator (due to, for example, the decay of the radioactive source), can change the biological response of insects, and may lead to the release of sub-sterile males. Many integrated pest management programmes with an SIT component may not have adequate quality assurance measures in place to alert to such an event. Others see that the produced insects are no longer reliably sterile, but do not know the cause thereof. A series of studies were completed in which insight was provided for possible causes of changing dose response in insects over time and the basis for implementing relevant quality control measures in SIT programmes.

Dose rate (Gy. min⁻¹)	Dose (Gy) 10 Gy	20 Gy	40 Gy	70 Gy
0.4	63.88	32.96	10.45	3.21
1	71.30[a]	41.43[a]	7.49[b]	1.11[b]
7.8	64.78	28.59[b]	12.47[a]	3.10
24.5	62.11[b]	33.91	7.35	2.98
79	67.95	37.20	4.80	5.45[a]
P-value:	*= 0.016*	*= 0.0001*	*= 0.0304*	*= 0.0048*

Residual fertility values in percent (%). Red represents the lowest dose rate effect (DRE) i.e. (lowest sterility achieved) at a given dose, and green shows the highest DRE (highest sterility achieved) for a given dose. P-values given at the base of each column result from the comparison (t-test) of the low and high DRE values highlighted.

In a general mosquito model, when lower doses (e.g. 10 and 20 Gy) are administered, the sterility increases as dose rate increases, whereas at higher doses (ex. 40 and 70 Gy), sterility decreased as dose rate increased. In other words, when identifying which dose rates resulted in the most and least effects on fertility with each dose, these switched when dose increased.

Results suggest that not only does dose rate alter irradiation-induced effects, but also that the interaction is not linear and may change with dose. We speculate that the recombination of reactive oxygen species (ROS) in treatments with moderate to high dose rates might minimize indirect radiation-induced effects in mosquitoes and decrease sterility levels, unless dose along with its direct effects is increased.

Mosquito Irradiation and Vector Competence

Current sex separation techniques of mass-produced *Aedes* mosquitoes are fairly efficient but still result in a small percentage of females (<1%) being released together with the sterile males in SIT field trials. This may lead to a short-term risk of increased biting rate and arboviral disease transmission. It is therefore important to assess whether the irradiation treatment of these females alters their vector competence.

In collaboration with the University of Zürich, Switzerland and the Centro Agricoltura Ambiente 'G. Nicoli' (an IAEA Collaborating Centre) in Bologna, Italy, we compared the transmission of dengue and chikungunya viruses by *Aedes aegypti* and *Aedes albopictus* females exposed as pupae to an irradiation dose of 40 Gy. Irradiation did not influence the dissemination of the dengue and chikungunya virus in the mosquitoes' tissues, nor their transmission when orally exposed to these viruses.

Reports

Sixteenth Session of the Commission on Phytosanitary Measures (CPM), International Plant Protection Convention (IPPC), 5, 7 and 21 April 2022 (virtual)

The Director of the FAO Plant Production and Protection Division and former IPPC Secretary, Jingyuan XIA, welcomed participants to the Sixteenth Session of the Commission on Phytosanitary Measures (CPM), and extended a particular welcome to Osama EL-LISSY in his role as the new Secretary of the International Plant Protection Convention (IPPC).

The FAO Deputy Director-General Beth BECHDOL also welcomed the new IPPC secretary and expressed her gratitude to the IPPC community and the IPPC Secretariat (hereafter referred to as 'the secretariat') for their work during the year. She highlighted some of the achievements of the year, thanked donors for their contributions, and emphasized the importance of the 'One Health' initiative and of aligning efforts in support of the new FAO Strategic Framework and the IPPC Strategic Framework 2020–2030.

On issues related with the Insect Pest Control Subprogramme, the CPM-16:

- The chairperson of the CPM Focus Group on Pest Outbreak Alert and Response Systems (POARS) presented a report on the activities of the focus group. The group had drawn up a set of recommendations for the CPM to consider regarding the development, implementation, and maintenance of POARS coordinated by the secretariat. With respect to the development of the global POARS itself, the CPM noted that any global system would need to be aligned with regional systems but that alternative options to the model proposed could include addressing the scope of POARS through FAO regions and Regional Plant Protection Organizations (RPPOs) or trying a regional system before expanding to a global system. CPM-16 agreed as an interim measure to establish a POARS Steering Group to work on establishing a POARS capability, to revise the POARS Steering Group Terms of Reference to reflect the discussions of the CPM. CPM-16 also requested that the Finance Committee consider how to allocate an appropriate level of resources to continue the work on POARS during 2022 and encouraged contracting parties to contribute extra-budgetary resources to help fund the POARS workplan.
- International Standards for Phytosanitary Measures (ISPM) 46 (Commodity-specific standards for phytosanitary measures) was adopted.
- Five phytosanitary treatments (PT) were adopted as Annex to ISPM 28 (Phytosanitary treatments for regulated pests):
    - PT 40 (Irradiation treatment for Tortricidae on fruits) as Annex 40 to ISPM 28
    - PT 41 (Cold treatment for *Bactrocera zonata* on *Citrus sinensis*) as Annex 41 to ISPM 28
    - PT 42 (Irradiation treatment for *Zeugodacus tau*) as Annex 42 to ISPM 28
    - PT 43 (Irradiation treatment for *Sternochetus frigidus*) as Annex 43 to ISPM 28
    - PT 44 (Vapour heat–modified atmosphere treatment for *Cydia pomonella* and *Grapholita molesta* on *Malus pumila* and *Prunus persica*) as Annex 44 to ISPM 28.

The Centro Agricoltura Ambiente (CAA) 'G.Nicoli' Re-designated as an IAEA Collaborating Centre

The IAEA has re-designed the Centro Agricoltura Ambiente (CAA) 'G. Nicoli', Italy, as an IAEA Collaborating Centre to Support the development and implementation of the Sterile Insect Technique (SIT) package for the suppression of *Aedes* mosquitoes which are vectors of several arbovirus including chikungunya, dengue, and Zika. The importance of these mosquito vectors is high and its control through the conventional methods based on insecticides is not efficient.

Mass-rearing module with a capacity of one million sterile male Aedes *mosquitoes per week.*

The SIT package is thus under development and field testing against this group at the world level. In Europe, CAA has been instrumental by initiating the first releases of sterile mosquitoes in the year 2000. The CAA owns a research laboratory and is conducting field monitoring and mosquito mass-rearing, advising public authorities and supervising the mosquito control project. Since 2017, CAA has supplied more than ten million sterile pupae to six European countries. In 2021, a new mass-rearing module was built, with a capacity of one million sterile males per week.

The CAA was already designated as IAEA Collaborating Centre for the periods 2011–2015 and 2017–2021 and had fruitful collaboration with IAEA throughout the previous designation periods, including research on all components of the SIT package, expertise and trainings. This re-designation will allow CAA to remain a driving force with respect to the expansion of the use of the SIT technology to control *Aedes* mosquitoes in Europe.

