Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

# Insect Pest Control Newsletter

http://www-naweb.iaea.org/nafa/index.html
http://www.fao.org/agriculture/fao-iaea-nuclear-techniques/en/

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## Contents



## To Our Readers

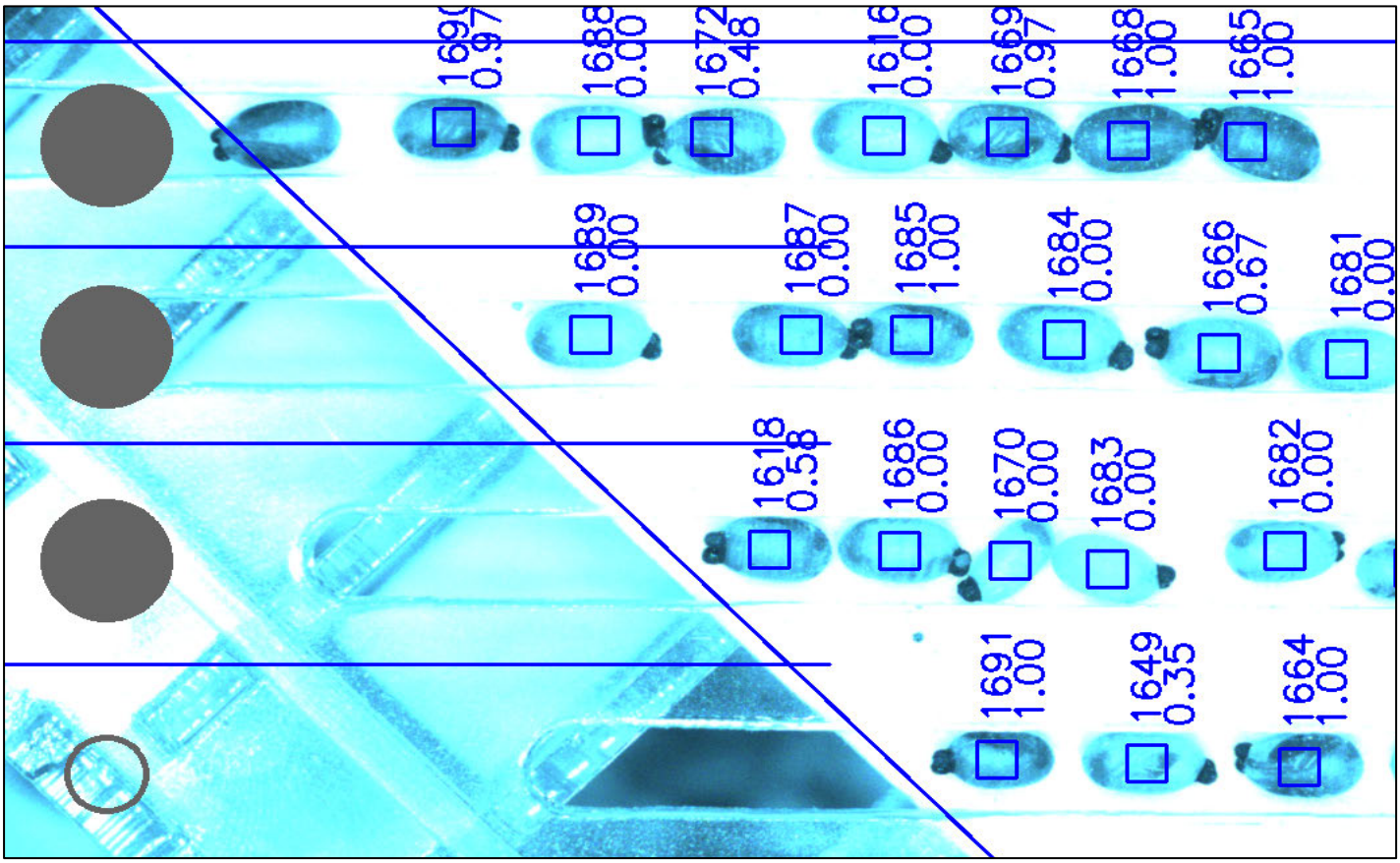



*Image obtained by the Near Infrared Pupae Sex Sorter (NIRPPS), used to assess the degree of melanization of the adult pharate inside the tsetse puparium. Melanization of the adult pharate occurs 6 to 7 days before emergence of tsetse adults, depending on the maturation temperature and species. Tsetse female pupae develop faster than males and reach the melanization point earlier than the males. The NIRPPS captures a video of the pupae under near infrared light that passes through the puparium. The pupae rotate as they move along the channel (four in the figure) under the camera, so that a set of images in every relative position is analysed for each pupa. A melanization index is then calculated in real time (numbers in the upper right side of the pupae) ranging from 0 (un-melanized pupa) to 1 (fully melanized pupa). Based on this index, the pupae will be sorted by a mechanical actuator at the end of the channel resulting in a sex separation.*

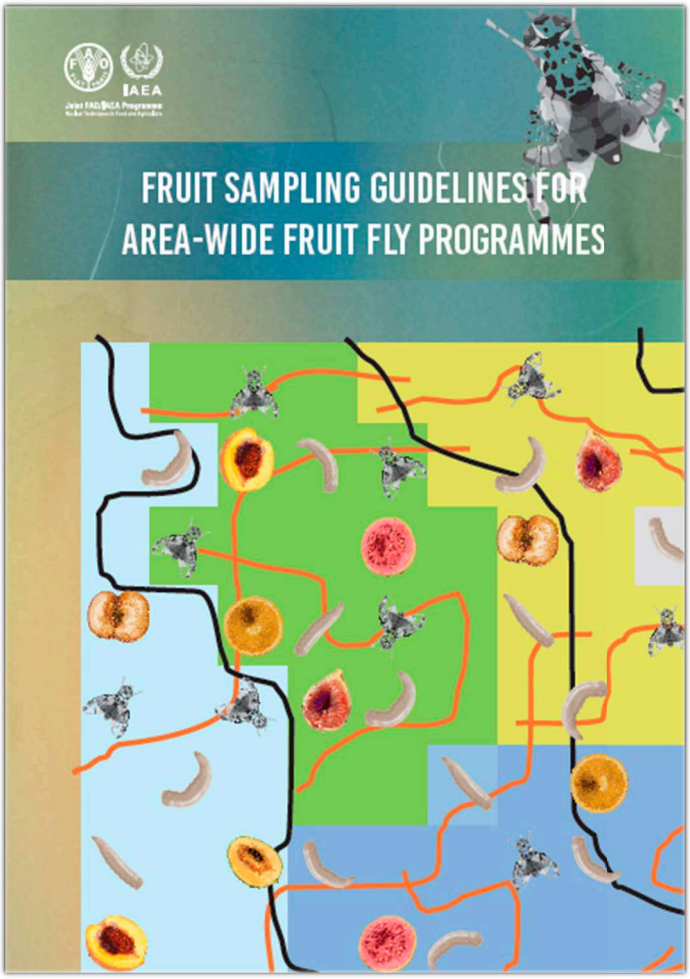
For more than 15 years, attempts have been made to develop methods to separate the sexes of tsetse pupae a few days before adult emergence. Different versions of "near infrared sex sorter devices" have been developed and tested, but the results were not consistent and satisfactory. The recent report (2016) that wing melanization inside the puparium can be made visible using near infrared was a breakthrough, as this phenomenon can be detected a few days earlier in females than males. The new sex separation device that was recently developed (see photo of the prototype being tested and additional information on page 25), allows the scrolling of the pupae whilst making several image frames for each pupa at different positions. This makes the detection of melanized wings much more accurate.

Another significant achievement was the development of the sterile insect technique (SIT) for the European grapevine moth *Lobesia botrana* and its ongoing trials in Chile. This species is an economic pest of grapes in Europe and an invasive species for Latin America. The pest attacks the vineyards and its larvae cause direct damage by feeding on grape clusters, causing yield decline. It was first detected in Chile in the Linderos area in the Metropolitan Region of the country capital, in April 2008. The pest has established in some urban areas of Chile from where it moved into the commercial grape plantations.

Given the high value of table and wine industry in Chile, the Servicio Agrícola y Ganadero (SAG), requested the IAEA support to develop the SIT for the suppression and eradication of the pest. Through the technical assistance from the Joint FAO/IAEA Division, the SIT package against this invasive pest was developed. It includes an artificial diet for mass-rearing, an effective irradiation dose for insect sterilization and a packing and release system. Field validation of the technology started in August 2019, through the IAEA technical cooperation project 'Implementing Pilot Level of Sterile Insect Technique for Control of *Lobesia botrana* in Urban Areas'. Each week, about 50 000 sterile moths are being released by ground over a suburban area of 25 hectares. Next steps include optimization of the mass-rearing and the use of drones for aerial release over the infested areas. This is an important adaptation of SIT to a new insect pest that inflicts severely economic damage to the grapevine production in Europe and is now affecting grape production in Chile and Argentina and threatening neighbouring countries, including Brazil and Peru.

We would like to announce that we have published the 'Fruit Sampling Guidelines for Area-wide Fruit Fly Programmes' (http://www.fao.org/3/ca5716en/ca5716en.pdf).

The most widely used surveillance measure for fruit fly pests is the trapping of adults by means of specific traps and attractants. But, as the adult stage represents only a small portion of the total pest population, fruit sampling becomes an important surveillance tool for population detection and monitoring. Fruit sampling also becomes an important pest detection tool in areas where sterile flies are being continuously released and where low-density trapping is kept to avoid high sterile fly recapture rates, and where traps are mainly aimed at monitoring the released sterile flies.

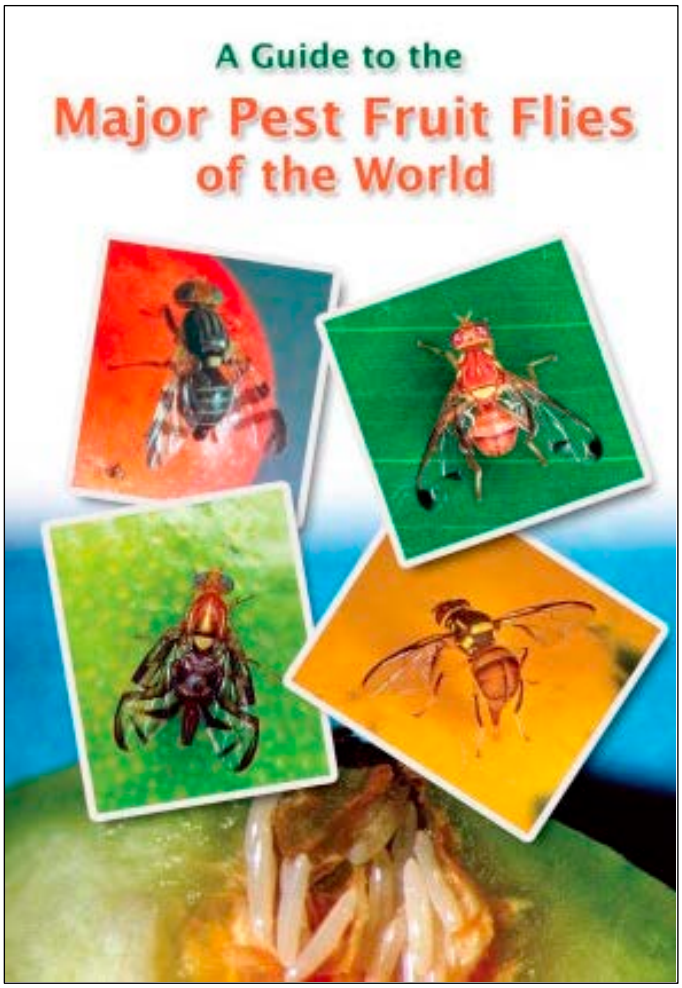



Given the large universe of fruit and vegetable hosts normally available in the field, stratification of the fruit population becomes essential to increase the probability of detection. This applies when the aim of fruit sampling is to assess the presence or absence of a pest through a detection survey, and also to evaluate the impact of suppression and eradication actions through a monitoring survey.

This guideline is aimed at facilitating the transfer of harmonized sampling procedures to National Plant Protection Organizations and horticultural industry, in FAO and IAEA Member States that want to apply fruit sampling procedures for fruit fly population surveys in area-wide action programmes.

'A Guide to the Major Pest Fruit Flies of the World' was also published and this is a very relevant instrument for the implementation of field programmes. This field guide provides a general reference for those involved in plant quarantine activities including the surveillance and management of fruit flies, and the marketing of fresh fruits which may be infested with fruit flies. Although this guide is not exhaustive, it includes the major pest fruit flies (Diptera: Tephritidae) in the world. The correct identification of fruit flies is a specialized task and specimens should be pre-

served properly and sent to fruit fly taxonomists in order to be identified to species level.




In addition, two other relevant documents were updated and made available on our website. The version 7.0 of the 'Product Quality Control for Sterile Mass-Reared and Released Tephritid Fruit Flies'. It includes a significant update of the post-production quality control of fruit flies (http://www-naweb.iaea.org/nafa/ipc/public/manuals-ipc.html).

The procedures set forth in this manual are for the most part based on published scientific findings. Otherwise recommended practices are based on many years of experience with field SIT action programmes. This is particularly important where transboundary shipment and release of sterile insects occurs. It also bolsters confidence in the production and use of sterile insects especially where private sector investment in mass-rearing facilities and fly production and release is involved.

Also, the 'Thematic Plan for the Development and Application of the Sterile Insect Technique (SIT) and Related Genetic and Biological Control Methods for Disease Transmitting Mosquitoes' was updated. This document resulted from a review of the previous mosquito thematic plan developed before the Zika crisis in 2015. It will serve as a strategic document to provide guidance on the opportunities and research gaps in fields related to the SIT and other potential tactics and strategies to control vector-borne diseases, including policy issues. The document can also be used for policy making, planning and implementation of AW-IPM approaches with a SIT component aligned with the FAO, IAEA and WHO policies and goals. The document is available online at http://www-naweb.iaea.org/nafa/ipc/public/thematic-plans-ipc.html.

Regarding publications, IPC staff participated in two papers that were published in high ranking scientific journals: (a) in Nature on 'Incompatible and sterile insect techniques combined eliminate mosquitoes', available online at https://www.nature.com/articles/s41586-019-1407-9 and (b) in Science on 'Maleness- on-the-Y (MoY) orchestrates male sex determination in major agricultural fruit fly pests' (https://science.sciencemag.org/content/365/6460/1457).

In December 2018, the United Nations General Assembly declared 2020 the International Year of Plant Health (IYPH). On 2 December 2019, the Secretariat of the International Plant Protection Convention (IPPC) launched the International Year of Plant Health (IYPH-2020, www.fao.org/plant-health-2020) during the FAO Council.


The main objective of the IYPH is to raise global awareness on how protecting plant health can help achieve the Sustainable Development Goals (SDGs) of the UN, including, end hunger, reduce poverty, protect the environment, and boost economic development.

We would also like to inform you about the progress of transition to the new IPCL. The process of relocation of all equipment and insect colonies was initiated in August 2019 and completed in November 2019, ahead of the estimated time to complete the transition, and the new IPCL is now fully operational. With this positive outcome, we expect to increase the support and services to our Member States

The 35th International Scientific Council for Trypanosomiasis Research and Control (ISCTRC) was held in Abuja, Nigeria in September 2019. At the meeting, the 70th Anniversary of the ISCTRC was commemorated and special recognition was awarded to individuals who have made outstanding contributions, in the last 10 years, towards the mission and values of ISCTRC. Among them, our colleagues from the Joint FAO/IAEA Programme for Nuclear Techniques in Food and Agriculture: Udo Feldman and Marc Vreysen. They received the award for having consistently excelled in their positions and demonstrated integrity and a strong commitment to the mission and values of ISCTRC.

***Rui Cardoso Pereira***
***Head, Insect Pest Control Section***

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# Forthcoming Events (2020)

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

Fourth RCM on Mosquito Handling, Transport, Release and Male Trapping Methods. 4–8 May 2020, Tapachula, Mexico.

Second RCM on Improvement of Colony Management in Insect Mass-rearing for SIT Applications. 11–15 May 2020, Antigua, Guatemala.

