Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Insect Pest Control Newsletter

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To Our Readers

Ecuador, one of the largest producers of tropical fruit in the Western Hemisphere, is adding non-traditional fruits such as tree tomato, dragon fruit and golden berries to its export portfolio as a result of successfully controlling the Mediterranean fruit fly with integrated pest management practices including the sterile insect technique. On the photo, we can see tree tomato being harvested that is now exported to markets in the United States, Latin America and the European Union. (Photo: AGROCALIDAD).

Under the umbrella of the National Fruit Fly Management Project, Ecuador has been implementing a Mediterranean fruit fly pest control scheme, based on an integrated pest management (IPM) approach that includes the sterile insect technique (SIT). The SIT is an effective and environment friendly pest control method, that, when integrated with other control tactics can effectively help reduce pest damage, maintain healthy crops and minimize the use of insecticides. As a result, fruit and vegetable quality and quantity is increased and international trade facilitated. The SIT was incorporated into the IPM approach in 2018, and as a result, farmers are now exporting golden berries, dragon fruit and tree tomatoes to markets in the United States, Latin America and the European Union.

Argentina is another South American country that has greatly benefited from increased exports of their fruits following the successful application of the SIT against Mediterranean fruit fly since the 1990s. Areas such as Patagonia and the Central and South Oasis in Mendoza Province that are growing cherries and other stone and pome fruits have been recognized by China as fruit-fly free, enabling exports to the world's largest fresh food market. This means that costly and time-consuming postharvest treatments for fresh fruit is no longer required.

Another important event was the eradication of a Mediterranean fruit fly outbreak lead by Mexico's national plant protection organization in Manzanillo, Colima, Mexico, that safeguarded Mexico's production and export of fruit and vegetables. The outbreak was detected on 24 April 2019 in the vicinity of the Manzanillo cargo port, and various phytosanitary measures were applied in 951 km^2 of the outbreak area, including the release of 740 million sterile male Mediterranean fruit fly adults and 28 million *Diachasmimorpha longicaudata* (a parasitoid of the Mediterranean fruit fly) on a continuous basis during 41 weeks. The last wild flies were trapped on 23 November 2019 and on 21 March 2020, after three biological cycles of the pest without any trap catches, eradication was declared.

We would also like to inform you about the progress with the transition into the new Insect Pest Control Laboratory (IPCL). The process of relocating all equipment and insect colonies was completed in November 2019 and the new IPCL is fully operational. With this positive outcome, we expect to increase the support and services to our Member States. An example is the new ecosphere (pictured), a climate-controlled area of more than 200 m^2, where behaviour, mating compatibility and competitiveness of insects of agricultural, livestock and medical importance can be studied under semi-field conditions. However, since the COVID-19 outbreak in Europe, all research activities had to be stopped at the IPCL due to the IAEA lockdown. The focus was shifted on maintaining our valuable insect colonies and strains. IPCL technicians continued working during the entire crisis and neither colonies nor strains were lost. I would like to express my sincere gratitude to our technical staff, and I recognize and acknowledge that their dedication and support has been instrumental for maintain our colonies that made it possible to return to normal research operations after the crisis.

General aspect of the ecosphere at the new Insect Pest Control Laboratory with field cage tests undergoing.

I would like to announce the publication of three manuals that are important for the research and field applications of the SIT against human disease vectors: 'Guidelines for Mass-rearing of *Aedes* Mosquitoes' (http://www-naweb.iaea.org/nafa/ipc/public/Guidelines-for-mass-rearingofAedes-osquitoes_v1.0.pdf), the 'Guidelines for Mark-Release-Recapture Procedures of *Aedes* Mosquitoes' (http://www-naweb.iaea.org/nafa/ipc/public/Guidelines-for-MRR-Aedes_v1.0.pdf), and the 'Guidance Framework for Testing the Sterile Insect Technique as a Vector Control Tool against *Aedes*-borne Diseases' (http://www-naweb.iaea.org/nafa/ipc/public/aedes-who-iaea-2020.pdf).

Finally, I am pleased to announce that Ms Chantel de Beer from South Africa, was appointed as the new leader of the Livestock Pests group in the IPCL. Chantel has extensive experience with research on tsetse fly rearing, behaviour and field applications. She has been a collaborator of the IPC subprogramme for more than a decade as national counterpart of TC projects and as chief scientific investigator of research contracts. I give a warm welcome to our new colleague.

Rui Cardoso Pereira
Head, Insect Pest Control Section

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Forthcoming Events (2020-2021)

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

Fourth RCM on Mosquito Handling, Transport, Release and Male Trapping Methods. 14–18 September 2020, Tapachula, Mexico.

Second RCM on Improvement of Colony Management in Insect Mass-rearing for SIT Applications. 19–23 October 2020, Guatemala City, Guatemala.

First RCM on Mosquito Radiation, Sterilization and Quality Control. 9–13 November 2020, Vienna, Austria.

Second RCM on Assessment of Simultaneous Application of SIT and MAT to Enhance *Bactrocera* Fruit Fly Management. First Quarter 2021, Beijing, China.

Third RCM on Integration of the SIT with Biocontrol for Greenhouse Insect Pest Management. March/April 2021, Hyderabad, India.

Second RCM on Generic Approach for the Development of Genetic Sexing Strains for SIT Applications. 12–16 April 2021, La Reunion, France.

Fourth RCM on Improved Field Performance of Sterile Male Lepidoptera to Ensure Success in SIT Programmes. 18 May–21 May 2021, Vienna, Austria.

First RCM Meeting on Improving SIT Fruit Fly Field Programmes. 6–10 September 2021, Vienna, Austria.

Third RCM on Improvement of Colony Management in Insect Mass-rearing for SIT Applications. 11–15 October 2021, Patras, Greece.

II. Consultants and Expert Meetings

FAO/IAEA Consultancy Meeting on Improving SIT Fruit Fly Field Programmes. 14–18 September 2020, Vienna, Austria.

FAO/IAEA Consultancy Meeting on Rearing of Lepidoptera for SIT Application. 24–27 May 2021, Vienna, Austria.

III. Other Meetings/Events

FAO/IAEA First 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). 17–21 August 2020, Vienna, Austria.

FAO/IAEA Regional Training Course on Development, Rearing and Evaluation of *Aedes aegypti* Genetic Sexing Strain for Sterile Insect Technique Applications (under Regional TC Project RAS5082 and RLA5074). 24 August–4 September 2020, Seibersdorf, Austria.

Fourth Meeting of the Tephritid Workers of Europe, Africa and the Middle East (TEAM). 4–8 October 2020, La Grande-Motte, Montpellier, France.

FAO/IAEA Workshop on Genetic Diversity Analysis and Colony Management. 15–17 October 2020, Guatemala City, Guatemala.

FAO/IAEA Workshop on Design and Evaluation of Mosquito Population Suppression Pilot Trials including Epidemiological Analysis (under Regional TC Project RAS5082). 19–23 October 2020, Nagasaki, Japan.

FAO/IAEA Regional Training Course on Stakeholder Engagement and Communication Strategy Development for SIT Pilot Projects (under Regional TC Project RLA5074). 19–23 October 2020, Santiago de Chile, Chile.

FAO/IAEA Final Coordination Meeting on Enhancing Capacity for Detection, Surveillance and Suppression of Exotic and Established Fruit Fly Species through Integration of Sterile Insect Technique with other Suppression Methods (under Regional TC Project RAF5074). 26–30 October 2020, Entebbe, Uganda.

Americas Congress on Fruit Flies and the 10th Meeting of the Tephritid Workers of the Western Hemisphere (TWWH). 3–7 November 2020, Bogota, Colombia.

FAO/IAEA Regional Mid-Term Review Meeting (under Regional TC Project RAS5082). 23–27 November 2020, Manila, Philippines.

FAO/IAEA Regional Workshop on Data Analysis and Reporting Methodologies (under Regional TC Project RLA5074). 23–27 November 2020, Montevideo, Uruguay.

Technical Panel on Phytosanitary Treatments (TPPT), International Plant Protection Convention, FAO. 7–11 December 2020, Vienna, Austria.

Second Symposium of the Tephritid Workers of Asia, Australia, and Oceania. (TAAO). First Quarter 2021, Beijing, China.

FAO/IAEA Final Regional Workshop on Sharing Knowledge on the Sterile Insect and Related Techniques for the Integrated Area-Wide Management of Insect Pests and Human Disease Vectors (under Interregional TC Project INT5155). 1–5 February 2021, Vienna, Austria.

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). 22–26 February 2021, Cyprus.

Sixteen Session of the Commission on Phytosanitary Measures, International Plant Protection Convention, FAO. 15–19 March 2021, Rome, Italy.

FAO/IAEA Workshop on Mass-rearing of Lepidoptera Greenhouses Pest. March/April 2021, Hyderabad, India.

XXVI International Congress of Entomology. 18–23 July 2021, Helsinki, Finland.

Past Events (2019-2020)

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

Second RCM on Integration of the SIT with Biocontrol for Greenhouse Insect Pest Management. 4–8 March 2019, Mendoza, Argentina.

Fourth RCM on Dormancy Management to Enable Mass-rearing and Increase Efficacy of Sterile Insects and Natural Enemies. 3–7 June 2019, Thessaloniki, Greece.

First RCM on Assessment of Simultaneous Application of SIT and MAT to Enhance *Bactrocera* Fruit Fly Management. 15–19 July 2019, Vienna, Austria.

First RCM on Generic Approach for the Development of Genetic Sexing Strains for SIT Applications. 7–11 October 2019, Vienna, Austria.

Third RCM on Improved Field Performance of Sterile Male Lepidoptera to Ensure Success in SIT Programmes. 21–25 October 2019, Mendoza, Argentina.

Fourth RCM on Comparing Rearing Efficiency and Competitiveness of Sterile Male Strains Produced by Genetic, Transgenic or Symbiont-based Technologies. 2–6 December 2019, Adelaide, Australia.

II. Consultants and Expert Meetings

FAO/IAEA Consultants Meeting on Mosquito Radiation, Sterilization and Quality Control (under Regional TC Project RER5022). 27–31 May 2019, Vienna, Austria.

III. Other Meetings/Events

FAO/IAEA Regional Training Course on Basic Use of R Software to infer Demographic Parameters of Wild and Sterile Mosquitoes from Entomological Monitoring Data (under Regional TC Project RER5022). 18–22 February 2019, Seibersdorf, Austria.

FAO/IAEA/WHO Workshop to Initiate the Development of Joint Guidance for the Application of SIT for Mosquito Borne Diseases (under Interregional TC Project INT5155). 27 February–1 March 2019, Tapachula, Mexico.

FAO/IAEA Workshop on Techniques for the Rearing, Quality Control and Radiation Sterilization of *Drosophila suzukii*. 10–12 March 2019, Mendoza, Argentina.

FAO/IAEA Interregional Training Course on The Use of the Sterile Insect and Related Techniques for the Integrated Area-wide Management of Insect Pests (under Interregional TC Project INT5155). 10 June–5 July 2019, Metapa de Dominguez, Chiapas, Mexico and Guatemala City/El Pino, Guatemala.

FAO/IAEA/WHO Workshop to Finalize Joint Guidance for the Application of SIT for Mosquito Borne Diseases (under Interregional TC Project INT5155). 2–4 July 2019, Vienna, Austria.

FAO/IAEA Regional Training Course on Modern Taxonomy and Identification Tools of Fruit Fly Species in Africa (under Regional TC Project RAF5074). 23–27 September 2019, Cotonou, Benin.

FAO/IAEA Regional Training Course on Communication within SIT Mosquito Projects (under Regional TC Project RER5022). 7–11 October 2019, Procida, Italy.

FAO/IAEA Regional Training Course on Area-wide Integrated Fruit Fly Management including Sterile Insect Technique (SIT) and Male Annihilation Technology (MAT) in Africa (under Regional TC Project RAF5074). 7–11 October 2019, Reduit, Mauritius.

FAO/IAEA Regional Training Course on Tsetse Dissections (under Regional TC Project RAF5080). 7–11 October 2019, Accra, Ghana.

FAO/IAEA Regional Training Course on New World Screwworm Epidemiology, Diagnostics, Population Genetics, Surveillance and Control (under Regional TC Project RLA5075). 7–11 October 2019, Porto Alegre, Rio Grande do Sul, Brazil.

FAO/IAEA Meeting on the Review of Thematic Plan for the Development and Application of the Sterile Insect Technique (SIT) and Related Genetic and Biological Control Methods for Disease Transmitting Mosquitoes (under Interregional TC Project INT5155). 14–18 October 2019, Vienna, Austria.

FAO/IAEA Workshop on a Best Practice Manual on Field Performance of Sterile Male Moths. 17–19 October 2019, Mendoza, Argentina.

FAO/IAEA Decision-Makers Workshop on the Use of the SIT (under Interregional TC Project INT5155). 27–29 November 2019, Guangzhou, China.

FAO/IAEA Second Coordination Meeting on Strengthening the Regional Capacities in the Prevention and Progressive Control of Screwworm (under Regional TC Project RLA5075). 25–29 November 2019, Medellín, Colombia.

FAO/IAEA Regional Training Course on Methods for the Mass-rearing, Irradiation and Release of sterile male *Aedes* species (under Regional TC Project RAS5082). 2–6 December 2019, Singapore, Singapore.

FAO/IAEA Regional Training Course on Tsetse Pupae Sex Sorter (under Regional TC Project 5080) 2–6 December 2019, Seibersdorf, Austria.

FAO/IAEA Regional Training Course on Marking, Handling, Transport and Release of Sterile Mosquitoes (under Regional TC Project RLA5074). 2–6 December 2019, Buenos Aires, Argentina.

FAO/IAEA/WHO Regional Coordination Meeting on the Potential of SIT for the Integrated Control of *Aedes* Invasive Mosquitoes in Europe (under Regional TC Project RER5022). 24–28 February 2020, Athens, Greece.

FAO/IAEA First Regional Coordination Meeting on Assessing the Efficiency of the Sterile Insect Technique for the Control of the Cocoa Pod Borer (under Regional TC Project RAS5086). 9–13 March 2020, Makassar, Indonesia.

FAO/IAEA First 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). The meeting was conducted virtually and split in four sessions on 14, 17 and 24 April and 1 May 2020.

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	National Projects	Technical Officer
Bolivia	BOL5022	Reducing Fruit Fly Populations in Different Regions Introducing an Integrated Pest Management Approach Including the Use of the Sterile Insect Technique	Walther Enkerlin
Botswana	BOT5013	Using the Sterile Insect Technique Integrated with Other Suppression Methods for Managing *Bactrocera dorsalis*	Daguang Lu
Brazil	BRA5061	Using the Sterile Insect Technique to Apply a Local Strain in the Control of *Aedes aegypti* (Phase II)	Rafael Argiles
Burkina Faso	BKF5020	Strengthening the Insectarium to Create Agropastoral Areas Permanently Liberated from Tsetse Flies and Trypanosomiasis	Adly Abdalla
Cambodia	KAM5006	Implementing Fruit Fly Surveillance and Control Using Area-wide Integrated Pest Management	Daguang Lu
Chad	CHD5007	Contributing to the Eradication of *Glossina fuscipes fuscipes* to Improve Food and Nutritional Security	Rafael Argiles
Chile	CHI5051	Implementing Pilot Level of Sterile Insect Technique for Control of *Lobesia botrana* in Urban Areas	Walther Enkerlin
China	CPR5020	Integrating the Sterile Insect Technique (SIT) for Area-wide Integrated Pest Management of Tephritid Fruit Flies	Rui Cardoso Pereira
China	CPR5026	Applying the Sterile Insect Technique as Part of an Area-wide Integrated Pest Management Approach to Control Two Fruit Flies	Daguang Lu
Cuba	CUB5021	Demonstrating the Feasibility of the Sterile Insect Technique in the Control of Vectors and Pests	Rafael Argiles
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	Hanano Yamada Walther Enkerlin

Ethiopia	ETH5022	Enhancing Livestock and Crop Production through Consolidated and Sustainable Control of Tsetse and Trypanosomosis to Contribute to Food Security	Rafael Argiles
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
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	MAR5026	Sustaining the Suppression of *Aedes albopictus* in a Rural Area with Possible Extension to An Urban Dengue-Prone Locality through Integrated Vector Management Strategy	Rafael Argiles
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
Oman	OMA5007	Strengthening Sterile Insect Technique Based Area-wide Integrated Management of Date Palm Pests	Marc Vreysen
Palau	PLW5003	Facilitating Sustainability and Ensuring Continuity of Area-wide Pest Management — Phase III	Daguang Lu
Philippines	PHI5033	Building Capacity in Using the Sterile Insect Technique against Dengue and Chikungunya Vectors	Wadaka Mamai
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	SUD5038	Implementing the Sterile Insect Technique for Integrated Control of *Anopheles arabiensis*, Phase II	Adly Abdalla
Turkey	TUR5026	Conducting a Pilot Program on Integrated Management of *Aedes aegypti* Including Sterile Insect Technique	Rafael Argiles
Uganda	UGA5036	Demonstrating the Feasibility of a Sterile Insect Technique Component as Part of an Area-wide Integrated Pest Management Approach to Increase Livestock Productivity	Rafael Argiles
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	Rafael Argiles
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
Viet Nam	VIE5021	Integration of the Sterile Insect Technique with Other Suppression Methods for Control of *Bactrocera* fruit flies in Dragon Fruit Production	Rui Cardoso Pereira
Zimbabwe	ZIM5023	Improving Crop and Livestock Production through the Eradication of Bovine and Human Trypanosomiasis in Matusadona National Park	Rafael Argiles

		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	RAF5080	Supporting Area-wide Tsetse and Trypanosomosis Management to Improve Livestock Productivity - Phase IV	Adly Abdalla Rafael Argiles
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 Europe	RER5026	Enhancing the Capacity to Integrate Sterile Insect Technique in the Effective Management of Invasive *Aedes* Mosquitoes	Jeremy Bouyer
Regional Latin America	RLA5074	Strengthening Regional Capacity in Latin America and the Caribbean for Integrated Vector Management Approaches with a Sterile Insect Technique Component, to Control Aedes Mosquitoes as Vectors of Human Pathogens, particularly Zika Virus	Hanano Yamada Rui Cardoso Pereira
Regional Latin America	RLA5075	Strengthening the Regional Capacities in the Prevention and Progressive Control of Screwworm	Walther Enkerlin

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 Programs	Hanano Yamada Rui Cardoso Pereira

		Interregional Project	
Interregional	INT5155	Sharing Knowledge on the Sterile Insect and Related Techniques for the Integrated Area-wide Management of Insect Pests and Human Disease Vectors	Jeremy Bouyer Rui Cardoso Pereira

Highlights of Technical Cooperation Projects

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 (ECU5031)

Nuclear Technique Opens New Markets for Ecuador's Fruits

Ecuador, one of the largest producers of tropical fruit in the Western Hemisphere, is adding non-traditional fruits to its export portfolio as a result of successfully fighting off the Mediterranean fruit fly with the help of nuclear techniques. After receiving technical assistance from the IAEA, in partnership with the Food and Agriculture Organization of the United Nations (FAO), to use – along with other methods – the sterile insect technique (SIT) to control the flies, farmers are now shipping golden berries, dragon fruit and tree tomatoes to markets in the United States, Latin America and the European Union.

