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/ag/portal/index_en.html

ISSN 1011-274X

No. 91, July 2018

Contents

To Our Readers

With the objective of developing the sterile insect technique (SIT) package for mosquitoes, aerial releases by drones were successfully validated. Tests were performed with a release machine mounted on a Dji Matrice 600 pro unmanned aerial vehicle filled with 50 000 sterile Aedes aegypti *males per flight. Tests were conducted in a 20-ha release site in Carnaíba do Sertão, Juazeiro, State of Bahia, Brazil. Results obtained on the sterile mosquito spatial distribution, sterile to wild ratio, and increases of egg sterility in the field site were very encouraging (Photo: WeRobotics).*

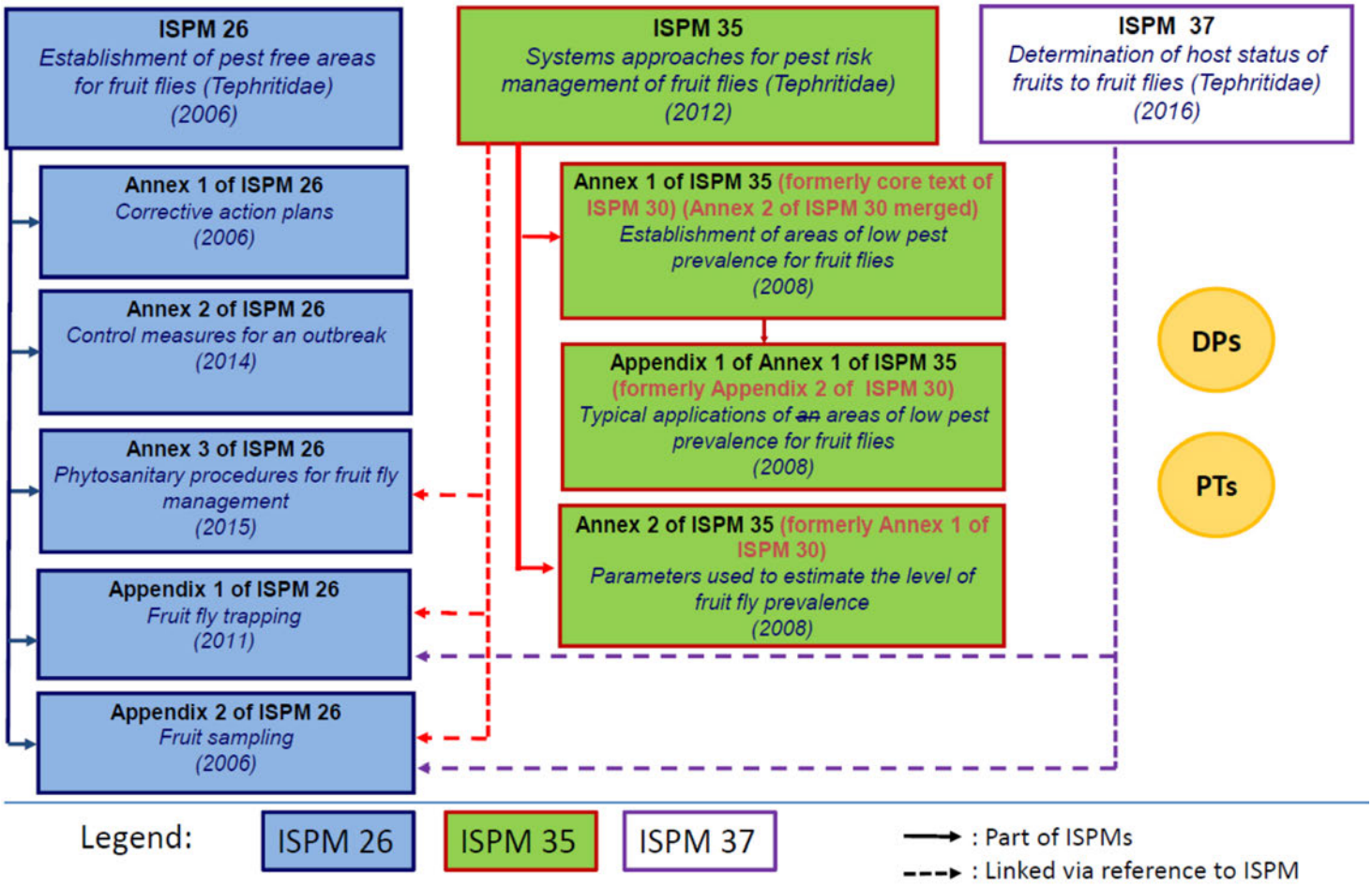
Implementation of the sterile insect technique (SIT) for mosquitoes that are vectors of diseases requires the development and optimization of sexing systems, mass-rearing, irradiation and handling, as well as release systems. Among these, the aerial release has been receiving special attention, facilitated by the recent overall development of remote-piloted aircraft systems (RPAS) or drones.

For other insects, aerial dispersal has relied on release machines mainly used in fixed-wings aircrafts, or occasionally helicopters. This is because the number of sterile insects needed per surface area is high (in the case of fruit flies and moths) or the distribution area is very large (in the case of tsetse flies). Additionally, adult mosquitoes are much more fragile, with long legs and antenna that can break easily when handled.

To overcome these constrains, mosquito release pilot tests have so far been conducted releasing insects by ground, without going through the insect chilling process. However, ground releases are limited by the areas that can be covered, require a large contingent of field staff, have complex logistics, and result in less uniform dispersal patterns. This makes ground releases less effective and costlier when compared with releases by air, especially for large areas.

The Joint FAO/IAEA Division, in collaboration with the Swiss-American non-profit group *WeRobotics*, has developed and validated an aerial release device that can be mounted on a drone and that has the capacity to disperse 50 000 sterile male mosquitoes per flight. The testing of the system was carried out in Brazil in March 2018 and sterile male *Aedes aegypti* were successfully released from an RPAS as part of ongoing efforts to integrate a nuclear technique in the management of the vector that spreads Zika and other diseases.

Another major achievement during the past semester has been the approval of the '*Reorganization and Harmonization of International Fruit Fly Standards*' by the Commission on Phytosanitary Measures (CPM) of the International Plant Protection Convention (IPPC). The IPPC acknowledged the Technical Panel on Pest Free Areas and Systems Approaches for Fruit Flies (TPFF) for its work towards the preparation of the proposal. The main objective was to reorganize and harmonize the existing suite of fruit fly standards (International Standard for Phytosanitary Measures or ISPMs) so that they are more logical, simplifying their implementation to facilitate agricultural trade and prevent the introduction and spread of invasive fruit flies.