First RCM on Mosquito Radiation, Sterilization and Quality Control. 6–10 July 2020, Vienna, Austria.

Second RCM on Assessment of Simultaneous Application of SIT and MAT to Enhance *Bactrocera* Fruit Fly Management. 22–26 August 2020, Beijing, China.

Third RCM on Integration of the SIT with Biocontrol for Greenhouse Insect Pest Management. 28 September–2 October 2020, Hyderabad, India.

## II. Consultants and Expert Meetings

FAO/IAEA Consultancy Meeting on Updating the Estimation of the Economic Impact of the Tsetse and Trypanosomosis Burden (under Regional TC Project RAF5080). March 2020, Vienna, Austria.

FAO/IAEA Consultancy Meeting on Improving SIT Fruit Fly Field Programmes. 20–24 April 2020, Vienna, Austria.

## III. Other Meetings/Events

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 Coordination Meeting on "Assessing the Efficiency of the Sterile Insect Technique for the Control of the Cocoa Pod Borer" (under Regional TC Project RAS5086). 2–6 March 2020, Tarrenge, Indonesia.

Americas Congress on Fruit Flies and the 10th Meeting of the Tephritid Workers of the Western Hemisphere (TWWH). 16–20 March 2020, Bogota, Colombia.

FAO/IAEA First Regional Project 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). 16–20 March 2020, Bogota, Colombia.

FAO/IAEA Workshop on Design and Evaluation of Mosquito Population Suppression Pilot Trials including Epidemiological Analysis (under Interregional TC Project RAS5082). 23–27 March 2020, Nagasaki, Japan.

Fifteen Session of the Commission on Phytosanitary Measures, International Plant Protection Convention, FAO. 30 March–3 April 2020, Rome, Italy.

FAO/IAEA Workshop on Genetic Diversity Analysis and Colony Management. 7–9 May 2020, Guatemala City, Guatemala.

Technical Panel on Phytosanitary Treatments (TPPT), International Plant Protection Convention, FAO. 22–26 June 2020, Vienna, Austria.

XXVI International Congress of Entomology. 19–24 July 2020, Helsinki, Finland.

Second Symposium of the Tephritid Workers of Asia, Australia, and Oceania. (TAAO). 18–21 August 2020, Beijing, China.

FAO/IAEA Workshop on Mass-rearing of Lepidoptera Greenhouses Pest. 24–26 September 2020, Hyderabad, India.

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 Final Coordination Meeting of the Regional TC Project 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. Date and venue to de confirmed.

# Past Events (2019)

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

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 Training 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.

# Technical Cooperation Projects

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

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

| Country | Project Number | Ongoing National Projects | Technical Officer |
|---|---|---|---|
| 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 | BRA5060 | Using the Sterile Insect Technique to Evaluate a Local Strain in the Control of *Aedes aegypti* | Rafael Argiles |
| Burkina Faso | BKF5020 | Strengthening the Insectarium to Create Agropastoral Areas Permanently Liberated from Tsetse Flies and Trypanosomiasis | Adly Abdalla |
| 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 |
| Cuba | CUB5021 | Demonstrating the Feasibility of the Sterile Insect Technique in the Control of Vectors and Pests | Rafael Argiles |
| Ecuador | ECU5029 | Improving Integrated Fruit Fly Management in Fruit and Vegetable Production Areas | Walther Enkerlin |
| Ethiopia | ETH5021 | Enhancing Livestock and Crop Production Through Continued Consolidated and Sustainable Control of Tsetse and Trypanosomosis | Rafael Argiles |
| Fiji | FIJ5001 | Examining Options for the Management of Fruit Flies | Daguang Lu |
| Guatemala | GUA5019 | 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 |
| Mexico | MEX5031 | Using the Sterile Insect Technique to Control Dengue Vectors | Danilo Carvalho |

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| Morocco | MOR5035 | Implementing the Sterile Insect Technique in the Souss Valley | Walther Enkerlin<br>Carlos Cáceres |
| Oman | OMA5007 | Strengthening Sterile Insect Technique Based Area-wide Integrated Management of Date Palm Pests | Marc Vreysen |
| Palau | PLW5002 | Improving the Quantity and Quality of Fruits for Exportation and Domestic Consumption Through Area-wide Integrated Pest Management of *Bactrocera* Fruit Flies in Tropical Fruit and Vegetable Production Areas (Phase II) | Daguang Lu |
| Papua New Guinea | PAP5001 | Supporting a Feasibility Study on Using the Sterile Insect Technique against the Cocoa Pod Borer | Marc Vreysen |
| Philippines | PHI5033 | Building Capacity in Using the Sterile Insect Technique against Dengue and Chikungunya Vectors | Wadaka Mamai |
| Senegal | SEN5037 | Supporting the National Programme to Control Tsetse and Trypanosomosis | Marc Vreysen<br>Rafael Argiles |
| South Africa | SAF5014 | Assessing the Sterile Insect Technique for Malaria Mosquitos in a South African Setting, Phase II | Hanano Yamada |
| 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 |
| Seychelles | SEY5009 | Suppressing Melon Fruit Fly Species through Environment-Friendly Techniques to Enhance Food Security | Rui Cardoso Pereira |
| Sri Lanka | SRL5047 | Establishing a National Centre for Research, Training and Services in Medical and Molecular Entomology for Vector-borne Disease Control | Kostas Bourtzis |
| Sudan | SUD5038 | Implementing the Sterile Insect Technique for Integrated Control of *Anopheles arabiensis*, Phase II | Adly Abdalla |
| 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 |
| 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 |

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| | | **Ongoing Regional Projects** | |
| Regional Africa | RAF5074 | Enhancing Capacity for Detection, Surveillance and Suppression of Exotic and Established Fruit Fly Species through Integration of Sterile Insect Technique with Other Suppression Methods | Daguang Lu |
| Regional Africa | RAF5080 | Supporting Area-wide Tsetse and Trypanosomosis Management to Improve Livestock Productivity - Phase IV | Rafael Argiles |
| Regional Asia (ARASIA) | RAS5076 | Harmonizing and Strengthening Surveillance Systems to Prevent and Control Exotic and Native Fruit Flies Including the Use of the Sterile Insect Technique | Walther Enkerlin<br>Adly Abdalla |
| Regional Asia | RAS5082 | Managing and Controlling *Aedes* Vector Populations Using the Sterile Insect Technique | Marc Vreysen<br>Hamidou Maiga |
| Regional Europe | RER5022 | Establishing Genetic Control Programmes for *Aedes* Invasive Mosquitoes | Jeremy Bouyer |
| Regional Latin America (ARCAL) | RLA5070 | Strengthening Fruit Fly Surveillance and Control Measures Using the Sterile Insect Technique in an Area-wide and Integrated Pest Management Approach for the Protection and Expansion of Horticultural Production (ARCAL CXLI) | Walther Enkerlin |
| 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<br>Rui Cardoso Pereira |
| Regional Latin America | RLA5075 | Strengthening the Regional Capacities in the Prevention and Progressive Control of Screwworm | Walther Enkerlin |
| | | **Ongoing 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<br>Rui Cardoso Pereira |

| | | New National Projects to Start in 2020 | |
|---|---|---|---|
| Brazil | BRA5061 | Using the Sterile Insect Technique to Apply a Local Strain in the Control of *Aedes aegypti* (Phase II) | Rafael Argiles |
| Cambodia | KAM5006 | Implementing Fruit Fly Surveillance and Control Using Area-wide Integrated Pest Management | Daguang Lu |
| China | CPR5026 | Applying the Sterile Insect Technique as Part of an Area-wide Integrated Pest Management Approach to Control Two Fruit Flies | Daguang Lu |
| 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<br>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 |
| 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<br>Carlos Cáceres |
| Palau | PLW5003 | Facilitating Sustainability and Ensuring Continuity of Area-wide Pest Management — Phase III | Daguang Lu |
| South Africa | SAF5017 | Assessing the Sterile Insect Technique for Malaria Mosquitoes — Phase III | Hanano Yamada |

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| Senegal | SEN5040 | Strengthening National Capacities to Create a Tsetse-Free Zone Using the Sterile Insect Technique | Marc Vreysen |
| 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 |
| Turkey | TUR5026 | Conducting a Pilot Program on Integrated Management of *Aedes aegypti* Including Sterile Insect Technique | 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 |
| 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 |
| | | **New Regional Projects to Start in 2020** | |
| Regional Asia & the Pacific | RAS5090 | Advancing and Expanding Area-wide Integrated Management of Invasive Pests, Using Innovative Methodologies Including Atomic Energy Tools | Walther Enkerlin |
| Regional Asia & the Pacific | RAS5086 | Assessing the Efficiency of the Sterile Insect Technique for the Control of the Cocoa Pod Borer | Marc Vreysen |
| Regional Europe | RER5026 | Enhancing the Capacity to Integrate Sterile Insect Technique in the Effective Management of Invasive Aedes Mosquitoes | Jeremy Bouyer |
| Regional Latin America | RLA5082 | Strengthening Food Security through Efficient Pest Management Schemes Implementing the Sterile Insect Technique as a Control Method | Walther Enkerlin |
| Regional Latin America | RLA5083 | Enhancing Capacity for the Use of the Sterile Insect Technique as a Component of Mosquito Control Programs | Hanano Yamada<br>Rui Cardoso Pereira |

# Highlights of Technical Cooperation Projects

## Implementing the Sterile Insect Technique in the Souss Valley (MOR5035)

Morocco exports annually around 500 000 tons of citrus, mainly to Europe and Russia. Most of the exported citrus (75%) is produced in the Souss Valley in southern Morocco. Although there is potential to double this exported amount, the presence of the Mediterranean fruit fly makes this challenging.

*The Mediterranean fruit fly mass-rearing facility in Agadir, Morocco is under construction.*

The Minister of Agriculture of Morocco, the National Office for Food Safety (ONSSA), the Regional Office of Agriculture in the Souss Valley and the fruit industry have an agreement to establish an area-wide sterile insect technique (SIT) programme against Mediterranean fruit fly in the Agadir region. First step is to build a Mediterranean fruit fly mass-rearing facility and a fly emergence and release facility large enough to produce and handle sterile males to cover the entire Souss Valley (40 000 ha of citrus). The Joint FAO/IAEA Division has assisted with the design of the mass-rearing and the fly emergence and release facility that has the capacity to produce initially 100 million sterile males per week, but with the perspective to eventually produce 300 million sterile males per week. Construction of the mass-rearing facility is currently in the final phase. The shell of the building has been completed and the final phase that comprises the installation of all equipment and services is currently ongoing. It is expected that the building will be finalized in the first quarter of 2020. The Joint FAO/IAEA Division will continue to provide technical assistance to facilitate the commissioning and acceptance of the buildings.

## Enhancing Capacity for Detection, Surveillance and Suppression of Exotic and Established Fruit Fly Species through Integration of Sterile Insect Technique with Other Suppression Methods (RAF5074)

**Regional Training Course on Modern Taxonomy and Identification Tools of Fruit Fly Species in Africa. 23–27 September 2019, Cotonou, Benin.**

The training course was organized by the University of Abomey-Calavi, in collaboration with the International Institute of Tropical Agriculture (IITA), both based in Cotonou, Benin. Fourteen participants from ten different African countries (Benin, Eswatini, Madagascar, Mauritius, Mozambique, Namibia, Nigeria, Uganda, Zambia, Zimbabwe) attended the training course.

The training focused on aspects related to proper and accurate identification of fruit flies of economic significance in Africa, including morphological and molecular approaches. An unambiguous and correct identification of any pest species is considered essential for any subsequent monitoring, suppression or eradication activities, as well as for the development of relevant research activities addressing different ecological and applied aspects. The objective of the course was, therefore, to provide the participants with basic taxonomic knowledge of the target group (tephritid fruit flies), and to have hands-on training in the use of modern taxonomy and identification tools.

*Participants of the Regional Training Course on Modern Taxonomy and Identification Tools of Fruit Fly Species in Africa (Cotonou, Benin).*

The training programme comprised theoretical modules on morphological terminology, introduction to the family of tephritid fruit flies and the most important genera and species of economic importance, larvae and adult fruit fly surveillance methodologies, the use of online and offline taxonomic resources, the technique of molecular identification through DNA barcoding, and the importance of proper handling of reference material, including development of associated databases and reference specimen and image

collections. This was supplemented with practical sessions on the use of fruit fly identification tools, proper preservation and imaging, as well as field work (for trapping methodologies) and visits to molecular laboratory and biotaxonomic research collections of the IITA Biodiversity Centre. In addition, lectures were provided touching on more general topics such as diversity and distribution of fruit flies in Africa, biological control, and fruit fly species and host plant relationships.

*Practical exercises on fruit fly identification during the Regional Training Course on Modern Taxonomy and Identification Tools of Fruit Fly Species in Africa (Cotonou, Benin).*

**Regional Training Course on Area-wide Integrated Fruit Fly Management including Sterile Insect Technique (SIT) and Male Annihilation Technique (MAT) in Africa and Indian Ocean. 07–11 October 2019, Reduit, Mauritius.**

*Participants of the Regional Training Course on Area-wide Integrated Fruit Fly Management including Sterile Insect Technique (SIT) and Male Annihilation Technique (MAT) in Africa and Indian Ocean (Reduit, Mauritius).*

The regional training course that was hosted by the University of Mauritius and organized by the Entomology Division, Ministry of Agro Industry and Food Security, was attended by 28 participants from 13 countries, i.e. Botswana, Burundi, Eswatini, Ghana, Kenya, Mauritius, Mozambique, Senegal, Seychelles, Sudan, Tunisia, Zambia and Zimbabwe.

The lecturers were Mr Marc De Meyer from the Royal Museum for Central Africa, Belgium and Ms M. Alleck from the Entomology Division of the Ministry of Agro Industry and Food Security, Mauritius. There were both theory and practical sessions. The topics covered included: fruit fly taxonomy, biology and ecology, fruit fly trapping, larval surveillance, fruit fly control using MAT, BAT, biocontrol by using parasitoids, sanitation and SIT. The participants had the opportunity to conduct a hands-on exercise by releasing sterile *Zeugodacus cucurbitae* and *Bactrocera dorsalis* in the field using paper bags.

*A participant of the Regional Training Course on Area-wide Integrated Fruit Fly Management including Sterile Insect Technique (SIT) and Male Annihilation Technique (MAT) in Africa and Indian Ocean is releasing sterile flies in the field using paper bags (Reduit, Mauritius).*

## Strengthening the Regional Capacities in the Prevention and Progressive Control of Screwworm (RLA5075)

**Regional Training Course on New World Screwworm (NWS) Epidemiology and Population Genetics. 7–11 October 2019, Porto Alegre, Rio Grande do Sul, Brazil.**

The training course was organized in conjunction with the Ministerio da Agricultura, Pecuaria e Abastecimento (MAPA) of Brazil. The course director on behalf of MAPA was Mr Jorge Caetano Junior.

The objective of the training course was to train professional staff in the diagnostics, epidemiology, control and basic population genetics of new world screwworm (NWS). The course consisted of a well-balanced programme that included lectures and practical field exercises. Participants had the opportunity to experience the NWS surveillance and control practices being applied in Brazil.

With this, the national capacities of the veterinary services of the Member States were strengthened, for timely detection of NWS cases and effective eradication of outbreaks in

pest free zones and management of populations in regions where the pest is established.

*Participants to the Regional Training Course on New World Screwworm (NWS) Epidemiology and Population Genetics (Porto Alegre, Rio Grande do Sul, Brazil).*

Participants were professional staff from countries participating in the regional project, including, from South America: Argentina, Bolivia, Brazil, Ecuador, Paraguay, Peru and Uruguay, from Central America: Honduras, Nicaragua, Panama, and from the Caribbean: Dominican Republic.

## Virtual Course on New World Screwworm (NWS), *Cochliomyia hominivorax*: Update on New Surveillance and Eradication Tools

In Argentina, at the Servicio Nacional de Sanidad y Calidad Agroalimentaria's (SENASA) virtual classroom, a virtual course was conducted as part of the activities of the International Atomic Energy Agency (IAEA) Regional Project RLA5075 entitled "Strengthening the Regional Capacities in the Prevention and Progressive Control of Screwworm".