Emerged sterile Mediterranean fruit flies ready to be released. (Photo: AGROCALIDAD).

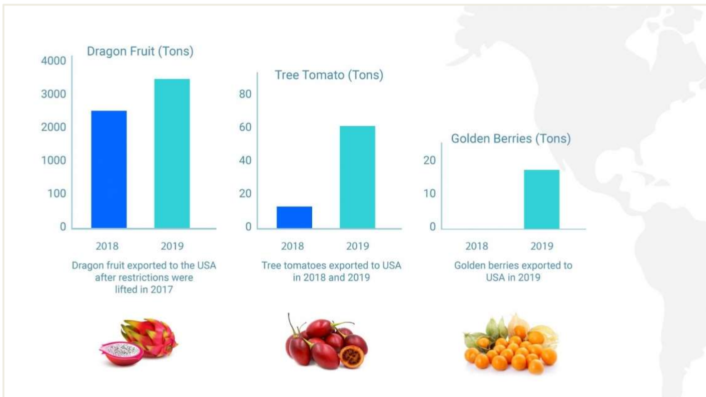
"The completion of the project will directly contribute to improving the livelihood of fruit producers in Ecuador by reducing the damage caused by fruit flies and increasing production for external markets," said Rodrigo Salas, Head of the Undersecretariat for Nuclear Control and Applications.

Mediterranean fruit fly is one of the most destructive agricultural pests. Many importing countries have quarantine restrictions in place for fruits coming from areas where the fruit fly is well established – in order to protect their own orchards from the pests. This quarantine measure makes it difficult and costly for producers to reach foreign markets, limiting their export-led growth opportunities.

Ecuador has implemented a fruit fly pest control scheme based on an integrated pest management (IPM) programme including SIT, within the National Fruit Fly Management Project (NFFMP), which was supported by the IAEA and the FAO. The IPM is an effective and environment-friendly pest control approach for crop production and protection that combines different management strategies and practices to effectively reduce pest damage, produce healthy crops and minimize the use of pesticides. In Ecuador, SIT was incorporated into the IPM approach in 2018.

"The area under NFFMP, where these non-traditional fruits are grown, covers over 35 000 hectares of commercial fruit production. Its significant reduction of fruit fly damage resulted in increased yields," said Patricio Almeida, Executive Director of Plant Health Control in the Ecuadorian Agency for Regulation and Control of Plant and Animal Health (AGROCALIDAD). "As a result of integrated methods including SIT to suppress the fruit fly population, last year's exports to the United States of these three fruits reached USD 22 million. In addition, the agricultural sector benefited from direct and indirect jobs that have been created along the production and export chain."

Three million sterilized fruit flies are shipped weekly from the El Pino fruit fly facility, Guatemala, to continental Ecuador where they are kept at a sterile fly emergence and release facility built under the auspices of an IAEA technical cooperation project. They are then released in fields over targeted production areas where IAEA trained agronomists from AGROCALIDAD monitor and control the fruit fly populations. Thanks to keeping the numbers of fruit flies at acceptable low prevalence levels in growing areas, the USA accepted to import dragon fruit from Ecuador for the first time in 2017. Import of tree tomatoes and golden berries followed in 2018 (See chart).



Ecuador is now seeking to expand the use of the SIT technology to other areas and other crops: "Currently, 890 farmers benefited from this project," said Almeida. "The promise of future yield and job prospects is an incentive for the country to further invest in the agricultural sector."

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

Argentina's Newly Recognized Fruit Fly Free Areas Expedite Fresh Fruit Exports to China

In what is expected to be a major boost to Argentina's niche fruit exports, China has recognized areas growing cherries and other stone and pome fruits as fruit fly free which will enable export to the world's largest fresh food market. The result was achieved with the help of nuclear techniques.

"This represents a major opportunity for all fruit growers and exporters in Argentina who seek to position themselves in the Chinese market, with special interest in the cherries that could be dispatched directly by air, reducing costs and time," said Carlos Paz, President of the National Plant Protection Organization of Argentina (SENASA). This means that costly and time-consuming postharvest treatments for fresh fruit is no longer required for export. In the 2019/2020 growing season, Argentina exported 5 600 tonnes of cherries, representing US$ 27.2 million in revenue. Exports to China accounted for a third of this.

With the help of nuclear techniques, areas in Argentina growing stone and pome fruits for export have been recognized by China as fruit fly free. (Photo: E. Rial, Los Antiguos).

The pest free status for these new areas is the result of the long-term effective work of SENASA through the National Fruit Fly Control and Eradication Programme (PROCEM) in cooperation with the fruit producers. The cooperation with the IAEA included technology transfer to support the application of the sterile insect technique (SIT).

In the 1990s, Argentina started implementing programmes to manage the Mediterranean fruit fly (*Ceratitis capitata*) in the Patagonia Region and the North, Central and South Oasis of Mendoza Province. Expert missions, training and technology transfer enabled the development and implementation of area-wide integrated pest management programmes with SIT as a component. This in turn led to the establishment of fruit fly free areas and reduction of postharvest treatments. Postharvest treatments, often a requirement of the importing country, are a way to minimize the occurrence of pests and are an additional step and cost after harvesting. By using the SIT, the need for postharvest treatments is diminished.

Complementary control measures to the twice-weekly release of sterile Mediterranean fruit flies to protect the pest free status, include the use of low environment impact insecticide-baits and removal of fruit from areas that present a high risk for fruit fly introduction due to the movement of people and merchandise. As a final step to ensure that the areas remain fruit fly free, quarantine checkpoints are set up to inspect all private and cargo vehicles which enter the protected areas.

The Customs General Directorate of the People's Republic of China carried out three technical visits in 2018 and 2019 to verify the phytosanitary status of the areas. The occurrence of pests in the area has to be zero for the area to be considered fruit fly free. The visits ascertained that the Patagonia Region and the Central and South Oasis in Mendoza Province met the necessary requirements to qualify as fruit fly free areas, and that postharvest treatments were not necessary anymore. This means that once harvested and inspected, the fruits can be exported.

But the newly acquired recognition and the fruit fly free status also has to be actively maintained. A surveillance network of 4 740 traps for fruit flies has been set up to screen for *C. capitata*, and the South American Fruit Fly (*Anastrepha fraterculus*) – a species present in the central and northern areas of the country – and other non-native fruit fly species. Fruit samples are also collected and inspected in the fields, in small and large markets and at designated quarantine checkpoints along the route of the fruits to the markets.

Installing an extensive trapping network is a requirement of the importer, to be able to monitor the pest status of these areas. Traps must catch no flies and if there is a catch there must be an emergency response to eradicate the outbreak.

Now that these areas are recognized as pest free through the use of the SIT and complementary control measures, the export of stone and pome fruits are expedited. Argentina's niche fruit export market looks set to boom in the world's largest fresh food market, China.

First Project Coordination Meeting (Virtual)

To coordinate the activities of pest control and plant health in the region, a series of virtual coordination meetings took place on 14, 17 and 24 April 2020 and on 1 May 2020. These meetings were attended by representatives of National Plant Protection Organizations (NPPOs) from Regional Latin America, who discussed the baseline and objectives of the project. The attending project counterparts also revised a detailed workplan, made new teleconferencing arrangements in view of the constraints posed by the COVID-19 pandemic. The participation of high-level officials from partner institutions ensured the elaboration of a comprehensive awareness strategy, focused on clear communication among stakeholders of integrated pest management and on the visibility of the project's progress with the authorities and the general public.

These coordinated actions will enable countries to adopt measures on pest control and quarantine, and they will facilitate the transfer of technologies and the exchange of knowledge between countries. The situation of pests varies across countries, so the project seeks to harmonize the use of innovative technologies in the region, by transferring knowledge which supports the monitoring and control of pests.

Harmonizing and Strengthening Surveillance Systems to Prevent and Control Exotic and Native Fruit Flies Including the Use of the Sterile Insect Technique (RAS5076)

Middle East Database for Non-Indigenous Pests (MEDNIP) Upgraded

The Middle East Database for Non-Indigenous Pests (MEDNIP) that started out as just being an information sharing platform for Israel, Jordan and the Palestinian Authority of the Middle East region, has now developed into a fully functioning database. From the first steps until now it has always been about collecting and sharing information on invasive pests and subsequently on their plant hosts and portraying such in a useful manner for its users and for decision makers within the three National Plant Protection Organizations (NPPOs). Furthermore, the collected knowledge on the page can also be used by its members for their own activities. In addition to this, the MEDNIP database uses the function of a Newsflash to inform its members of possible threats by non-indigenous pests in the area. By doing so, the reaction time for applying counter measures is greatly reduced.

The latest additions to the database have made it even more user friendly adding a draft function, thus creating a two-step process for creating pages as well as including information on transmitted diseases. Furthermore, copying information is now much smoother and easier.

The MEDNIP database has come a long way since its first version. Through continuous development and changes it has become a great tool of collaboration between Israel, Jordan and the Palestinian Authority.

Assessing the Efficiency of the Sterile Insect Technique for the Control of the Cocoa Pod Borer (RAS5086)

First Coordination Meeting of RAS5086. Makassar, Indonesia, 9–13 March 2020

The cocoa pod borer (CPB) is the most devastating insect-pest for cocoa throughout Southeast Asia. This species is found in the Philippines, Malaysia, Indonesia and Papua New Guinea, among others. It was first recorded in North Sulawesi, Indonesia, in the mid-1800s, followed by several introduction events due to cocoa pod movements between cocoa areas. Today, it is one of the most devastating pests of cocoa in southeast Asia and Pacific archipelagos. The CPB larvae cause vast losses of yield and consequently, this pest is currently responsible for an average of 40-60% loss of cocoa production in the entire Southeast Asian region, and up to 80% losses in unmanaged farms. This pest is in part responsible of the decline of the Indonesian cocoa productions and for the drastic reduction of the cocoa industry in Malaysia. In Papua New Guinea, cocoa exports have basically collapsed or been severely reduced to 50%.

Various control measures have been implemented to reduce populations of this pest, but most are not very effective, or are labour intensive and time consuming. At present, the most common method for the control of CPB remains the use of insecticides, but the cost/efficiency ratio remains poor due to the pest’s life cycle (once the larvae is in the pod, the insecticides have no impact). The liberal use of insecticides may in the long run also lead to resistance and create harmful effects to humans and the environment.

Participants of the first coordination meeting of RAS5086 (Makassar, Indonesia).

The sterile insect technique (SIT) has been effectively implemented as part of an area-wide integrated pest management approach to control insect-pest populations in other crops. A new regional TC project (RAS5086) was approved for the 2020–2021 TC cycle, to assess the feasibility of using the SIT against this pest. The implementation of the SIT against CPB would significantly reduce the direct and indirect impacts of this pest to both cocoa productions and the farmers' quality of life. Indonesia, Malaysia, Papua New Guinea, Philippines and Viet Nam are the participating Member States.

The first coordination meeting of RAS5086 'Assessing the Efficiency of the Sterile Insect Technique for the Control of the Cocoa Pod Borer' was held in Makassar, Indonesia from 9–13 March 2020. The meeting reviewed the status of CPB (damage, control activities etc.) in the participating Member States and discussed the status of the rearing of CPB as a requirement for the implementation of the SIT. Gaps that need to be addressed to make progress with the SIT, bottlenecks and potential constraints and solutions were discussed and explored. A detailed workplan for 2020–2021 was prepared and a detailed list of equipment needs prepared.

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

Ecuador's National Parks Better Understand Parasitic Fly Threatening Darwin's Galápagos Finches

The Galápagos Islands, the archipelago associated with Charles Darwin's theory of natural selection and evolution, are a living symbol of endemic biodiversity. Today, however, at least 20 species of bird native to the islands—including several species of Darwin's finches—are under threat from a parasitic fly, *Philornis downsi*, a non-indigenous species of fly that was accidentally introduced to the islands in the luggage of visitors.

Laboratory work with larvae of the Philornis *fly in the Charles Darwin Foundation laboratory. (Photo: L.D. Lalova/ Charles Darwin Foundation).*

"The rapid and accelerated invasion of the parasitic fly is putting at risk the long-term conservation of the land birds of the Galápagos Islands," said Paola Lahuatte, the manager of the *Philornis* laboratory at the Charles Darwin Foundation's Research Station in Galápagos islands.

The Philornis downsi *fly. (Photo: S. Rowley/ Charles Darwin Foundation).*

To protect the unique ecosystem of the islands, the Joint FAO/IAEA is supporting Ecuadorian experts as they study the basic and reproductive biology of this pest species to eventually rear the fly under laboratory conditions and test methods for its control.

A new national technical cooperation project 'Building Capacity for Mass Rearing, Sterilization and Pilot Release of *Aedes Aegypti* and *Philornis downsi* Males' (ECU5032) was recently launched to continue to address capacities-related needs in Ecuador, and particularly in the Galápagos to support the study of *Philornis*' basic and reproductive biology, including analyses of the species' mating systems and intersexual selection.

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

Regional Training Course on Methods for the Mass-Rearing, Irradiation and Release of Sterile Male *Aedes* Species. 2–6 December 2019, Singapore

A regional training course on 'Methods for the Mass-Rearing, Irradiation and Release of Sterile Male *Aedes* Species' was hosted by the Environmental Health Institute, National Environment Agency (NEA), Singapore from 2–6 December 2019. The purpose of the training course was for participants (i) to gain an understanding of the theory and biology behind mass-rearing, handling, marking, packing, transport, irradiation, quality control and release of sterile male *Aedes* species; (ii) to gain practical, hands-on experience in handling, marking, irradiation of male pupae, packaging and transport, and quality control protocols to ensure optimal releases of sterile adult male mosquitoes; (iii) to review protocols and information in the form of presentations and learning materials provided by local and international experts and (iv) to strengthen national and regional mechanisms for mosquito population control, including networking, co-ordination and information exchange. The participating countries were Bangladesh, Cambodia, China, Indonesia, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri-Lanka and Thailand. Lecturers from Brazil, China, French Polynesia, Singapore and IAEA provided lectures and shared their experience.

The new facility of the NEA with a production capacity of 5 million sterile males per week was also inaugurated and visited by the participants during the training course.

Demostration of the release of sterile male mosquitoes in the target area in Singapore.

Establishing Genetic Control Programmes for *Aedes* Invasive Mosquitoes (RER5022)

Final Coordination Meeting of RER5022. 24–28 February 2020, Athens, Greece

During the project's final coordination meeting, FAO/IAEA experts and counterparts revised the workplan for a follow-up TC project RER5026 on 'Enhancing the Capacity to Integrate Sterile Insect Technique in the Effective Management of Invasive *Aedes* Mosquitoes', to be launched in 2021, with the support of representatives of the World Health Organization (WHO).