FAO/IAEA Consultancy Meeting on Mosquito Male Performance, 23–27 May 2022, Vienna, Austria

The last decades has seen an increase from requests of Member States (MSs) with respect to the application of the Sterile Insect Technique (SIT) in area-wide integrated pest management (AW-IPM) programmes. The MSs requests include developing and refining the SIT package for mosquitoes as an innovative and sustainable approach, for managing mosquito populations to improve human health by reducing the burden of mosquito-borne diseases.

The success of an SIT project essentially depends on the efficiency of the released sterile males to compete with wild males for wild females. Since the SIT is based on reducing the birth rate of the target population, understanding all different aspects of the natural history and reproductive biology of *Aedes* mosquitoes, especially under field conditions, is crucial. In this context, the Insect Pest Control Section of the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture organized a consultancy meeting to explore and discuss the need for a new Coordination Research Project (CRP) on sexual male performance.

The meeting was held in Vienna, IAEA headquarters from 23–27 May with the participation of five external experts from Israel, Mexico, Singapore, Spain, and the United States of America. These experts are actively involved in research activities in related topics and also participate in SIT field programmes.

Participants of the Consultancy Meeting on Mosquito Male Performance (Vienna, Austria).

During the meeting, technical discussions took place focusing on the steps, procedures, challenges, and bottlenecks faced during the production process and release of sterile males that can affect the insect performance in the field. A new CRP proposal focuses on critical knowledge gaps in male mosquito reproductive biology, particularly investigating the factors that contribute to the mating success of sterile males in SIT programs.

The new CRP proposal includes the following thematic research areas grouped into three major categories with specific research topics: 1) pre-copulatory behaviour in laboratory and natural conditions; 2) copulation and insemination processes, and 3) patterns of female remating and factors that control it.

Announcements

11th International Symposium on Fruit Flies of Economic Importance

Second Announcement, 4 March 2022

Abstract Submission Closes 30 June 2022

Abstracts for the 11th International Symposium on Fruit Flies of Economic Importance to be held from 13–18 November 2022, in Sydney, NSW, Australia have to be submitted before 30 June 2022. The venue will be located at the Macquarie University North Ryde Campus.

11th International Symposium on
FRUIT FLIES
of Economic Importance
13-18 NOV 2022 • SYDNEY • AUSTRALIA

Submit your Abstract

Please be sure to follow the submission guidelines.

All presenters with accepted abstracts must register to attend the Symposium which will be held in a hybrid format, providing in-person and virtual options.

Registrations

Early bird registration at reduced rates is available until 31 August 2022, view the website for a full list of fees.

Register Now

In-person registration fees include symposium materials, proceedings, coffee breaks and lunch during the four working days. Technical tours on Wednesday and evening Social Function will be optional.

Virtual registration fees will include access to the Virtual Platform; streaming all live working day sessions allowing you to participate in live Q&A, virtual networking with colleagues, and virtual exhibition.

Both in-person and virtual registrations will have six months post-symposium access to the Virtual Platform to revisit session recordings on demand.

View the full Registration Information.

Technical tours will be AU $75 (incl GST) including lunch. The evening social function will be AU $100 (incl GST).

More information will be available soon, if you register now, you will be provided with an opportunity to add the Tours and Social Function at a later date.

Sponsorship and Exhibition

Your organisation may be interested in a commercial stand or sponsorship opportunity, the various packages include registrations for your attendees. Please view the sponsorship prospectus or be in touch for a custom package.

Further information is available at: www.11isffei.com. You can also contact us at 11isffei@theconferencecompany.com

Looking forward to seeing you in Sydney or online,

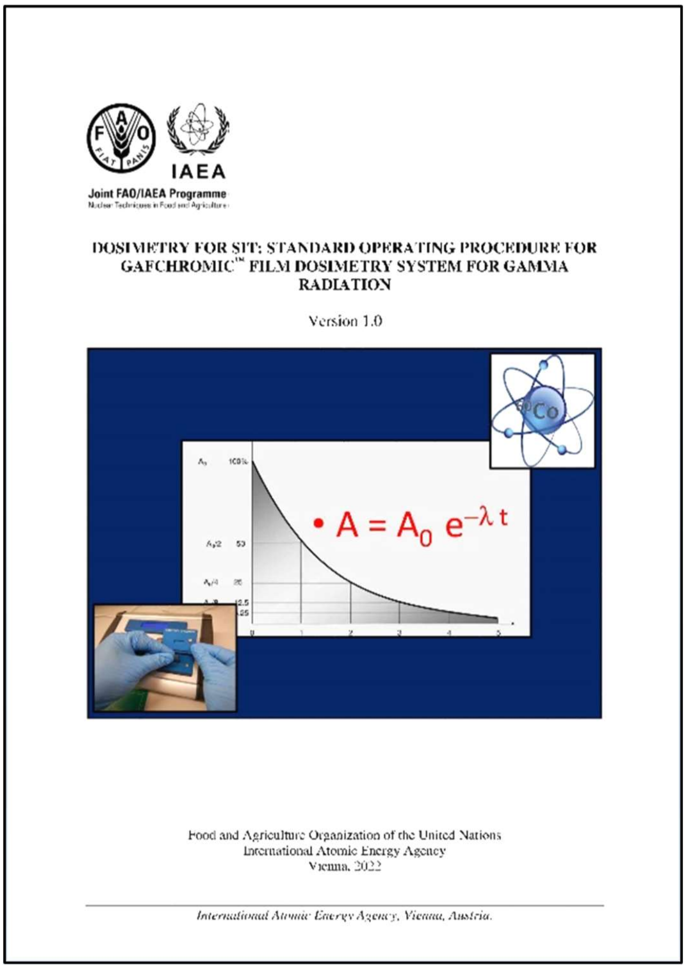
Polychronis Rempoulakis (Chair of the Local Organizing Committee)

Rui Cardoso Pereira (Chair of the International Fruit Fly Steering Committee)

Dosimetry for SIT: Standard Operating Procedures for Gafchromic™ Film Dosimetry System for Gamma Radiation and Low Energy X Radiation

Two Standard Operating Procedures (SOPs) manuals for gamma radiation and low energy X radiation were produced. Both are available in English and Spanish and can be downloaded at IPC website:

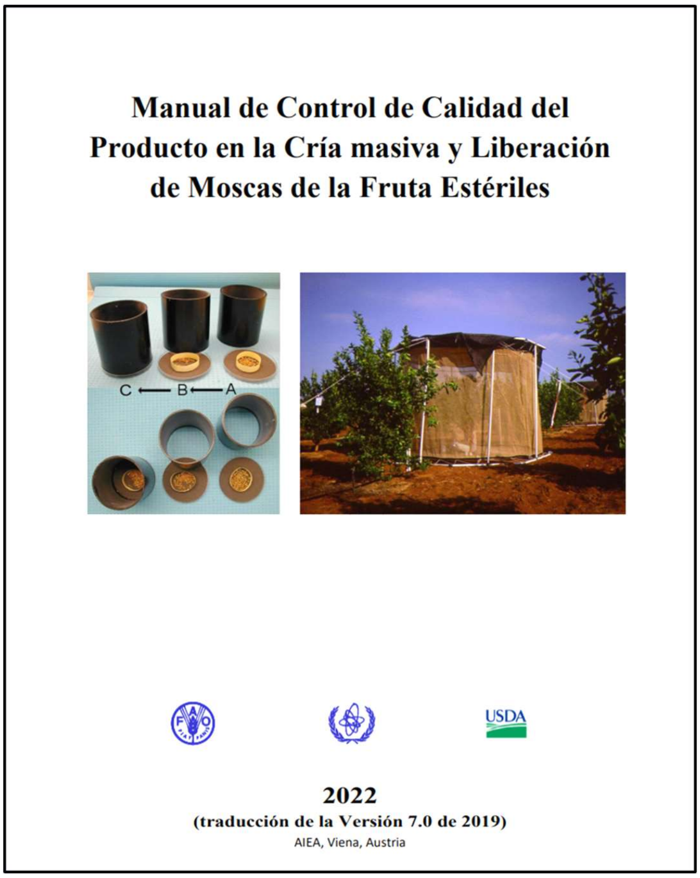
- Standard Operating Procedures for Gafchromic™ Film Dosimetry System for Gamma Radiation v1.0 (English version) https://www.iaea.org/sites/default/files/gamma-sop-en-excel-embedded.pdf.
- Standard Operating Procedures for Gafchromic™ Film Dosimetry System for Gamma Radiation v1.0 (Spanish version) https://www.iaea.org/sites/default/files/22/03/gamma-sop-es-excel-embedded.pdf.
- Standard Operating Procedures for Gafchromic™ Film Dosimetry System for Low Energy X Radiation v1.0 (English version) https://www.iaea.org/sites/default/files/x-ray-sop-en-excel-embedded.pdf.
- Standard Operating Procedures for Gafchromic™ Film Dosimetry System for Low Energy X Radiation v1.0 (Spanish version) https://www.iaea.org/sites/default/files/22/03/x-ray-sop-es-excel-embedded.pdf.



The SOPs bring together in one place a description of the components of the Gafchromic™ dosimetry system, the procedure for its characterization, and its application to process validation and process control, together with references to the relevant standards. It provides a readily available source of information that can be accessed by both research workers and production facility managers. Due to a significant difference in photon energy between low energy (150-225 keV) X radiation and gamma radiation from ^{60}Co or ^{137}Cs, many dosimetry procedures are different. For this reason, the SOPs for gamma radiation and low energy X radiation are separated into two independent SOPs.

Manual de Control de Calidad del Producto en la Cría masiva y Liberación de Moscas de la Fruta Estériles, (traducción de la Versión 7.0 de 2019)

The FAO/IAEA/USDA manual on ‘Product Quality Control and Shipping Procedures for Sterile Mass-Reared Tephritid Fruit Flies’ has provided and continues to provide an objective set of standards for assessing quality of sterile fruit flies used in sterile insect technique (SIT) programmes. The manual version 7.0 from 2019 (https://www.iaea.org/sites/default/files/qcv7.pdf) addresses an essential need by those working in fruit fly control programmes to measure insect performance in concert with other operational activities.



This manual is a living document and is subject to periodical updates; this most recent version had been translated into Spanish and now is available for download at IPC website https://www.iaea.org/sites/default/files/qcv7-en-espanol.pdf.

In Memoriam

Antigone Zacharopoulou (1945–2022)

With great sadness, we announce the passing away of Antigone Zacharopoulou, Emeritus Professor at the Department of Biology, University of Patras, Greece, on 27 May 2022. Antigone graduated in science with an emphasis on Biology from the Aristotle University of Thessaloniki and she received a PhD degree in Biology with an emphasis on Genetics from the Department of Biology, University of Patras, the Department where she worked for her entire career. Although her initial research work focused on *Drosophila*, Antigone spent most of her career working with insects of economic importance.

Antigone pioneered cytogenetic studies on the mitotic and polytene chromosomes of major tephritid pest species as well as tsetse flies. Her research work contributed to the development and improvement of genetic sexing strains for SIT applications and provided tools for taxonomic, phylogenetic and species resolution studies. During her long career, Antigone collaborated with many research groups from all over the world. She was a visiting scholar at the Harvard University-USA, University of Sydney-Australia, Institute of Cytology and Genetics, Novosibirsk and Institute of Developmental Biology-Russia, Moscamed and Moscafrut Facility, Tapachula-Mexico, and she also worked for almost two years as Consultant at the Insect Pest Control Laboratory of the Joint FAO/IAEA Centre of Nuclear Applications in Food and Agriculture.

Antigone supervised many MSc and PhD students; she was an excellent, inspiring teacher and mentored many fruit fly workers who are currently following her steps in different parts of the world. She published more than 70 research papers and coordinated and/or participated in many national, European, and international research grants, including Coordinated Research Projects (CRPs) of the Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture.

Antigone is leaving a deep empty space among all those who knew and worked with her. Her in-depth scientific knowledge and outstanding research work on genetics and cytogenetics of fruit flies of economic importance will be sorely missed. But above all, we will miss her amazing personality, generosity, collaborative spirit, as well as her dedication to the support and training of young students and research scientists.

Richard (Dick) Earl Gingrich (1931–2021)

With great sadness we have to inform that Richard (Dick) Gingrich, former Head of the Entomology Unit of the Joint FAO/IAEA Laboratory in Seibersdorf, Austria from 1980 to 1992, passed away on 6 December 2021.

Dick was born in Hamilton, Ohio on 23 November 1931. He graduated from Ohio state university and obtained PhD degree in Entomology in 1961. He had a career as a Research Scientist in Insect Pathology for the United States Department of Agriculture (USDA) and the International Atomic Energy Agency (IAEA). He was a member of the Houston Zoo as a docent, a past member of the Texas Archaeological Society and a proud veteran of the United States Army.

Dick served as head of Entomology Unit in Seibersdorf Laboratory from 1980 to 1992. Besides his great efforts on the leading role of the laboratory research activities supporting the member states on tsetse fly, Mediterranean fruit fly and screwworm SIT applications, he also put his research endeavour on *Bacillus thuringiensis* (Bt) as a potential microbial control agent for Mediterranean fruit fly. Dick was also involved in assessing the risks of microbial contamination of blood diets for tsetse colonies that may cause 'blood mortality' i.e., dead flies with fully engorged abdomen. His contributions culminated in a standardised bacteriological QC screening test for blood batches collected at abattoirs for tsetse blood diets.

Dick was not only a dedicated scientist; he was also a fascinating person off the professional stage – to which his hobbies no doubt contributed. He had a passion for mountain hiking, antique clocks, fish farming, cycling and spending time with his kids and grandkids.

With the departure of Dick, we have lost a remarkable scientist and friend. Those who knew him will remember Dick for his friendship, his scientific endeavour and his kindness.