Approved reorganization of International Fruit Fly Standards by the Commission on Phytosanitary Measures (CPM) in 2018. Diagnostic protocols (DPs) and phytosanitary treatments (PT) provide additional linkages to enhance usability of the standards.

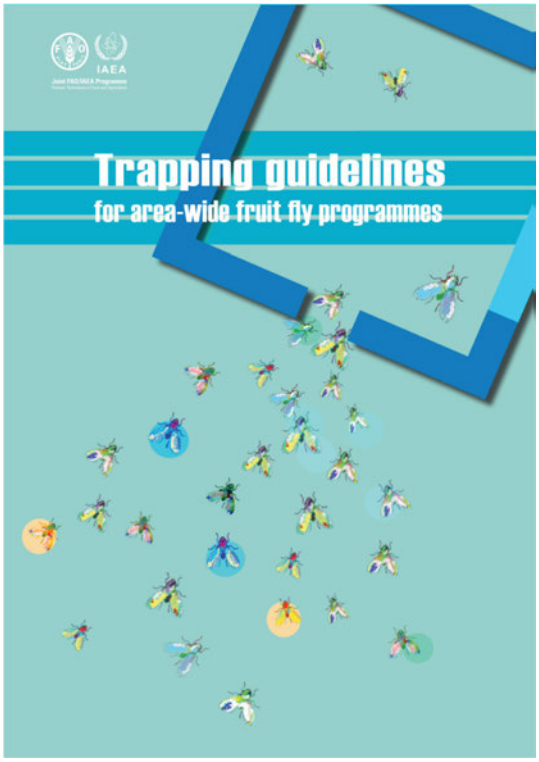
Following this recently approved reorganization, exporting and importing countries first use ISPM 37 (*Determination of host status of fruits to fruit flies (Tephritidae)*) to determine if the commodity is a fruit fly host or not. If not, the commodity can be exported without any additional phytosanitary measures. If it is a host, then ISPM 26 (*Establishment of pest free areas for fruit flies (Tephritidae)*) should be used to identify if the area is a fruit fly free area (FF-PFA) or not. If it is a FF-PFA, no additional measure is necessary to export the commodity. However, if the area is infested, then ISPM 35 (*Systems approach for pest risk management of fruit flies (Tephritidae)*) has to be applied, where two or more pre- and post-harvesting measures are combined to mitigate the risk of introducing the pest to the importing country. The new complete reorganization of fruit fly standards is presented in the figure on the previous page, illustrating how the approach is now simplified to three ISPMs (26, 35 and 37).

To ensure that the fruit fly ISPMs' logical application matches production and trade practices for fruits and vegetables, it was necessary to integrate the existing ISPM 30 (*Establishment of Areas of Low Pest Prevalence for Fruit Flies*) as an annex to ISPM 35. There was no example in international trade of countries using a fruit fly area of low pest prevalence (FF-ALPP) as a stand-alone measure to export. In all know cases, FF-ALPP are used as part of a systems approach.

The reorganization included all ISPMs, annexes and appendices (adopted from 2006 to 2016) and the TPFF reviewed the 13 core documents of the suite of fruit fly ISPMs to ensure harmonization and consistency among them. Repetitive information in some of the ISPMs was removed, and additional links established between the standards, and standards and the adopted diagnostic protocols and phytosanitary treatments, to enhance usability of the standards.

Finally, over the last ten years some technical changes occurred, specifically within taxonomy, in particular the synonymization of four species of *Bactrocera* (*B. dorsalis, B. invadens, B. papaya* and *B. phillipinensis*) within a single species *B. dorsalis*. That change has a direct positive impact on fruit and vegetable trade worldwide, and was included.

The FAO/IAEA trapping guidelines, of which the first edition was published in 2003, have proven to be important guidelines that have supported the development of Appendix 1 of ISPM 26 (*Fruit fly trapping*). In view of new technical developments in this field and the adoption of Appendix 1 of ISPM 26, there was a need to produce an updated version. This second edition of the '*Trapping guidelines for area-wide fruit fly programmes*' has now been finalised and is freely available on the Insect Pest Control website (https://www.iaea.org/sites/default/files/trapping-guideline_0.pdf). They provide detailed information on trapping under different pest situations for different tephritid fruit fly species of economic importance. The specific trapping system to be used will depend on the objective of the pest control programme, economic and technical feasibility, the target species of fruit fly and the phytosanitary condition of the target areas, which can be either infested, an FF-ALPP, or an FF-PFA. They describe the most widely used trapping systems, including materials, applications, as well as procedures for assessment of trap layouts and trap densities based on pest risk, and data recording and analysis.



Finally, collaboration is an essential part of our mandate and recently the Moscamed Brazil (Juazeiro Bahia, Brazil) and the Centro Agricoltura Ambiente (Bologna, Italy) have been designated as IAEA Collaborating Centres for the period 2018–2022 and 2017–2021, respectively. Both centres have the mandate to conduct research and implement SIT in relation to human disease vectors.

Brazil was one of the countries in South America most severely affected by the mosquito transmitted Zika virus outbreak in 2015. Therefore, Moscamed Brazil is implementing programmes to combat the disease-carrying *Aedes* mosquitoes and has become a leader in the application of the SIT for the control of the *Aedes* mosquitoes.

The Centro Agricoltura Ambiente has been instrumental in developing mosquito mass-rearing equipment to support SIT pilot projects in Italy and in other European countries. Their goal for the near future is to continue optimizing mass-rearing equipment that can be used by all countries and to support pilot trials in neighbouring European countries.