The objective of the training was to offer knowledge on the epidemiology of the myasis caused by the New World Screwworm (NWS), *Cochliomyia hominivorax*, as well as the sanitary actions that can be applied by the Veterinary Services of the countries to reduce its impact, in the countries where the pest is endemic and present as well as in the countries where the pest has been eradicated and it is absent.

Course participants included 33 veterinarians and animal husbandry professionals from 10 countries in Latina America and the Caribbean: Bolivia, Colombia, Costa Rica, Ecuador, El Salvador, México, Perú, Dominican Republic and Uruguay, in addition to professionals from SENASA, Argentina.

The programme of the course was composed of 4 modules. Each module was covered in one week. Students learned through the materials available on the e-learning course including main reading materials as well as complementary materials. At the end of each module, students were evaluated through a quiz.

During the development of each weekly module, participants interacted with the professor and a tutor through consultation forums and privately through the communication network of SENASA's virtual classroom.

## Second Coordination Meeting on Strengthening the Regional Capacities in the Prevention and Progressive Control of Screwworm. 25–29 November 2019, Medellín, Colombia.

The meeting was organized in collaboration with the Instituto Colombiano Agropecuario (ICA). Delegates from 18 countries participated in the meeting: Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, México, Nicaragua, Panamá, Paraguay, Perú, Uruguay, and the USA.


*Participants of the Second Coordination Meeting of the Technical Cooperation Project RLA5075 (Medellin, Colombia).*

Progress made during the past two years was reviewed including the outputs that were produced as well as activities which remain pending. Relevant outputs include: (1) At least 50 veterinary doctors trained in New World screwworm (NWS) surveillance, emergency response and control methods; (2) increase in the number of countries with obligatory notification for NWS; (3) preparation and adoption of manuals for NWS sampling; (4) assessment of the geographical distribution of NWS in some of the countries; (5) mating compatibility studies between the mass-reared strain and the Peru wild population; (6) availability of 477 samples from NWS populations in Argentina, Brazil, Uruguay for DNA sequencing; (7) development of an e-learning course on NWS surveillance, diagnostics and control jointly with

Servicio Nacional de Sanidad y Calidad Agroalimen-taria (SENASA); (8) preparation of a strategic plan for NWS eradication from Argentina, Brazil and Uruguay subregion and (9) preparation of an economic feasibility study for NWS eradication from the above mentioned sub-region.

The work plan for 2020, which is the last year of the project, was discussed and agreed. The activities will focus on training through the implementation of drills to respond to NWS outbreaks in pest free zones, on further generating baseline information for an NWS intervention in suitable sites and on outreach activities to further engage the livestock industry and decision makers of the veterinary services of the countries.

## Demonstrating the Feasibility of the Sterile Insect Technique in the Control of Vectors and Pests (CHD5007)

The second Stakeholders Coordination Meeting on the Campaign Against Tsetse Flies and Trypanosomoses in Chad was held in Moundou from 7–9 November 2019. The project in Chad aims at sustainably eliminating the tsetse flies in Mandoul. This location is one of the few active sleeping sickness foci in the country. In the framework of the initiative by the World Health Organization (WHO) to eliminate the Gambiense Human African Trypanosomosis (gHAT) by 2030, the national institutes in the Ministry of Health (Plan National de Lutte contre les Trypanosomoses Humaines Africaines, PNLTHA) and Ministry of Livestock (Institut de Recherche en Elevage pour le Development, IRED) have joined forces with international partners to eliminate the tsetse fly *Glossina fuscipes fuscipes,* the only cyclical vector of HAT in Mandoul using the sterile insect technique (SIT) as the final component. Entomological baseline data collection and genetic population analysis have demonstrated that the population of tsetse flies in Mandoul is isolated. The wild population of tsetse flies has been suppressed to extremely low levels through the deployment of tiny targets, thanks to the support of international partners (programme Trypa-NO).

The counterpart has built a field insectary at the premises of the University of Doba that has been equipped under the Technical Cooperation project. Vectorial competence studies conducted at the Institut de Recherche pour le Dévelopement (IRD, France) indicate that the sterile males fed with trypanocydal drugs before release cannot transmit the parasites. Future releases of sterile flies will be done by air using drones, for which the authorisation from the Ministry of Defence has already been obtained. Staff at the IRD and PNLTHA have received specific training on all the components of a SIT project, including mass-rearing and release of sterile flies, trypanosomes identification through PCR, geographic information systems and entomological dissections.

## Supporting Area-wide Tsetse and Trypanosomosis Management to Improve Livestock Productivity - Phase IV (RAF5080)

### Regional Training Course on Tsetse Dissections. 7–11 October 2019, Accra, Ghana.

This training course on tsetse dissections was organised in cooperation with the Government of Ghana through the Ghana Atomic Energy Commission (GAEC) at the request of the Member States during the last Pan-African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC) Coordinators Meeting.

*Tsetse female reproductive system showing the ovaries, the spermatheca and the uterus (Accra, Ghana, photo credit: Stephen Leak).*

Eleven participants from eight African tsetse-infested countries attended the training that included theoretical and practical dissection sessions. After the training course, the participants were capable of identifying tsetse species and groups, determining the females physiological age by dissection, determining abortions in females, determine the males age by wing fray analysis, determine the mating status by analysis of spermathecae and determine the feeding status of the flies.

### Regional Training Course on Tsetse Pupae Sex Sorter. 2–6 December 2019, Seibersdorf, Austria.

The aim of this training course was to train key staff of the main African tsetse mass-rearing facilities on the operation of the new Near Infrared Pupae Sex Sorter. This recently developed machine (see details on page 25) allows sex identification and sorting of pupae 6-7 days before adult emergence, resulting in a reduction of workload and improvement of quality of the sterile tsetse flies. It also allows long distance shipment of sterile male pupae at ambient

temperatures, leading to an increase of quality of the sterile males. Ten participants, two from each of the mass-rearing facilities of Kality (Ethiopia), IBD and CIRDES (Burkina Faso) and four fellows at the moment under training at Insect Pest Control Laboratory in Seibersdorf were trained in the operation, calibration and maintenance of this device.


*Participants of the Regional Training Course on Tsetse Pupae Sex Sorter (Seibersdorf, Austria).*

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

### Regional Training Course on Communication within SIT Mosquito Projects. 7–11 October 2019, Procida, Italy.

Mosquito-borne diseases are causing growing concerns globally. The Regional Technical Cooperation project (RER5022) is supporting European Member States with the transfer and application of the SIT against invasive mosquito species by supporting cooperation and networking among participating countries already affected, or at high risk of being affected, by invasive mosquito species that transmit diseases including chikungunya, dengue, Zika and yellow fever. The stakeholder engagement is also critical in area-wide integrated vector management of mosquitoes with a SIT component.

The Government of Italy, through the Università degli Studi di Napoli Federico II, hosted the FAO/IAEA Regional Training Course. The main goal was to train the participants on the method "Communication for Behavioural Impact (COMBI)" in order to improve social mobilization in SIT application. For more information on COMBI visit: https://www.who.int/ihr/publications/combi_toolkit_outbreaks/en/.

In summary, the COMBI is a method allowing carefully planned and monitored social mobilization directed at the task of mobilizing all societal and personal influences on an individual and family to prompt individual and family action with respect to specific healthy behaviours. In summary, the COMBI is an interagency (FAO, UNICEF, WHO) toolkit for behavioural and social communication in outbreak response. It will be useful for anyone wanting to design effective outbreak prevention and control measures in community settings. Therefore, this method is relevant for SIT programmes since social mobilization is a key factor in the success of *Aedes* mosquito control strategies and in preventing outbreaks.

*Participants of the Regional Training Course on Communication within SIT Mosquito Projects (Procida, Italy).*

The main goal of the training was to:

- Offer comprehensive and innovative managerial insight to planning social mobilization and communication for behavioural impact;
- Provide examples of what has and what has not worked;
- Introduce readers to the 10 steps of COMBI planning so that they can introduce this method in the preparation of their SIT pilot trials and action programmes against mosquitoes.

Participants also presented their experience of public involvement when conducting mosquito control operations in their home countries. Nine participants from Albania, Bulgaria, Cyprus, Georgia, Greece, Portugal, North Macedonia, Romania and Serbia attended the course.

## Sharing Knowledge on the Sterile Insect and Related Techniques for the Integrated Area-wide Management of Insect Pests and Human Disease Vectors (INT5155)

### Interregional Training Course on Use of the Sterile Insect and Related Techniques for the Area-wide Integrated Management of Insect Pests. 10 June–5 July 2019, Metapa de Dominguez, Chiapas, Mexico and Guatemala City/El Pino, Guatemala.

The four-week long course targeted trainees from all regions of the world to train them in developing and managing projects using nuclear and other techniques to manage insect pests that affect plants, animals and humans. The course was successfully held in Mexico and Guatemala, with 21 participants from 20 countries in Africa, Asia, Eu-

rope and Latin America, selected for the course among close to one hundred applicants. The excellent organization and hospitality both in Mexico and Guatemala are much appreciated.

*Participants of the interregional training course on Use of the Sterile Insect and Related Techniques for the Area-wide Integrated Management of Insect Pests (Guatemala City, El Pino and Retalhuleu, Guatemala and Metapa and Tapachula, Mexico).*

The course was held at the Moscamed/Moscafrut complex in Metapa, the Public Health Research Center (CRISP) in Tapachula, Chiapas, Mexico, and in Guatemala City, El Pino mass-rearing facility and Retalhuleu, Guatemala. It provided a thorough overview and training on all processes involved in the application of nuclear-related techniques within the context of area-wide integrated insect pest management programmes to managers of insect control programmes, animal/human health and plant protection officials and applied research entomologists.

The course also provided a thorough overview of radiation-induced sterility, the sterile insect technique (SIT), inherited sterility (F1 Sterility), integration of pre- and post-harvest control methodologies, compatibility of control methods, the biology, ecology, genetics and surveillance of pest insect populations subjected to control, economic analysis of area-wide programmes and reviews of major past and ongoing SIT programmes. Visits were made to three fruit fly mass-rearing and sterilization facilities, mass-production of parasitoids, rearing and releases of mosquitoes, fruit fly and parasitoids release centres, monitoring and other field operations, as well as various hands-on laboratory exercises.

At the end of the course the participants made six group presentations on case studies, to provide an opportunity for them to apply the principles learned during the course. That group exercise was successfully conducted contributing to discussions on several insect management projects and approaches presented.

## Workshop to finalize the Guidance for the Application of SIT for Mosquito Borne Diseases. 2–4 July 2019, Vienna, Austria.

When it comes to transmitting diseases among people, mosquitoes are unsurpassed in the economic and health burdens they impose. In the absence of efficient drugs or vaccines and given the need to reduce the use of insecticides, international efforts are required to develop and implement new, complementary control techniques for mosquito species such as the sterile insect technique (SIT). To help advance its development for large scale use against *Aedes* mosquitoes, a second workshop to finalize the "Guidance for the Application of SIT for Mosquito Borne Diseases", was hosted at the IAEA headquarters.

*Participants of the Workshop to Finalize the Guidance Framework Document on SIT Applied to Mosquito-Borne Diseases (Vienna, Austria).*

This guidance document will clarify most of the aspects of the SIT application against *Aedes* mosquitoes, from risk assessments to the testing of sterile male releases. It follows an initial meeting in 27 February to 1 March 2019 in Tapachula, Chiapas, Mexico, during which the purpose and contents of the guidance document were agreed upon (see our NL 93, July 2019).

The meeting participants shared the latest developments in their respective fields of expertise. Participants from the World Health Organization (WHO) provided updates on novel vector control activities being implemented in Europe, and other experts discussed the need for community engagement and cost-effectiveness in the application of the SIT. Participants visited the Insect Pest Control Laboratory in Seibersdorf, Austria to observe the recent developments in mass-rearing and irradiation of *Aedes* mosquitoes.

In addition to FAO/IAEA staff and two professionals from the WHO, 13 experts from 11 countries (China, Egypt, France, India, Italy, Kenya, Mexico, Singapore, Thailand, United Kingdom and the United States of America) attended the meeting. For detailed information, please visit the web story at: (https://www.iaea.org/newscenter/news/iaea-and-who-to-develop-a-new-framework-for-the-application-of-nuclear-techniques-against-mosquito-borne-diseases).

## 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. 14–18 October 2019, Vienna, Austria.

In June 2014, an experts' meeting was convened to develop a "Thematic Plan for the Development and Application of the Sterile Insect Technique (SIT) and Related Genetic and Biological Control Methods for Disease Transmitting Mosquitoes".

*Participants of the 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. (Vienna, Austria).*

However, soon after the experts' meeting and the publication of the thematic plan, the Zika crisis in late 2015 changed the public perception regarding mosquito-borne diseases, especially Zika which is often associated with phenomena of micro-encephalitis. Moreover, dengue incidence is increasing exponentially and since 2016, there has been no significant progress in the further reduction of global malaria cases. Consequently, more efforts to manage human disease vectors have to be undertaken, as evidenced by a surge in demand from FAO and IAEA Member States to support national campaigns for the control of these vectors.

In response to this demand, the Joint FAO/IAEA Division increased efforts towards the full development and improvement of the SIT package for the area-wide management of mosquitoes to support its Member States. This was done through a significant extrabudgetary contribution in support of research and development activities. Collaborators have also intensified their research and implementation of SIT in pilot projects against human disease vectors.

Therefore, the recent progress made on the development of the SIT package for mosquito vectors and the status of the transfer of the existing technology in view of the continuous requests by the Member States were the main drivers for reviewing the existing Thematic Plan.

During the meeting, future research and development needs were identified, including requirements for the development and fine-tuning components of the mosquito SIT package as well as the implementation of field projects. The revised document should then be used for policy making, planning and implementation of AW-IPM approaches with a SIT component aligned with the FAO, IAEA and WHO policies and goals.

The document is available online at: http://www-naweb.iaea.org/nafa/ipc/public/thematic-plans-ipc.html.

## Decision Makers Workshop on the Use of the SIT. 27–29 November 2019, Guangzhou, Guangdong, China.

Mosquito-borne diseases represent a major threat to human kind. Recently, the incidence of malaria has stopped decreasing while that of dengue is increasing exponentially. The World Health Organization (WTO) stresses the urgent need for alternative mosquito control methods, including the sterile insect technique (SIT), which has seen significant developments recently.

The Sun Yat-Sen University hosted a Decision Makers Workshop on the use of SIT against mosquitoes. The purpose of the event was to discuss with decision makers requirements towards incorporating the environment-friendly sterile insect technique (SIT) among the national tools for mosquito control. The decision makers were informed on all the steps towards the full implementation of the SIT, including feasibility studies, implementation of pilot projects and all requirements for implementation of an operational action programme.

As with plant and livestock pests, the implementation of the SIT for vector control is challenging, management intensive and a phased conditional approach is therefore recommended to minimize the risks of failure. The phased-conditional approach developed by FAO/IAEA was presented, including a series of go/no-go criteria. The joint "Guidance Framework for Testing the Sterile Insect Technique (SIT) as a Vector Control Tool against Aedes-Borne Diseases" developed by IAEA and WHO in 2019 was also presented. This guidance covers all processes for decision support—including risk assessment and regulatory aspects, technical aspects (e.g., insect mass rearing), entomological and epidemiological indicators, as well as community involvement, cost-effectiveness and programme monitoring and evaluation.

The meeting also included a one day visit to the Wolbaki mosquito rearing facility and the field sites where *Aedes albopictus* was successfully suppressed by the release of sterile males.

# 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<br>Carlos Cáceres |
| D4.10.27 | Assessment of Simultaneous Application of SIT and MAT to Enhance *Bactrocera* Fruit Fly Management (2019–2024) | Carlos Cáceres<br>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 |

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

The sterile insect technique (SIT) is more efficient when integrated with other suppression methods. So far, the integration of SIT with the male annihilation technique (MAT) has been used only sequentially for *Bactrocera* species. The MAT is used first to reduce the male population, followed by the release of sterile insects after the removal of the MAT blocks. However, the simultaneous use of both methods could significantly increase the effectiveness of fruit fly suppression and eradication.