During the meeting, 18 participants from 10 countries met with five experts and three representatives of the WHO to review the lessons learned and best practices developed during the first project, and to prepare the activities of a subsequent, follow-up project. The participants discussed how to integrate and use the SIT within the context of an integrated *Aedes*-control programme and explored the possibility of closer collaboration with their respective European Ministries of Health and with the WHO. During the meeting, participants visited the area where an SIT pilot trial was implemented in Vravrona—east of Athens—and noted the engagement of local stakeholders, from municipal community leaders to representatives from the private insect pest control sector. Under the auspices of the first project, which was implemented from 2016 to 2020, a series of capacity-building workshops and training courses were organized to disseminate the skills necessary for the effective integration of the SIT. Moreover, some countries launched pilot SIT trials between 2017 and 2019. In Vravrona, for example, 15 000 male mosquitoes were sterilized and released per week in a five-hectare area in 2018, and in 2019, an additional 30 000 sterile males per week were released in an expanded area of 10 ha.

Visit of the SIT release area in Vravrona, east of Athens, in Greece's Attica region.

Based on the successful SIT pilot in Greece, the participating countries will continue working towards integration of the SIT as part of their area-wide integrated pest management to prepare for possible eradication programmes in case of detection of new invasive *Aedes* species.

Coordinated Research Projects (CRPs)

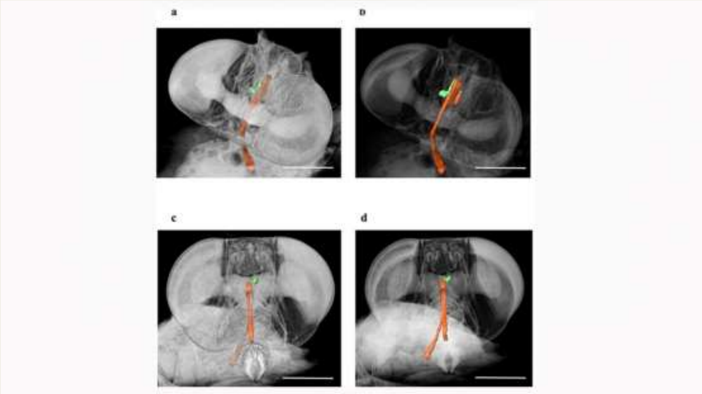
Project Number	Ongoing CRPs	Project Officer
D4.10.25	Dormancy Management to Enable Mass-rearing and Increase Efficacy of Sterile Insects and Natural Enemies (2014–2019)	Rui Cardoso Pereira
D4.20.16	Comparing Rearing Efficiency and Competitiveness of Sterile Male Strains Produced by Genetic, Transgenic or Symbiont-based Technologies (2015–2020)	Kostas Bourtzis
D4.40.02	Mosquito Handling, Transport, Release and Male Trapping Methods (2015–2020)	Rafael Argiles
D4.10.26	Improved Field Performance of Sterile Male Lepidoptera to Ensure Success in SIT Programmes (2016–2021)	Marc Vreysen
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 Carlos Cáceres
D4.10.27	Assessment of Simultaneous Application of SIT and MAT to Enhance *Bactrocera* Fruit Fly Management (2019–2024)	Carlos Cáceres Rui Cardoso Pereira
D4.40.03	Generic Approach for the Development of Genetic Sexing Strains for SIT Applications (2019–2024)	Kostas Bourtzis
	New CRPs	
D4.40.04	Mosquito Radiation, Sterilization and Quality Control (2020–2025)	Jeremy Bouyer

A Special Issue Published on the Use of Symbiotic Bacteria to Enhance the Effectiveness and Efficiency of the Sterile Insect Technique

Insects are, in many ways, the dominant multicellular lifeform on land. They are successful across multiple ecosystems and maintain intricate and complex interactions with the other organisms in their habitats. Many of the interactions between insects and plants, and insects and vertebrates have been extensively studied, but the associations between insects and microorganisms, while pervasive and of paramount ecological and evolutionary importance, are only gradually being understood. Insects depend on symbiotic associations with a variety of microorganisms, which affect many aspects of the hosts' biology and physiology including their nutrition, mating behaviours, immunities and reproductive success.

Tephritid fruit flies are no exception and maintain intricate interactions with multiple micro-organisms. It is these complex relationships that are being explored by the IAEA, in partnership with the Food and Agriculture Organization of the United Nations (FAO), to help develop sustainable methods to reduce the spread of these destructive insect species.

The sterile insect technique (SIT) has been effectively deployed to reduce fruit fly populations for over 60 years. The SIT is a species-specific and environment-friendly technology which is often used as a component of area-wide integrated pest management (AW-IPM) programmes. Experience has shown that the efficiency of SIT can be hampered by the quality of the mass-reared and sterilised male insects, that must remain competitive with wild males after release, and the cost effectiveness of mass-rearing the billions of insects required for a sustainable operational project. Research efforts focussed on ways to improve these processes have recognised the symbiotic relationships between tephritids and particular species of bacteria as potential targets for improving the quality of the sterilized males and reducing costs of production.



Different sections of the alimentary tract in the head of a fruit fly. The colonies of symbiont bacteria species which contribute to regulate the physiology of the fruit fly typically congregate in this area. (Photo: Kala Bhandari, University of Adelaide).

This area of research has been further explored in an IAEA Coordinated Research Project (CRP) on the 'Use of Symbiotic Bacteria to Reduce Mass-Rearing Costs and Increase Mating Success in Selected Fruit Pests in Support of SIT Application.' The CRP was initiated in 2012 under the auspices of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture with four main objectives: To determine the effect of radiation on the symbiotic communities in target species; to develop methods of using beneficial bacteria to replace costly ingredients in larval diets; to explore the use of symbionts as probiotics provided to adult sterile males before their release to significantly improve their performance; and, to harness symbiotic microorganisms as reproductive manipulators and determine their ability to suppress target populations.

The CRP has illustrated the utility of harnessing symbiotic associations towards the reproductive manipulation and suppression of target populations. Specifically, the effect of *Wolbachia* infection on *Ceratitis capitata* has been studied, revealing the practical potential for introducing this bacterium into mass-reared and wild populations. In addition, the bacteria associated with most of the tephritid pests have been identified for the first time and the role of bacteria in mass rearing facilities has been elucidated for several key pest species.

The research studied and documented the effect of sterilizing radiation on the microbiota of several mass-reared species. The use of symbionts as probiotic supplements to improve larval rearing and adult quality was also studied in several species of *Anastrepha*, *Bactrocera*, and *Ceratitis capitata*.

All the major achievements of the CRP were published in a dedicated Special Issue, with 19 papers, in a Cross-Journal Supplement of BMC Microbiology and BMC Biotechnology (https://www.biomedcentral.com/collections/FAO-IAEAsymbioticbacteria). This Special Issue provides an important contribution to our knowledge on tephritid fruit flies and their symbionts, and the related potential for enhancing applied SIT technology in the field.

In addition, an online tool for calculating distribution of operational taxonomic units generated from new generation sequencing approaches has been developed (http://www.qplots.eu/). And a compilation of all the microorganisms identified before and during the CRP was produced and included in the final report of the CRP (https://www-naweb.iaea.org/nafa/ipc/crp/RCM4-Use-Symbiotic-Bacteria-Report.pdf).

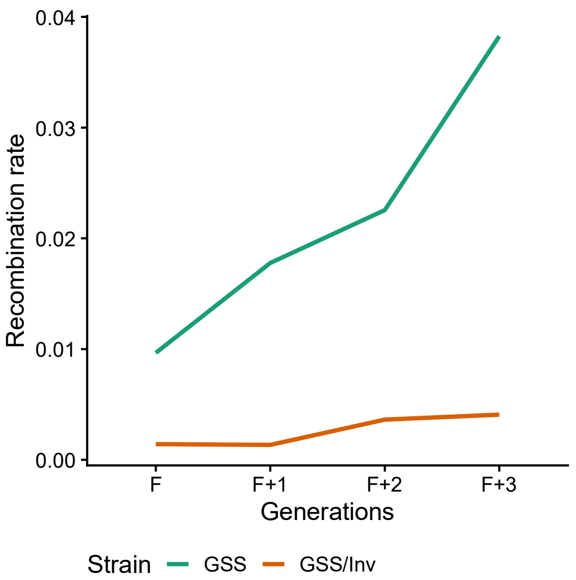
Developments at the Insect Pest Control Laboratory (IPCL)

Genetics and Molecular Biology

Genetic Stability and Quality Control Analysis of an *Aedes aegypti* Genetic Sexing Strain, with and without an Inversion, under Small Scale Rearing Conditions

The development of a genetic sexing strain (GSS) would greatly benefit the implementation of the sterile insect technique (SIT) for the suppression of populations of the major mosquito vector species *Aedes aegypti*. The elimination of females from the production line would enhance the efficiency and cost-effectiveness as well as the safety of a SIT programme. Using a morphological marker, an *Aedes aegypti* GSS has been developed at the IPCL. Although the selectable marker is on the same chromosome (chromosome I) as the male determining locus (Nix), it is distantly linked and exhibits a significant recombination rate.

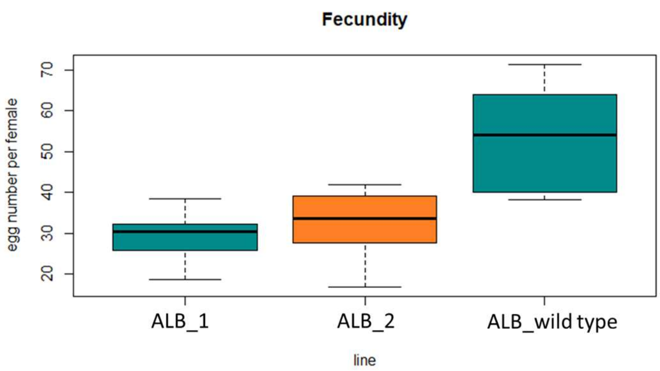
Using irradiation and classical genetic approaches, an inversion was induced and integrated in the GSS (GSS/Inv) to reduce the recombination rate, as it is known that chromosomal inversions act as recombination suppressors. In a series of experiments, we compared the genetic stability and the quality of the GSS strain with and without the inversion (GSS and GSS/Inv). Our experimental data indicated that, although the inversion reduces productivity of the strain, the recombination rate was significantly reduced in the presence of the inversion over a number of generations, thus enhancing the genetic stability of the strain, particularly in the absence of a filter rearing system.



Genetic stability of an Aedes aegypti *genetic sexing strain, with and without a chromosomal inversion.*

Quality Control Assessment of an *Aedes albopictus* Selectable Marker for the Development of a Genetic Sexing Strain

The isolation and characterization of morphological markers for *Aedes albopictus* is one of the primary target areas for the IPCL towards the development of a GSS for SIT applications. Screening of natural populations has led to the isolation of a morphological colour marker that is recessive in respect to the wild type allele and evident from the early larval stages to the adults. Pure lines of the dominant and the recessive allele, respectively, were created and their stability in terms of expressivity of the relevant phenotype was checked for several consecutive generations. The two pure lines as well as the initial natural population of *Ae. albopictus* were assessed for several quality control parameters including developmental times of all stages, fecundity, hatching, pupal weight, sex ratio and longevity. All the above-mentioned parameters are part of the standard Quality Control (QC) procedures applied for the evaluation of insect strains used in SIT applications under small-scale rearing conditions. The fecundity tests (see figure) indicated a clear difference in egg production per female between the wild type population and the other two pure lines, thus implying a potential cost of the selectable marker. Further studies, including flight ability and male mating competitiveness tests, will shed more light on the fitness of these lines and the potential costs of the selectable marker.



Aedes albopictus *egg production per female for the two pure lines (ALB_1 & ALB_2) and the natural population.*

Combining Sterile and Incompatible Insect Techniques for the Population Suppression of *Drosophila suzukii*

Since its first confirmed recordings in Europe and North America in 2008, the spotted wing Drosophila (SWD), *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae), an invasive species originating from Asia, has been recognized as a major concern in agriculture. Insecticide applications are currently the front-line method used to control *D. suzukii* in conventional and organic crop areas. The regulatory limitations governing the classical chemical control methods, coupled with the concerns over the risks of their use, demonstrate the urgent need to develop an alternative environmentally sound and sustainable method to combat *D. suzukii*. The sterile insect technique (SIT) in combination with *Wolbachia* symbiosis (incompatible insect technique, IIT) as a population suppression approach, has been suggested as a potential component of an area-wide integrated pest management program. The IPCL has developed a combined SIT/IIT protocol which could potentially be considered for the population suppression of *D. suzukii*.

Two *Wolbachia* candidate strains (*w*Ha and *w*Tei) were used and three low irradiation doses were evaluated. The two transinfected *D. suzukii* lines were irradiated with 45, 60 and 90 Gy and after crosses with naturally-infected *w*Suz fertile individuals, complete sterility was observed both for *w*Ha and *w*Tei females at all three doses (see table). Similar encouraging results were also obtained for males (99.9% sterility for *w*Ha males and 98.9% sterility for *w*Tei males irradiated with 45 Gy). None of the quality control parameters (adult emergence, longevity and flight ability) were negatively affected by the 45 Gy radiation dose, with the exception of irradiated *w*Ha adults that were positively affected, showing an elevated emergence rate compared to the non-irradiated ones.

Effect of irradiation on the egg hatch and pupation of the wHa and wTei Drosophila suzukii *lines, when females or males of these lines are irradiated.*

Cross	Irradiation dose (Gy)	Number of eggs	Number of hatched eggs	Number of pupae
*w*Ha ♀ x *w*Ha ♂	0	600	563	453
*w*Tei ♀ x *w*Tei ♂	0	600	554	418
*w*Suz ♀ x *w*Suz ♂	0	593	524	435
*w*Ha ♀ x *w*Suz♂	45	6	0	0
*w*Ha ♀ x *w*Suz♂	60	0	0	0
*w*Ha ♀ x *w*Suz♂	90	0	0	0
*w*Tei ♀ x *w*Suz♂	45	1	0	0
*w*Tei ♀ x *w*Suz♂	60	6	1	0
*w*Tei ♀ x *w*Suz♂	90	1	0	0
*w*Suz ♀ x *w*Ha♂	45	782	1	0
*w*Suz ♀ x *w*Ha♂	60	926	2	0
*w*Suz ♀ x *w*Ha♂	90	300	1	0
*w*Suz ♀ x *w*Tei♂	45	1,537	17	16
*w*Suz ♀ x *w*Tei♂	60	1,048	25	19
*w*Suz ♀ x *w*Tei♂	90	300	3	1

Our data indicate that a SIT/IIT protocol can be a competent approach for *D. suzukii* management and it can be considered as an alternative approach for suppression of these pest populations. However, knowledge on male mating competitiveness will also be required prior to any small or large-scale application.

Searching for Temperature Sensitive Lethal Genes to be Used as Selectable Markers for the Development of Genetic Sexing Strains in SIT Applications

GSSs have significantly enhanced SIT applications against major insect pest species by improving the efficiency and cost-effectiveness. The most successful example of a GSS is the VIENNA 8 strain which is currently mass-reared and used worldwide to suppress or even eradicate populations of the Mediterranean fruit fly (medfly) *Ceratitis capitata*. The strain contains two selectable markers, the *white pupae* (*wp*) gene and the *temperature sensitive lethal* (*tsl*) gene. VIENNA 8 females are homozygous for the recessive alleles of these genes while males are heterozygous, with the wild type (rescue) alleles having been transferred on the Y chromosome closely linked to male determining gene, the *MoY* gene, through a radiation-induced translocation. Being homozygous for the recessive allele, females die when exposed as embryos at elevated temperatures. This allows the production of only males at mass-rearing facilities for SIT applications as male embryos survive by carrying the resistant wild type (rescue) allele on the Y chromosome.

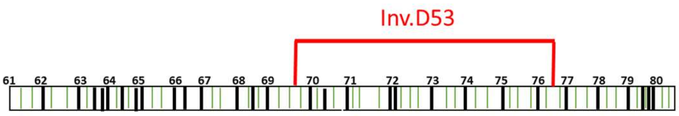
Since the development of the *tsl*-based Mediterranean fruit fly GSS, research efforts have focused on the isolation of a *tsl* mutation in other SIT-targeted pest species and its use for the development of similar GSS. None of them has been successful so far, except for the isolation and establishment of a *tsl* mutant strain in *Anopheles arabiensis*. Due to this challenge, an alternative approach is currently being considered. Given that most of the temperature-sensitive genes present in the model organism *Drosophila melanogaster* are conserved in tephritid and other pest species, we started looking for other temperature sensitive lethal genes which could be used as selectable markers for the development of GSS and their use in SIT applications against insect agricultural pests and disease vectors. There are several temperature sensitive lethal genes which differ in their mode of action and phenotype, including the lethality temperature, severity of paralysis, developmental stage of expression etc. One of them is *shibire*. The *shibire* gene encodes for a dynamin GTPase, which plays a catalytic role in endocytosis. In a mutant phenotype, endocytosis is blocked, thus preventing membrane cycling leading to a reduction of necessary vesicles at the synaptic terminals. This is a reversible temperature-dependent phenotype which depends on the nature of the mutation as shown in the table. For example, in *D. melanogaster*, homozygous individuals for *shibire ts1* mutations show embryonic lethality and larval-adult paralysis at 29°C whereas the phenotype is wild-type at 22°C. The IPCL has initiated research efforts to isolate and/or induce similar mutations in SIT-targeted insect pest species.