Rui Cardoso Pereira

Head, Insect Pest Control Section

Staff

Joint FAO/IAEA Division of Nuclear Applications in Food and Agriculture

Name	Title	Email	Extension	Location
Qu LIANG	Director	Q.Liang@iaea.org	21610	Vienna

Insect Pest Control Subprogramme

Insect Pest Control Section, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
P.O. Box 100, 1400 Vienna, Austria
Tel.: (+) 43 1 2600 26077; Fax: (+) 43 1 26007

Insect Pest Control Laboratory, FAO/IAEA Agriculture & Biotechnology Laboratories
2444 Seibersdorf, Austria
Tel.: (+) 43 1 2600 28404; Fax: (+) 43 1 26007 2874

Name	Title	Email	Extension	Location
Rui CARDOSO PEREIRA	Section Head	R.Cardoso-Pereira@iaea.org	26077	Vienna
Rafael ARGILES	Entomologist (Livestock Pests)	R.Argiles-Herrero@iaea.org	21629	Vienna
Walther ENKERLIN	Entomologist (Plant Pests)	W.R.Enkerlin@iaea.org	26062	Vienna
Daguang LU	Entomologist (Plant Pests)	D.Lu@iaea.org	25746	Vienna
Svetlana PIEDRA CORDERO	Programme Assistant	S.Piedra-Cordero@iaea.org	21633	Vienna
Elena ZDRAVEVSKA	Team Assistant	E.Zdravevska@iaea.org	21632	Vienna
Marc VREYSEN	Laboratory Head	M.Vreysen@iaea.org	28404	Seibersdorf
Adly ABD ALLA	Virologist	A.Abdalla@iaea.org	28425	Seibersdorf
Antonios AVGOUSTINOS	Geneticist	A.Avgoustinos@iaea.org	28754	Seibersdorf
Kostas BOURTZIS	Molecular Biologist	K.Bourtzis@iaea.org	28423	Seibersdorf
Jeremy BOUYER	Medical Entomologist (Human Disease Vectors)	J.Bouyer@iaea.org	28407	Seibersdorf
Carlos CÁCERES	Entomologist (Plant Pests)	C.E.Caceres-Barrios@iaea.org	28413	Seibersdorf
Danilo CARVALHO	Molecular Biologist	D.Carvalho@iaea.org	28438	Seibersdorf
Vanessa DIAS	Entomologist (Post-harvest)	V.Dias-De-Castro@iaea.org	28450	Seibersdorf
Wadaka MAMAI	Medical Entomologist (Rearing Specialist)	W.Mamai@iaea.org	28429	Seibersdorf
Hamidou MAIGA	Medical Entomologist	H.Maiga@iaea.org	28421	Seibersdorf
Andrew PARKER	Entomologist (Livestock Pests)	A.Parker@iaea.org	28408	Seibersdorf
Hanano YAMADA	Entomologist (Human Disease Vectors)	H.Yamada@iaea.org	28429	Seibersdorf
Stephanie BECKHAM	Programme Assistant	S.Beckham@iaea.org	28259	Seibersdorf
Melika OSMIC	Team Assistant	M.Osmic@iaea.org	28473	Seibersdorf

Forthcoming Events (2018 - 2019)

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

First RCM on Colony Management of Insects for Sterile Insect Technique Application. 23–27 July 2018, Vienna, Austria.

Third RCM on Mosquito Handling, Transport, Release and Male Trapping Methods. 12–16 November 2018, Juazeiro, Bahia, Brazil.

Second RCM on Integration of the SIT with Biocontrol for Greenhouse Insect Pest Management. 25 February–1 March 2019, Mendoza, Argentina.

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

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

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

Third RCM on Improved Field Performance of Sterile Male Lepidoptera to Ensure Success in SIT Programmes. 21–25 October 2019, San Rafael, 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 Expert Meeting on Required Parameters for Mosquito SIT Application (under Interregional TC Project INT5155). 8–10 October 2018, Vienna, Austria.

FAO/IAEA Consultants Meeting on Mosquito Radiation, Sterilization and Quality Control. 4–8 February 2019, Vienna, Austria.

III. Other Meetings/Events

FAO/IAEA Training Course on Data Management, GIS and Modelling to Optimize SIT Control Efforts of Invading Mosquito Species in Europe (under Regional TC Project RER5022). 9–13 July 2018, Montpellier, France.

FAO/IAEA Second Coordination Meeting of Africa Regional Project Enhancing Capacity for Detection, Surveillance and Suppression of Exotic and Established Fruit Fly Species through Integration of Sterile Insect Technique with Other Suppression Methods (under Regional TC Project RAF5074). 23–27 July 2018, Accra, Ghana.

Meeting of an Expert Panel on Drafting a Procedures Manual on Establishment and Maintenance of Pest Free Areas (PFA) and Areas of Low Pest Prevalence (ALPP) in support of International Standards of Phytosanitary Measures of the Plant Protection Convention (IPPC). 23–27 July 2018, Raleigh, North Carolina, USA.

FAO/IAEA Regional Training Course on Identification and Diagnostics of New World Screwworm (under Regional Latin America RLA5075). 13–17 August 2018, Panama City, Panama.

FAO/IAEA Regional Training Course on the Use of GIS and International Standards for Phytosanitary Measures (ISPMs) for Fruit Fly Activities in Africa (under Regional TC Project RAF5074). 20–24 August 2018, Gaborone, Botswana.

FAO/IAEA Regional Training Course on Early Detection of Invasive Non-native Fruit Fly Species and Emergency Response (under Regional TC Project RAS5076). 7–11 October 2018, Amman, Jordan, and 14–18 October 2018, Arava, Israel.

FAO/IAEA Regional Training Course on the Use of Georeferenced Fly Rounds for Cost-Effective Entomological Surveillance of Savannah Tsetse Species (under Regional TC Project RAF5080). 29 October–2 November 2018, United Republic of Tanzania.

FAO/IAEA Regional Joint Meeting between Entomologists, Virologists and Epidemiologists to Boost the Collaboration for Vector Control in the European region (under Regional TC Project RER5022). 5–9 November 2018, Tirana, Albania.

FAO/IAEA Workshop on Regulatory Aspects Affecting International Trade Regarding Fruit Fly Pests (under Regional TC Project RLA5070). 12–16 November 2018, Santo Domingo, Dominican Republic.

FAO/IAEA Regional Training Course on Molecular Tools Applied to Tsetse Control Programmes (under Regional TC Project RAF5080). 19–30 November 2018, Bobo Dioulasso, Burkina Faso.

FAO/IAEA Workshop on Techniques for Rearing *Tuta absoluta*, *Spodoptera* and *Helicoverpa spp.* for SIT Research and Application. 3–5 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 Antigua / El Pino, Guatemala.

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

Past Events (2018)

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

Fourth RCM on Exploring Genetic, Molecular, Mechanical and Behavioural Methods of Sex Separation in Mosquitoes. 19–23 February 2018, Bangkok, Thailand.