Other News

Sterile Fly Preventive Release Programme in Argentina

Mediterranean fruit fly is one of the most important pests of fruits and vegetables in Argentina. This is due to the direct damage to fruit production and the consequential damages to the commercialization because of the limiting exports to countries that impose quarantine restrictions due to the presence of fruit fly pests. This translates into millions of US dollars of losses every year affecting food security and safety.

To mitigate the fruit fly problem, in 1994, Argentina created the National Fruit Fly Control and Eradication Programme (PROCEM) of the National Service for Food Health and Quality (SENASA). The PROCEM, with the support of the FAO and IAEA for the adoption of the sterile insect technique (SIT), established fruit fly pest free areas in the Province of Mendoza and in the region of Patagonia. This allowed the diversification of fruit production and the access to export markets that were previously vetted because of the presence of the fruit fly pest. The pest free areas have become the main production regions of pome and stone fruits in the country.

From the mid 2020's, and in an effort to protect the free areas established in the Centre and South of Mendoza and in the Patagonia Region, a sterile Mediterranean fruit fly preventive release programme (PRP) was adopted and successfully implemented as part of an area-wide integrated pest management scheme.

It is a similar model to the one implemented since 1994 in the Los Angeles Basin California and since 1998 in Miami Florida, USA, to protect these states from the incursions of the invasive Mediterranean fruit fly. The preventive release programme was implemented over urban and suburban areas that are subjected to constant risk of incursions of the pest. The number of outbreaks was reduced from an average of seven per year to only occasional ones since the full implementation of the preventive release programme in 1996. Benefits have outweighed the costs resulting in a high return on investment.

A distinctive difference between the traditional SIT control strategy and the preventive releases of sterile flies, is that the first one is done in infested areas to suppress or eradicate a pest, whereas the second strategy is applied in pest free areas to prevent the introduction of the pest.

At present, Argentina applies the preventive releases of sterile flies over 34 700 hectares. This includes the fruit fly pest free areas in Mendoza and Patagonia. Releases are carried out over dynamic blocks based on a risk assessment using densities that range from 1 500 to 4 500 sterile males per hectare. Sterile flies are released over the blocks two or three times per week.

The sterile flies are supplied by the mass-rearing and sterilization facility 'Santa Rosa' of the Mendoza Agricultural Health and Quality Institute (ISCAMEN). The facility is the largest Mediterranean fruit fly mass rearing facility in South America, with a production capacity of 700 million sterile male flies per week (using the VIENNA 8 genetic sexing strain). Moreover, a Fly Emergence and Release Facility, located in south of the Mendoza Province, has a capacity to process 500 million sterile flies per week. This centre is the strategic link to supply the sterile fly material to the Centre and South Mendoza Oasis, as well to areas in Patagonia subject to preventive releases.

Most of the sterile flies are released by air using the chilled adult release system. In addition, complementary ground releases are conducted in specific high-risk sites such as touristic sites and sites where large volumes of fruit are gathered. Ground releases are also done when aerial releases are suspended due to unfavourable climatic conditions.

Samples of chilled adults being taken to measure quality parameters. (Source: PROCEM-SENASA Argentina).

The sterile insect recapture index (Sterile Flies Per Trap per Day (FTD)), allows to have control on the release activity and correct any deviation of the FTD that have been set up for each block. The continuous analysis of the sterile FTD values allows the adjustment of the sterile fly density, release frequency and spatial distribution of the sterile flies.

In order to identify opportunities for improvement and optimization of the sterile fly releases, the preventive release programme is subjected to continuous oversight. This is done through the experienced local staff and continuous technical support from FAO and IAEA experts. According to an economic evaluation carried out in recent years for the Patagonia region, since its declaration as a fruit fly pest free area (PFA), a Cost-Benefit Ratio of 15.4 to 1 has been obtained from increased exports and savings in quarantine treatments.

As a result of the implementation of the sterile fly release programme, the status of PFA has been maintained for almost 20 years in the Patagonia region as well as in the Mendoza Centre and South Oasis. These areas have been recognized as PFA by Chile, China, Trinidad Tobago and the USA, among other countries, significantly favouring the regional economy and strengthening food security, while protecting the environment. Now, with the preventive release programme, the maintenance of the status is more cost-effective and sustainable.

Source: Wilda Ramirez, National Service for Food Health and Quality (SENASA), Argentina.

The Sweet Potato Weevil has been Successfully Eradicated in South-western Islands of Japan

In November 2020, the sweet potato weevil *Cylas formicarius* was declared eradicated from Tsuken Island, Okinawa, Japan. This is the second eradication success of sweet potato weevil in the world, following the eradication achieved on Kume Island, also in Okinawa, in 2012. The eradication was achieved by the application of the sterile insect technique (SIT) integrated with the male annihilation technique (MAT).

Despite the fact that both Kume and Tsuken Islands are small (63.65 and 1.88 km^2 respectively), it took 19 and 13 years to achieve the eradication, much longer than the eradication of melon fly *Zeugodacus cucurbitae* on Kume Island, which only took about five years. Research indicated that, surprisingly, the pest's low dispersal ability was one of the main hindering factors in the eradication of sweet potato weevil on both islands.

The laboratory experiments showed that females have extremely low flight activity and fly only short distances. Although males show a better flight ability than females, it is much lower when compared to fruit flies (e.g. the melon fly). The low dispersal ability of females resulted in an uneven distribution of this pest on Kume Island. In addition, the low dispersal ability of males was the main hindering factor that sterile releases could not cover the inaccessible forest areas mainly inhabited by the blue morning glory *Ipomoea indica*, a wild host plant which is abundant on the island. An investigation indicated that sweet potato weevil was infesting blue morning glory plants in a remote area called 'Aara mountain', that was previously used as paddy fields by the residents of an abandoned village that used to exist at the foot of the mountain. It is likely that the sweet potato weevil was artificially introduced to this area when it was rice paddy and was unnoticedly maintained through the generations without expanding its distribution area. To control the pest in this area, a pier was built at the foot of the mountain to enable and approach the abandoned rice paddy from the ocean.

On Tsuken Island, the situation was opposite. The Island is at least 4 km away from Okinawa Island. The mark-release recapture study showed that the sweet potato weevil has a flight ability up to 2 km over the ocean. In this regard, it was assumed that sweet potato weevil will not be able to flight from Okinawa Island to Tsuken Island. However, while the pest population detected in host plants was almost completely eliminated on Tsuken Island within two years after the initiation of SIT releases, hundreds of males were being caught every year by monitoring traps using sex pheromones on Tsuken Island. The host plants were investigated all over Tsuken Island to identify all the sweet potato *I. batatas* fields and wild hosts (blue morning glory *I. indica* and beach morning glory, *I. pes-caprae*) populations. No sweet potato fields or wild host communities were found infested by sweet potato weevil.

The abandoned village in Kume Island, where sweet potato was found (Photo: OPPPC).