Different shibire *point mutations and the temperature required for the induction of the phenotype.*

Name	Nucleo-tide change	Amino acid position	Amino acid change	Temperature of paralysis (homozy-gosity)
shi^{ts1}	G -> A	268	Gly -> Asp	27,5 °C
shi^{ts2}	G -> A	141	Gly -> Ser	27,0 °C
shi^{ts4}	C -> T	171	Pro -> Ser	28,5° C

Ceratitis capitata VIENNA 7 and VIENNA 8 Genetic Sexing Strains and D53 Inversion: Genetic Stability and Quality Control Analysis under Small-Scale Rearing Conditions

It is well known that development of a GSS can greatly facilitate the implementation of an efficient and cost-effective SIT operational programme against insect pest species of agricultural, veterinary or human health importance. The most successful GSS ever developed has been the VIENNA 7 and VIENNA 8 GSS which are currently being used in large-scale SIT programmes against the Mediterranean fruit fly, *Ceratitis capitata*. An important concern during the mass-rearing of Mediterranean fruit fly GSS has been the occurrence of recombination events, and hence their genetic stability. This potential problem has been addressed through the development of a Filter Rearing System (FRS) and chromosomal inversions, one of which is the inversion D53 (see figure). Inversions are well known recombination suppressors. However, inversions are also chromosomal rearrangements and may have a negative effect on fitness.



Schematic illustration of the Ceratitis capitata *polytene chromosome 5 indicating the two breakpoints of the D53 inversion.*

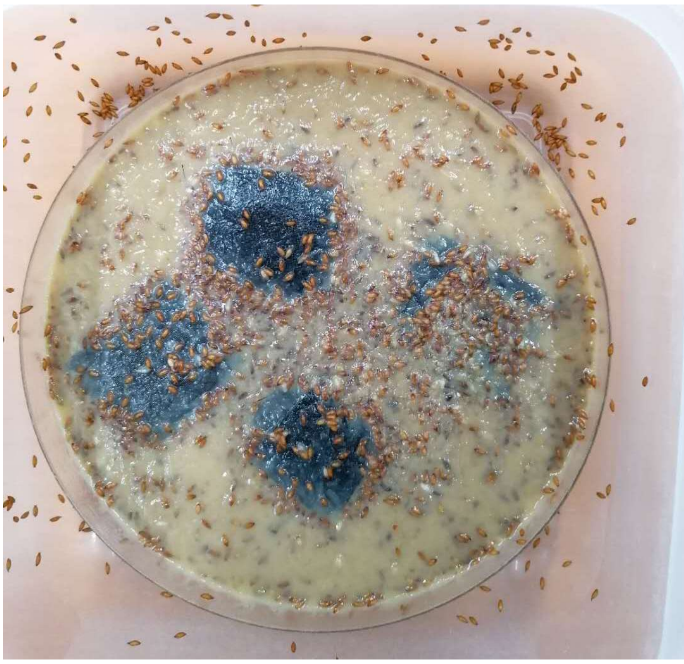
In a series of experiments, we investigated whether the inversion D53: (a) can efficiently suppress recombination in VIENNA 7 and VIENNA 8 GSS, which are based on two different translocation breakpoints (in VIENNA 8 GSS, the translocation breakpoint is more distant from the selectable markers (*white pupae* and *temperature sensitive lethal* genes) than the translocation breakpoint of the VIENNA 7 GSS) and (b) has an impact on the fitness and biological quality of the two GSS. Our experimental data clearly showed that the recombination was drastically reduced (almost eliminated) in both VIENNA 7 and VIENNA 8 GSS in the presence of the D53 inversion, thus enhancing the genetic stability of the GSS, which is an important and critical factor for the mass-rearing of these strains. However, this comes at a cost since a reduction in egg hatch was observed, the level of which seems to depend on the type of the translocation being higher in the VIENNA 8 GSS.

Plant Pests

Spotted Wing Droshophila, *Drosophila suzukii*

The rapid spread of *Drosophila suzukii* and the subsequent economic losses of the affected areas has encouraged the development of different approaches for the efficient management of this pest. The SIT can potentially be integrated in area-wide integrated pest management (AW-IPM) approaches to manage this pest under confined environment systems such as greenhouses. Staff of the IPCL have been working on the development of the SIT package for *D. suzukii* including determination of the optimum sterilization dose, development of effective mass-rearing procedures and quality control protocols as well as the assessment of their mating behaviour.

To date, the conventional larval diet for rearing the Mediterranean fruit fly, *Ceratitis capitata,* has been used to rear *D. suzukii*. However, this larval medium is not optimal for *D. suzukii* and efforts have been undertaken to develop a more specific larval diet that allows improved larval rearing efficiency as well as facilitating separation of larvae from pupae in the diet.



Larval diet for Drosophila suzukii *based on potato powder.*

Different ingredients and recipes have been tested to identify economically viable formulations that could be easily adapted to mass-rearing conditions for *D. suzukii*. A very promising formulation that uses potato powder or sweet potato powder as a bulking agent was first developed at Instituto de Sanidad y Calidad Agropecuaria de Mendoza (ISCAMEN), Mendoza, Argentina and is now being tested at the IPCL.

The South American Fruit Fly *Anastrepha fraterculus*

The South American fruit fly, *Anastrepha fraterculus* (Diptera: Tephritidae), is a pest that has a major impact on the fruit industry of Brazil and all other countries in South America. The SIT can be an additional control tactic to manage this pest on an area-wide basis. Significant advances in the domestication and artificial rearing technology for *A. fraterculus* have been made. As reported in previous newsletters, an *A. fraterculus* genetic sexing strain (GSS) based on a colour mutation of the pupae (black pupae) was developed from a laboratory population of *A. fraterculus* morphotype 1, distributed in the north and south of Argentina. Ms Paloma Guazzelli Della Giustine, a fellow from Brazil, was involved in the assessment of the biological characteristics of the strain during a 10-month TC fellowship. One main outcome of this work was the development of the complete radiation dose response curve for both males and females. This achievement will greatly facilitate the selection of the appropriate irradiation dose for SIT application in field action programmes against this important pest.

The black pupae GSS was transferred to the Centre of Nuclear Energy in Agricultura (CENA) and the University of Sao Paulo in Piracicaba, Sao Paulo, Brazil, where a colony has been established to be used in a future male-only release pilot project in the south of Brazil.

Raycell MK2 Blood Irradiator for SIT

Mr Yeudiel Gomez Simuta, a consultant from Moscafrut Program, Mexico, was hired to characterize and assess the performance and dosimetry of a 'Raycell MK2', an X-ray machine produced by Best Theratronics Inc. (Canada). The irradiator consists of two units: one containing the two X-ray tubes, control system, power supply and the canister, and the other containing the heat-exchanger for cooling the tubes (see figure). X-rays are produced by bombarding targets with electrons, which are accelerated in a vacuum through a high-voltage electrical field. The dose is delivered by two opposing X-ray tubes. with the sample canister located centrally between them. The two cone-shaped beams ensure that a tight dose is delivered to the product and good dose uniformity is obtained. Dose delivery is controlled by setting and monitoring the irradiation time, based on the central dose rate. Irradiation time is controlled by two independent microprocessors.

The advantage of X-ray generators is that dose variation effects can be reduced, once the energy is kept constant and the range of variation can be obtained through dose mapping knowledge. The variation can be reduced through adjusting the parameters of the equipment and/or configuring the volume of the irradiation products. The primary findings in the characterization of this equipment showed that the dose variation in a vertical way inside the irradiation container is very small, with a DUR of 1.2.

The Raycell MKII.

This data helps to ensure that all insects in the irradiation chamber will receive the dose between the specific range, fulfilling one of three main process control elements recommended into the SIT to avoid accidental release of insect that are significantly under-dosed. These three elements which control various steps in the irradiation process are: Sterility Testing, Routine Dosimetry and Radiation-Sensitive Indicators and thus complement each other.

Another advantage of the incorporation of ionizing radiation produced by electric energy is that the delivered dose is not affected by the decay factors, e.g. as with gamma rays. For comparison, the absorbed dose obtained from the MK2 X-ray generator is similar to what would be received by exposing a sample for 4.2 minutes in a Cobalt-60 gamma source type Gammacel-220 with an activity of 1 000 Curies (3.7 x 1013 Bq); however, it would be necessary to increase 12 % of the exposure time at the year in order to get the same dose; while the X-ray generator will keep the same irradiation time during the whole year, beside that the X-ray machine can be turn off when the source is without use. In conclusion, the findings of the small dose variation within the irradiation chamber of the Raycell MK2-ray blood irradiator support the possibility that this X-ray generator could be used in pilot or medium scale SIT projects as an alternative to self- shielded gamma irradiators.

The FAO/IAEA/USDA Project on Phytosanitary Treatment

The IPCL has continued to evaluate the relative tolerance of fruit fly populations to cold phytosanitary treatments. A research project evaluating the tolerance of *Zeugodacus tau* populations to cold treatments below 1.67°C for up to 16 days is nearly completed. Our results have shown that *Z. tau* third instars from Baipail (Bangladesh), Fujian (China), and Palampur (India) do not differ in their responses to phytosanitary cold treatments. In addition, a scientific manuscript reporting our results on phytosanitary cold treatment against five populations of the *Anastrepha fraterculus* complex has been recently published in the Journal of Economic Entomology.

Zeugodacus *tau third instar larvae that died after exposure to cold phytosanitary treatment.*

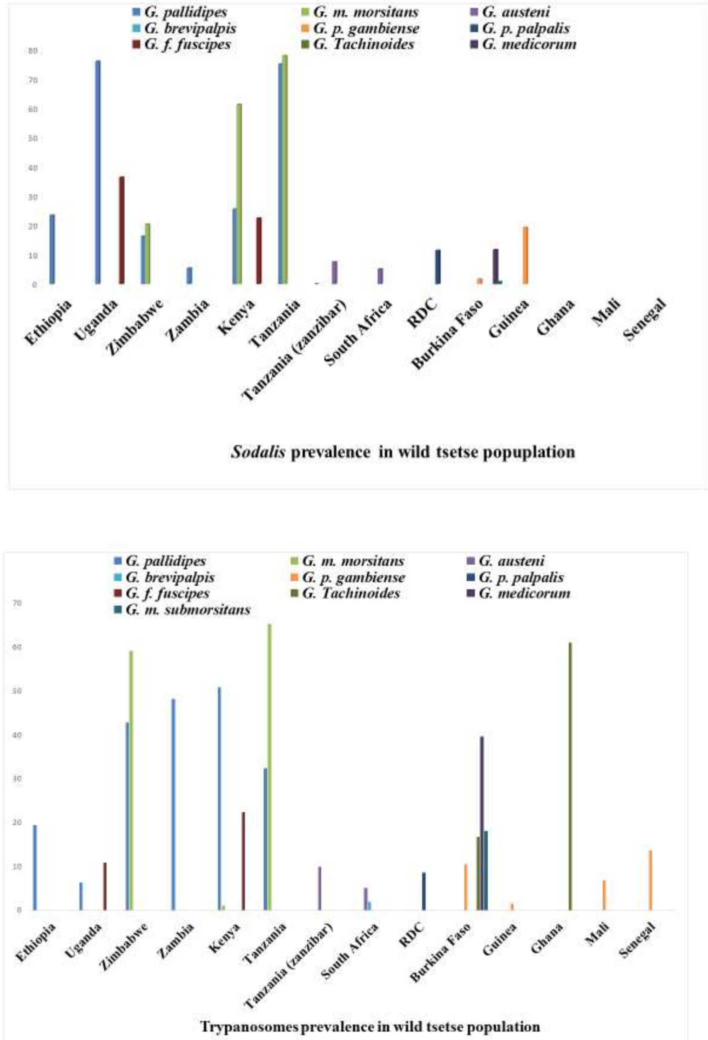
On fruit fly phytosanitary irradiation, the IPPC Commission on Phytosanitary Measures (CPM) will evaluate the recommendation made by the Technical Panel on Phytosanitary Treatments (TPPT), based on IPCL data regarding the removal of restrictions from phytosanitary irradiation treatments under modified atmospheres for fruit flies. If accepted by CPM, phytosanitary irradiation treatments against fruit flies may be applied under low oxygen levels, facilitating agricultural trade among Member States of the FAO and IAEA. A manuscript summarizing the scientific data on phytosanitary irradiation under hypoxia and severe hypoxia was submitted for publication.

With the normalization of our research activities in the IPCL, we plan to evaluate the effect of radiation sources on phytosanitary irradiation efficacy and initiate research on fruit fly tolerance to vapour heat treatments using a controlled atmosphere temperature treatment system (CATTS) chamber donated by the U. S. Department of Agriculture (USDA).

Livestock Pests

The Prevalence of the Tsetse Symbiont *Sodalis glossinidius* and Trypanosome Infection in Natural Tsetse Populations

Tsetse flies are harbouring four symbiont bacteria that may play an important role in tsetse biology including productivity, performance and their susceptibility to trypanosome infections. The symbionts bacteria are *Sodalis*, *Wigglesworthia*, *Spiroplasma* and *Wolbachia*. *Sodalis* infections seem to be correlated with enhanced trypanosome infection and therefore it is important to assess *Sodalis* and trypanosome prevalence in natural tsetse population to explore any correlation or effect of *Sodalis* infection on the development of trypanosome infections.

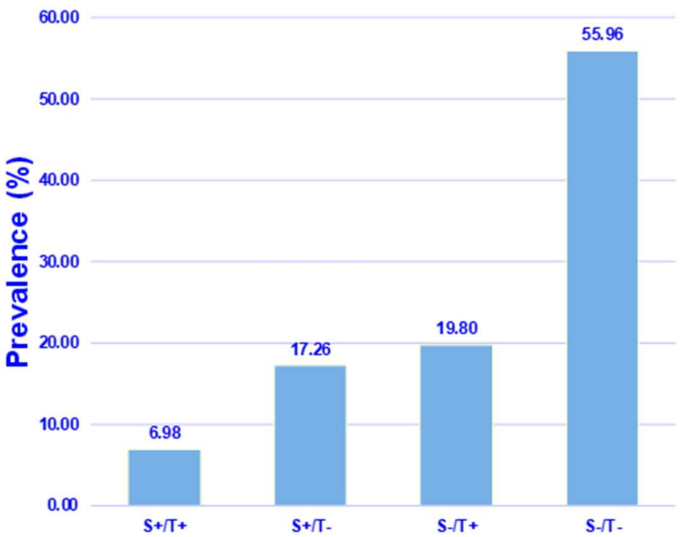


Global prevalence of Sodalis *(top) and trypanosomes (bottom) in wild tsetse populations.*

Therefore, Mr Mouhamadou Dieng, a consultant from Senegal, was employed in IPCL to assess *Sodalis* and trypanosome prevalence in natural tsetse populations. So far, 6 758 individual tsetse flies from eleven tsetse species and subspecies collected from fifteen countries were screened for the presence of *Sodalis* and trypanosome infections. The preliminary results indicate that the *Sodalis* prevalence varied from 0-95% depending on the tsetse species and the geographical location (see figure top graph). *Sodalis* prevalence was greater in *Glossina pallidipes* and *G. morsitans morsitans* and *G. f. fuscipes* in east and central Africa, but the prevalence was lower in West Africa. No *Sodalis* infection was recorded in tsetse flies collected from Ghana, Mali and Senegal.

Similar to *Sodalis* prevalence, trypanosome infection prevalence varied from one tsetse species to another based on the location. The global prevalence of trypanosome infection was around 26%, with 17% showing mixed infections with two or more trypanosome species. The infection rate reached 60% in *G. m. morsitans* in Tanzania and Zimbabwe and *G. tachinoides* in Burkina Faso. *G. pallidipes* also showed high infection rates (up to 30-50%) in Kenya, Tanzania, Zambia and Zimbabwe. No trypanosome infection was recorded in tsetse flies collected from Ghana, Mali and Senegal.

The results indicate that around 7% of the total samples showed infection with both *Sodalis* and trypanosomes, however 17.3% of the samples were infected with *Sodalis* only and 19.8% were infected with trypanosomes only, indicating no clear correlation between the presence of *Sodalis* and trypanosomes (see figure bottom graph). Caution is required in interpreting these data as it might lead to wrong conclusions. Therefore, a careful analysis of the *Sodalis* and trypanosome infection is required for each tsetse species and location. This study is currently being carried out at the IPCL.



Co-infection of Sodalis *and trypanosomes in wild tsetse populations.*

Human Disease Vectors

Assessing the Efficiency of an Automatic Mosquito Pupae Sex Sorter for *Aedes albopictus*.

For sterile insect technique-based approaches or any other population suppression approach, the elimination of female mosquitoes prior to male releases is not only essential, but mandatory for its application. Many sex sorting methods are being used, such as metal sieving plates and the Fay-Morlan glass separator or are under investigation, such as a computer vision analysis. However, these methods are time-consuming or have so far failed to eliminate all the females in order to achieve male-only releases for SIT or other related applications.