Second RCM on Improved Field Performance of Sterile Male Lepidoptera to Ensure Success in SIT Programmes. 12–16 March 2018, Palmerston North, New Zealand.

Third RCM on Comparing Rearing Efficiency and Competitiveness of Sterile Male Strains Produced by Genetic, Transgenic or Symbiont-based Technologies. 18–22 June 2018, Bangkok, Thailand.

II. Consultants and Expert Meetings

FAO/IAEA Expert Meeting on Harmonization of Irradiation and Dosimetry Protocols for *Aedes* Invasive Mosquitoes (under Regional TC Project RER5022). 12–14 February 2018, Vienna, Austria.

FAO/IAEA Consultants Meeting on Dashboard for Process Control in Mass-rearing Facilities, and Automatic Insect Density Estimation for Sterile Insect Release. 23–27 April 2018, Tapachula, Mexico.

III. Other Meetings/Events

FAO/IAEA First Coordination and Consultative Meeting of Managing and Controlling *Aedes* Vector Populations Using the Sterile Insect Technique (under Regional TC Project Asia Pacific RAS5082). 12–16 February 2018, Bangkok, Thailand.

FAO/IAEA Workshop to Develop a Best Practice Manual on Field Performance of Sterile Male Moths. 17 March 2018, Palmerston North, New Zealand.

FAO/IAEA First Coordination Meeting of Latin America Regional Project Strengthening the Regional Capacities in the Prevention and Progressive Control of Screwworm (under Regional TC Project RLA5075). 19–23 March 2018, Montevideo, Uruguay.

FAO/IAEA Regional Training Course on Training in Methods for the Handling, Marking, Transportation and Release of Sterile Male *Aedes aegypti*, as Components of the SIT Package for the Control of Mosquito Disease Vectors of Zika, Dengue and Chikungunya (under Regional TC Project RLA5074). 19–23 March 2018, Juazeiro, Brazil.

Thirteenth Session of the Commission on Phytosanitary Measures, International Plant Protection Convention, FAO. 16–20 April 2017, Rome, Italy.

10th International Symposium on Fruit Flies of Economic Importance. 23–27 April 2018, Tapachula, Mexico.

FAO/IAEA Second Coordination Meeting of Latin America Regional Project 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 (under Regional TC Project RLA5070). 23–27 April 2018, Tapachula, Chiapas, Mexico.

FAO/IAEA Stakeholder Engagement Meeting for Sterile Male Mosquito Release Pilot Trials in Europe (under Regional TC Project RER5022). 23–27 April 2018, Vienna, Austria.

FAO/IAEA Second Coordination Meeting of the Latin America and Caribbean Regional Project 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 (under Regional TC Project RLA5074). 7–11 May 2018, Vienna, Austria.

FAO/IAEA Project Mid-Term Review Meeting (under Interregional TC Project INT5155). 14–17 May 2018, Bologna, Italy.

FAO/IAEA Workshop on Recent Developments and Impact Assessment of Sterile and Incompatibility Insect Techniques for Mosquito Control (under Regional TC Project RAS5082). 4–8 June 2018, Singapore.

FAO/IAEA Stakeholders Meeting for Discussions on Alternative Pest Management Approaches Including SIT against the Parasitic Fly *Philornis downsi* on the Galapagos Islands (under Regional TC Project RAS5070). 11–13 June 2018, Vienna, Austria.

Scoping Meeting on the Issues and Implications of Guidance on International Trade and Transport of Insects. 19–20 June 2018, London, United Kingdom.

Technical Cooperation Field Projects

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

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

Country	Project Number	National Projects	Technical Officer
Angola	ANG5012	Supporting Feasibility Studies for using Sterile Insect Techniques as part of Area-wide Integrated Pest Management for Control of Tsetse Flies (*G. morsitans centralis*)	Rafael Argiles
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

Libya	LIB5011	Enhancing Area-wide Integrated Management of Fruit Flies	Walther Enkerlin
Mexico	MEX5031	Using the Sterile Insect Technique to Control Dengue Vectors	Danilo Carvalho
Morocco	MOR5035	Implementing the Sterile Insect Technique in the Souss Valley	Walther Enkerlin 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
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 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	Antonios Avgustinos
Sudan	SUD5038	Implementing the Sterile Insect Technique for Integrated Control of *Anopheles arabiensis*, Phase II	Adly Abdalla
Thailand	THA5052	Developing Sustainable Management of Fruit Flies Integrating Sterile Insect Technique with other Suppression Methods	Daguang Lu
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

		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 Adly Abdalla
Regional Asia	RAS5082	Managing and Controlling *Aedes* Vector Populations Using the Sterile Insect Technique	Kostas Bourtzis
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 Rafael Argiles
Regional Latin America	RLA5075	Strengthening the Regional Capacities in the Prevention and Progressive Control of Screwworm	Walther Enkerlin
		Interregional Project	
Interregional	INT5155	Sharing Knowledge on the Sterile Insect and Related Techniques for the Integrated Area-wide Management of Insect Pests and Human Disease Vectors	Jeremy Bouyer Rui Cardoso Pereira

Highlights of Technical Cooperation Projects

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

First Regional Coordination Meeting, Montevideo, Uruguay, 19–23 March 2018

National counterparts from the Regional Latin America Technical Cooperation Project RLA5075 met in Montevideo, Uruguay to participate in the First Coordination Meeting under this regional project.

Participants of the Regional Coordination Meeting (Montevideo, Uruguay).

The meeting was organized by the IAEA in cooperation with the Government of Uruguay, specifically by the relevant authorities of the Ministry of Industry and the counterpart institution from the Ministry of Livestock, Agriculture and Fisheries.

High level representatives participated, including the Undersecretary of the Ministry of Livestock, Agriculture and Fisheries of Uruguay, the General Director of Livestock Services, the FAO Office in Uruguay, the United States Department of Agriculture (USDA), and the Panama Director for the Panama-USA Commission for the Eradication and Prevention of Screwworm (COPEG).

This project aims to build on the products and achievements of the previous regional project (RLA5067), which since 2014 has been supporting capacity building efforts in the Latin American and the Caribbean region for the prevention and progressive control of the New World screwworm (NWS). During the meeting, the counterparts presented the status of the NWS in their countries and provided valuable information to discuss the required actions with participating experts and partners.