The simultaneous use of MAT and SIT may be compromised by elimination of sterile males to MAT formulations. However, studies on multiple *Bactrocera* species showed that pre-release exposure of sterile males to semiochemicals dramatically reduces their response to lures formulations used for the implementation of the MAT. This results in "male replacement": sterile males will remain in the field while their wild counterparts are removed by MAT.

Bactrocera *flies respond to strong synthetic lures such as methyl eugenol used for MAT. The objective of this CRP is the simultaneous application of SIT and MAT.*

Furthermore, it has been shown that feeding on semiochemicals [e.g., methyl eugenol (ME), raspberry ketone] significantly increases male activity, improves male mating success, and accelerates sexual development of some *Bactrocera* species.

The CRP objective is to explore the potentially synergistic relationship between MAT and SIT when applied simultaneously to dramatically improve the efficacy of *Bactrocera* fruit fly management. The assessment of semiochemicals to enhance *Bactrocera* spp. SIT application against these pest fruit flies will include:

1. Assessment of the effect of exposure of major *Bactrocera* pest species to semiochemicals on earlier sexual maturation and improved male sexual performance, as well as reduced response of exposed sterile males to MAT traps.
2. Evaluation of key parameters in large field cages such as wild fly sex ratio, degree of lure response of sterile flies, sterile:wild over-flooding ratio and bisexual release to determine their influence on the effectiveness of simultaneous MAT and SIT.
3. Field evaluation of simultaneous MAT and SIT within a pilot or operational setting that includes compatible management practices.

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

*Participants of the first RCM on "Generic Approach for the Development of Genetic Sexing Strains for SIT Applications" (Vienna, Austria).*

The First Research Coordination Meeting was held in Vienna International Centre, Vienna, Austria. The meeting was attended by 22 scientists from Argentina, Australia, Cameroon, Canada, China, Czech Republic, France, Germany, Greece, Guatemala, Israel, Italy, Mexico, Switzerland, Thailand, United Kingdom and United States of America. In addition, ten observers from Germany, Greece, Israel, Italy, Netherlands, Thailand and United States of America attended the meeting.

Twenty-three scientific presentations on several genetic, genomic and molecular methods were presented. Such methods would allow us to identify suitable selectable markers to be used in the development of high-throughput insect genetic sexing. There were several presentations about sex determination pathways of insect pests and disease vectors targeted by sterile insect technique (SIT) applications. During the meeting there was thorough discussion and exchange of ideas resulting in concrete work plan for the next 18 months and for the 5 years CRP, for achieving the three main objectives of the CRP: (a) the isolation of selectable markers to be used for generic strategies for the construction of genetic sexing strains (GSS); (b) the development of generic approaches for the construction of GSS for SIT targeted agricultural pests and human disease vectors and (c) the evaluation at small-scale of the GSS strains developed with the generic approaches (for both agricultural pests and human disease vectors).

## Third RCM on *Improved Field Performance of Sterile Male Lepidoptera to Ensure Success in SIT Programmes*. 17–25 October 2019, Mendoza, Argentina

The "Instituto de Sanidad y Calidad Agropecuaria Mendoza" (ISCAMEN) hosted the Third RCM on "Improved Field Performance of Sterile Male Lepidoptera to Ensure Success in SIT Programmes". The RCM was attended by 30 participants and observers from Argentina, Bangladesh, Canada, Chile, China, India, Israel, Mauritius, New Zealand, South Africa, and the USA.

*Participants of the third RCM on "Improved Field Performance of Sterile Male Lepidoptera to Ensure Success in SIT Programmes" (Mendoza, Argentina).*

During the first two days of the RCM, the participants made oral presentations and presented their research activities of the last 18 months and how these were aligned with the objectives of the CRP. During the last two days of the RCM, the research activities for the next 18 months were discussed, refined and agreed upon in 2 working groups by

insect species (1) false codling moth, codling moth, oriental fruit moth group, and sugar cane moths (2) *Lobesia botrana* and other Lepidoptera.

On Wednesday 23 October 2019, a field visit was organised to the Santa Rosa Mediterranean fruit fly mass-rearing facility of Mendoza (morning), where the participants could view the entire mass-rearing process and preparations for the releases. In the afternoon, a visit was organised to an airstrip, where the chilled adult release of Mediterranean fruit fly was demonstrated. In addition, a new release device for the release of *L. botrana* from a drone was likewise presented and demonstrated.

*Drone releasing sterile* Lobesia botrana *from a newly developed release device.*

## Workshop on the Development of a Guideline for the Post Production Handling of Sterile Moths. 17–19 October 2019, Mendoza, Argentina.

The participants of the workshop (Des Conlong, Evan Esch, Rachael Horner, Gustavo Taret, Hernan Donoso) continued to develop the guideline based on the outline and initial draft prepared during the previous workshop in Palmerstone North, New Zealand. The following topics were addressed: routine quality control tests, periodic quality control tests, ancillary tests, irradiation, dosimetry, and packing/shipping procedures. The document will be edited and sent out for peer review, before posting on the Insect Pest Control website.

## Final 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

The RCM was attended by 24 scientists from Argentina, Australia, China, Germany, Greece, Guatemala, Italy, Mexico, Panama, Thailand and United States of America. Twenty scientific papers and related presentations were presented with an emphasis on rearing efficiency and male mating competitiveness, which are critical parameters as concerns the quality of male-only strains and covered the following topics: (a) the development and/or refinement of male-only strains; (b) the quality of sterile males produced by classical genetic, transgenic or symbiont-based technologies with respect to their rearing efficiency and competitiveness and (c) studies related to the genetic stability of strains and potential horizontal gene transfer phenomena.


*Participants of the final RCM on "Comparing Rearing Efficiency and Competitiveness of Sterile Male Strains Produced by Genetic, Transgenic or Symbiont-based Technologies" (Adelaide, Australia).*

During the meeting, the participants also visited the new mass-rearing facility of Queensland fruit fly, *Bactrocera tryoni* in Port Augusta, South Australia which has the capacity to produce 50 million sterile flies per week. These sterile flies are used for sterile insect technique applications to protect the agricultural production and keep the Queensland fruit fly free status of South Australia state. In addition, the participants also discussed the plans for the publication of a special issue in a peer-review scientific journal which will consist of scientific papers summarizing the main results and achievements of this CRP.

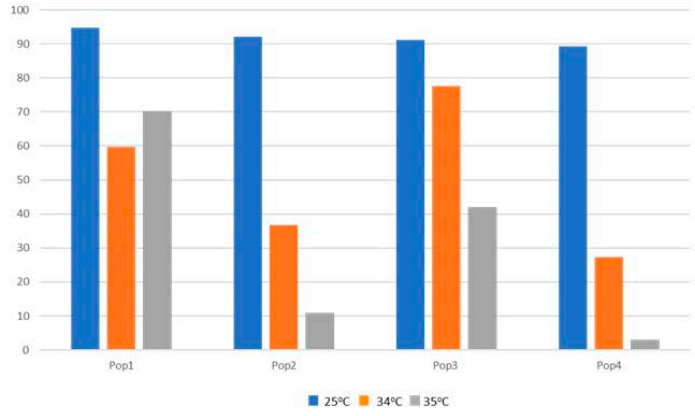
# Developments at the Insect Pest Control Laboratory (IPCL)

## Genetics and Molecular Biology

### Evaluation of the *tsl* Phenotype in Various *Ceratitis capitata* Strains

The second-generation genetic sexing strain (GSS) of the Mediterranean fruit fly *Ceratitis capitata* was based on the discovery of a *temperature-sensitive lethal* (*tsl*) mutation that resulted in males emerging from brown pupae and being resistant to elevated temperatures (34–35 °C), and females emerging from white pupae and being sensitive to elevated temperatures. The sensitivity of females is expressed at the early embryonic stage which provides an opportunity to kill female embryos before hatching by exposing 24-h-old eggs at 34–35 °C for 24 h.

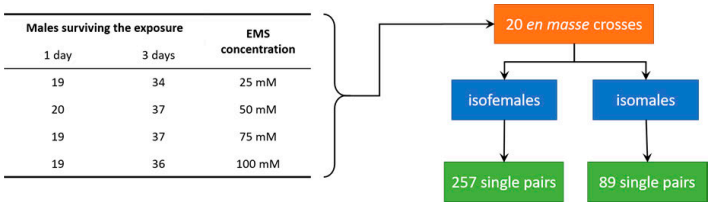
Towards an effort to characterize the *tsl* phenotype in various Mediterranean fruit fly populations, we applied the standard '*tsl*' test in different Mediterranean fruit fly strains currently reared in the IPCL. Egg hatch was measured at 25 °C, 34 °C and 35 °C. Three replicates were performed per day, on three consecutive days for each one of the four populations tested. The figure below shows the egg hatch rates at the different temperature treatments applied. Interestingly the populations presented variation at elevated temperatures. Although the *tsl* mutation is known for having a certain degree of variability, further experiments are required to shed light on the variation noticed in our study.




*Egg hatch (%) of different laboratory Mediterranean fruit fly populations.*

### An EMS Mutagenesis Screen for the Isolation of Selectable Markers to be Used in the Construction of *Aedes aegypti* Genetic Sexing Strains.

The identification of selectable markers is a prerequisite for the development of a genetic sexing strains (GSS) using classical genetics. Such a GSS should include markers that allow for sex separation since their inheritance is linked to the sex (wild type phenotype linked to males, mutant phenotype to females). These selectable genetic markers could be visible mutations or conditionally lethal mutations. The isolation of such mutations can be facilitated by exposing the insect population to mutagenic factors that induce random mutations in the genome such as irradiation or chemical substances (ethyl methanesulfonate-EMS). We are reporting here the application of EMS to *Aedes aegypti* mosquitoes aiming to identify and characterize novel selectable markers. Male mosquitoes were divided into two age groups (1 and 3 days after emergence) and each group was offered an adult-feeding sugar solution for 24h that contained different EMS concentrations (25, 50, 75 and 100 mM). Surviving males from each group were crossed with virgin females from the same strain and batch.




*Schematic flow chart of ethyl methanesulfonate EMS exposure to establish single pair families.*

The offspring was then sex-separated to set up male and female isofamilies. A total of 257 single pair crosses for the isofemale group and 89 for the isomale group were set up (see below figure). The table shows the summary of the single pair crosses that resulted in established lines. These lines will be screened for selectable markers at different life stages, including also screening for temperature sensitive lethal phenotypes.

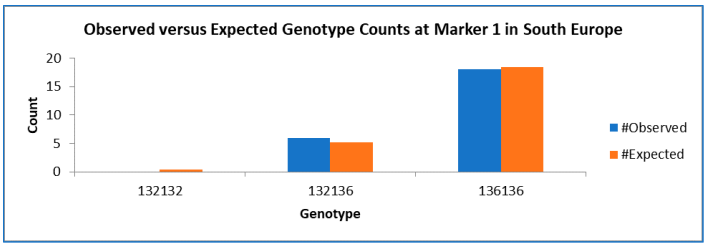
*Number of single pair crosses for each ethyl methanesulfonate EMS concentration by age of exposure*

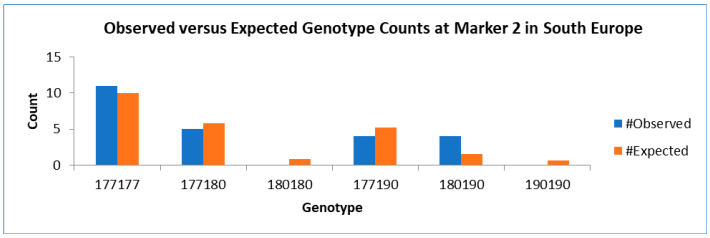
| EMS Concentration | Isofemales | | Isomales | |
|---|---|---|---|---|
| | 1 day | 3 days | 1 day | 3 days |
| 25 mM | 63 | 126 | 37 | 0 |
| 50 mM | 38 | 0 | 43 | 1 |
| 75 mM | 78 | 0 | 0 | 2 |
| 100 mM | 15 | 0 | 0 | 0 |

### Analysis of *Drosophila suzukii* Genetic Variability in European Countries Using Microsatellite Markers

First records of *Drosophila suzukii* in North America date back to 2008. In Europe, this fly was first recorded in Spain in the autumn of 2008 and in North Italy in 2009. By late 2010, *D. suzukii* had colonized the Western and Eastern USA, Canada, and most of the Mediterranean region. Latest records report the presence of this pest in additional countries such as Austria, UK, Belgium, Germany, Hunga-

ry, Romania Turkey, Ukraine, Brazil, Chile, Argentina and Uruguay.




*Allele frequencies observed and expected of* Drosophila suzukii *markers 1 and 2 used in the study.*

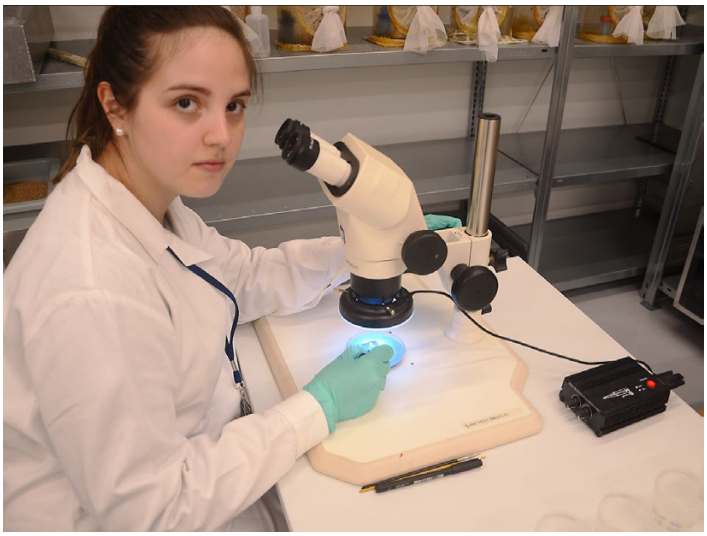
Field-collected samples of *D. suzukii* from several European locations were analysed on the basis of polymorphism of eight microsatellite loci. Microsatellites are particularly informative in the study of recent population phenomena, such as biological invasions. All the markers used in this study were located on autosomal chromosomes and have been characterized as substantially polymorphic. The figure below shows the different frequencies observed for two markers in a population collected in southern Europe. Further analysis of all markers will show if the European populations are genetically homogenous.

## Plant Pests

### The South American fruit fly *Anastrepha fraterculus*

The South American fruit fly *Anastrepha fraterculus* is a pest that has a major impact on the fruit industry of Brazil and other countries in South America. The SIT can be an additional component to manage this pest on an area-wide basis. Significant advances in the domestication and artificial rearing have been made for *A. fraterculus* in Peru and Brazil including an artificial rearing system that allows a rapid build-up of the colony and production of larger numbers of sterile flies that could be used to satisfy the demand of pilot-programmes against this pest. However, only bisexual strains of *A. fraterculus* are being reared in South America and it is known that sterile male and female fruit fly releases are less efficient than male-only releases in introducing sterility into the target population in the field.

Therefore, a genetic sexing strain (GSS) of *A. fraterculus* has been developed at the IPCL that is based on a pupal colour dimorphism, i.e., the adult males emerge from brown pupae, whereas the females emerge from black pupae. Using this pupal colour phenotype, the females can be easily separated from the males allowing male-only releases in the field. The *A. fraterculus* GSS was developed from a laboratory population of the *A. fraterculus* morphotype 1, i.e. the population that is distributed in southern and northern Argentina. Ms Paloma Guazzelli Della Giustine, a fellow from Brazil has been assisting with an assessment of the productivity and quality control profile of the GSS. In addition, mating compatibility studies have been carried out as the new GSS strain could potentially be transferred to Brazil for releases in a pilot SIT project against this pest.



*Ms Paloma Guazzelli Della Giustine preparing* Anastrepha fraterculus *eggs and flies to set-up mating studies.*

### Spotted Wing Droshophila, *Drosophila suzukii*

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. Experiments have been carried out to develop a practical method to separate the pupae from the larval medium, and currently a method based on the washing of pupae is being assessed (see photos next column).