Therefore, the investigation was conducted on the possibility that male sweet potato weevils may have flown from outside of Tsuken Island, i.e. the shore of Okinawa Island opposite to Tsuken Island, where they occur. Sterile insects were released at several points on this area in Okinawa Island to determine if they could reach Tsuken Island. The recapture results showed that a small number of released weevils were trapped in Tsuken Island, indicating that sweet potato weevil males can travel considerably longer distances than previously thought. However, this is considered as passive long-distance travel on the wind rather than active flight. Since these frequent fly-in entries from outside the island were basically thought to involve only males, there was almost no concern about re-colonization on the island due to this process. However, since hundreds of sweet potato weevil males were trapped every year and there was no way to distinguish weather the captured males are flying in from outside the island or occurring on the island, the eradication could not be confirmed.

In response to this, the idea was to identify the main source of sweet potato weevils flying in from outside the island and controlling that area to indirectly reduce the number of trapping in the island. Based on the results of the above mark-release recapture experiment and the density survey using pheromone traps, it was assumed that the area called Heshikiya in Okinawa Island might be the main source of the sweet potato weevils' entry in Tsuken Island. So, the suppression of sweet potato weevil males by mass-trapping in this area was conducted. Although MAT is much easier and less costly to be conducted by using fiber boards, mass trapping was performed in order to properly evaluate the hypothesis by counting the number of males trapped. Continuous control in the Heshikiya area resulted in a decrease in the number of weevils trapped at Tsuken Island, as expected, and the investigation to confirm eradication could be conducted without hindrance.

Mark-release recapture experiment (Photo: OPPPC).

This would be the first case in the world on the eradication of a pest in an area where transitory entries that do not lead to re-establishment occurs. Maintenance of the pest free status after eradication is likely to be quite costly in such locations, if delimitation survey has to be done in the vicinity of each case of trap catch, as is done for the fruit flies.

Therefore, prior to confirm the eradication, a system was created to support surveillance after eradication. The idea is to distinguish between the transitory entry from outside the island and re-colonization on the island by the pattern of trap catch with surveillance traps. This is done by weighting the number of catches in a particular trap according to the suspected occurrence in the vicinity of the trap, such as multiple simultaneous or consecutive catches, and calculating the score. When this score is significantly higher than the statistically expected number of catches by surveillance traps in the absence of a re-colonization on the island, an alert is issued, prompting to conduct a confirmation survey of the re-colonization. This system enables to efficiently and accurately identify the presence and (if any) area of sweet potato weevil occurrence.

The eradication confirmation investigation in Tsuken Island was conducted under the Covid-19 Pandemic, which caused many hardships, including the inability to dedicate a large number of personnel to the survey. As the island is remote with no police or hospital and many of the residents are elder, there was a period that entry from outside the island was severely restricted. More than a year has passed since the eradication was confirmed, but a formal celebration of the eradication has yet to be held.

Read more:

Himuro C., et al. (2022). First case of successful eradication of the sweet potato weevil, *Cylas formicarius* (Fabricius), using the sterile insect technique. *PLoS One*, 17 (5): e0267728. https://doi.org/10.1371/journal.pone.0267728;

Ikegawa Y., et al. (2022) Eradication of sweetpotato weevil, *Cylas formicarius*, from Tsuken Island, Okinawa, Japan, under transient invasion of males. Journal of Applied Entomology, 00,1–10. https://doi.org/10.1111/jen.13004.

Source: Atsushi Honma, Okinawa Prefectural Plant Protection Center (OPPPC), Japan.

Researchers Use Simulation Model to Optimize Delimitation Trapping Surveys

The global costs associated with invasive insects add up to more than US $70 billion every single year—and that price tag is expected to increase as climate change, global trade, and an overall uptick in human movement help expand the ranges of exotic pests.

*When an invasive insect appears, responders must quickly set monitoring traps in the area to determine the extent of the pest outbreak. For an outbreak of Mediterranean fruit flies (*Ceratitis capitata*), for instance, traps such as this McPhail trap might be used (Photo: Peggy Greb, USDA Agricultural Research Service, Bugwood.org).*

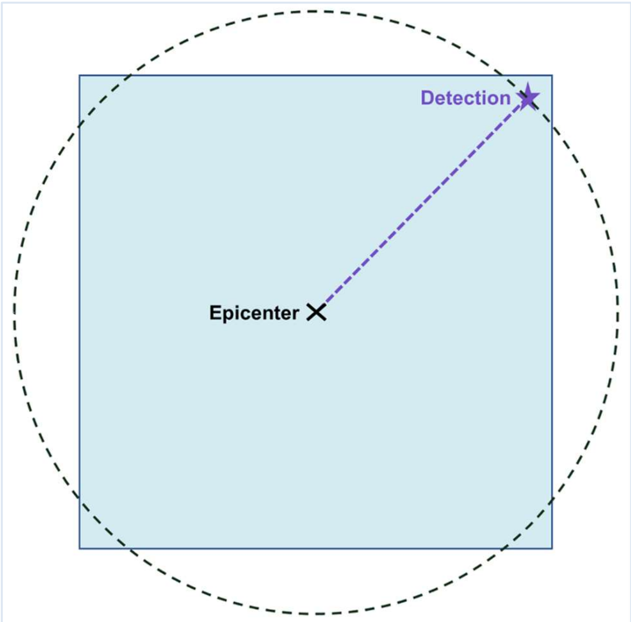
That expensive problem inspired a collaboration between researchers from the United States Department of Agriculture's (USDA) Animal and Plant Health Inspection Services (APHIS) and Agricultural Research Service (ARS) as well as the Center for Integrated Pest Management at North Carolina State University. In a study published in October 2021 in the *Journal of Economic Entomology* (https://doi.org/10.1093/jee/toab184), the team used simulated outbreak data to look at the design of trapping surveys for determining how far an outbreak has reached. They found that factors like grid shape and size, insect dispersal ability, trap density, and trap attractiveness all make a difference when it comes to optimizing surveys.

"In the US, after an exotic pest is detected there's usually an early need to determine the boundaries of the population," says Barney Caton, pest exclusion analysis coordinator with USDA-APHIS and the first author of the paper. "So, the delimiting survey is one tool aimed at doing that."

This means establishing a grid over the outbreak and deploying traps to figure out how far the pests have spread. That—or visual surveys for insects that can't be trapped—provides the data that agencies and stakeholders need to figure out the next steps in dealing with an outbreak.

The default design is a fully trapped square, using a 5-by-5-mile grid for less mobile insects or a 9-by-9-mile grid for more mobile pests. But are these ideal for the job?

Tasked with this question, Caton reached out to Nicholas Manoukis, a supervisory research biologist with USDA-ARS who had a model perfect for the project: TrapGrid. The team used TrapGrid to look at 30-day randomized outbreaks and calculate the mean probability of capturing individual pests using default and modified survey designs.