Therefore, there is a need to develop automated and efficient sorting methods to ensure reasonably consistent sex separation with an acceptable level of female contamination for large-scale release operations. The automatic mosquito pupae sex sorter developed by the Chinese company Wolbaki Biotech (see figure below) is presently being used successfully to separate the sexes of a *Wolbachia*-infected *Ae. albopictus* strain based on pupal size dimorphism. The machine was loaned to the IPCL to test its efficacy.

The automatic mosquito pupae sex sorter for Aedes *mosquitoes.*

To assess the efficiency of this equipment and explore the possibility of its use at a regional level, we used a comparative approach against the manual sorting method using the Fay-Morgan glass plate separation. The preliminary results showed that the automatic separator is able to separate 75 000 male *Ae. aegypti* pupae/hour with a female contamination rate below 0.5%. In comparison, 4 hours are needed to sort 75 000 male pupae with the manual glass sorter and a female contamination rate of 1%. However, the male recovery rate was lower for the automatic sorter. This automatic mosquito larval counter is a promising instrument to standardize the separation process and therefore increase time efficiency and reduce manpower for sex sorting of *Aedes* mosquitoes.

Optimization of Mass-rearing Methods for *Aedes albopictus* Larval Stages: Effect of Feeding Regime, Diet Source and Mosquito Strain on Male Production and Quality

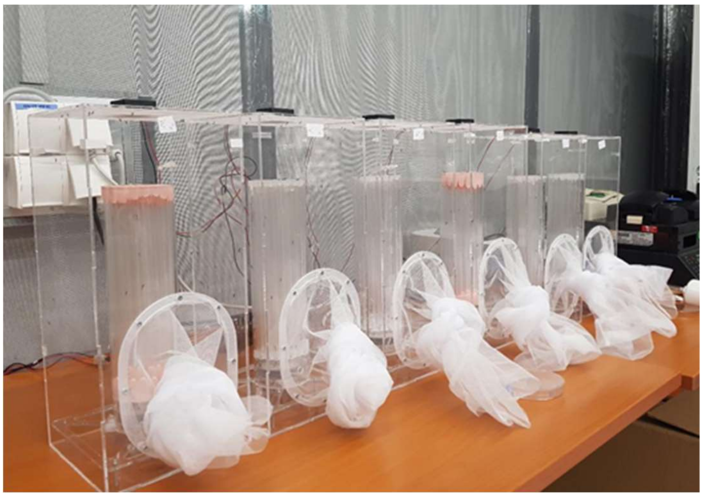
The increasing demand for the sterile insect technique as a component of area-wide integrated pest management to control or suppress vectors of diseases has necessitated the development of cost-efficient methods for mass production of insect vectors. Quantity and quality of factory produced insects are key to the success of any sterile male release programme. When a new equipment and/or novel cost-effective diet are developed, there is no guarantee that it will work with the same efficiency for all species, strains or feeding regimes. It is thus necessary to identify the most suitable diet formulation/feeding regime that leads to maximum production of pupae with only one tilt/sorting event.

To this end, six new feeding regimes using different diet formulations (ground and unground ingredients) were designed and compared to the standard feeding regime previously used at the IPCL. From this experiment, the best feeding regime was selected and evaluated on two different strains of *Ae. albopictus*. Finally, we compared these best feeding regimes to those of counterpart laboratories using our reference *Ae. albopictus* Rimini strain.

Ingredient particle size, mosquito strains and feeding regimes all had significant impacts on insect production and quality and therefore need to be considered when planning mass-rearing operations. More than 50% of the male pupae recovery rate was obtained after 24h from first pupation when 6% IAEA liquid diet using ground ingredients with a daily feeding regime consisting of 0.17; 0.33; 0.67; 0.67; 0.5 mg/larva was used. Moreover, this feeding regime resulted in 80% recovery rate of the males when tilted/sorted 44h after first pupation. These results are valuable information for the development of standard operation procedures for large-scale rearing of *Ae. albopictus* mosquitoes.

Development and Assessment of a Second Generation of Mosquito Flight Test Device for *Aedes* Mosquito Species

The success of genetic insect pest control techniques involving the release of sterile insects relies on the release of high-quality insects. The IPCL has recently developed a rapid quality control test (based on the flight ability of the mosquitoes) to foster the development of genetic control in mosquitoes. The large containment tube of the reference model was modified to a square containment tube to ease operations. Several parameters including the use of a fan only, lure only, fan + lure and the colour of the inner tube, were quantified and compared between *Aedes* mosquito species. Preliminary results show that *Aedes* mosquito species may exhibit different flight behaviour resulting in significant different flight rates between *Aedes aegypti* and *Aedes albopictus*. In addition, the use of a transparent inner tube, lure and fan are critical in standardizing the flight test device for *Aedes* mosquito species.

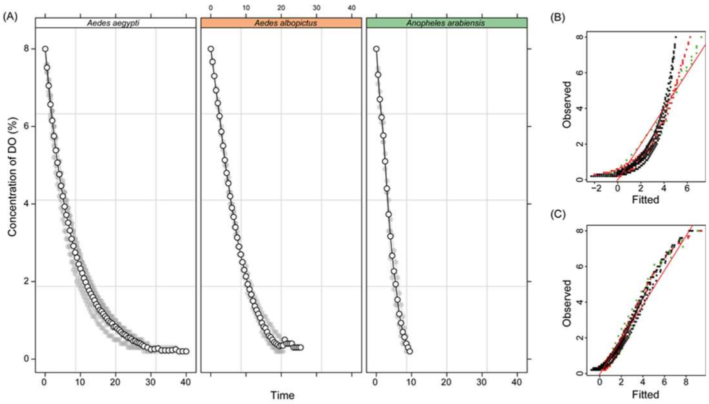


Flight test comparing the colour of the inner tubes (pink versus transparent).

Oxy-regulatory Behaviour in Pupae of *Aedes aegypti*, *Ae. albopictus*, and *Anopheles arabiensis*

Following preliminary studies investigating the effects of exposure of mosquito pupae to ionizing radiation in water versus in air, the oxy-regulatory behaviour of mosquito pupae in water was studied to better understand the consequences of irradiation in water, as hypoxic environments may be created during the irradiation process.

All three mosquito species depleted the water of dissolved oxygen (DO) to levels under 0.5% within 30 minutes, with *An. arabiensis* only needing 10 minutes to consume the oxygen. Following irradiation, the protective effect of hypoxia was observed across species and doses, increasing at higher doses. This effect was most pronounced in *An. arabiensis* (see figure).



A) Dissolved oxygen uptake by Aedes aegypti, Aedes albopictus*, and* Anopheles arabiensis *submerged in water. Dissolved oxygen (DO) level in percent (%) over time (minutes). B) O2 concentration or C) its log transform (log(c+1)). (black dots =* Aedes aegypti*, red =* Aedes albopictus*, and green =* Anopheles arabiensis*).*

It was found that the consumption of DO by pupae submerged in water was significantly different between species, indicating that their oxy-regulatory capacity may have possibly evolved and adapted according to their preferred breeding site characteristics. This needs to be considered when sterilizing male mosquito pupae in water. Depending on the species, their DO consumption rates and their density, irradiation doses needed to achieve full sterility may vary significantly and anoxia may be detrimental to pupae quality. Further assessments are required to ascertain optimal conditions in terms of ambient atmosphere during pupal irradiation to produce competitive sterile males, and temperature and density dependent effects are expected.

Irradiation of Adult *Aedes albopictus* Males: Effects of Chilling on Dose-response

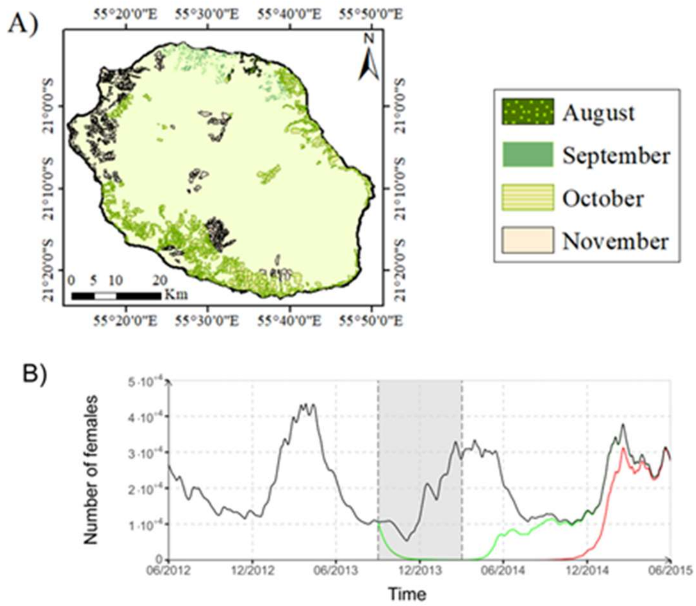
The effects of chilling on the dose-response of both pupae and adult *Aedes albopictus* was assessed in a series of small-scale preliminary studies. First results have shown that chilling reduces radiation effects in both developmental stages, reducing the overall induced sterility by around 3-5%. Longevity was not affected by the chilling nor the irradiation for the first three weeks. Thereafter, chilled treatment groups (both pupae and adults) showed a slight reduction in longevity compared to non-chilled controls.

After adjusting irradiation doses in the chilled groups to match the induced sterility levels to be the same in both chilled and non-chilled groups, flight tests were carried out for all treatment groups after 1 day of recovery time post-irradiation. First results indicated that flight ability was not affected by chilling despite the increase in dose.

Although it is still early in the series of experiments, initial results have been positive and indicate possible qualitative advantage of irradiating *Ae. albopictus* (and possibly other species) at the adult stage.

Modelling the Control of *Aedes albopictus* Mosquitoes Based on Sterile Male Release Techniques in a Tropical Environment

A novel approach named ‘boosted SIT’ has been proposed to strengthen the SIT technique in *Aedes* mosquitoes, which consists of coating sterile males with a biocide that will be transferred to the mated females which will then contaminate the oviposition sites. A study conducted within the European Research Council (ERC) Revolinc project was aimed at exploring demographic effects of both techniques (SIT and boosted SIT) through their inclusion in a weather-driven abundance model of the *Aedes albopictus* population dynamics in the geographical context of La Reunion Island. Sensitivity analysis showed that the start date of the release, as well as the quantity of sterile males released and their competitiveness, are of key importance for both control methods.



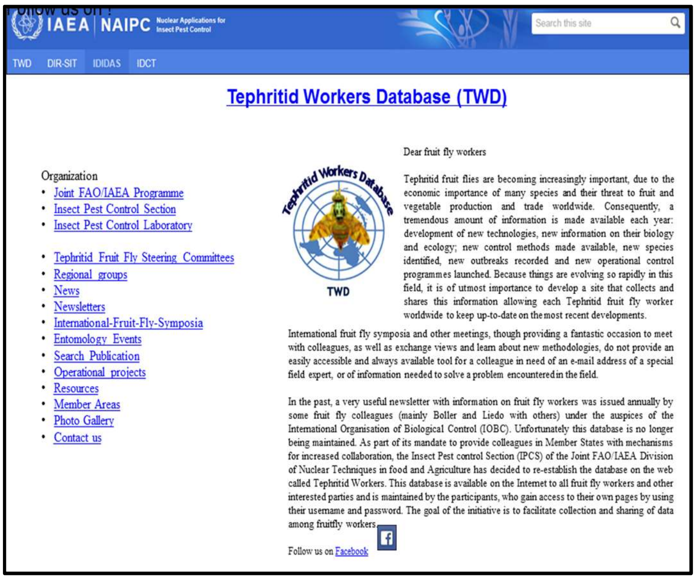
A) Optimal starting month for the start of sterile males releases to obtain a maximal reduction rate according to the mALBORUN-SIT model at La Reunion Island. B. Constant versus density-dependent sterile males release in SIT: Population dynamics without control (in black), with constant releases (in red) and with proportional release (in green). Source: Haramboure et al. 2020.

According to the results, boosted SIT allows 1) increasing the effectiveness of the SIT when the sterile males released are of medium quality in terms of competitiveness, and 2) extending the optimal window to start the control period. The model allowed the identification of the best month to start sterile male releases according to the location on La Reunion Island but also the comparison of the impacts of two release strategies for the number of sterile males, either constant or proportional to the adult females’ density. The constant release strategy was more efficient, with longer protection of the target area thanks to a greater reduction of the target populations.

Reports

Insect Pest Control Databases "Knowledge Warehouse"

The Insect Pest Control (IPC) Section provides free access to four databases (TWD, DIR-SIT, IDIDAS, IDCT) and makes hundreds of scientific and technical publications available for free online at http://www-naweb.iaea.org/nafa/ipc/index.html. The databases provide scientific and technical information related to the integration of nuclear applications for area-wide management of key insect pests that endanger crops, livestock and human health. The databases also provide information on insect sterilization and disinfestation for phytosanitary treatments, fruit and vegetable irradiation tolerance and directories of fruit fly workers and sterile insect technique (SIT) facilities. The IPC's objective is to provide a warehouse of knowledge on these wide range of topics where data are compiled, organised in a meaningful way, stored and disseminated, particularly to our partners and also to the general public. For example, the application of the SIT to many insect species, from the time of the discovery of ionizing radiation, has generated a large amount of data dispersed in thousands of primary and secondary data sources. However, grouping and processing this dispersed information in one place, enables to see the general pattern, makes comparative analysis on radiation sensitivity among insects possible, and helps to provide a decision support system. Another important goal of databases is to contribute in preserving the knowledge across generations.



Home page of the Tephritid Workers Database (TWD).

The development of the **Tephritid Workers Database (TWD)** was initiated in 2004 (https://nucleus.iaea.org/sites/naipc/twd/Pages/default.aspx). Beside the storage of information on tephritid fruit flies, TWD provides news on the latest development in this field such as up-coming events, best practices, and regional groups' activities. This TWD database is completed with Fruit Fly News (FFN) newsletter and Facebook page (FB-TWD) to help disseminate the information to our community members. Currently, there are more than 1500 members subscribing to FFN belonging to three fruit fly regional groups:

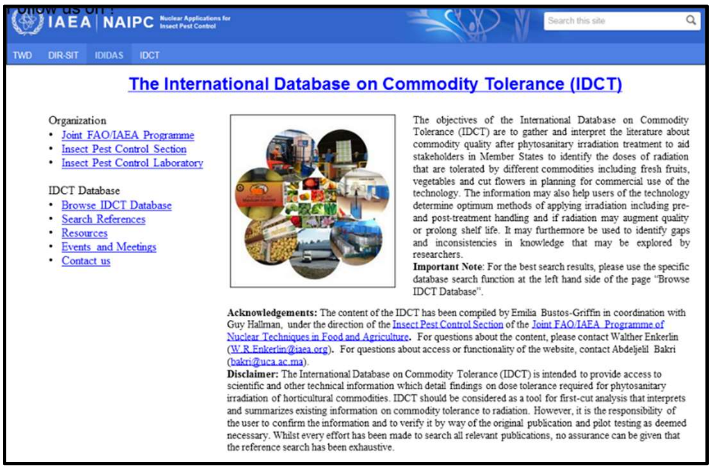
- Tephritid Workers of Europe, Africa and the Middle East (TEAM)
- Tephritid Workers of the Western Hemisphere (TWWH)
- Tephritid Workers of Asia, Australia and Oceania (TAAO)

In order to assist the National Plant Protection Organizations (NPPOs) and business sector interested in applying area-wide SIT, in dealing with fresh fruit and vegetable export and import requirements, **the International Database on Insect Disinfestation and Sterilization** (IDIDAS) was developed and launched in 2000 (https://nucleus.iaea.org/sites/naipc/ididas/Pages/Browse-IDIDAS.aspx). The goal is to help provide a decision support system for SIT and phytosanitary irradiation. IDIDAS records are organized by insect and mite species. Each record provides various data, such as the doses for sterilization and for disinfestation at various insect and mite stages, the level of the irradiation effect, and the commodities associated with the pest. To this date, there are 378 records and more than 5 556 references. References are available to help users check the original source of information. IDIDAS records include information related to arthropods of economic importance, belonging to 216 genera, 83 families, 8 insect orders and 2 arachnid orders. Of these, 29% are Diptera, 24% Coleoptera, 24% Lepidoptera, 9% Hemiptera, 7% Acari, 3% Thysanoptera, 1.5% Hymenoptera, 1% Blattodea, 1% Araneae, and less than 1% Orthoptera and Phthiraptera. Users have also access to various elements such as videos, glossaries, and event news.

Home page of the International Database on Insect Disinfestation and Sterilization (IDIDAS).

The application of the phytosanitary irradiation requires the knowledge of the commodity tolerance.