*Separation of pupae of* Drosophila suzukii *from the larval medium using the water washing method.*

## Irradiation dose response curves for *Bactrocera* zonata

Two visiting scientists from China, Ms Yan Liang and Ms Jingjing Wang were hosted at the IPCL to develop irradiation dose response curves for *Bactrocera zonata*. Pupae were irradiated 24 hours before adult emergence under hypoxia or normoxia conditions. The aim of this study is to assess the irradiation doses needed for induction of reproductive sterilization for the application of the SIT against this pest species.

## The FAO/IAEA/USDA project on phytosanitary treatment

Research on phytosanitary irradiation under modified atmosphere is complete for four fruit fly species. Irradiation of third instars under hypoxia and severe-hypoxia with low doses of irradiation increased the proportion of phanerocephalic pupae, pharate adults, and fully formed adults of *Anastrepha fraterculus*, *Anastrepha ludens*, *Bactrocera dorsalis*, and *Ceratitis capitata*. All third instars irradiated with high doses, including approved doses required by phytosanitary irradiation protocols, in either hypoxia or severe-hypoxia did not advance in their development and died as coarctate larvae.

Scientific data generated by the research conducted at the IPCL on phytosanitary irradiation under modified atmospheres was recently evaluated by the International Plant Protection Convention (IPPC) Technical Panel on Phytosanitary Treatments (TPPT). The findings on phytosanitary irradiation under hypoxia and severe-hypoxia against *A. fraterculus, A. ludens, B. dorsalis*, and *C. capitata* supported the TPPT decision to recommend to the IPPC Standards Committee (SC) the removal of the restriction from irradiation treatments under modified atmosphere against tephritid fruit flies. This removal can increase their applicability and facilitate agricultural trade among FAO and IAEA Member States.

Work continued to evaluate the tolerance of *Zeugodacus tau* populations to cold phytosanitary treatments below 1.67°C for 3 to 16 days using small-scale experiments. Preliminary results have shown that *Z. tau* larvae from Bangladesh, China, and India respond similarly to phytosanitary cold treatments. Interestingly, a few third instars from these *Z. tau* populations survived after either 15 or 16 days of cold treatment but failed to pupariate and did not survive to the adult stage.

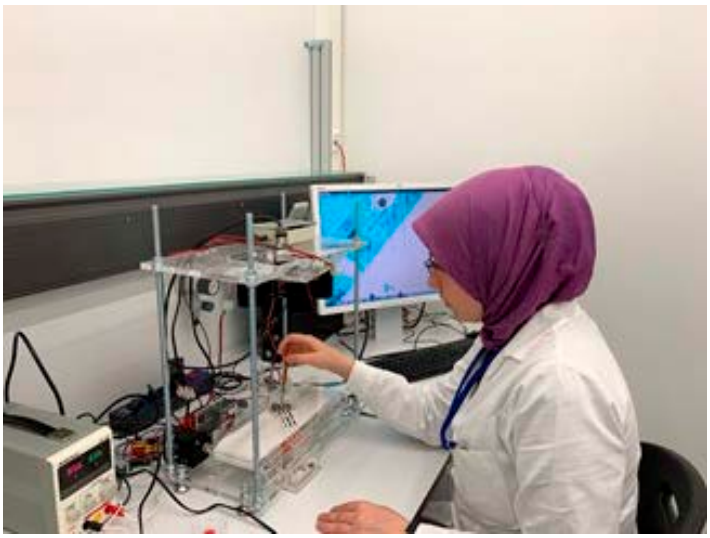
Zeugodacus tau *female infesting a navel orange in a laboratory cage for phytosanitary cold treatment research.*

A manuscript on phytosanitary cold treatment against four morphotypes of the *A. fraterculus* complex has been submitted for publication. Research focusing on broadly applicable phytosanitary treatments against members of fruit fly cryptic species complexes constitutes a proactive strategy to prevent trade barriers and ensure plant health protection in the case of new species description.

## Livestock Pests

### The Development and Evaluation of a Near Infrared Pupal Sex Sorter (NIRPSS) in Support of the *Glossina palpalis gambiensis* Eradication Programme in Senegal.

In view of their low reproductive ability and hematophagous feeding requirements, the rearing of tsetse flies in large numbers represents a significant challenge. It is therefore necessary to retain female tsetse flies for colony maintenance and only release males for SIT implementation.

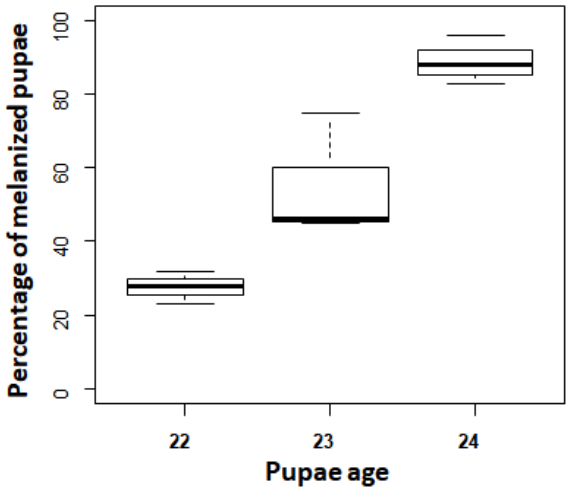


*Ms Sumejja Canic sorting male and female tsetse pupae using the near infrared sex pupal sorting machine.*

One of the main limitations when implementing a SIT programme for tsetse flies is the lack of an automated and efficient system to separate the males from females in the pupal stage. To date, males and females can only be separated during adult emergence making use of the relative protogyny, i.e. females develop and emerge 1-2 days before the males, but there is still considerable overlap in the emergence.

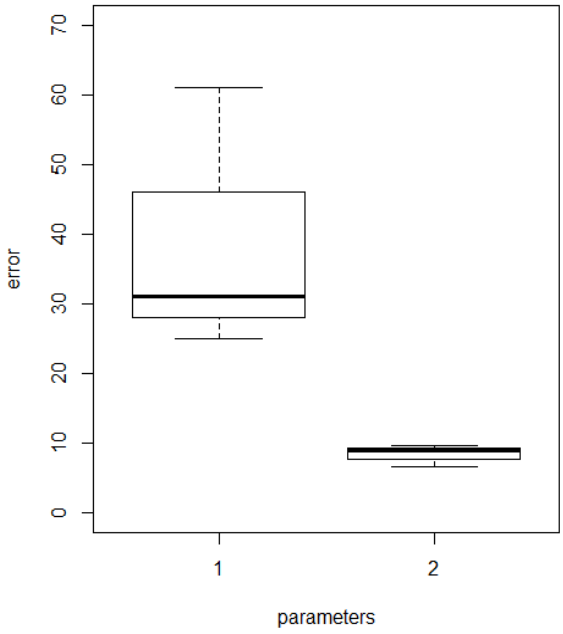
In addition, long distance shipments of male pupae are difficult and require chilling of the male pupae after the female emergence flush. However, extended chilling of pharate adult males results often in reduced quality and increased mortality. Therefore, the availability of a system that enables the separation of the sexes several days before adult emergence would be extremely beneficial and significantly increase the quality of the shipped sterile male pupae.

Since more than 15 years, attempts have been made to separate the sexes of tsetse pupae a few days before adult emergence. Different versions of "near infrared sex sorter devices" have been developed and tested, but the results were not consistent.




*The proportion of melanized pupae in relation to the age of the pupae.*

The discovery in 2016 that differences in wing melanization of the pupae can be made visible using near infrared was a breakthrough, as this phenomenon can be detected a few days earlier in females than males. The main problem remained the exact position of the pupae to detect the differences. A new sex separation device was recently developed that allowed the scrolling of the pupae whilst making several image frames for each pupa at different positions, making the detection of melanized wings much more accurate. The new Near Infrared Pupal Sex Sorter (NIRPSS) was developed in collaboration with Prof. Gustavo Salvador Herranz from the Cardenal Herrera University (CEU), Valencia, Spain.




*Error rate (number of females emerged from un-melanized (males) pupae) sorted by NIRPSS machine at two different parameter including pixel intensity threshold, rate of dark pixels in one frame to consider it as dark frame, and the minimum percentage of dark frames for a given pupae to consider it a melanized pupae (1) 210, 0.20, 25; (2) 225, 0.15, 20)s.*

As the melanization process is progressing with pupal age, the most suitable pupal age for the sorting was determined. In addition, several parameters were tested to improve the accuracy of the sex separation. So far, an accuracy of 91% of males was found in un-melanized pupae (assumed to be males) sorted by the NIPSS. It is important to note that the development rate of the pupae is affected by temperature and relative humidity. Therefore, having a relative constant environmental condition and synchronized pupal age will improve the accuracy of the NIPSS machine in separating the sexes of the pupae. Work is continuing to further optimize the NIRPSS system and to analyse the impact of the sorting process on adult male performance.

In addition, test shipments of male *G. p. gambiensis* pupae sorted with the NIRPSS system at the IPCL and shipped to Dakar, Senegal have been initiated. Preliminary results are encouraging and indicate more than 70% operational males in the first shipments.

## Human Disease Vectors

### The effects of water hardness and electrical conductivity on the development and survival of *Aedes* mosquitoes

Water quality is an important determinant of the oviposition behaviour of female mosquitoes and whether the resulting immature stages will survive and successfully complete their development to the adult stage. In nature, water quality influences the development of the immature stages, pupation, and adult emergence. In response to variations in the rearing outputs in some FAO and IAEA Member States, the effect of water hardness/conductivity on mosquito development, productivity and thus adult quality and survival was assessed.

We used a comparative approach between *Aedes aegypti* and *Aedes albopictus* in small laboratory cages to explore their respective responses to increasing water hardness/conductivity by using deionised water (low water hardness), tap water (high water hardness) and a mix of varying proportions of deionised and tap water. Preliminary results show that high water hardness/conductivity negatively impacted pupae production in both species. However, the extend of this impact differed between the two species. In all water treatments, *Ae. aegypti* developed faster than *Ae. albopictus*, but *Ae. albopictus* lived longer than *Ae. aegypti*. Work continues to assess the importance of water hardness/ conductivity under mass-rearing conditions.

### A cost-efficient mass-rearing cage for *Aedes albopictus*

In previous newsletters, it was reported that in the framework of the USA grant ("Surge Expansion of Sterile Insect Technique (SIT) to Control Mosquito Populations that Transmit the Zika Virus") that was awarded in 2016 to the IPCL, a prototype low-cost plexiglass mass-rearing cage was developed and tested for *Aedes aegypti* egg production and egg hatch in comparison to the currently used stainless-steel cage. The new mass-rearing cage that has the same design and dimensions, but is 90% cheaper than the stainless-steel cage, has now been tested with *Aedes albopictus* resulting in high production of fertile eggs.

*Blood feeding of 12 000 female* Aedes *albopictus with a collagen blood sausage in the new mass-rearing cage.*

### Interspecific mating between *Aedes aegypti* and *Aedes albopictus*

The SIT targets one mosquito species at a time, but in areas where two species co-occur, the best scenario would be that the released males of one species could mate and induce sterility in both species. This would be the situation for La Reunion Island as both *Aedes albopictus* and *Aedes aegypti* are present on the island.

In laboratory cage experiments it was observed that the release of irradiated male *Ae. albopictus* may not suppress *Ae. aegypti* populations due to the existence of interspecific mating barriers (caused by the development of resistance to satyrization behaviour in *Aedes aegypti*) It will therefore be important to consider this phenomenon in the management strategy of two competent species in a sympatric area.

## Oxy-regulatory capacity of mosquito pupae in hypoxic environments and its implication for irradiation protocols

In response to reports that indicated variations of induced sterility levels following irradiation of mosquito pupae at similar doses, there was a need to investigate factors that may affect dose response. Preliminary studies assessing the effects of differing handling methods suggested that mosquito pupae may respire when submerged in water, accounting for differential atmospheric conditions during irradiation.

Pupae of *Anopheles arabiensis, Aedes aegypti* and *Ae. albopictus* were all able to use dissolved oxygen (DO) when submerged in water, depleting the water to levels below 0.5% DO within 30 minutes. Subsequent irradiation in these low oxygen environments resulted in significantly reduced sterility levels in all three species following irradiation at various doses. These findings show that species, DO consumption rates (likely also affected by temperature), and pupal densities are important factors inducing variable sterility levels following irradiation and need to be taken into account for the standardization of irradiation protocols.

## Characterization of three South African *Anopheles arabiensis* strains and mating compatibility for the evaluation of rearing efficiency and field releases in Kwazulu Natal, South Africa

In the context of the South African TC project entitled "Assessing the Sterile Insect Technique for Malaria Mosquitoes in a South African Setting, Phase II", three *Anopheles arabiensis* strains were compared in terms of life history traits and mating characteristics to evaluate their suitability for mass-rearing and release in the field; (1) the KWAG strain was collected and colonized from the proposed field site in Kwazulu-Natal province in South Africa, (2) the AY-2 strain is a fluorescent sexing strain with an *An. arabiensis* Dongola genetic background (Sudan), and (3) the sKWAG is the AY-2 strain backcrossed into the original KWAG strain. T

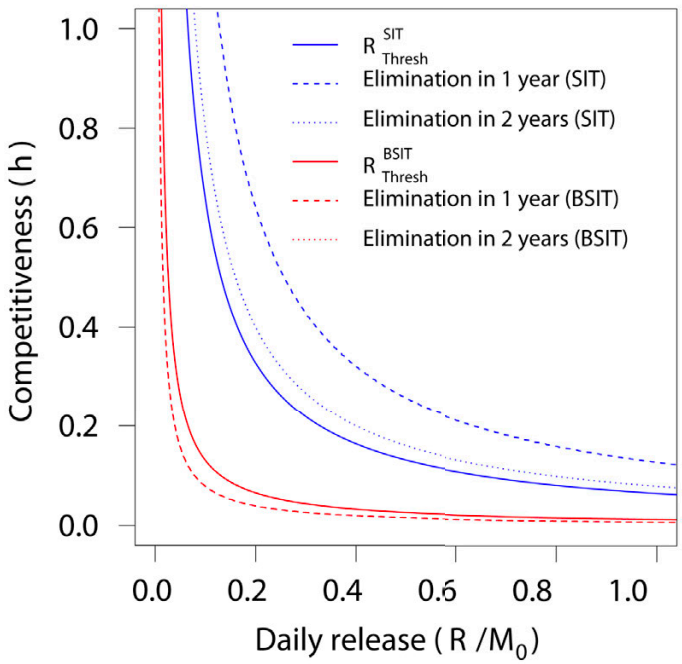
he three strains showed differences in larval development and productivity, but no differences in radiation sensitivity. Backcrossing the fluorescent marker into the KWAG did not reduce the performance of their sorting using a Complex Object Parametric Analyzer and Sorter (COPAS$^{TM}$). Mating compatibility and sterile male competitiveness tests were carried out, and results are being analysed.

## Short assessment of psocid infestation in mosquito egg stocks and implications in mass rearing.

Psocids are common scavengers found globally and are known for their nuisance in households, libraries, warehouses and food storages. Although they are very common in mosquito rearing insectaries, their appearance and significance has not been reported to date. A small-scale test was carried out to assess their impact in mosquito rearing, showing that these pests indeed thrive in dark, damp environments, especially in egg storage boxes often used for *Aedes* spp. rearing.

*Psocid feeding on the chorion of an* Aedes *egg, resulting in the desiccation of the embryo.*

They scavenge the eggs, thereby damaging egg chorions and consequently killing mosquito embryos and reducing egg hatch. It is therefore imperative to control the infestation of these psocids by preventing their entry into the laboratories in paper products and cardboard boxes, and their establishment by freezing oviposition papers prior to use. Regularly purging egg storage boxes with boiling water also showed a reduction of their incidence in the insectary.