Many current standard guidelines for delimitation surveys call for square trapping grids, but a circle design is more efficient. As this diagram shows, a pest that can reach the far corner of a square grid can easily reach beyond the grid if moving in a different direction. Conversely, a square grid large enough to cover a pest's maximum travel radius would cover excess area—21.5% more than needed (Image originally published in Caton et al 2021, Journal of Economic Entomology).

"No one had really done a whole lot of work on determining how the schemes were doing—in particular whether the sizes were right or whether the densities were right," Caton says. "So, our work was the first example of using more advanced analytics to actually go back and evaluate the traditional design."

Some of the findings confirm what many experts already do in the field—like the shape of the grid. Caton says it's intuitive to set these up as a circle, measuring the max distance the pest should move from the center of the outbreak in every direction. However, the published designs default to square grids. The corners of those squares are outside the radius, so using a circle means a 21.5% reduction in traps and area to service.

Optimizations like this could mean better quality data and conserved resources, which may be a big deal down the road. "If exotic species continue to be introduced and potentially established and the rates are going up, as some studies suggest, we may be doing more and more delimitation surveys over time," Caton says. "So, doing them cheaply is going to be important to constrained budgets and make this manageable."

The study highlighted the value of updating survey designs for pests with low to moderate mobility to avoid oversizing grids. Another important factor is trap density, which may be tied to how attractive the traps are and how serious the pest is.

For traps that are super attractive to the insect—like those that use pheromone lures with irresistible cues a pest can follow some distance—a survey likely needs fewer traps. Traps that use food-based or visual lures, which only pull in pests that are hungry or close enough to notice color, may require higher densities.

The research team verified their simulation results by running empirical data from detection surveys through the model. As predicted, they found that a number of those surveys were oversized.

Now, they are conducting field experiments in Hawaii using the Mediterranean fruit fly (*Ceratitis capitata*) to demonstrate how their design improvements work in the field.

Source: Entomology Today. By Melissa Mayer, 22 November 2021, https://entomologytoday.org/2021/11/22/simulation-model-optimize-delimitation-trapping-surveys-invasive-insects/.

How did Adelaide Eradicate its Queensland Fruit Fly Outbreak?

The Successful Campaign Took Planning, a Strategic Approach – and an Impressive Number of Sterile Fruit Flies

A year-long outbreak of Queensland fruit fly in metropolitan Adelaide was declared eradicated on 22 February 2022, bringing an end to restrictions on transport of fruit across the city.

It is a relief for South Australian communities, who have battled several outbreaks of both Queensland fruit fly (*Bactrocera tryoni*) and Mediterranean fruit fly (*Ceratitis capitata*) across the state in recent years.

At the height of the outbreaks in 2021, the South Australian Department of Primary Industries and Regions (PIRSA) was eradicating 11 Mediterranean fruit fly outbreaks and one

Queensland fruit fly outbreak in metropolitan Adelaide, one Mediterranean fruit fly outbreak in Port Augusta, and five Queensland fruit fly outbreaks in the Riverland. The Mediterranean fruit fly outbreaks in metropolitan Adelaide were declared over in December 2021.

Credit: Department of Primary Industries and Regions (PIRSA).

This recent announcement brings the number of remaining outbreaks down to two: both of Queensland fruit fly in the Riverland. So how did Adelaide manage to outsmart this horticultural pest?

The fly is described by the Queensland Department of Agriculture and Fisheries as a “major and frequent pest”. Females lay their eggs in fruit on trees or on the ground, and hatching maggots feast on the fruit.

According to Nick Secomb, General Manager of the Fruit Fly Response Program at PIRSA, the wide host range of the fruit fly is part of what makes it dangerous.

“In South Australia there’s about $1.3 billion worth of produce grown every year that the fruit fly can infect,” he explains.

Credit: Department of Primary Industries and Regions (PIRSA).

Effectively combating a fruit fly outbreak requires a few different strategies, targeting different stages in the insect life cycle.

Strategically placed traps across the state emit pheromones to attract flies for monitoring purposes. Adult flies are targeted with a bait containing an insecticide called Spinosad, derived from a soil bacterium.

“It’s really specific to fruit fly and they come and feed on it and die,” says Secomb. “Because it’s organic, we can use it in residential areas.”

Fallen fruit is collected and composted at high temperatures to kill off any fruit fly eggs or larvae that may be lurking within. Once the fly populations have been brought down sufficiently, it’s time to send in the sterile flies.

Sterile insect technique was key to PIRSA’s fruit fly control effort. “It starts in a really specialised factory,” says Secombe. “For the Queensland fruit fly, we’ve got our own facility in Port Augusta.”. Sterile Mediterranean fruit flies, meanwhile, are grown in Western Australia.

The sterilised flies are sent to an operations team, who release them into the outbreak area, either with a plane or from the back of a specialised pickup truck. When the sterile flies, which. When the sterile flies, which are otherwise “fit and healthy”, mate with wild flies, no viable offspring can be created. For eradication, it’s important to be able to flood the wild population with enough sterile flies to disrupt reproduction for the whole population.

Sounds pretty effective, so why isn’t this being used to eradicate Queensland fruit fly all over the country? “Sterile flies really struggle to be effective if there’s millions of wild flies out there anyway,” Secomb says. “They can’t overwhelm the population as they need to. So, the places where there’s lots of fruit fly naturally, it’s really hard for sterile flies to do their job. Luckily for Adelaideans, in this case the fruit fly numbers were controlled to a degree that allowed the sterile flies to fulfil their destiny.

Source: Cosmos, by Matilda Handsley-Davis, 24 February 2022. https://cosmosmagazine.com/earth/agriculture/adelaide-eradicate-queensland-fruit-fly/.

Sterile Insect Technique Trial Heralds Pesticide-free Future

British fruit growers moved a step closer to chemical-free production after a world-first field trial using sterile insects achieved a 91 per cent reduction in the detection of destructive pest spotted-wing drosophila (SWD).

Reading-based agritech start-up BigSis conducted the trial using an updated version of the sterile insect technique (SIT) in partnership with BerryGardensand the research institute NIAB EMR.

The SIT has long been recognised as 'the perfect solution' for insect pest control, BigSis founder Glen Slade said, but in the 60 years since it was conceived, it’s always been too expensive to deploy beyond a limited number of special-use cases. However, BigSis turned to artificial intelligence and robotics to automate SIT, he revealed: a breakthrough that slashed the cost of SIT solutions by as much as 90%.

The SIT basic premise is simple, he explained: sterilise and release male insects into the crop, where they mate with wild females to prevent the rapid increase in pest populations that leads to crop damage.

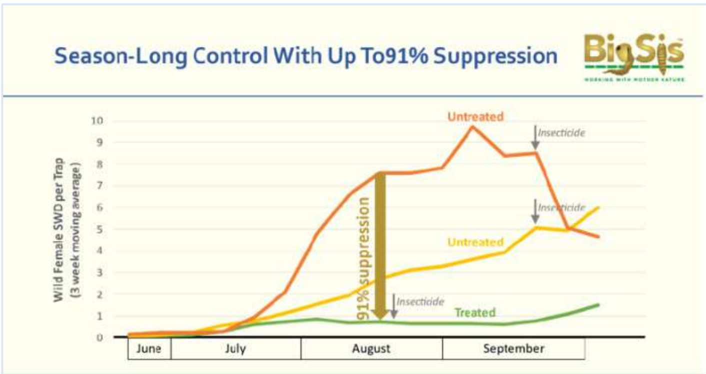
"We're finally bringing SIT to growers as an affordable, farm-scale solution for insect pest control in agricultural crops," he said.