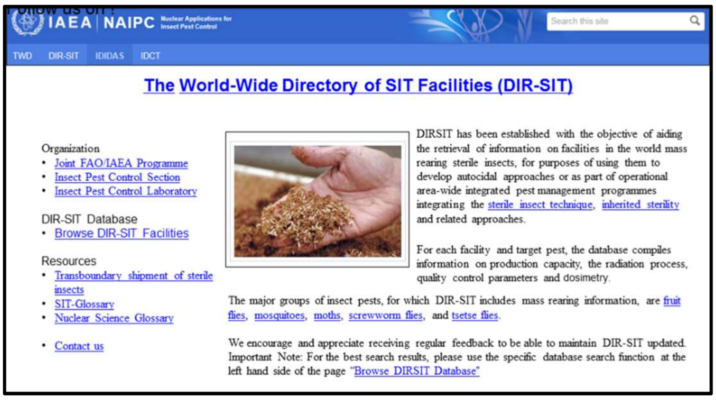
Therefore, the development of the **International Database on Commodity Tolerance** (IDCT) (https://nucleus.iaea.org/sites/naipc/IDCT/Pages/Browse-IDCT.aspx) was launched in 2016 to complete the IDIDAS information. IDCT data is organized by commodity cultivars. There are 260 records related to commercialized fresh fruit, vegetables and flowers and the number is expected to increase as review and analysis of specific literature is still ongoing. The original references are also provided as well as numerous resources and e-Learning courses. The ultimate goal of IDIDAS and IDCT is to help identify trade opportunities using pest risk mitigation schemes through area-wide SIT and phytosanitary irradiation and also the knowledge gaps where research is needed.



Home page of the International Database on Commodity Tolerance (IDCT).

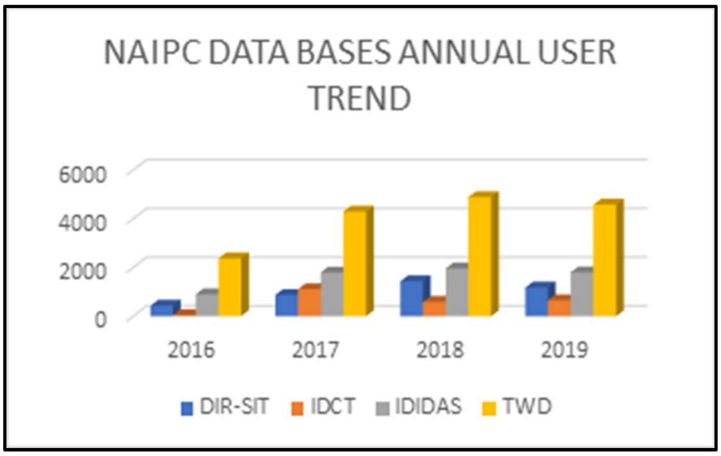
One of the major centers dedicated to SIT application are the mass-rearing facilities.

The World-Wide Directory of SIT Facilities (DIR-SIT) (https://nucleus.iaea.org/sites/naipc/dirsit/SitePages/All%20Facilities.aspx) is a database which lists the major 38 facilities with data on the insect species produced, the production capacity, and the irradiation sterilization parameters. The information is presented in a dynamic list that can be sorted and filtered by country, species or the production size.



Home page of the World-Wide Directory of SIT Facilities (DIR-SIT).

Over the past three years, from June 2016 to March 2020, the databases have been regularly visited by users from all over the world. More than 8 000 visitors/year have been recorded, with TWD being the most visited followed by IDIDAS.



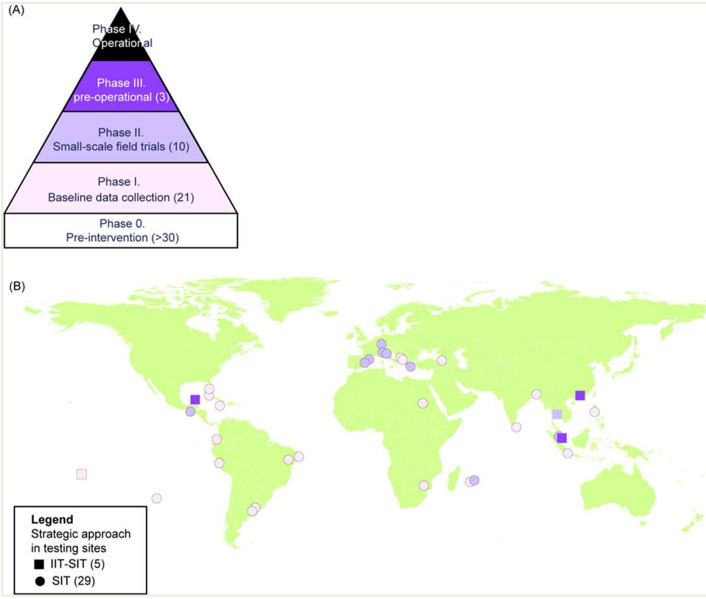
Annual visits of the four databases (DIR-SIT, IDCT, IDIDAS and TWD) from 2016 to 2019 (data for 2016 only 7 months).

To help disseminate the knowledge and reach a large audience, the information about databases has been posted in Wikipedia and also in social media such as Facebook.

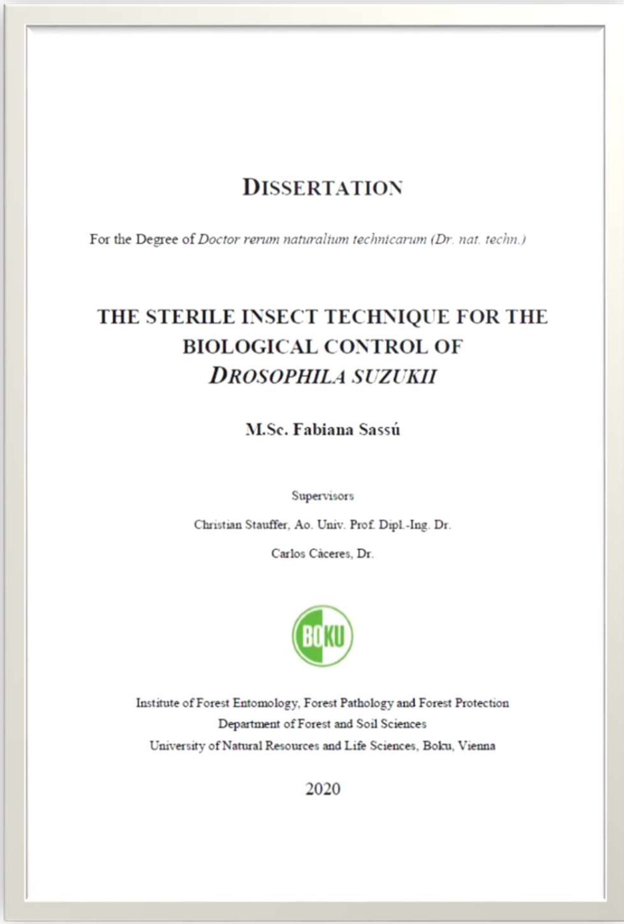
Phased Conditional Approach for Mosquito Management using the Sterile Insect Technique

As with plant and livestock pests, the implementation of the SIT for vector control is challenging and management-intensive and a phased conditional approach is therefore recommended to minimize the risks of failure. Although the different phases might be different for different insect groups, the principle remains identical, i.e. support or advancement to the next phase is conditional to the completion of all (or most) activities in the previous phase and the scope, expense and commitment increase along the process. Based on the accumulated experience of the Insect Pest Control Subprogramme in developing and providing technical advice and assistance in implementing SIT projects against various insect pests worldwide, we proposed a phased conditional approach to assess the feasibility, potential large-scale deployment and effectiveness of the SIT, as a component of an area-wide-integrated pest management (AW-IPM) approach against mosquitoes.

The proposal is graphically depicted in the figure (A). The proposed phases are (0) pre-intervention, (I) baseline data collection, (II) small-scale field trial, (III) pre-operational, and (IV) operational. Testing sites currently implementing SIT against mosquitoes, alone or in combination with the Incompatible Insect Technique (IIT) are mapped by phase in the figure (B).



Schematic representation of the proposed phased-conditional approach and location of the pilot sites in each phase. A. The pyramid symbolizes the amount of innovation related to operational research that is needed in the different phases whereas the volume of activities and investment will overall grow in the opposite way. Commitment of the stakeholders will be necessary in all phases and capacity building and technology transfer will be specific to each phase. Testing site numbers in each phase are presented in brackets. B. Distribution of testing sites implementing the sterile insect technique (SIT) against mosquitoes, some of them in combination with the Incompatible Insect Technique (IIT-SIT). Testing site numbers in each strategy are presented in brackets. Phase 0 sites are not shown on the map. (Source: Bouyer et al. 2020).



DISSERTATION

For the Degree of *Doctor rerum naturalium technicarum (Dr. nat. techn.)*

THE STERILE INSECT TECHNIQUE FOR THE BIOLOGICAL CONTROL OF *DROSOPHILA SUZUKII*

M.Sc. Fabiana Sassù

Supervisors

Christian Stauffer, Ao. Univ. Prof. Dipl.-Ing. Dr.

Carlos Càceres, Dr.

Institute of Forest Entomology, Forest Pathology and Forest Protection
Department of Forest and Soil Sciences
University of Natural Resources and Life Sciences, Boku, Vienna

2020

Ms Fabiana Sassú obtains her PhD from the University of Natural Resources and Life Sciences, Vienna, Austria

Ms Fabiana Sassú from Italy successfully defended her PhD thesis on 12th May 2020 at the University of Natural Resources and Life Sciences (BOKU), Vienna, Austria. Fabiana did her PhD academic studies at BOKU and the research at the Insect Pest Control Laboratory (IPCL) in Seibersdorf, Austria.

The PhD thesis entitled ‘The sterile insect technique for the biological control of *Drosophila suzukii*’ was part of a bilateral (Austria – France) research project named SUZUKILL (Managing cold tolerance and quality of mass-produced *Drosophila suzukii* flies to facilitate the application of biocontrol through incompatible and sterile insect techniques) which aims to develop new approaches for the suppression of populations of *D. suzukii*, a major agricultural pest. The volume and the quality of the research conducted was very impressive, and the research findings are being published as scientific papers in renowned peer-reviewed journals.

Fabiana tested the suitable range of radiation doses that consequently will determine the optimal dose to reach adequate sterility level for pest control and developed an efficient oviposition system allowing the production of large numbers of flies.

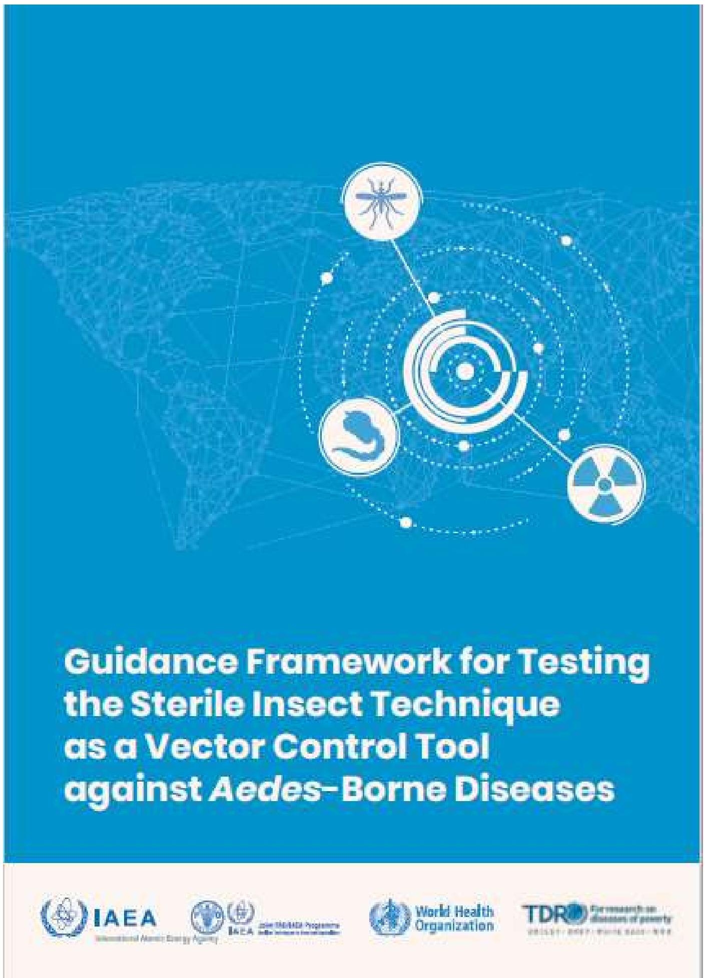
The data obtained from Fabiana’s thesis have been instrumental in furthering our understanding of the optimal conditions for irradiation and improvements of mass-rearing methods for *D. suzukii*. The research results show that *D. suzukii* flies can be produced in large quantities, irradiated, and transported for SIT programmes, setting out the basic conditions for the effective use of the SIT as a control method for this invasive pest.

Next step will be the transfer of technology to field pilots to evaluate the effectiveness of the SIT in confined environments (e.g. soft fruit greenhouses).

Announcements

Guidance Framework for Testing the Sterile Insect Technique as a Vector Control Tool against *Aedes*-Borne Diseases

The sterile insect technique (SIT) has historically been used against agricultural pests, attacking crops and livestock. The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture has been providing technical support to over 60 countries in implementing the SIT technology. It has now been adapted for use against *Aedes* mosquitoes, and it was thus necessary to standardize the process in order to support these pilot trials.

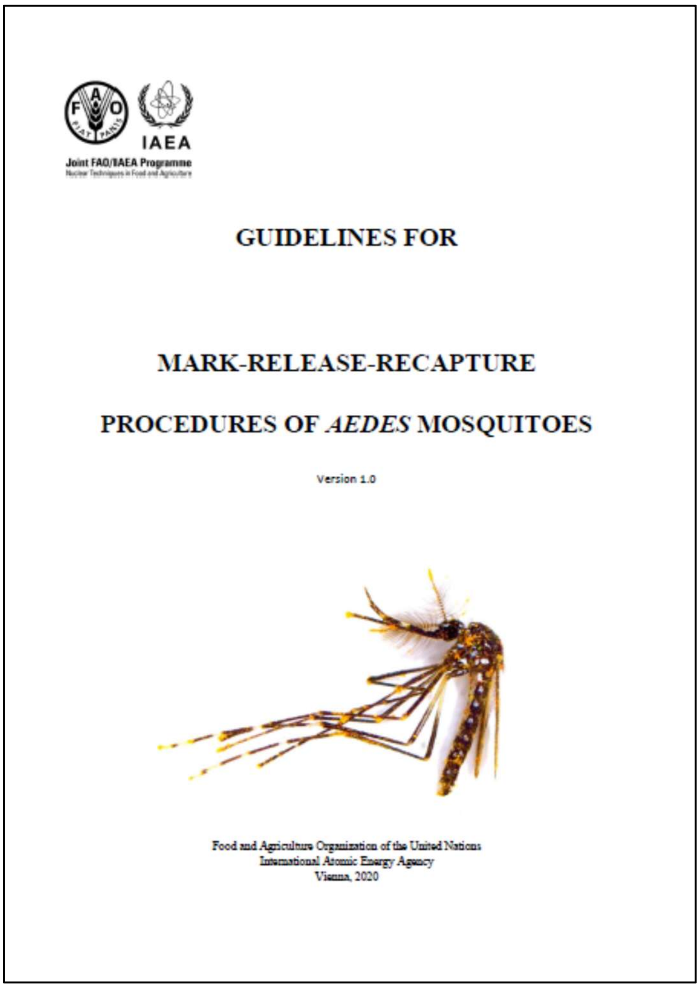


Through a collaboration between the IAEA, FAO, the Special Programme for Training and Research in Tropical Diseases (TDR) and the World Health Organization (WHO), the 'Guidance Framework for Testing the Sterile Insect Technique as a Vector Control Tool against *Aedes*-Borne Diseases' (http://www-naweb.iaea.org/nafa/ipc/public/aedes-who-iaea-2020.pdf) was released in April 2020. Written with the involvement of 15 experts from 12 countries, it will serve as guidance for countries interested in using this technique.

The document will guide Member States on how to fight diseases transmitted by *Aedes* mosquitoes such as chikungunya, dengue, yellow fever and Zika which cause over a million deaths per year. The nine chapters outline how a programme can be initiated first through a phased conditional approach where decisions to continue to the next phase will depend on the completion of the previous one.

The document also covers aspects of scaling-up to action programmes and its full implementation, risk assessment, technical topics such as the mass-rearing of insects, and entomological and epidemiological indicators to monitor the impact of pilot trials. Also, it offers guidance on engaging communities, ensuring cost-effectiveness and carrying out effective programme monitoring and evaluation.