*Relationship between the competitiveness and the daily release rate of sterile males to obtain elimination of a local population of* Aedes albopictus *in one or two years. Below a competitiveness of 0.2, the release rate (R) is increasing asymptomatically for SIT whereas boosting the sterile males with pyriproxifen (BSIT) still permits a reasonable release rate (with M0 the initial density of males). Two years (dotted) and 1-year (dashed) elimination thresholds for BSIT (red) are indistinguishable.*

## Modelling the impact of SIT and boosted SIT on *Aedes* mosquitoes

IPCL staff contributed to modelling the impact the SIT and its variant "boosted SIT" where sterile males are also used to transfer biocides to their female counterparts. In particular, the gains to SIT for *Aedes* control of either boosting with pyriproxyfen (BSIT) or contaminating mosquitoes at auto-dissemination stations were assessed. Thresholds in sterile male release rate and competitiveness were identified, above which mosquitoes are eliminated asymptotically. Both SIT and BSIT successfully eliminated target populations and boosting reduced these thresholds and aided population destabilisation, even at sub-threshold release rates. No equivalent bifurcation was observed in the auto-dissemination sub-model. Analysis suggested that BSIT could reduce by over 95% the total release required to circumvent dengue epidemics compared to SIT. We concluded that BSIT might represent a powerful new tool for the integrated management of mosquito borne diseases.

## Development of molecular diagnostic tools for pathogens in mosquito mass rearing facilities for sterile insect technique programmes to control mosquito populations

Mosquitoes are vectors of several diseases including malaria and many viruses, and therefore, routine quality control procedures are required in mosquito rearing facilities to ensure that (i) the material collected from the field and used to initiate a colony is free of any disease, (ii) the established large-scale colony is free from any pathogens or parasites. In addition, mosquitoes can be infected with other insect pathogens (i.e. viruses, bacteria, fungus, protozoa) that affect the productivity of the colony. To ensure the colony sustainability, a routine diagnosis of these pathogens is required.

*Mr Zhaoyang Tang extracting mosquito RNA.*

Molecular detection tools for mosquito viruses and parasites are available and well optimized for the disease detection in humans, but the detection of these viruses in mosquitoes still requires further optimization. For example, for the detection of virus infection in a mosquito colony, many details are missing, such as determining if the tests should be carried out on individual insects or in groups of females. Whereas doing detection tests in individuals will not cost effective, the detection in groups of females will require as assessment of the largest sample that will still enable the detection of the virus/parasite when only one mosquito is infected. To estimate these parameters, we used mosquito infected samples provided by the project Infravec2 (Research infrastructures for the control of vector-borne diseases) with various infection ratios such as 1(infected) to 20, 100, 200 and 300 non-infected adults and later subjected to a RT-qPCR for detection. The results indicated that at the highest ratio 1: 300, the viruses (Chikungunya, Usutu, WNV or Zika) were still detectable even with using 4 ng total RNA as template per reaction. This work was done by Mr Zhaoyang Tang, an intern from China.

# Reports

## Mosquito Population Successfully Suppressed Through Pilot Study Using Nuclear Technique in China

For the first time, a combination of the nuclear sterile insect technique (SIT) with the incompatible insect technique (IIT) has led to the successful suppression of mosquito populations, a promising step in the control of mosquitoes that transmit dengue, the Zika virus and many other devastating diseases. The results of the recent pilot trial in Guangzhou, China, carried out with the support of the IAEA in cooperation with the Food and Agriculture Organization (FAO), were published in Nature on 17 July 2019 (https://www.nature.com/articles/s41586-019-1407-9).

*Mosquito larval rearing racks at a mosquito mass-rearing facility at the Wolbaki Biotech Company in Guangzhou, China, in May 2019. The company is using the most advanced mass-rearing technology for mosquitoes. These racks are based on models developed by the Joint FAO/IAEA Insect Pest Control Laboratory. Each has the capacity of producing about 500 000 males per week.*

The main obstacle in scaling up the use of the SIT against various species of mosquitoes has been several technical challenges to produce and release enough sterile males to overwhelm the wild population. Researchers at Sun Yat-sen University, and its partners, have now successfully addressed these challenges, with the support of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture.

For example, the researchers used racks, each able to rear over 500 000 mosquitoes per week that were constructed based on models developed at the Joint FAO/IAEA Division's laboratories near Vienna, Austria. A specialized irradiator for treating batches of 150 000 mosquito pupae was also developed and validated with close collaboration between the Joint FAO/IAEA Division and the researchers.

The results of this pilot trial, using SIT in combination with the IIT, demonstrate the successful near elimination of field populations of the world's most invasive mosquito species, *Aedes albopictus* (Asian tiger mosquito). The two-year trial (2016-2017) covered area of 32.5 hectares on two relatively isolated islands in the Pearl River in Guangzhou. It involved the release of about 200 million irradiated mass-reared adult male mosquitoes exposed to *Wolbachia* bacteria.

The study has also showed the importance of socio-economic aspects for the successful use of the IIT/SIT approach. Social acceptance, for example, increased during the study as support of the local community increased following mosquito releases and the resulting decrease in nuisance biting. For the IIT/SIT approach to be successful, the local community needs to be on board and work together to ensure consistent and integrated use of the approach over the entire area in order to effectively counteract and control the movement of the insects. Another aspect is the cost-effectiveness; overall future costs of a fully-operational intervention are estimated at US$ 108-163 per hectare per year, which is considered cost-effective in comparison with other control strategies.

## IAEA Advises Bangladesh on Potential Use of Nuclear Technique to Fight Dengue Mosquitoes

Experts from the International Atomic Energy Agency (IAEA) and the World Health Organization (WHO) helped Bangladesh assess the current dengue outbreak in the country and develop a plan to test a nuclear technique to suppress the mosquitoes spreading the disease.

At the request of the Government, the IAEA and WHO experts recently visited the capital Dhaka and met officials from the Ministry of Health and Family Welfare and the Ministry of Science and Technology to discuss the possibility of using of the sterile insect technique (SIT). The SIT is a type of insect birth control that uses radiation to sterilize male insects. These are released in large numbers to mate with wild females, which then do not produce any offspring, reducing the target insect population over time.

Aedes *mosquitoes transmit diseases such as dengue, zika and yellow fever.*

The experts agreed with Bangladesh officials on a four-year workplan that includes the selection of a pilot site for the release of sterile male mosquitoes and a schedule for IAEA technical assistance, in partnership with the FAO, to

train national staff, upgrade existing facilities to mass-rear and sterilize the insects, and collect baseline data before the release phase.

"The SIT has been successfully implemented against numerous insect pests of agricultural importance and is now being adapted for use against mosquitoes," said Rafael Argiles Herrero, entomologist at the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. "The method is very specific to the target species and has no impact on other living organisms or the environment."

A country of some 160 million people, Bangladesh is facing the worst outbreak of dengue since its first recorded epidemic in 2000. The South Asian nation has seen the number of cases rise to over 38 000 since January 2019, with the daily admission of over 1 500 new dengue patients in hospitals in recent weeks. The outbreak has also caused over 40 deaths since the beginning of the year.

"Bangladesh already established a mosquito insectary in 2008 under an FAO/IAEA project to conduct basic research on the application of SIT," said Mahfuza Khan, Director and Chief Scientific Officer at the country's Institute of Food and Radiation Biology. "The insectary can produce 30 000 to 40 000 mosquito larvae per week for SIT application, and the aim in the next four years is to increase this number and test the sterile male mosquitoes under semi-field and field conditions."

The joint mission to Bangladesh was part of a newly established collaboration between the IAEA and WHO. The two organizations signed a Memorandum of Understanding in July 2019 to intensify research and development on the use of SIT to fight disease-transmitting mosquito vectors.

"The collaboration aims to provide more evidence on the benefits of the SIT against human diseases transmitted by mosquitoes," said WHO expert Rajpal Yadav. "Preliminary results from field trials using sterile male mosquitoes are very encouraging, but we need more data to show reduced disease incidence before large-scale implementation can be recommended".

Vector-borne diseases such as malaria, dengue, Zika, chikungunya, and yellow fever account for 17 per cent of all infectious disease deaths globally, claiming one million lives each year. In recent decades, the incidence of dengue has increased dramatically due to environmental changes, unregulated urbanization, transport and travel, and insufficient vector control methods.

As part of the IAEA and WHO collaboration, a recent call was put out by the Special Programme for Research on Tropical Diseases (TDR/WHO) for public health partners to test the SIT technology against mosquitoes and carry out epidemiological evaluations. Three multi-country proposals targeting main disease-transmitting mosquito vectors *Aedes aegypti* and *Aedes albopictus* will be selected for pilot projects that would take two years to complete.

## Identification of the Male Determining Factor Reduces the Cost of SIT Application Against Insect Pests

The insect family Tephritidae includes many invasive pest species of major agricultural and economic importance and there is an urgent need to develop and apply the sterile insect technique (SIT) against them, as a component of an area-wide integrated pest management approach. A critical step in the SIT applications against insect pests is sex separation. By releasing only male adult insects, the efficiency, efficacy and cost-effectiveness of SIT is greatly increased. Sex separation can be achieved by using genetic sexing strains which allow the elimination of females and the selection and use of males only. In these species, male sex is determined by the maleness factor, a genetic locus (gene) on the Y chromosome.

The results of a study that has announced the isolation and functional characterization of the male determining factor in three major agricultural pests, the Mediterranean fruit fly (*Ceratitis capitata*), the Oriental fruit fly (*Bactrocera dorsalis*) and the olive fruit fly (*Bactrocera oleae*) were published in the prestigious journal Science on 29 August 2019.

*Male Oriental fruit fly,* Bactrocera dorsalis.

The study, which was carried out by the University of Naples "Federico II", in partnership with the University of Zurich, the University of Perugia, the Hebrew University of Jerusalem, the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and others, showed that the male determining factor is the Y-linked gene maleness-on-the-Y (MoY), which produces a small, novel and functionally conserved protein in major Tephritidae fruit fly pest species.

The discovery and characterization of the male determining factor opens the way for the development of novel generic, and potentially more efficient, methods for the construction of genetic sexing strains thus reducing the cost and enhancing the SIT applications against other agricultural pests and also human disease vector species. This will be the focus of a new IAEA Coordinated Research Project "Generic approach for the development of genetic sexing strains for SIT applications".

The SIT has been used for over six decades in many parts of the world against major agricultural tephritid pest species, such as the Mediterranean fruit fly, the Mexican fruit fly *Anastrepha ludens*, the Oriental fruit fly and the melon fly *Zeugodacus cucurbitae*. The SIT is based on the use of radiation to sterilize male insects. Through continuous releases in the field, these males are engaged in sterile matings with wild females thus suppressing or even locally eliminating, a target pest population. Every week, more than two billion sterile tephritid males are being released worldwide to manage these major agricultural pests.

## U.S. Grant Helps Optimize Nuclear Technique to Reduce Disease-Transmitting Mosquito Populations

Using a nuclear technique applied at a large scale against agricultural pests around the world to control disease-transmitting mosquitoes has been an elusive goal for scientists over the last decade. Thanks to a US$ 3.96 million grant to the IAEA by the U.S. Government, important milestones have been reached in recent years. The research has been implemented in cooperation with the Food and Agriculture Organization of the United Nations (FAO).

Optimizing the mass-rearing of mosquitoes for sterile insect technique (SIT) applications and improving technologies to separate males from females, both being crucial for large-scale implementation of the technique, are key outcomes.

"The focus of this research was to develop the SIT package for disease-transmitting mosquitoes, with an emphasis on the *Aedes* mosquito which transmits the Zika virus, and to pass on this technology to the Member States," said Rui Cardoso Pereira, Head of the Insect Pest Control Section at the FAO/IAEA Joint Division of Nuclear Techniques in Food and Agriculture. "Thanks to this grant, more advanced and cost-effective tools are now available for any country wishing to carry out pilot trials."

Aedes *mosquito.*

More than half of the world's population lives in areas where this mosquito species is present, according to the World Health Organization (WHO). In addition to the Zika virus, the *Aedes* mosquito also carries viruses that cause chikungunya, yellow fever and dengue fever, among others.

One of the main challenges in SIT is separating males from females in order to ensure that only sterilized males are released into the wild. Eliminating reared female mosquitoes is essential for safety reasons, as they, unlike males, can transmit viruses. It is also useful for SIT programme efficacy: Since the goal is for sterile males to mate with wild females, releasing sterile females introduces more competition for mating and may delay progress in suppressing a pest population.

Thanks to the U.S. grant, scientists have found a two-step process to tackle this problem. Using radiation, they trigger the emergence of natural characteristics unique to females or males, which will subsequently enable scientists to clearly differentiate males from females. In the case of *Aedes aegypti*, they have identified a genetic sexing strain that brings out red eye colour in females that has so far showed favourable results.

Second, a laser prototype that uses this difference in eye colour to sort the mosquito pupae by sex was tested on three species of the *Aedes* mosquito. It had excellent results, leading to a very high recovery rate for the males with an extremely low rate of female contamination, an important element to ensure that no females are accidentally released into the wild, Cardoso Pereira said.

Another challenge is scaling up and optimizing SIT technology, which is necessary to ensure the feasibility of large-scale implementation and cost effectiveness, Cardoso Pereira said. Testing the technology for mass-rearing conditions simulates how it will be used outside laboratory settings and reducing its costs will make it more affordable.

Certain core elements of the SIT technology were made more cost-effective as a result of this research and development (R&D). As an example, the original designs of racks and cages to mass-rear the *Aedes* mosquito used stainless steel, a relatively expensive material. Switching to aluminium and plastic frames greatly reduced the cost of the racks and the cages, without comprising performance of the mosquitoes, Cardoso Pereira said. It has decreased the cost per unit of the cages tenfold with no difference in the mosquitoes' performance and made the racks three times cheaper without a change in production efficiency. Researchers were also able to reduce the cost of the larval diet for the mosquitoes by more than 50% by changing its composition using proteins derived from insects.

Funds from the grant were used to employ eight staff and to set up the appropriate infrastructure and equipment needed for the 34-month period between September 2016 and June 2019, over which this R&D was conducted.

Following the success of this R&D project, the U.S. Government provided an additional contribution of US$ 1.47 million starting in July 2019 to continue the project activities for another year, with a focus on transferring the technology from the laboratory to the field.

## Technical Panel on Phytosanitary Treatments Meeting, International Plant Protection Convention. 8–12 July 2019, Vienna, Austria

The International Plant Protection Convention (IPPC) Technical Panel on Phytosanitary Treatments (TPPT) met in Vienna, Austria to discuss various phytosanitary treatments (PTs) related issues. The meeting was organized by the IPPC Secretariat and hosted by the Joint FAO/IAEA Division. The panel reviewed the submissions sent by national and regional plant protection organizations (NPPOs and RPPOs) in response to a call for treatments from the IPPC Secretariat.

*Participants of the International Plant Protection Convention (IPPC) Technical Panel on Phytosanitary Treatments meeting (Vienna, Austria).*

The TPPT also reviewed the objection to the heat treatment of wood and prepared a recommendation to be revised by the Standards Committee (SC). Twelve draft phytosanitary treatments (PTs) were discussed during the meeting; and the following draft PTs were recommended to the SC for approval for first consultation:

1. Irradiation treatment for Tortricidae on fruits
2. Cold treatment for *Thaumatotibia leucotreta* on *Citrus sinensis*
3. Cold treatment for *Bactrocera zonata* on *Citrus sinensis*
4. Vapour heat modified atmosphere treatment for *Cydia pomonella* and *Grapholita molesta* in fruit of *Malus pumila* and *Prunus persica*

The TPPT then discussed the links between the IPPC Strategic Framework 2020–2030 and the TPPT's work and how they can contribute to help implement the framework. They reviewed liaison activities with the Ozone Secretariat and the Phytosanitary Measures Research Group (PMRG) and looked at ways to improve collaboration. Based on results of research conducted by the Joint FAO/IAEA Division, participants agreed to recommend to the SC to lift the restriction from irradiating fruit flies on commodities stored in modified atmosphere. Indeed, the research shows that there is no difference in the efficacy of treatments using phytosanitary irradiation doses.

*Source: https://www.ippc.int/en/news/phytosanitary-treatment-options-for-plant-health-the-ippc-technical-panel-on-phytosanitary-treatments-meeting/.*

## International Congress on Invertebrate Pathology and Microbial Control & 52nd Annual Meeting of the Society for Invertebrate Pathology & 17th Meeting of the IOBC-WPRS Working Group "Microbial and Nematode Control of Invertebrate Pests". 28 July–1 August 2019, Valencia, Spain

The event gathered more than 430 researchers in insect pathology, covering microbial, fungal, microsporidia, nematode and viral diseases. Many research papers were presented focusing on the resistance to microbial control agents, host-pathogen interactions and covert virus infections in insects. The IPC staff made an oral presentation entitled "Characterization of novel RNA viruses isolated from tsetse fly *Glossina morsitans morsitans* and discussed the results and got feedback from the audience.