Spotted-wing drosophila is a major pest in soft fruit and stone fruit.

Conducted in Kent, the field trial focused on the control of SWD, a global invasive pest of soft fruit, first detected in the UK in 2012, that can cause thousands of pounds worth of damage.

BigSis released sterile male SWD in and around a crop of everbearing strawberries between April and the end of harvest. Using sticky traps with lures, numbers of wild female SWD were monitored at the treated site and two control sites.

During the trial, numbers of female SWD in the treated plot barely rose above one per trap per week, compared to a peak of nearly ten insects per trap per week in untreated controls, BigSis said.



"We are thrilled that this world-first trial of SIT to control SWD has given such a convincing demonstration of season-long control, with a suppression result of up to 91 per cent," said Slade.

Source: Fresh Produce Journal, 30 November 2021, By Luisa Cheshire. https://www.fruitnet.com/fresh-produce-journal/sit-trial-heralds-pesticide-free-future/186971.article.

Sterile Moth Programme Aims to Protect Local Almond and Pistachio

Sterile moths taking off from an airport in Shafter, California on the week of 14 March 2022 are the latest recruits for a test programme local almond and pistachio growers hope will lead to the eradication of one of their worst enemies.

Environmental scientist Cameron Poole loads a plane in Shafter, California with roughly 750 000 sterile moths. The moths will be released over ag fields in Fresno County (Rod Thornburg).

Planes loaded with navel orangeworms, all of them raised and irradiated in Phoenix, Ariz., will fly to Fresno County. There they will be released and, if all goes well, mate with wild populations without producing offspring.

The flights are designed to help scientists determine how many of the sterile insects are needed to overwhelm a given pest population. Another goal is to test whether the human-raised moths can be effectively released into the wild using the same equipment that was deployed in the successful U.S. eradication of the cotton pest pink bollworm.

The navel orangeworm is a top concern for growers of almonds and pistachios, Kern's third and fourth top-grossing crops in 2020 at US $1.1 billion and US $945 million, respectively. Not only does the insect eat the crops, but they can introduce a fungus for which international tolerance levels are low.

Growers have contributed hundreds of thousands of dollars to support the sterile moth project, which builds on work done by the California Natural Resource Board. The effort is in its third year as a U.S. Department of Agriculture programme.

The programme's budget stands at US $8.1 million, up from an earlier allocation of US $6 million. Richard Matoian, president of the American Pistachio Growers, said by email that industry is pushing for a US $12 million appropriation next year on the way to, ideally, US $21 million, based on federal projections of how much it might cost to scale up the effort.

"This is a great project because, if successful, it will reduce the number of sprays and the total amount of pesticides used," Matoian wrote.

Richard Waycott, president and CEO of the Almond Board of California, said by email his organization has monitored the results of the federal programme. The board supports development of new crop pest management solutions, "especially for navel orangeworm, almonds' No. 1 pest," he wrote.

Initially, sterile moths from Phoenix were released over Lost Hills. That stopped when the grower whose orchard was the site of the release also introduced mating disruption, whose use of pheromones makes it hard to trap males for testing to determine how well the sterile moth program works.

A big question now is how to ensure enough moths will survive being released at speeds of 100 mph or more at no lower than 500 feet elevation, said Bob Klein, manager of the California Pistachio Research Board.

"There are a number of technical issues that have to be worked out," Klein said. He estimated that if things go well, the sterile moth programme might be ready a full rollout in as soon as five years.

Source: Bakersfield.com, 14 March 2022, by John Cox. (https://www.bakersfield.com/news/sterile-moth-program-aims-to-protect-local-almond-pistachio-grows/article_44cb064c-a3c5-11ec-a995-33005f0040a7.html).

Innovative Smartphone App Helps Identify Fruit Flies of Major Economic Significance in EU and Africa

The European research project FF-IPM, In-silico boosted, pest prevention, and off-season focused IPM against new and emerging fruit flies ('OFF-Season'), targets three highly polyphagous fruit fly species (Tephritidae) that cause devastating losses in the fresh fruit producing industry, the Mediterranean fruit fly (*Ceratitis capitata*), the Oriental fruit fly (*Bactrocera dorsalis*) and the peach fruit fly (*B. zonata*). These pests pose an imminent threat to European horticulture.

One of the goals of FF-IPM is to produce rapidly identification tools to intercept specimens in imported commodities and at processing industries. Rapid identification of fruit flies is crucial in preventing fruit flies from entering mainland EU territories and keeping the new populations at low levels of spreading.

On the framework of the FF-IPM an electronic multi-entry identification key for fruit flies that are considered of significance for quarantine measures in the EU was developed. The key contains characters to differentiate between adults of 23 fruit fly species of the subfamily Dacinae, that are determined as of economic significance to the European Union and other associated regions. The shortlist of 23 species includes the three target fruit flies (*Bactrocera dorsalis*, *B. zonata* and *Ceratitis capitata*) of FF-IPM and several species closely related to these.

This multi-entry identification key is based also on the work of Project F3 Fruit Fly Free, a multi-collaborations project that aims to develop a regionally harmonized framework for development and implementation of recognized Pest Free Areas (PFAs) and Areas of Low Pest Prevalence (ALPPs) for regulated fruit fly pests of commercial fruit commodities in southern Africa (South Africa and Mozambique). The Project F3 Fruit Fly Free has created a key to the fruit flies in Africa of major economic significance.

These two keys are now converted to user friendly mobile applications that can be installed on your smartphone and they are downloadable for free through the following links:

Key important fruit flies EU

https://play.google.com/store/apps/details?id=com.lucidcentral.mobile.fruit_flies_ffipm.

https://apps.apple.com/app/key-important-fruit-flies-eu/id1600191559.

Key selected fruit flies Africa

https://play.google.com/store/apps/details?id=com.lucidcentral.mobile.fruit_flies_africa.

https://apps.apple.com/app/key-selected-fruitflies-africa/id1600205756.

Source: FFIPM Bulletin • ISSUE 04 • March 2022. https://fruitflies-ipm.eu/wp-content/uploads/2021/07/FFIPM_newsletter_04.pdf.

Relevant Published Articles

The Sterile Insect Technique is Protected from Evolution of Mate Discrimination

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Abstract

Background: The sterile insect technique (SIT) has been used to suppress and even extinguish pest insect populations. The method involves releasing artificially reared insects (usually males) that, when mating with wild individuals, sterilize the broods. If administered on a large enough scale, the sterility can collapse the population. Precedents from other forms of population suppression, especially chemicals, raise the possibility of resistance evolving against the SIT. Here, we consider resistance in the form of evolution of female discrimination to avoid mating with sterile males. Is resistance evolution expected?