A clear difference was identified between the countries where the myiasis disease is endemic and the countries which have eradicated the NWS and so focus on early detection and emergency response in case of incursions. The workplan and activities were fine-tuned to address Member State needs for the duration of the project.

In addition, discussions were held on the possibilities of starting an initiative for a sub-regional programme for the suppression and eradication of NWS by applying integrated pest management approaches based on the SIT in the region of Uruguay, Eastern Argentina, Southern Brazil, and Southern Paraguay. There were representatives of the public and private sectors of Uruguay, including cattle and wool associations, who reported the importance of the NWS problem in the country and demonstrated their interest in effective and environment-friendly pest control alternatives such as the area-wide application of SIT.

Field visit to the Center Dr. Alberto Gallinal for Research and Experimentation (CIEDAG).

The Minister of Livestock, Agriculture and Fisheries, H.E. Mr. Enzo Benech and the Director of Livestock Services, Mr. Eduardo Barre, participated in a visit to the Center Dr. Alberto Gallinal for Research and Experimentation (CIEDAG) of the Secretariado Uruguayo de la Lana (SUL), in Cerro Colorado, Departamento de Florida. It was an opportunity for all the relevant stakeholders from the private and public sectors and partners to meet and raise technical and operational matters relevant to gaps, research issues, and the feasibility for an eventual implementation of an area-wide programme for NWS eradication in the region.

Harmonizing and Strengthening System to Prevent and Control Exotic and Native Fruit Flies, Including the Use of SIT (RAS5076)

Regional Coordination Meeting, Vienna, Austria, 4–8 December 2017

A meeting was held to review progress under the Middle East Regional Technical Cooperation Project RAS5076 and to plan its future project activities.

Global trade, and the ever-increasing demand to step-up international trade in agricultural products, have increased the possibility and probability of the entry of new non-native pests into the Middle East. A number of pests have already entered the region, such as *Tuta absoluta* (a pest of tomatoes) in 2010, causing both direct and indirect damage

by the closure of markets. The area is also being threatened by many invasive fruit fly species, such as the peach fruit fly and the Oriental fruit fly, that are polyphagous and are likely to cause even greater damage. To combat these threats from non-native pests, concerted actions by all counterparts are necessary. Human migration into the region also increases the risk of invasive pest entry via fruit and vegetable commodities brought into the area.

Participants of the Regional TC Project RAS5076 Meeting (Vienna, Austria).

The previous Middle East Regional TC Project RAS5059 laid the foundations for the cooperation on non-native fruit flies and other pests among the Israel, Jordan and Palestinian Authority counterparts. This included developing a regional database on plant pests and setting-up a fruit fly surveillance network at high risk points of entry. Nevertheless, through the current regional TC project RAS5076, further enhancement and harmonization of the surveillance networks and emergency response is taking place, as well as additional input is being provided to make the database functional according to the current SharePoint versions used by IAEA. The database needs to be further upgraded incorporating additional and more user-friendly features. The generic action plans that were prepared in the previous projects will be used as the basis to focus on new pests such as the false codling moth (*Thamautotibia leucotreta*), an emerging problem in the region.

The activities identified for a possible project extension are: 1) Stabilizing the MEDNIP database so that it is technically fully functional, useful and applicable, 2) Prioritizing the pest list to focus on the most important non-indigenous pests for the Middle East region, that are potentially most harmful to important economic crops and have the highest possibility of entering and becoming established in the region, 3) Increasing communication between the National Plant Protection Officers (NPPOs), 4) Organizing a meeting to input the relevant information into the database with regards to achieving the goals and to further develop the strategic upgrade of the database, and 5) Upgrading the database incorporating a pest alert system concerning interceptions of non-indigenous pests, and developing a supportive decision making tool such as emergency plans against specific invasive pests.

Implementing the Sterile Insect Technique in the Souss Valley, Morocco (MOR5035)

Morocco exports annually around 400 000 tons of citrus, mainly to Europe and Russia. Most of exported citrus (75%) is produced in the Souss Valley in southern Morocco. Although there is potential to double or triple this exported amount, the presence of the Mediterranean fruit fly makes this challenging.

Layout of the Mediterranean fruit fly mass-rearing and fly emergence and release facilities (top) and construction site in April 2018 (bottom).

The fruit fly is mainly controlled using insecticide sprays. During the last years, citrus producers, exporting agencies and the National Plant Protection Organization (ONSSA) from the Ministry of Agriculture carried out a pilot project to suppress the Mediterranean fruit fly in 5 000 ha of the Souss Valley using an area-wide integrated pest management approach with a sterile insect technique (SIT) component. It was carried out with FAO/IAEA technical assistance and each week 8 million sterile male Mediterranean fruit flies were released that were imported initially from Madeira, Portugal, and later from the mass-rearing facility in Valencia, Spain.

In August 2014, the Minister of Agriculture of Morocco, the ONNSA, and the Regional Office of Agriculture in the Souss Valley signed an agreement to establish an area-wide SIT programme against Mediterranean fruit fly in the Agadir region. In addition, the Government of Morocco signed an agreement with the fruit industry to build a Mediterranean fruit fly mass-rearing facility and a fly emergence and release facility large enough to process sufficient sterile

males to cover the entire Souss Valley (40 000 ha of citrus plus surroundings).

The Joint FAO/IAEA Division has assisted with the design of the mass-rearing, fly emergence and release facility that has the capacity to produce initially 130 million sterile males per week, but with the intend to eventually produce 300 million sterile males per week. Construction of the rearing facility has been initiated and is expected to be finalized in summer 2019, and to be fully operational by the beginning of 2020.

A recent mission of the Technical Officer of the project in April 2018, coincided with a visit of a delegation of the Ministry of Agriculture, headed by the Minister, H.E. Mr Aziz Akhenouch. The delegation visited the construction site of the rearing facility in Souss Massa, Agadir. Mr Akhenouch pointed out the importance of the citrus industry in Morocco and the commitments of the Government to establishes an SIT project to control the Mediterranean fruit fly population to facilitate export, open new markets and avoid rejections by importing countries due to the detection of larvae in fruits or too high levels of insecticide residues.

The IAEA through TC Project MOR5035 has facilitated the donation of a ^{60}Co irradiator (Gamma Cell 220) by the Government of Austria and of mass-rearing equipment by Madeira, the Government of Portugal.