Guidelines for Mark-Release-Recapture procedures of *Aedes* mosquitoes



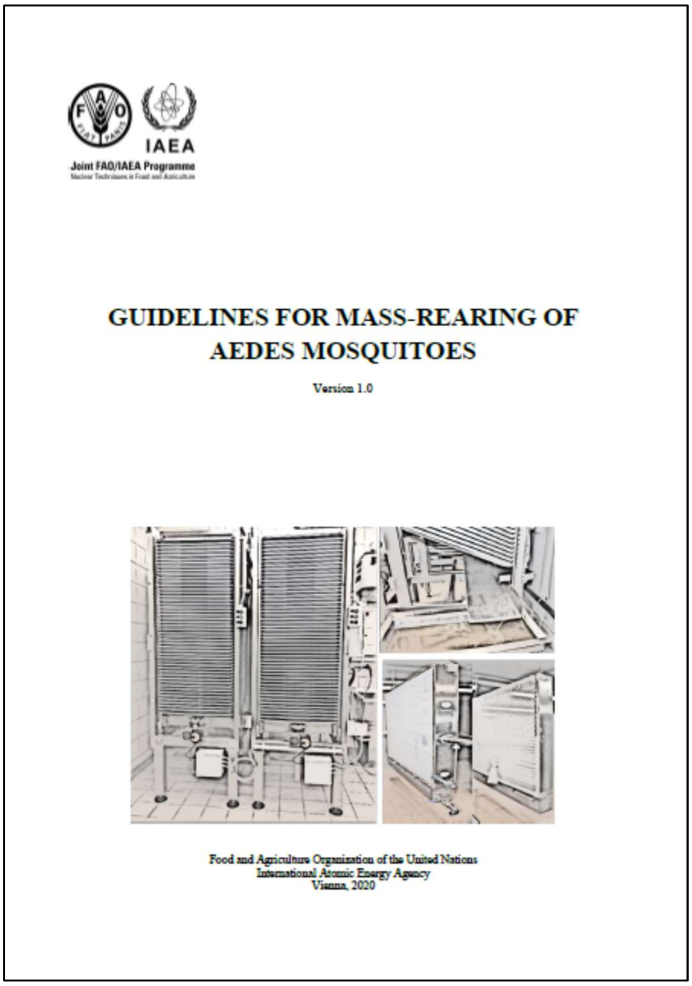
The objective of these guidelines is to provide guidance to implement mark-release-recapture (MRR) activities to evaluate sterile male dispersal, survival rate and their competitiveness in an open field settings, as well as the density of the wild population. The protocols presented in this guideline have been tested in the field and derive from tests (Tirana, Albania for *Aedes albopictus* and Juazeiro, Brazil for *Aedes aegypti*). However, each ecological questioning and each set of particular environmental conditions require an adapted protocol.

The major originality of the presented protocols is that they allow measuring competitiveness, by estimating the ratio of sterile to wild males and the induced sterility of females in the same sites. Estimating these entomological parameters is crucial for any SIT programme and should be conducted during the feasibility phase since they are mandatory to define projects needs in terms of sterile male production, release frequency and density, and swaths between release lines or distance between release points.

The guideline can be downloaded at: https://www.iaea.org/sites/default/files/guidelines-for-mrr-aedes_v1.0.pdf.

Guidelines for Mass-Rearing of *Aedes* Mosquitoes

The sterile insect technique (SIT) relies on producing sterile males of good quality in large enough numbers to achieve the target production level of males to be released. Therefore, the conditions and procedures under which mosquitoes are produced are of utmost importance for the overall success of the SIT activities.



The objective of these guidelines is to provide guidance on the procedures required for *Aedes aegypti* and *Aedes albopictus* mass-rearing. It is a summary of necessary steps of larval and adult mass-rearing as used at the Insect Pest Control Laboratory of the Joint FAO/IAEA Division. This is a temporary guide and will be continuously updated considering the improvements brought to the mass-rearing of mosquitoes.

The guideline can be downloaded at: http://www-naweb.iaea.org/nafa/ipc/public/Guidelines-for-mass-rearingofAedes-osquitoes_v1.0.pdf.

Forthcoming Regional Fruit Fly Events

The 4th Meeting of the Tephritid Workers of Europe, Africa and the Middle East (TEAM). 4–8 October 2020, La Grande-Motte, France

The event will be held from 4–8 October 2020, in La Grande-Motte, the southern part of France, one of the main fruit production areas in the country. This TEAM symposium will provide opportunities for interaction between academia, researchers, extension and industry specialists, who will present their latest scientific results and deliberate on a number of pertinent issues on fruit fly biology, ecology and control. As in the past event no particular theme is selected for this symposium, but all relevant topics and major items will be addressed in specific sessions, in order to have a broad forum for all to present their recent findings.

In addition to the topics relating to the 'true' fruit flies, Tephritidae, attention and room for presentation of research results will also be given to the drosophilid fruit fly *Drosophila suzukii*. This because of the overlap and common interest with regard to damage in the fruit industry, pest control, invasion biology and the general importance of this invasive pest to the region. Not only will this event broaden the knowledge base of all concerned, but it will also enhance the synergies between the different institutions of the three regions and business sectors. For more information: https://www.alphavisa.com/team/2020/index.php.

Americas Congress on Fruit Flies and the 10th Meeting of the Tephritids Workers of the Western Hemisphere (TWWH). 3–7 November 2020, Bogota, Colombia

The Colombian Agricultural Institute (ICA) and the Working Group on Fruit Flies of the Western Hemisphere (TWWH), with the support of the Colombian Horticultural Association (ASOHOFRUCOL) - National Fund for Fruit and Vegetable Development and the Colombian Entomology Society (SOCOLEN), as a preamble to the celebration of the International Year of Plant Health, are pleased to expand information regarding the Americas Congress on Fruit Flies, in the framework of the 10th Meeting of the Working Group on Fruit Flies of the Western Hemisphere.

The website is already available on the following link: https://www.ica.gov.co/10twwh. Here you can check all the details of the event. You can also pre-register and send the summary of your work. For this purpose, enter the following link: https://www.ica.gov.co/10twwh/sobre-el-evento/inscripcion.

The 2nd Meeting of the Tephritid Workers of Asia, Australia and Oceania (TAAO), 18–21 August 2020, Beijing, China (Postponed to First Quarter 2021)

The TAAO was established as an independent professional and scientific organization with the purpose of bringing together tephritid workers from Asia, Australia, and Oceania. The presence of highly invasive tephritid fruit flies continues to threaten the commercial fresh fruit industry arising from higher production costs in controlling those pests and quarantine restrictions. In managing those pests, the threat of multiple species' invasion underpins the need for building an effective collaborative network among agricultural action and research agencies in identifying and halting the spread of those pests.

There will be 8 sessions in TAAO 2020 symposium, including Survey and Monitoring; Risk Assessment, Management and Communication; Species Complex and Species Diagnosis; Population Tracing and Invasive Pathway; Phytosanitary Treatment and Eradication; Area-wide management and SIT; Global Change and Invasion Mechanism; Regional and International Collaboration.

The online registration is open. For more information: http://www.aiencode.net/en-US/Home/Index.

In Memoriam

Jean-Baptiste Rayaisse (1967–2020)

It is with great sadness that we have to announce the passing away of Jean-Baptiste Rayaisse, Research Entomologist at the International Centre for Research and Development on Livestock in Subhumid Zones (CIRDES), Bobo-Dioulasso, Burkina Faso, on 23 March 2020.

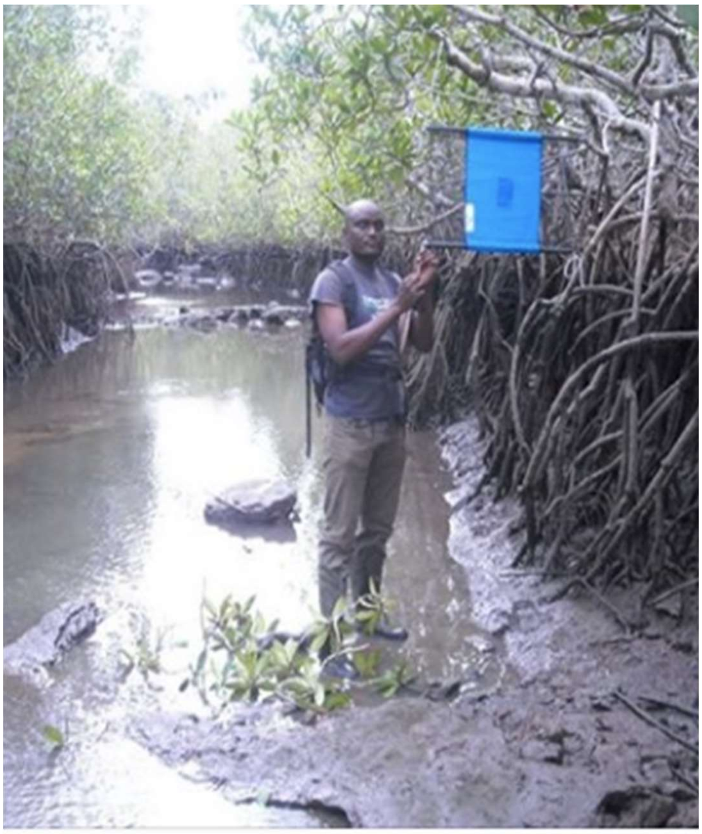
Jean-Baptiste Rayaisse at the CIRDES.

Jean-Baptiste spent most of his career working on tsetse flies, vector of animal and human trypanosomosis in sub-Saharan Africa, becoming a leading expert in this field. Jean-Baptiste worked in partnership with several national and international institutions and organizations including the French Research Institute for Development (IRD), The French Agricultural Research Centre for International Development (CIRAD), the Liverpool School of Tropical Medicine, the University of Neuchâtel / Switzerland, the Pierre Richet Institute, the Center for Medical and Veterinary Entomology (CEMV), the International Atomic Energy Agency (IAEA), the World Health Organization (WHO), the Food and Agriculture Organization of the United Nations (FAO), the PAN-AFRICAN Tsetse and Trypanosomiasis Eradication Campaign (PATTEC) programme of the African Union, as well as the national Human African trypanosomiasis (HAT) control programmes in Burkina, Côte d'Ivoire, Guinea and Chad.

Jean-Baptiste was instrumental in many research topics, amongst them 'the Tiny target' concept (photo), an effective and efficient tool to control tsetse fly populations and currently used with success in five countries (Chad, Democratic Republic of Congo, Guinea, Ivory Coast, Uganda).

Jean-Baptiste received an MSc degree from the Institute of Tropical Medicine, Antwerp, Belgium in 2005 and a PhD degree from the University of Neuchâtel, Switzerland in 2011. He was awarded the Accreditation to Supervise Research (HDR) from Montpellier University, France in 2017. He worked at the CIRDES since 2008 and became the Head of the Vector Control Team and the CIRDES Insectarium in 2012 and the Head of the Vector and Biodiversity Diseases Unit in 2019.

Jean-Baptiste published more than 40 research papers in peer reviewed international journals, he contributed as a reviewer in eleven scientific journals and he was a member of five educational societies. He supervised many MSc and PhD students. In view of his scientific excellence and his significant contribution in implementing the scientific objectives of CIRDES, the CIRDES board awarded him the 'Best Researcher for Exceptional Contribution' in 2017, 2018, and 2019.



Jean-Baptiste Rayaisse deploying a "Tiny target" screen in a mangrove in Guinea (bottom).

Jean-Baptiste's cheerful personality, in-depth scientific knowledge and his desire to help solving the tsetse and trypanosomosis problem will be sorely missed.

Aligui Djiteye (1955–2020)

It is with great sadness that we have to announce the passing away of Aligui Djiteye, the former director of the National Directorate of Veterinary Services (DNSV), Bamako, Mali on 11 May 2020.

As a research entomologist, as national coordinator of the Pan African Tsetse and Trypanosomosis Eradication Campaign (PATTEC) programme of the African Union in Mali and as a counterpart of the International Atomic Energy Agency technical cooperation projects, Aligui dedicated his life to the control of tsetse flies and trypanosomosis in Mali.

He was born in 1955 and received his master's degree in biological sciences from the High school in Bamako and a Diploma of Advanced Studies (DEA) and a PhD degree in Medical Entomology & Parasitology from the Higher Institute of Training and Applied Research (ISFRA) of the University of Bamako.

Aligui was one of the key persons in West Africa whose keen interest in the biology and the control of tsetse flies significantly contributed to the development and implementation of control strategies as well as epidemiological assessments. Aligui served for 20 years as the Head of the Research Programme on Parasitic Diseases and Vector Control at the Central Veterinary Laboratory in Bamako. He was the coordinator of the Project against Tsetse Flies (PLMT), and the African Development Bank (ADB) supported Multinational Project 'Eradication of Tsetse and Trypanosomosis in Sub-Saharan Africa'.

Aligui's cheerful personality, and his efforts to help solving the tsetse and trypanosomosis problem will be sorely missed.

Other News

Eradication of a Mediterranean Fruit Fly Outbreak in Manzanillo, Colima, Safeguarded Mexico's Production and Exports of Fruit and Vegetables

The Secretariat of Agriculture and Rural Development (SADER) of Mexico successfully concluded the actions to eradicate the Mediterranean fruit fly, *Ceratitis capitata,* transitory entrance to Manzanillo, Colima, which was detected in the vicinity of the Manzanillo cargo port, on 24 April 2019.

Jackson trap being placed on a property in Manzanillo, Colima, Mexico, for detection of the Mediterranean fruit fly.

The National Service for Plant Health, Food Safety and Agri-Food Quality, (SENASICA) reported to the North American Plant Protection Organization (NAPPO) that the pest was eradicated, since the last captures of this species were recorded on 23 November 2019. Therefore, on 21 March 2020, three biological cycles in absence of the pest were achieved.

Derived from the foregoing, in compliance of international regulations, the Secretariat of Agriculture terminated the National Emergency Protocol against the Mediterranean fruit fly in Manzanillo, which had been activated in May 2019 after the pest entry was detected.

With these actions, Mexico's fruit and vegetable production and commercialization was safeguarded. As this pest can attack more than 200 plant species, its establishment in the national territory would have seriously affected Mexican growers' production and exports to international markets.

In order to eradicate the transitory entry of the Mediterranean fruit fly into the seaport of Manzanillo and avoid its spread into the national territory, the Secretariat of Agriculture with the collaboration of the Government of the State of Colima, the Association of Avocado Producers and Packers of Michoacán (APEAM) and the growers from Colima State, invested more than 40 million pesos (equivalent to more than USD 2.0 million).

As part of the eradication protocol, SENASICA technicians applied various phytosanitary measures in an area of 951 km^2. 1 933 traps were installed, and 76 687 trap inspections conducted. 6 392 samples of tropical almond (*Terminalia catappa*) fruits were collected and studied. *T. catappa* was the only *C. capitata* host recorded in this outbreak.

Fruit host disposal after stripping.

Population suppression actions included placement on infested sites of 18 112 bait stations with hydrolyzed protein. More than sixty tons of tropical almond fruit and other potential hosts were collected and destroyed, and ground bait sprays with environmentally friendly products were applied.

In addition, almost 28 million *Diachasmimorpha longicaudata* (a parasitoid of the Mediterranean fruit fly), were released, and to achieve eradication, 739.34 million sterile male Mediterranean fruit fly adults were released on a continuous basis during 41 weeks over the entire affected area.

To avoid the spread of the pest to other regions of the country, SENASICA placed four domestic quarantine check points in the towns of Marabasco, Camotlan de Miraflores, El Colomo and Coyutlan, where 30 quarantine officials inspected 210 238 vehicles and seized more than 15 tons of host fruits. In addition, at Manzanillo International airport, the luggage of 409 national and international flights was inspected.

In the implementation of the emergency protocol, 201 plant health technicians participated in a phased manner, supported by two canine units on the quarantine checkpoints. 12 technicians from the United States Department of Agriculture (USDA), also supported SENASICA in the emergency protocol.

Given the pest risk, the surveillance system against non-native fruit flies of quarantine importance will continue operating at the port of Manzanillo, with an enhanced trapping network and a permanent field operation center.

Inspection of fruit hosts at a quarantine road station.

The implementation of the emergency protocol was supervised by a Panel of Mexican Technical Advisors (specialists in fruit fly control and eradication), who issued recommendations which contributed to strengthening the strategies and actions to achieve pest eradication.

The SENASICA applied the phytosanitary measures in accordance with the 'Technical Manual to Implement the National Emergency Protocol of the Mediterranean fruit fly in the national territory (except Chiapas)' and the International Standards for Phytosanitary Measures (ISPM) regarding to the transience of a pest and the maintenance of fruit fly free areas.

The press release in Spanish can be accessed at: https://www.gob.mx/agricultura/prensa/reporta-agricultura-la-erradicacion-de-colima-de-la-mosca-del-mediterraneo-salvaguardada-produccion-y-exportacion-hortofruticola-del-pais.

Source: *Secretariat of Agriculture and Rural Development (SADER) of Mexico, 26 April 2020.*

Kick off Meeting of Phase 2 SIT Project in La Reunion Island, France: Pilot Demonstration of the Efficacy of SIT Application for the Control of *Aedes albopictus*

The start of the pilot release phase marks an important moment in the SIT programme in La Reunion, France: the kick-off meeting of phase 2 of the project took place on 10–13 February 2020. The meeting brought together key stakeholders including institutional representatives, participants from the private sectors, local authorities, and all major scientific partners (French National Research Institute for Sustainable Development (IRD), Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, International Cooperation Center for Agronomic Research and Development (CIRAD), French Regional Health Agency (ARS), School of Public Health, Rennes (EHSP), French Blood Establishment (EFS), Qualitropic competitiveness cluster and University of La Reunion).

TECHNIQUE DE L'INSECTE STÉRILE

One of the meeting's highlights was an update on the main scientific achievements in the earlier phases of the programme on the island from 2009 to 2019. In brief, the feasibility phase of the SIT programme allowed developing scientific and technical expertise and gathering useful information for the development and application of a sterile male release strategy for the control of *Ae. albopictus* in La Reunion.