VALENCIA
SIP/IOBC
2019

During the conference, IPC staff held a meeting with Monique van Oers and Vera Ros, from Wageningen University, to discuss the current and future collaboration with IPCL and the work plan of the PhD candidate, Ms Caroline Mirieri who is currently conducting her research at the IPCL in collaboration with Wageningen University. Moreover, IPC staff also met with Stephen R Sharpe from the Hawkesbury Institute for the Environment, Western Sydney University who mentioned that several viruses were discovered in the Queensland fruit fly. In addition, IPC staff met with Sean Moore from Citrus Research International (CRI), South Africa. IPC staff also discussed with several participants of the CRP on 'Improvement of colony management in insect mass-rearing for SIT applications' the current status and the future work plan.

## 18th Pan African Tsetse and Trypanosomosis Eradication Campaign (PATTEC) Coordinators Meeting, 35th International Scientific Council for Trypanosomosis Research and Control (ISCTRC) and 8th PATTEC Steering Committee Meetings. 23–27 September 2019, Abuja, Nigeria

The 35th General Conference of the International Scientific Council for Trypanosomiasis Research and Control (ISCTRC) was held jointly with the 18th Pan African Tsetse and Trypanosomosis Eradication Campaign (PATTEC) Coordinators Meeting.

During the plenary sessions, countries progress reports and PATTEC Coordination Office activities were presented, including open discussions on the achievements and current situation of the PATTEC initiative. Most of the countries emphasised the importance of regular funding for the field activities against tsetse and trypanosomosis (T&T). Nigeria announced a plan to launch a sterile insect technique (SIT) programme and the construction of an insectary for tsetse mass-rearing and sterilization. WHO presented the progress of the campaign for the elimination of the Human African Trypanosomosis (HAT) gambiense form as a public health concern in 2020. The campaign is meeting the milestones with less than 1 000 cases reported in 2018.


*Award received by the Joint FAO/IAEA Division colleagues.*

During the closing ceremony, the 70th Anniversary of the ISCTRC was commemorated and special recognition was awarded to individuals who have made outstanding contributions in the last 10 years, towards the mission and values of ISCTRC. Among them, our colleagues from the Joint FAO/IAEA Programme for Nuclear Techniques in Food and Agriculture Udo Feldman and Marc Vreysen received the award for having consistently excelled in their positions and demonstrated integrity and a strong commitment to the mission and values of ISCTRC. These awards were presented on behalf of the Chairperson of the Africa Union Commission and the thirty-seven countries affected by tsetse flies and human and animal trypanosomosis.

## The IPPC International Symposium for Pest Free Areas and Surveillance, 28 October–1 November 2019, Shizuoka, Japan

The symposium brought together the world's phytosanitary community to discuss these important topics on Pest Free Areas (PFAs), Areas of Low Pest Prevalence (ALPP) and Surveillance. An important new 'Guide for Establishing and Maintaining Pest Free Areas' was released during the symposium to help International Plant Protection Convention (IPPC) contracting parties implement PFAs.

*Participants of the IPPC International Symposium for Pest free Areas (PFAs) and Surveillance (Shizuoka, Japan).*

The main objectives of the symposium were:

- Raise awareness of:
  - The international phytosanitary framework for PFA, ALPP and Surveillance.
  - Resources for implementing the IPPC - with an emphasis on the PFA and Surveillance related materials.
  - The IPPC and the International Year of Plant Health (IYPH) 2020.
- Provide a platform for presenting and promoting specific PFAs, ALPP and surveillance initiatives.
- Generate ideas for national and global capacity development strategies on PFAs, ALPPs and surveillance.
- Reinforce partnerships and collaboration between IPPC contracting parties, regional plant protection organizations and different stakeholders at the national, regional and global levels.

The symposium was organized by the IPPC Secretariat in close cooperation with the Steering and Technical Committees of the symposium. Financial support has been provided by Agriculture and Agri-Food Canada (AAFC); the European Commission (EC); and the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF). The symposium is hosted by MAFF.

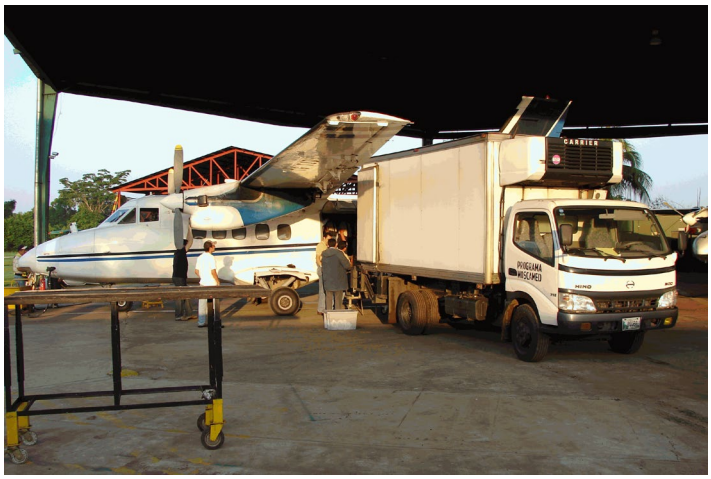
*Source: https://www.ippc.int/en/news/the-ippc-international-symposium-for-pest-free-areas-pfas-and-surveillance/?fbclid=IwAR0OlDJ4DhSWd-2OthThcs2PzvAIU5M_nl6FwfvurzDeQHhD8EnYrsdlM2s.*

## Technical Advisory Panel to Review the Current Situation of the Guatemala-Mexico-United States Trinational Moscamed Programme, 18–22 November 2019, Guatemala and Chiapas, Mexico

The Governments of Guatemala, Mexico and the USA established the regional Moscamed Programme to prevent the northern spread of the invasive Mediterranean fruit fly from its current location in Guatemala. The programme operates a containment barrier at the border between Guatemala and the state of Chiapas, Mexico based on area-wide application of the sterile insect technique (SIT). Since 1982, the containment barrier has protected the horticultural industry of the three countries valued at tens of billions of dollars per annum.

*Technical Advisory Panel (TAP): clockwise from top left Mr Walther Enkerlin (Joint FAO/IAEA Division), Mr Patrick Gomes (retired USDA-APHIS), Mr Ricardo Rodriguez (retired SAG Chile) and Mr Brain Barnes (retired ARC Infruitec-Nietvoorbij South Africa).*

Due to recent changing conditions and related increasing risks such as climate change, human migration and the changes in land use, the pest pressure over the barrier has mounted, jeopardizing its capacity to contain the northward spread of the pest. Given this situation, the Moscamed Programme officially requested urgent support to the IAEA on the establishment of an independent Technical Advisory Panel (TAP) of international experts to review the situation and provide recommendations.



*Loading of sterile male medflies for aerial release over areas under eradication at the border between Guatemala and Chiapas, Mexico.*

The TAP reviewed the programme from 18–22 November 2019. The review activities included presentations by programme managers and field visits to infested areas both in Guatemala and Chiapas, Mexico. A mission report was prepared and presented to programme directors during the last day of the visit. Among the most relevant findings, the TAP cited a significant reduction in programme budget which has affected field operation, including:

1. significant reduction in field staff,
2. closure of a field operation subcenter,
3. reduction of the trapping and fruit sampling networks by 30%,
4. suspension of aerial bait sprays, and
5. cancelation of three quarantine checkpoints (out of seven).

If the infestation trend continues as in 2018 and 2019, the barrier that has been in place since 1982 will fail and the infestation will spread northward into northern Guatemala (Peten), the interior areas of Mexico, Belize, and susceptible areas of southern USA.

The recommendations included:

1. to prepare and agree on a single regional strategy given the transboundary nature of the pest,
2. to resume the teamwork as has been the case in the Moscamed Programme in the past and
3. to provide the necessary financial resources, in the first instance, to eradicate the pest from areas that have been re-infested in Guatemala and Chiapas and to re-establish the containment barrier in the interior of Guatemala.

# Announcements

## Fruit Sampling Guidelines for Area-wide Fruit Fly Programmes

This guideline is aimed at facilitating the transfer of harmonized procedures to National Plant Protection Organizations and horticultural industry of FAO and IAEA Member States that want to apply fruit sampling procedures for fruit fly population survey in area-wide action programmes. The guideline will be useful also as a reference source to Appendix 2 "Guidelines for fruit sampling" of ISPM No. 26 "Establishment of pest free areas for fruit flies (Tephritidae)."

*Stratified fruit sampling through collection of fruits from natural hosts and with infestation symptoms.*

The guideline follows the three categories of host status (Natural Host, Conditional Host and Non Host) of fruit to fruit flies as per the International Standard of Phytosanitary Measures (ISPM) 37 "Determination of host status of fruit to fruit flies (Tephritidae)."

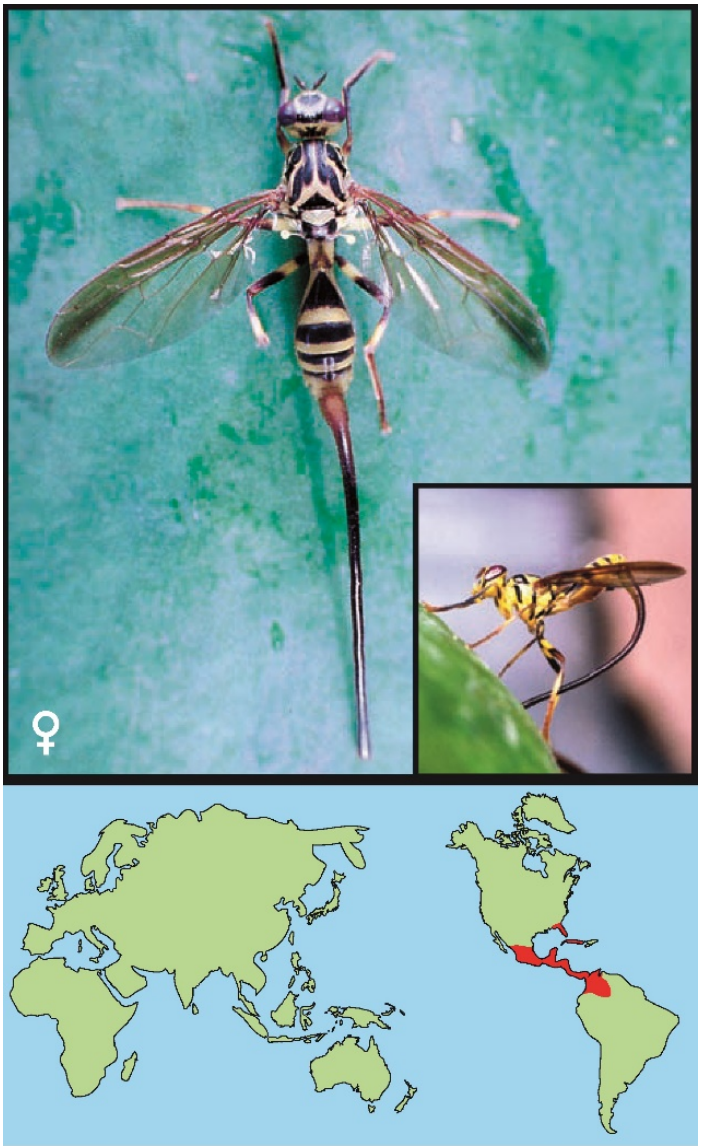
The guideline can be downloaded for free from the website of Insect Pest Control Section (http://www-naweb.iaea.org/nafa/ipc/public/ca5716en.pdf).

## A Guide to the Major Pest Fruit Flies of the World

This published guide is not exhaustive and only includes the major pest fruit flies (Diptera: Tephritidae) in the world. The correct identification of fruit flies is a specialized task and specimens should be preserved properly and sent to fruit fly taxonomists in order to be identified to species level.

This guide has been jointly produced by Scientific Advisory Services and the Insect Pest Control Section, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture with the support of the Department of Technical Cooperation of IAEA through technical cooperation regional Africa project RAF5062 and is aimed at supporting area-wide management programmes.

For each species presented, the maps show approximate distributions of the various species, however, the responsible government agencies should be contacted in each country for more detailed information on their distribution and hosts.

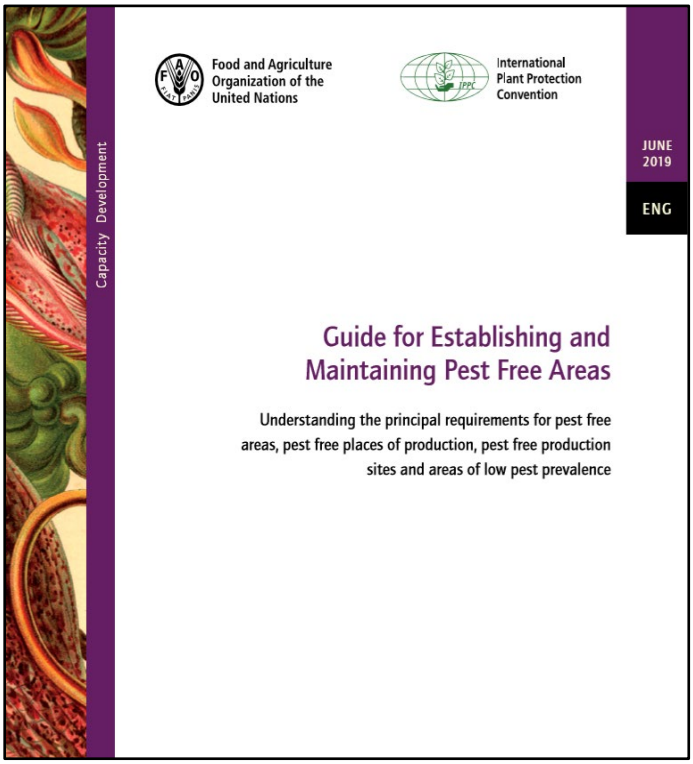



*(top) Papaya Fruit Fly female* Anastrepha curvicauda*, formerly known as* Toxotrypana curvicauda*. (Placement under* Anastrepha *pending decision by ICZN), (bottom) Distribution map.*

The hosts presented are some of the major commercially important fruits and vegetable types, however, for most species, there are other hosts. In the absence of any specific synthetic attractants for some species, proteins, ammonium compounds, sugar, vinegar and fruit-based attractants may be used for surveys.

## Guide for Establishing and Maintaining Pest Free Areas: Understanding the Principal Requirements for Pest Free Areas, Pest Free Places of Production, Pest Free Production Sites and Areas of Low Pest Prevalence

This guide was drafted by a panel of experts commissioned by the International Plant Protection Convention (IPPC). It was released during the IPPC International Symposium for Pest Free Areas and Surveillance, held from 28 October to 1 November 2019 in Shizuoka, Japan.