Promoting the Sharing of Expertise and Infrastructure for Dengue Vector Surveillance towards Integration of the Sterile Insect Technique with Conventional Control Methods among South and South East Asian Countries (RAS5066)

Workshop on Innovative Vector Control Strategies in the Pacific: Efficacy, Safety, Acceptability, Moorea, French Polynesia, 27 November–1 December 2017

The workshop was organized by the Institut Louis Malardé with support from the IAEA. The participating countries (including American Samoa, Cook Islands, Fiji, French Polynesia, Guadeloupe, La Reunion, New Caledonia, Samoa and Singapore) presented their respective mosquito control programmes. The FAO/IAEA Technical Officer highlighted in his presentation the progress made by the Insect Pest Control Section in the development of the technical package of the SIT component for an area-wide management mosquito programme.

After the workshop, the FAO/IAEA Technical Officer worked with Hervé Bossin, medical entomologist of the Institut Louis Malardé and leader of the mosquito project, on the design of a mass-rearing facility for a target production level of 5 million sterile male pupae per week of *Aedes polynesiensis* and *Aedes aegypti*. Floor plans and work flow schemes were developed. The size of the colonies (bisexual and male only colonies) was calculated based on the current values of key biological parameters. The Institut Louis Malardé is planning to start the construction of the mass-rearing facility in 2018. It should be operational in 2019 to produce sterile mosquitoes for field control programmes after the successful suppression of the *Aedes polynesiensis* population achieved on the island of Tetiaroa in 2015 through the release of *Wolbachia*-infected mosquito males.

Participants of the Workshop on Innovative Vector Control Strategies in the Pacific: Efficacy, Safety, Acceptability (Moorea, French Polynesia).

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

First Regional Coordination Meeting, Bangkok, Thailand, 12–16 February 2018

The kick-off meeting of the IAEA regional Asia TC project RAS5082 was held in Bangkok, Thailand. Forty-three participants from fifteen countries (Bangladesh, Cambodia, China, Fiji, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand and Viet Nam), as well two experts (Japan and United Kingdom), a representative from the Pacific Community, and a WHO representative attended this meeting.

Aedes species are the main vectors of major human pathogens including dengue, chikungunya, yellow fever, and Zika in South and South East Asian countries. Due to the lack of efficient drugs and vaccines, as well as the increasing resistance against insecticides, there is an urgent need of alternative and sustainable control methods.

The FAO/IAEA Insect Pest Control Subprogramme has developed, and continues refining, SIT-based approaches against *Aedes aegypti* and *Ae. albopictus* to suppress mosquito populations in the frame of area-wide Insect Vector Management (AW-IVM) management strategies. Project

RAS5082 aims to transfer this technology to Member States.

Participants of the 1st Regional Coordination Meeting (Bangkok, Thailand).

In the frame of the kick-off meeting, participants presented the status and future challenges with respect to *Aedes* mosquito population surveillance and suppression activities in their countries. Emphasis was given to participants' needs to develop the SIT-based package and implement it in a phase conditional approach. In addition, dissemination activities and local public engagement programmes were discussed, as well as, how efforts such as mosquito mass-rearing, could be coordinated at a regional level.

Establishing a National Centre for Research, Training and Services in Medical and Molecular Entomology for Vector-borne Disease Control (SRL5047)

The main aim of the project is to develop a national centre that will support the control of vector-borne diseases. Dengue virus is a major threat in the area and A*edes albopictus* and *Ae. aegypti* are the main vectors that need to be controlled. A variety of vector control strategies are currently considered, such as the SIT, biological control agents and development of new traps. In addition, community awareness activities and training of staff are being implemented. The project has made substantial progress during the last year.

The SIT-based approaches are a priority, both for *Aedes albopictus* and *Ae. aegypti*, with priority given to the first species. Many activities have been implemented and pilot trial sites have been selected. Entomological baseline data have been collected for more than two years and the prevalence of the dengue virus is monitored in mosquito populations. Irradiation protocols have also been developed. Rearing is being optimized and different strategies for sex sorting are explored, to ensure male-only releases.

Manpower and resources to expand the facility towards mass-rearing are secured. Training and workshops for scientists and staff involved in vector control have been performed. The development of the Entomological Museum, the Information Centre, and the Exhibition Area has progressed, which is important for community awareness and public engagement activities.

Participants of the mid-review evaluation (Colombo, Sri Lanka).

Based on the needs and requests of the Sri Lankan counterpart, support has been provided at different levels, including fellowships and scientific visits to different laboratories to gain expertise in mosquito rearing and taxonomy, sexing strategies, irradiation, molecular biology and bioinformatics. Procurement has supported the development and equipping of the rearing facility, the molecular biology laboratory, and the Entomological Museum, among others. Expert missions for workshops and training courses have been supported as well.

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

First Regional Coordination Meeting, Chania, Crete, Greece, 18–20 December 2017

The participants of this regional Europe meeting presented and reviewed the progress made so far and the workplan for 2018-2019.

The most notable achievement was the successful implementation of a mark-release-recapture experiment in Tirana, Albania in September 2017, with sterile male *Aedes albopictus* mosquitoes produced in Italy. This trial allowed a first estimation of the field competitiveness of sterile male *Ae. albopictus*. In addition, suppression trials against *Ae. albopictus* populations were planned in Montenegro and Greece for summer 2019.

Meeting on Harmonizing Irradiation and Dosimetry Protocols for Invasive *Aedes* Mosquitoes in Europe Region, Vienna, Austria, 12–14 February 2018

Growing concerns on health and environmental impact of extensive insecticide use, has boosted demand for more sustainable pest management measures. The regional TC project RER5022 is supporting European Member States with the transfer and application of the SIT against invasive mosquito species. The project supports cooperation and networking among European countries already affected, or at high risk of being affected, by invasive disease-transmitting mosquito species, and is introducing or strengthening capacity to manage genetic control methods through pilot suppression programmes.

A meeting on harmonizing irradiation and dosimetry protocols for *Aedes* invasive mosquitoes for the Europe region was held. International SIT experts from Brazil, France, Italy, Japan and the USA presented a series of irradiation protocols and, together with participants from Albania, Greece, Montenegro and Serbia, discussed results from induced sterility and mass-rearing activities in their home countries. Participants also visited the FAO/IAEA Insect Pest Control Laboratory in Seibersdorf, Austria, where technical staff demonstrated irradiation protocols and dosimetry procedures used to assess irradiation doses.

Participants touring the Insect Pest Control Laboratory (Seibersdorf, Austria).