Release of sterile males by the IRD team to conduct a mark-release-recapture trial in the Duparc area of Sainte-Marie, Reunion island.

Building on previous achievements, the focus during the kick-off meeting was on exchanges between scientific partners on the SIT project vision, the requirements for implementing the pilot release of sterile males to control *Aedes albopictus* and the criteria for evaluating the effectiveness and impacts of these interventions. Partners discussed the implementation of the pilot releases and related activities with emphasis on the following essential objectives and tasks: (1) the development and implementation of a communication strategy and procedures for requesting authorization taking into account the regulatory framework for the use of SIT in the context of vector control; (2) the evaluation of the level of social acceptability; (3) scaling-up of mosquito production based on existing knowledge and the required sterile males for pilot release; (4) the development and implementation of an intervention strategy integrating the releases of sterile males; and (5) the development of a plan to assess the effectiveness and impact of SIT, taking into account entomological, epidemiological and socio-economic indicators.

This kick-off meeting also represented an important step in the stakeholder consultation processes prior to the implementation. The interactive discussions that followed provided valuable inputs to SIT priorities development pathways and the design and scheduling of the application of the SIT strategy as part of the integrated programme against *Aedes albopictus* in La Reunion.

Overall, the project kick-off meeting proved very fruitful and served as an official start of the pilot testing phase of SIT in La Reunion. The demonstration of the efficiency of sterile male releases under realistic conditions and the evaluation of potential impact are planned for the period January 2020 to December 2022. The project is funded by the Regional European Development Fund (ERDF) and the French Ministry of Health.

Source: Louis Clement Gouagna, Principal Investigator (www.tis.re).

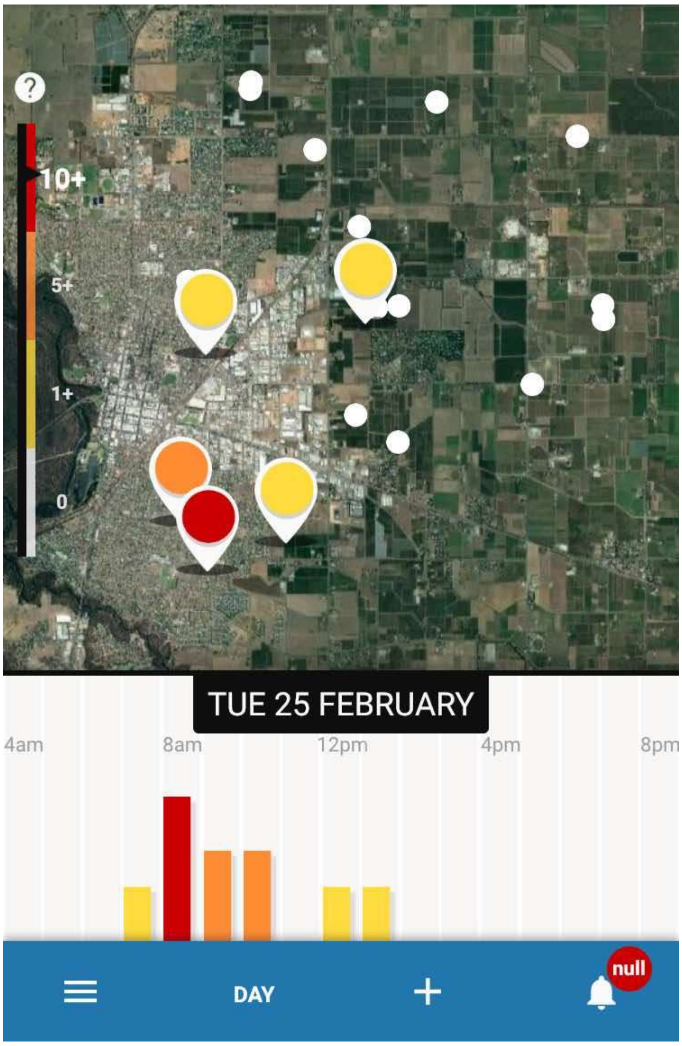
Digital Fruit Fly Surveillance and Management developed in Australia: Real-time Monitoring for the Presence and Location of Fruit Fly

Monitoring insect traps is a corner stone of best practice for pest management. However, checking traps by hand is costly, and can add to delays in managing the problem. Automated insect monitoring is becoming a reality and solutions are increasingly available in the marketplace.

RapidFLY low-power device.

In Australia, a solution developed by a team of scientists formerly from the national research facility, Commonwealth Scientific and Industrial Research Organisation (CSIRO) is being adopted by growers, local government and grower associations. The Company, RapidAIM Pty Ltd, now provides the RapidFLY digital fruit fly surveillance and monitoring service for Queensland fruit fly (*Bactrocera tryoni*). The service is underpinned with platform technology in the form of low-power, easy-to-use sensors that detect flies, communicate information to the cloud, and then to the mobile app of the end user in real time.

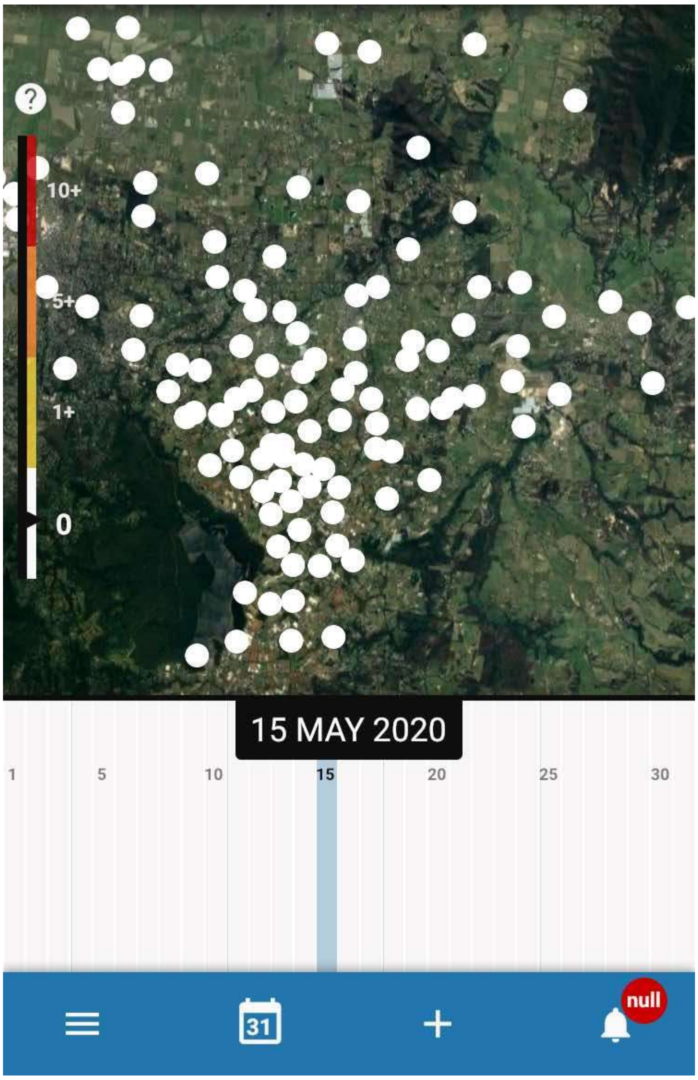
"We developed our digital surveillance and monitoring platform technology because we want to break down the barriers to sustainable pest management." Dr Nancy Schellhorn, co-inventor of the technology, said, "This technology integrates well with other tools and technologies because when you can see problem areas then you can target control, biological or chemical, and know quickly if control is working".



Screenshot of the RapidFLY mobile app showing the location and time of day of fruit fly detections across a 300 ha urban-rural area. Coloured locator icons indicate fruit fly detections, while the small white circles indicate no detections.

The technology was scientifically validated in a national trial with the Australian Government. The study showed that Qfly catches were not different in the RapidFLY traps compared to the Lynfield trap, the Australian government standard trap, and that automated detection performance was very reliable; rarely was a fly missed and false alarms hovered around 2-5%. In addition, RapidFLY was shown to reduce the cost of manual trap checking by 35%. With battery life exceeding 12 months, the main maintenance is for lure change. The work is currently being prepared for peer review.

The low-cost, low power sensors are now being deployed at industrial scale across regions for surveillance, and at high density across orchards allowing for a tight link with management.



One of the RapidFLY surveillance grids covering 200km².

Beyond the commercial offering, the telescopic granularity of the data flow has lead to many interesting observations. "On the RapidAIM mobile app we can see the time of day that male Qflies are active, and the relationship to weather, and we can also see the source of first detections in the season and how the flies move and spread across a region", said Nancy. The team will continue to develop the technology for application across the tephritid group and beyond.

Source: www.rapidaim.io.

Why the Government Breeds and Releases Billions of Flies a Year

A program in Panama breeds, sterilizes, and releases 20 million screwworm flies a week to protect livestock from flesh-eating larvae. This is how it works.

Just east of the Panama Canal, tucked between patches of rainforest, farmers' fields, and the Pacora River, there's a green-roofed building that looks like any other factory facility on Earth. Except inside this building, which is jointly operated by the Panamanian and United States governments, they breed flies.

These aren't your usual houseflies, however. These are highly destructive New World screwworm flies, also known as cattle borers. And to combat them, scientists systematically expose their pupae to radiation in the lab to render them sterile before they're released en masse above the wilds of Central America.

This elaborate—if somewhat disgusting—operation maintains a little known but hugely important invisible barrier. It's part of a decades-long effort to protect livestock throughout North and Central America by keeping screwworm flies and their flesh-eating, parasitic larvae south of Panama. Native to the Americas, New World screwworms were eradicated from the U.S. in 1966 and are kept at bay by the Panama-U.S. Commission for the Eradication and Prevention of the Cattle Borer Worm (COPEG), using a technique that also helps protect strawberries, coffee beans, and cotton—among other things—from pests.

"They can lay their eggs in a wound as tiny as a tick bite," says Vanessa Dellis, general director of the U.S. Department of Agriculture's Screwworm Program. A screwworm infestation can be lethal.

Fortunately, scientists have found a way to thwart the parasites: Regular releases of millions of irradiated, sterile flies every week has managed to eradicate them from the U.S. all the way down through Central America. Now, 25 years after the U.S. and Panama first partnered on this fly-breeding and -irradiating venture, it's clear the program has been a success, keeping both humans and animals free of the ravenous parasites.

"The flies have a unique biology," says Pamela Phillips, technical director of the USDA's Screwworm Program. Females only mate once in their three-week lifespan, so if the male they mate with is sterile, there will be no new screwworm larvae. Saturating an area with sterile males will eventually lead to the fly's demise. It's known as the "sterile insect technique" and also has been used to eradicate tsetse flies, from Unguja Island in Zanzibar.

By exploiting this biological weakness of the screwworm fly, the U.S. government was able to eradicate screwworms in the country in 1966. Using the sterile insect technique to control screwworms has been one of the most successful entomological success stories of all time, according to the USDA.

“We have a lot of pride to have this program here in Panama,” says Enrique Samudio, general director for the Panamanian Ministry of Agriculture side of COPEG. “It’s unique in the whole world.” To maintain this progress against the screwworm however, scientists must annually release billions of irradiated males, overwhelming the wild, fertile male screwworm supply that could mate with the available females. The sterile, good-guy flies are released by airplane to the tune of six flights over Panama’s southeastern Darién region every week.

Reserve flies have been used to eradicate screwworm outbreaks on the island of Aruba twice, once 2004, and again in 2011. But most recently, this triumphant science was used to save a population of endangered miniature deer native to the Florida Keys in 2016.

Armed with 190 million flies from Panama, USDA experts started releasing three consecutive generations of sterile screwworm flies onto islands throughout the Florida Keys. At the same time, a team made up of staff from the USFWS, National Key Deer Refuge, Monroe County, and nearly to 200 volunteers began helping the deer that were already infected by coaxing them to eat donut holes laced with anti-parasitic medication.

By March, the USDA declared the screwworms extinguished and the Key deer safe.

The sterile fly technique is good for more than protecting us against screwworms. In fact, you might be benefitting from it every time you take a bite of strawberry or a sip of coffee.

This is because there are plenty of flies that would prefer to lay their eggs in fruits and vegetables rather than on animals. And when they do, their larvae turn crops into rotting mush.

“The Mediterranean fruit fly, for example, is probably one of the most devastating fruit and vegetable pests worldwide,” says Ken Bloem, national fruit fly coordinator for USDA Animal and Plant Health Inspection Service (APHIS).

But they, too, can be combatted using the sterile insect technique, which APHIS runs continuously in areas where these flies tend to pop up, like California and Florida.

“It’s a great technology,” says Bloem. “We’ve also used it recently to declare the eradication of the pink bollworm, which is a cotton pest.”

Source: National Geographic, see complete story at: (https://www.nationalgeographic.com/animals/2019/12/north-american-screwworm-barrier/).

USDA Funding Will Help Move Forward Sterile Insect Technology for Navel Orangeworm

Navel Orangeworm is the number one pest for tree crops. There's a lot of work that needs to be done. Rearing sterile navelorange worm in a USDA facility in Phoenix and from there the sterile insects will be flown and released over almond and pistachio orchards throughout California in hopes to manage the pest. Similar to what was done in the pink bollworm program in cotton.

Richard Matoian is executive director of the American pistachio growers. “We did get funding from the federal government for this sterile navel orangeworm facility. So we're actually ramping up the number of acres that the sterile moths are going to be tested on,” Matoian said.

“Previously they were in the Kern County. And this year area it'll be in Western Fresno County in an area that has both almonds and pistachios. The moths will be put on both and it's apparently an area where there's been higher navel orange worm damage,” Matoian said. “So, it'll be an opportunity to see a little more clearly or a little more definitively, whether that navel orangeworm, sterile releases actually have an effect or we're going to be able to see better results,” he said.

Matoian said these flyovers with a sterile navel orangeworms will go into orchards without mating disruption, which will give them a clearer picture on whether or not it works.

Source: California Tree Nut Report, AgInfo Network, 25 May 2020, (https://www.aginfo.net/report/46037/California-Tree-Nut-Report/USDA-Funding-Will-Help-Move-Forward-Sterile-Insect-Technology-for-Navel-Orangeworm).

Relevant Published Articles

Development and Validation of Real-Time PCR Method to Estimate Stored Sperm in the Spermathecae of *Ceratitis capitata* (Diptera: Tephritidae)

Marta Catalá-Oltra, Elena Llácer, Alberto Urbaneja, Meritxell Pérez-Hedo[4]

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Abstract

The development of polymerase chain reaction (PCR) markers to identify the Y chromosome of Ceratitis capitata Wiedemann has permitted the detection of sperm transferred to females during mating. However, a molecular technique to quantify the sperm transferred has not yet become available. The current method to quantify the amount of sperm has been the direct counting of sperm heads. Thus, the purpose of this research was to develop and validate an accurate molecular method of diagnosis based on the application of an absolute quantitative real-time PCR, which allows the assessment of the quantity of sperm stored in the spermathecae. For this, Y-specific sequences were used to re-design and test distinct sperm markers. From the amplification product of samples detected as strong positives in conventional PCR, a cloning process of the target sequence was carried out to build the required standard curve. A series of known dilutions of this standard material was prepared for the absolute quantification process. A Roche Lightcycler 480 Real-Time PCR System and SYBRGreen fluorescent dye were used to quantify the sperm contained in the spermathecae of 4-d-old mated females and virgins. Wild-type and Vienna-8 strain sterile males were used to quantify the sperm transferred at four mating durations (10, 30, 60, and 90 min) under laboratory conditions. To validate the reported quantitative method, our results were compared by counting sperm heads under a fluorescent microscope using the same experimental design. In addition, DNA samples were also evaluated and compared by conventional PCR.

The full paper was published in: Journal of Economic Entomology, toaa042, https://doi.org/10.1093/jee/toaa042.

Integrating Sterile Insect Technique with the Release of Sterile Classical Biocontrol Agents for Eradication: is the Kamikaze Wasp Technique Feasible?

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Abstract

Eradication of new pests can avoid ongoing management costs. Although predominantly employed for suppression, classical biological control (CBC) may support eradication attempts, but also may cause non-target impacts in the long term. While CBC is potentially less costly than other approaches, complete eradication is difficult, especially when pests can sustain their populations at low levels. The sterile insect technique (SIT) involves the massrearing and release of sterilised insects to disrupt fecundity. This has proven to be synergistic with the release of biological control agents such as egg parasitoids. Here we describe a newly conceptualised tool, the 'Kamikaze Wasp Technique' (KWT), which uses a novel combination of CBC and SIT in an eradication to avoid impacts on non-target organisms. This technique proposes the release of sterile parasitoids, as irradiating mated female parasitoids can induce sterility without inhibiting their ability to kill the host. Future work should characterise the irradiation biology of parasitoids. *Halyomorpha halys* Stål (Hemiptera: Pentatomidae) and its natural enemy, *Trissolcus japonicus* Ashmead (Hymenoptera: Scelionidae), provide a model system for assessing the potential of the KWT.

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