Methods: We offer mathematical models to consider the dynamics of this process. Most of our models assume a constant-release protocol, in which the same density of males is released every generation, regardless of wild male density. A few models instead assume proportional release, in which sterile releases are adjusted to be a constant proportion of wild males.

Results: We generally find that the evolution of female discrimination, although favored by selection, will often be too slow to halt population collapse when a constant-release implementation of the SIT is applied appropriately and continually. The accelerating efficacy of sterile males in dominating matings as the population collapses works equally against discriminating females as against non-discriminating females, and rare genes for discrimination are too slow to ascend to prevent the loss of females that discriminate. Even when migration from source populations sustains the treated population, continued application of the SIT can prevent evolution of discrimination. However, periodic premature cessation of the SIT does allow discrimination to evolve. Likewise, use of a 'proportional-release' protocol is also prone to escape from extinction if discriminating genotypes exist in the population, even if those genotypes are initially rare. Overall, the SIT is robust against the evolution of mate discrimination provided care is taken to avoid some basic pitfalls. The models here provide insight for designing programs to avoid those pitfalls.

The full paper was published in: PeerJ 10:e13301 https://doi.org/10.7717/peerj.13301.

New World Screwworm (*Cochliomyia hominivorax*) Myiasis in Feral Swine of Uruguay: One Health and Transboundary Disease Implications

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Abstract

Background: Feral swine (*Sus scrofa*) are highly invasive and threaten animal and human health in the Americas. The screwworm (*Cochliomyia hominivorax*) is listed by the World Organization for Animal Health as a notifiable infestation because myiasis cases affect livestock, wildlife, and humans in endemic areas, and outbreaks can have major socioeconomic consequences in regions where the screwworm has been eradicated. However, a knowledge gap exists on screwworm infestation of feral swine in South America, where the screwworm is endemic. Here, we report screwworm infestation of feral swine harvested in Artigas Department (Uruguay), where the Republic of Uruguay shares borders with Brazil and Argentina.

Methods: Myiasis caused by the larvae of screwworm were identified in feral swine with the support and collaboration of members of a local feral swine hunting club over a 3-year period in the Department of Artigas. Harvested feral swine were examined for the presence of lesions where maggots causing the myiasis could be sampled and processed for taxonomic identification. The sites of myiasis on the body of infested feral swine and geospatial data for each case were recorded. The sex and relative size of each feral swine were also recorded. Temperature and precipitation profiles for the region were obtained from public sources.

Results: Myiases caused by screwworms were recorded in 27 of 618 the feral swine harvested. Cases detected in males weighing > 40 kg were associated with wounds that, due to their location, were likely caused by aggressive dominance behaviour between adult males. The overall prevalence of screwworm infestation in the harvested feral swine was associated with ambient temperature, but not precipitation. Case numbers peaked in the warmer spring and summer months.

Conclusions: This is the first report on myiasis in feral swine caused by screwworm in South America. In contrast to myiasis in cattle, which can reach deep into host tissues, screwworms in feral swine tended to cause superficial infestation. The presence of feral swine in screwworm endemic areas represents a challenge to screwworm management in those areas. Screwworm populations maintained by feral swine may contribute to human cases in rural areas of Uruguay, which highlights the importance of the One Health approach to the study of this invasive host species ectoparasite interaction.

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Integrated control of *Aedes albopictus* in Southwest Germany Supported by the Sterile Insect Technique

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Abstract

Background: Background: The invasive species *Aedes albopictus*, commonly known as the Asian tiger mosquito, has undergone extreme range expansion by means of steady introductions as blind passengers in vehicles traveling from the Mediterranean to south-west Germany. The more than 25 established populations in the State of Baden-Württemberg, Palatine and Hesse (south-west Germany) have become a major nuisance and public health threat. *Aedes albopictus* deserves special attention as a vector of arboviruses, including dengue, chikungunya and Zika viruses. In Germany, *Ae. albopictus* control programs are implemented by local communities under the auspices of health departments and regulatory offices.

Methods: The control strategy comprised three pillars: (i) community participation (CP) based on the elimination of breeding sites or improved environmental sanitation, using fizzy tablets based on *Bacillus thuringiensis israelensis* (fizzy Bti tablets; Culinex® Tab plus); (ii) door-to-door (DtD) control by trained staff through the application of high doses of a water-dispersible Bti granular formulation (Vectobac® WG) aimed at achieving a long-lasting killing effect; and (iii) implementation of the sterile insect technique (SIT) to eliminate remaining *Ae. albopictus* populations. Prior to initiating large-scale city-wide treatments on a routine basis, the efficacy of the three elements was evaluated in laboratory and semi-field trials. Special emphasis was given to the mass release of sterile *Ae. albopictus* males.

Results: More than 60% of the local residents actively participated in the first pillar (CP) of the large-scale control program. The most effective element of the program was found to be the DtD intervention, including the application of Vectobac® WG (3000 ITU/mg) to potential breeding sites (10g per rainwater container, maximum of 200 l = maximum of approx. 150 000 ITU/l, and 2.5 g per container<50 l) with a persistence of at least 3 weeks. In Ludwigshafen, larval source management resulted in a Container Index for *Ae. albopictus* of < 1% in 2020 compared to 10.9% in 2019. The mean number of *Aedes* eggs per ovitrap per 2 weeks was 4.4 in Ludwigshafen, 18.2 in Metzgergrün (Freiburg) (SIT area) and 22.4 in the control area in Gartenstadt (Freiburg). The strong reduction of the *Ae. albopictus* population by Bti application was followed by weekly releases of 1013 (Ludwigshafen) and 2320 (Freiburg) sterile *Ae. albopictus* males per hectare from May until October, resulting in a high percentage of sterile eggs. In the trial areas of Ludwigshafen and Frieburg, egg sterility reached 84.7±12.5% and 62.7±25.8%, respectively; in comparison, the natural sterility in the control area was 14.6±7.3%. The field results were in line with data obtained in cage tests under laboratory conditions where sterility rates were 87.5±9.2% after wild females mated with sterile males; in comparison, the sterility of eggs laid by females mated with unirradiated males was only 3.3±2.8%. The overall egg sterility of about 84% in Ludwigshafen indicates that our goal to almost eradicate the *Ae. albopictus* population could be achieved. The time for inspection and treatment of a single property ranged from 19 to 26 min depending on the experience of the team and costs 6–8 euros per property.

Conclusions: It is shown that an integrated control program based on a strict monitoring scheme can be most effective when it comprises three components, namely CP, DtD intervention that includes long-lasting Bti-larviciding to strongly reduce *Ae. albopictus* populations and SIT to reduce the remaining *Ae. albopictus* population to a minimum or even to eradicate it. The combined use of Bti and SIT is the most effective and selective tool against *Ae. albopictus*, one of the most dangerous mosquito vector species.

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