During the meeting, the experts discussed a preliminary harmonized irradiation protocol for pilot SIT suppression programmes in Albania, Greece, Montenegro and Serbia. The protocol is expected to be finalized by autumn 2018.

According to Romeo Bellini (Director, Department of Medical and Veterinary Entomology, Centro Agricoltura Ambiente 'Giorgio Nicoli'), "this was a great opportunity not only to analyze and discuss issues related to irradiation protocols for mosquitoes, but also to clarify and better understand induced sterility and competitiveness of sterile male mosquitoes as observed in the laboratory, under semi-field and field conditions. By sharing this information, we hope to achieve better harmonization and standardization of irradiation protocols across all regions and to prepare for the quick suppression of mosquito populations in case of epidemics."

Meeting on Stakeholder Engagement for Sterile Male Mosquito Release Pilot Trials in Europe, Vienna, Austria, 23–27 April 2018

The meeting was attended by representatives of European countries that are planning pilot trials in 2018–2019, and are therefore in need of a communication strategy for the public and other stakeholders. Experts from Guatemala, Sweden and Thailand with practical experience in stakeholder engagement during vector control campaigns provided assistance with the identification of key messages, with different ways of conveying them, and with designing and drafting public information materials.

Sterile Insect Technique for *Aedes* Mosquito Control as Vector of Human Pathogens, Particularly Zika Virus in Latin America and the Caribbean (RLA5074)

Training Course on Methods for the Handling, Marking, Transportation and Release of Sterile Male *Aedes aegypti*, as Components of the SIT Package for the Control of Mosquito Disease Vectors of Zika, Dengue and Chikungunya, Juazeiro, Brazil, 19–23 March 2018

A regional training course was organized for tier 1 (Member States ready to initiate pilot trials) and tier 2 Member States (medium advanced) in Latin America at the Biofabrica Moscamed, Juazeiro, Brazil. During the course a large-scale mark-release-recapture study (drone-mediated and ground release) was conducted by international experts, FAO/IAEA staff, and training course participants themselves. This provided hands-on training in post-irradiation procedures and sterile male releases for all trainees.

Second Regional Coordination Meeting, Vienna, Austria, 7–11 May 2018

Participants of the Second Regional Coordination Meeting, (Vienna, Austria).

A second coordination meeting for all participants of regional TC project RLA5074 was held in Vienna, Austria, where the counterparts presented progress made and the data collected for analysis. All Member States have now tools, equipment and protocols to furbish an insectary, colonize and rear the local strain, collect field data and initiate public engagement activities.

Member States maintaining, or that have advanced to tier 1 status (preparing to initiate pilot trials) include Brazil, Cuba, Mexico and Panama. Member States that are close to completing the tier 2 activities and therefore may move to tier 1 by the end of 2018 include Argentina, Chile, Jamaica, and Peru. A full workplan for the next biennium was developed to support the Member States progressing from one phase of the project to the next, following a phased conditional approach toward the initiation of pilot trials.

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

Project Mid-Term Review Meeting, Bologna, Italy, 14–17 May 2018

The goal of the meeting was to review the progress made by participating countries and to update the workplan for 2018–2019 accordingly. Two WHO representatives participated in the workshop and informed the participants on the WHO Global Strategy for the Control and Prevention of Vector Borne Diseases, as well as the new procedures used by WHO to evaluate new vector control technologies like the SIT, particularly regarding their impact on mosquito-borne disease transmission.

Participants observing a sterile mosquito release during the field visit near Bologna, Italy.

Participants received information on the phased conditional approach applied to SIT mosquito projects. Countries were grouped into three tiers depending on their level of advancement (Tier 3, Collection of entomological baseline data; Tier 2, Pre-operational activities including technology transfer; and Tier 1, Pilot testing and validation in the field). They prioritized their expectations from the INT5155 project, focusing on activities that should be addressed at the interregional level. Most advanced countries, with ongoing or planned pilot trials, presented their progress and technical discussions between representatives from the different continents allowed to advance considerably on identifying problems and solutions.

The major activities identified for the INT5155 project included: (1) addressing regulatory issues associated with the transport and release of sterile male mosquitoes, (2) the need for guidelines for irradiation of large quantities of mosquitoes, and (3) stakeholder engagement.

Finally, the participants visited a field release site of the Centro Agricoltura Ambiente (CAA) and participated in the release of 10 000 sterile male *Aedes albopictus*, which is part of the routine weekly releases that are presently being implemented in pilot sites in Italy.

Assessing the Sterile Insect Technique for Malaria Mosquitos in a South African Setting, Phase II (SAF5014)

Technical Cooperation project has continued to provide support to the South African mosquito project that is advancing rapidly following the construction of a medium-scale rearing facility for *Anopheles arabiensis* wild type strain and a genetic sexing strain (now introgressed into the South African genetic background). The mass-rearing equipment provided under the TC project has now been transferred into the facility and testing of the building has been initiated.

Community engagement activities at a school to support upcoming sterile male mosquito releases in Jozini, Kwazulu-Natal, South Africa.

An expert mission was implemented to assist in a second, large-scale mark-release-recapture study at the pilot field sites in Jozini, Kwazulu-Natal in late February 2018.

Recently, a community engagement officer has been appointed and outreach activities have started in the field sites in Jozini. Initial responses have been positive and the community is supportive of the field activities ongoing in the area.

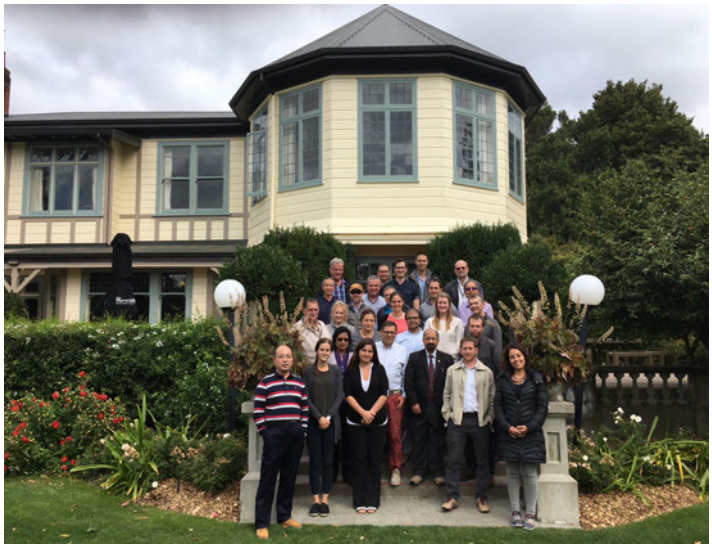
Coordinated Research Projects (CRPs) and Research Coordination Meetings (RCMs)