Guide for establishing and maintaining pest free areas. *FAO, 2019. Rome, Italy.*

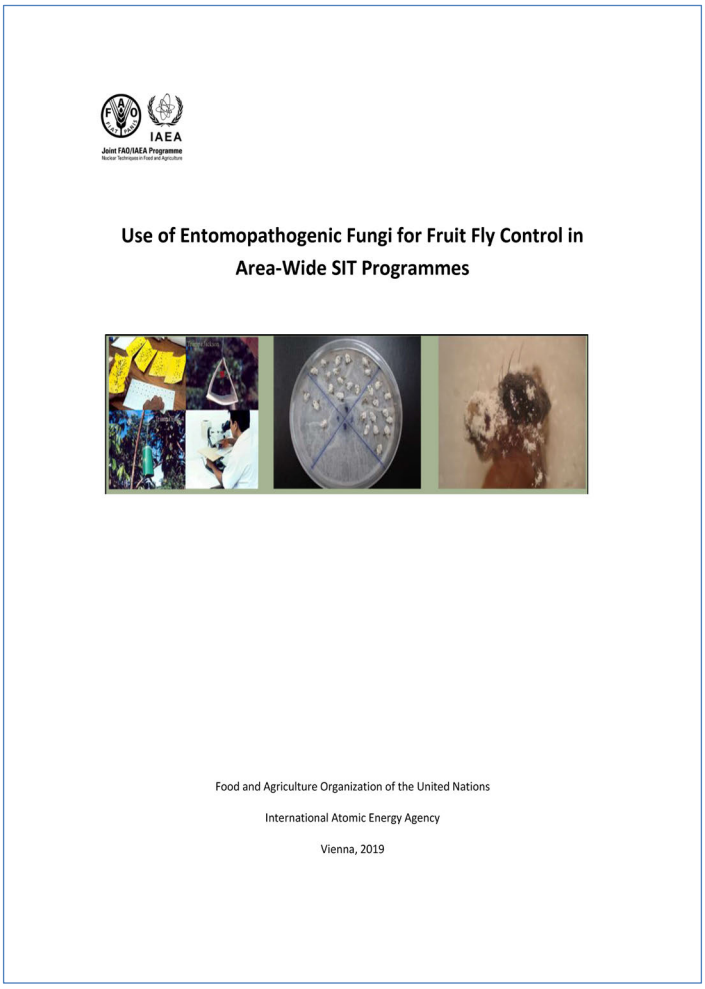
The guide supports national plant protection organizations (NPPOs) who wish to establish and maintain pest free areas (PFAs) - including pest free places of production (PFPP) and pest free production sites (PFPS) as well as areas of low pest prevalence (ALPPs). It will provide users with a better understanding of phytosanitary standards related to PFAs and ALPPs by providing technical information and best practices from around the world. This practical guide includes case studies and a "decision tree" that outlines five programme development phases: initiation, feasibility, establishment, maintenance, and market access.

The panel of experts received a Certificate of Appreciation from the IPPC Secretariat for the *Outstanding contribution in the development of the IPPC guide*. The panel members included: Alies Muller, Walther Enkerlin, Ahmed Elsayed, Roberto Razera Papa and Ken Bloem.

The guide can be downloaded at: http://www.fao.org/3/ca5844en/CA5844EN.pdf.

## Use of Entomopathogenic Fungi for Fruit Fly Control in Area-wide SIT Programmes

This document presents a review of different studies that support the use of entomopathogenic fungi to suppress fruit fly populations. It describes the process to characterize pathogenic fungi strains, the inoculation process of sterile flies, handling of the sterile flies used as vectors, biosecurity recommendations and release densities of inoculated sterile flies, as well as the density of the disseminator devices. The integrated use of the SIT and Microbial Control as components of area-wide management strategies is presented.




This document is now available in English and Spanish. The PDF version can be downloaded from the website of IPC (www-naweb.iaea.org/nafa/ipc/public/10072019-eng.pdf) – English version and (www-naweb.iaea.org/nafa/ipc/public/ 10072019-esp.pdf) – Spanish version.

## Website on Fruit Fly Identification Australia (fruitflyidentification.org.au)

Fruit flies are recognised as some of the most damaging insect pests to affect horticultural production around the world. As many fruit flies can appear similar, being able to accurately identify different species is important for pest management and emergency response.

Fruit Fly ID Australia

Fruit Fly Identification Australia is a hub of information to assist in the accurate identification of fruit fly species that occur within Australia and species that are not present within Australia but pose the most significant threat to horticultural industries. The website was developed to support Australia's fruit fly researchers, academics, surveillance officers, diagnosticians and laboratory scientists.

This site includes species pages with high resolution images, information on molecular diagnostic tools, an online Lucid key to 65 species of Dacine flies, a rotatable 3D fruit fly to assist in identifying key morphology features and a downloadable 'The Australian Handbook for the Identification of Fruit Flies'.

For more information: https://fruitflyidentification.org.au/.

## INSECT DOCTORS

INSECT DOCTORS is an innovative new European Joint Doctoral Programme (EJD) funded in the framework of the H2020 Marie Skłodowska-Curie ITN programme. The aim of this programme is to train promising young scientists to develop the knowledge, technical skills and tools to manage infectious disease problems in commercial insect production systems. The Joint FAO/IAEA division is one of the partners for this program. Advertisements for the individual PhD positions will be posted on the Euraxess website and the portals of the hiring organizations.

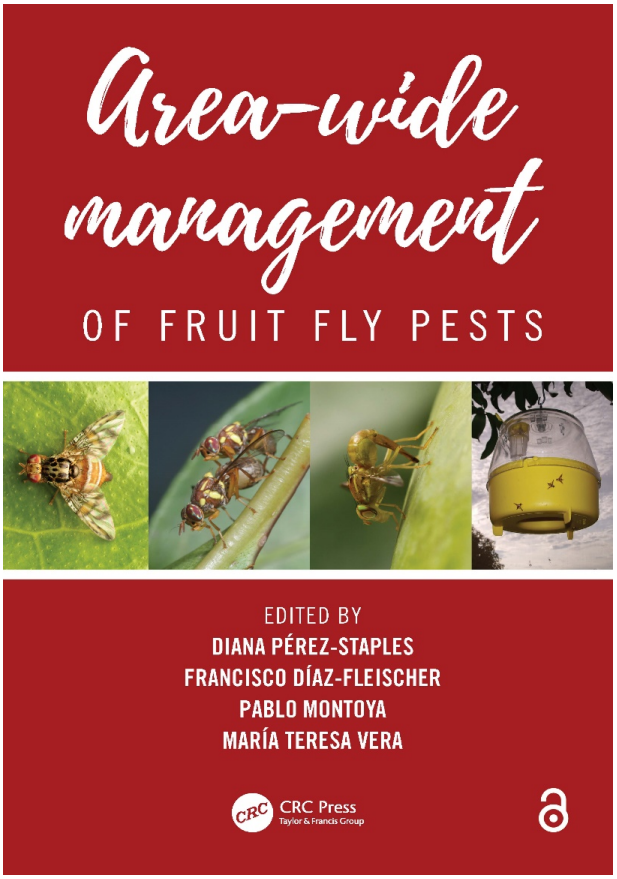
INSECT DOCTORS

For more information, please visit:
https://www.insectdoctors.eu/en/insectdoctors.htm.

## Area-wide Management of Fruit Fly Pests

This book is a compilation of the Proceedings of the 10th International Symposium on Fruit Flies of Economic Importance, held in Tapachula, Chiapas, Mexico, from 21 to 27 April 2018.

Fruit fly (Diptera: Tephritidae) pests have a profound impact on horticultural production and economy of many countries. It is fundamental to understand their biology and evaluate methods for their suppression, containment, or eradication. Area-wide Management of Fruit Fly Pests comprises 31 contributions from 126 authors all over the world.




The first three sections of the book explore aspects of the biology, ecology, physiology, behaviour, taxonomy, and morphology of fruit flies. The next two sections provide evidence on the efficacy of attractants, risk assessment, quarantine, and post-harvest control methods. The fifth and sixth sections examine biological control methods such as the sterile insect technique and the use of natural enemies of fruit flies. The seventh section focuses on area-wide integrated pest management and action programs. Finally, the eighth section examines social, economic, and policy issues of action programs aimed at involving the wider community in the control of these pests and facilitate the development of control programs.

This book is open access and available online to a large audience through the CRC website at https://www.taylorfrancis.com/books/9780429355738.

## Forthcoming Regional Fruit Fly Events

### Americas Congress on Fruit Flies and the 10th Meeting of the Tephritids Workers of the Western Hemisphere (TWWH). 16–20 March 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.

Americas Congress on Fruit Flies
10th Meeting of Tephritid Workers 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

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.

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

4th TEAM meeting 2020
From 4 to 8 OCTOBER
La Grande-Motte - SOUTH OF 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 last time 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.

# Other News

## Thevenard is now Mediterranean fruit fly free

**The fruit fly quarantine in Thevenard has now been lifted.**

A Mediterranean fruit fly outbreak was declared in Thevenard, Australia after the detection of larvae in January 2019, following the completion of a successful eradication operation to an outbreak last November 2018.

Ceduna had also been declared a quarantine zone after an outbreak last year, with restrictions lifted in May 2019.

*Thevenard has been declared free of Mediterranean fruit fly after a successful eradication programme.*

Primary Industries declared the eradication programme in Thevenard a success and said as a result, restrictions on the movement of both homegrown and shop-purchased fruits and vegetables within the area had been lifted.

Minister for Primary Industries and Regional Development Tim Whetstone said the use of sterile insect technique (SIT) played an important role in the eradication.

'Thanks to the cooperation of local residents and businesses and the state government's successful eradication programme, we have gotten rid of Mediterranean fruit fly on the West Coast', he said.

The Thevenard eradication included the removal of wild flies through baiting, sterile insect releases and the collection of 1 460 kilograms of host fruit and vegetables from the outbreak area.

'South Australia's borders are under constant pressure from interstate areas which are endemic with fruit fly and that's why we need to continue to remind people not to bring fruit and vegetables into the state', Minister Whetstone said.

Member for Flinders Peter Treloar said community support was vital to the success of the eradication programme.

'I would like to thank the West Coast community for its cooperation', he said.

The support shown by local residents and businesses has allowed the quarantine programme to be successful, effectively eradicating fruit fly.

'Such vigilance is paramount in the fight to ensure the state remains fruit fly free'.

*Source: https://www.westcoastsentinel.com.au/story/6456129/thevenard-is-now-fruit-fly-free/.*

## Queensland fruit fly aerial attack targets fruit-growing areas of Cobram and Hillston

**Millions of sterile Queensland fruit flies are being released from aircraft over two fruit fly-populated areas of New South Wales and Victoria during the spring and summer period.**

Sterile fruit flies have so far been only released from an aircraft in an emergency when fruit flies were found in a suburb of Adelaide which is a fruit fly-free area.

The inaugural experiment with the sterile fruit fly involves a number of states including South Australia where the flies are bred and Tasmania which is helping to fund the trial.

Professor Phil Taylor, Director of the ARC Centre for Fruit Fly Biosecurity, said two fruit-growing areas of Cobram in Victoria and Hillston in NSW had been chosen.

'From now until April next year around 2 million sterile fruit flies will be released each week from a plane flying over farmland and the town areas of those two places'.

*Sterile Queensland fruit flies are being released in the fruit-growing areas of Cobram in Victoria and Hillston in NSW as part of a plan to eradicate the fruit fly population.*

He said Hort Innovation was funding this unique trial where it would have scientists on the ground monitoring the effect the sterile fly would have on the normal fruit fly population.

'The two areas were chosen because the Queensland fruit fly is not native to the towns and the fruit fly population is not huge', Professor Taylor said.

The sterile fruit flies are bred at the special mass-rearing facility in Port Augusta in South Australia where production can rise to tens of millions of flies a week.

The sterile flies are then shipped out to holding centre in Tatura in Victoria and Yanco in New South Wales waiting for dispatch to the target areas.

'Female fruit fly which mate with the sterile fly will fail to reproduce and this means a reduction in the wild population without the use of chemicals'.

'It's something that's safe to use in production areas and safe in townships and is a sustainable means of controlling this terrible pest', Professor Taylor said.

'Basically, we have an aircraft with a chilled device in it containing the flies and an augur is used from the plane to drip the sterile flies out of the back as it covers the test areas.

'The flies have a dye on them and so we can easily identify the sterile flies, and each week we change the dye colour to see how long they survive in the wild'.

*A sterile Queensland fruit fly on citrus.*

'Over the next few months we should see a decline in the numbers of wild flies but the program will take time to have a big effect', Professor Taylor said.

'The sterile insect program does not kill the wild fly population but it's a form of birth control that will affect numbers of the next generation'.

Professor Taylor said he expected a carryover effect late in the summer next year and predicted low numbers of wild fruit flies at the start of next spring in the two areas.

'We can't eliminate Queensland fruit fly across Australia as it is a native species, but we can make areas like Cobram and Hillston fruit fly free zones'.

'In West Australia we can have programs to eliminate the Mediterranean fruit fly, as that is not a native to the west', Professor Taylor said.

*Source: https://www.abc.net.au/news/rural/2019-10-01/queensland-fruit-fly-aerial-attack-from-sterile-fruit-fly/11559286.*

## Sterile mosquitoes released on Captiva Island

Lee County Mosquito Control District (LCMCD) is using sterilized male mosquitoes to help reduce the insect's population on Captiva Island, Florida, the United State.


According to mosquito control, the male mosquitoes are grown in LCMCD laboratories using eggs from the local population and are sterilized using X rays and then released to mate with wild female mosquitoes.

They say the females will be unable to produce viable eggs, decreasing the population.

This initial round of releases will determine the flight range of male mosquitoes once released, which will aid LCMCD biologists in determining effective release points.

The sterile mosquitoes are dusted with a fluorescent powder for identification purposes. They do not bite and may be noticed in flight as they search for the wild females.

The District will target the *Aedes aegypti* population on Captiva and eventually continue releases in other areas of the county.

Source: *https://www.fox4now.com/news/protecting-paradise/sterile-mosquitoes-released-on-captiva-island.*

# Relevant Published Articles

## Oriental Fruit Fly Eradication in Florida 2015–2016 Program Implementation, Unique Aspects, and Lessons Learned

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In this paper, the authors describe the major eradication program conducted successfully against *Bactrocera dorsalis* in Florida during 2015–2016. In addition to describing the standard detection systems that are in place continuously, we describe the delimitation surveys triggered by initial detection of an invasive fruit fly and the eradication and quarantine activities started when threshold population indicators were met. Additionally, the authors provide insight into new approaches and methods employed, as well as lessons learned that will be useful should it be necessary to implement similar programs in the future.

Oriental fruit fly female.

*The full paper was published in: American Entomologist, 65(2):108-121.*

## Dietary Methoprene Enhances Sexual Competitiveness of Sterile Male Queensland Fruit Flies in Field Cages

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**Abstract**

Queensland fruit flies *Bactrocera tryoni* (Froggatt) have a long adult maturation phase which, together with high mortality rates, can substantially reduce number of released flies that survive to mature and contribute to SIT programmes. This constraint on SIT can potentially be addressed by incorporating methoprene, a juvenile hormone analogue, into an adult diet of sugar and yeast hydrolysate for 2 days after emergence. Methoprene treatments have been found to accelerate sexual development of male Queensland fruit fly, resulting in increased mating propensity of 5–7-day-old males in no-choice laboratory trials. Before considering deployment of methoprene as a pre-release treatment in SIT, it is necessary to demonstrate mating competitiveness and compatibility of methoprene-treated flies under field-like conditions. In the present study, we assessed whether methoprene treatment increases ability of sterile males (5 and 7 days old) to compete with mature males for mating with mature females in field cages. We also investigated mating compatibility to test for sexual isolation between sterile flies and mature (wild or laboratory) fertile flies. In mating competitiveness tests, methoprene-treated males of either age outperformed mature wild or laboratory males for mating with mature wild or laboratory females, respectively. Untreated 5-and 7-day-old males were less competitive than mature wild or laboratory mature males and hence had lower relative sterility indexes. In mating compatibility trials, methoprene-treated males mated equally with methoprene-treated females and mature females, whereas methoprene-treated females tended to mate more often with mature males than with methoprene-treated males. However, untreated flies of both sexes exhibited substantial sexual isolation. Pairings that comprised methoprene-treated males and mature females had shorter mating latency and longer copulations than other pairings. Methoprene-treated females did not exhibit changes in mating latency or duration. Overall, the present study supports the use of pre-release dietary methoprene treatment in Queensland fruit fly SIT.

*The full paper was published online in: Journal of Pest Science, 24 October 2019.*

# Papers in Peer Reviewed Journals

## In Press

CARVALHO D.O., J. TORRES-MONZON, P. KOSKINIOTI, G. PILLWAX, K. BOURTZIS et al. *Aedes aegypti* lines for combined sterile insect technique and incompatible insect technique applications: the importance of host genomic background. Entomologia Experimentalis et Applicata (in press).

CISS, M., M.D. BASSÈNE, M.T. SECK, M.J.B. VREYSEN, J. BOUYER et al. Environmental impact of tsetse eradication in Senegal. Scientific Reports (in press).

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DROSOPOULOU E., A. SYLLAS, P. GOUTAKOLI, A.G. ZISIADIS, A.A. AUGUSTINOS, K. BOURTZIS et al. The complete mitochondrial genome of *Bactrocera carambolae* (Diptera: Tephritidae): genome description and phylogenetic implications. Insects (in press).

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