Project Number	Ongoing CRPs	Scientific Secretary
D4.40.01	Exploring Genetic, Molecular, Mechanical and Behavioural Methods of Sex Separation in Mosquitoes (2013-2018)	Kostas Bourtzis
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)	Andrew Parker
D4.20.17	Improvement of Colony Management in Insect Mass-rearing for SIT Applications (2018-2023)	Adly Abd Alla Carlos Cáceres
	New CRP	
D4.10.27	Assessment of Simultaneous Application of SIT and MAT to Enhance *Bactrocera* Fruit Fly Management (2019-2024)	Carlos Cáceres Rui Cardoso Pereira

Second RCM of the CRP on *Improved Field Performance of Sterile Male Lepidoptera to Ensure Success in SIT Programmes.* 12–16 March 2018, Palmerston North, New Zealand

'Plant and Food Research' from New Zealand hosted this 2nd RCM, and the 'Workshop on a Best Practice Manual on Field Performance of Sterile Male Moths' (17 March 2018). The RCM and workshop were attended by participants from Argentina, Austria, Bangladesh, Canada, Chile, China, India, Israel, Mauritius, New Zealand, and South Africa. The contract and agreement holders from Guatemala, Tunisia, Syria and the USA were for various reasons not present.

During the first two days of the RCM, the participants presented their research activities of the last 18 months and highlighted how these were aligned with the objectives of the CRP. During the last three days of the RCM, the research activities for the next 18 months were discussed, refined and agreed upon in two working groups (1) false codling moth, codling moth, and Oriental fruit moth group, (2) *Lobesia botrana*, sugar cane moths and other Lepidoptera.



Participants of the 2nd RCM, Palmerston North, New Zealand.

A field visit was organized to Hawke's Bay, where orchards were visited, and the RCM participants could view releases with drone aircraft of sterile moths obtained from Canada.

Sterile codling moths being transferred to a release container that is attached to the wings of a fixed-wing drone in Hawke's Bay.

During the one-day workshop, the participants brainstormed on an outline of the manual/protocol for assessing field performance, and a first draft was prepared working in three working groups.

Final RCM of the CRP on *Exploring Genetic, Molecular, Mechanical and Behavioural Methods of Sex Separation in Mosquitoes.* 19–23 February 2018, Bangkok, Thailand

The Fourth Research Coordination Meeting of this CRP was attended by 16 scientists from Brazil, Cameroon, France, Germany, Italy, Pakistan, South Africa, Spain, Sri Lanka, United Kingdom and USA. In addition, six observers from France, Germany, Singapore, Spain and Thailand attended this meeting.

Seventeen scientific papers and related scientific presentations on genetic, molecular, mechanical and behavioral methods of sex separation in mosquitoes were presented and reviewed. During the discussion it was concluded that the main objectives of the CRP were achieved since several sex separation methods have been developed for *Aedes* and *Anopheles* species. These sex separation methods are based on genetic sexing strains, developed by classical genetic and / or molecular approaches, on the exploitation on natural occurring dimorphism such as pupal size and protandry in *Aedes* species, as well as the diet.

Participants of the Fourth Research Coordination Meeting of the Coordination Research Project 'Exploring genetic molecular, mechanical and behavioral methods of sex separation in mosquitoes' in Bangkok, Thailand.

The successful separation of females from males is a key step for the implementation of the SIT-based methods for the population suppression of mosquito vector species at a large scale. It was also decided to publish the main results of this in a special issue of a peer-reviewed scientific journal.

Developments at the Insect Pest Control Laboratory (IPCL)

INSECT GENETICS AND MOLECULAR BIOLOGY

Assessment of the potential of *Bactrocera dorsalis* morphological markers for the construction of genetic sexing strains

The Oriental fruit fly, *Bactrocera dorsalis*, is a highly destructive agricultural pest in different parts of the world. It is a target for the SIT, which can be greatly enhanced by the availability of robust genetic sexing strains (GSS). Naturally occurring morphological markers can be included in a GSS package, either as the main selectable marker or as supportive for sex identification. The availability of naturally occurring mutations greatly simplifies utilization of such strains in the field and helps to overcome regulatory and biosafety issues. Currently available GSS for this species are based on the *wp* mutation, but this strain has not yet been utilized in large-scale operational projects that have an SIT component (see Figure).

*Wild type eye (*or+*) (top left) and orange eye (*or*) (top right). Arrows indicate the color of the eye. Wild type stripes (*wstr+*) (middle left) and white stripes (*wstr*) (middle right). Arrows indicate the color. Wild type pupae (*wp+*) (bottom left) and white pupae (*wp*) (bottom right).*

Different criteria must be met for a marker to be suitable for a GSS. Expressivity and penetration must be 100%, the inheritance pattern must be well studied, the mutation must not have any significant cost (either related to rearing in a facility or competitiveness in the field), and the phenotype must be linked to the sex, ideally with 100% genetic stability.

In collaboration with Ms Weerawan Sukamnouyporn (Thailand), three phenotypic markers are currently being evaluated at the IPCL. These are the color of the eye, the color of the stripes, and the color of the pupa. The color of the pupae, although designated as 'white pupae', has been identified independently from another *wp* mutation used in the past and has not yet been verified whether it represents the same mutation or not. Preliminary genetic analysis has provided no evidence of these three mutations being genetically linked either with the sex chromosomes or with each other. Quality control of the mutant strains is currently carried out to investigate whether they could be used for the development of a GSS following the Mediterranean fruit fly VIENNA GSS example.

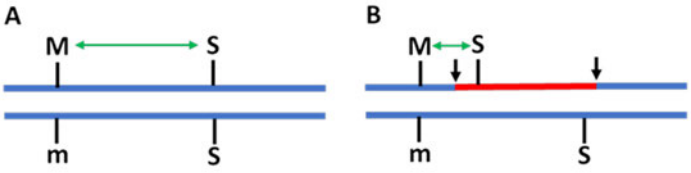
Construction of genetic sexing strains in *Aedes aegypti* using classical genetic approaches: the importance of chromosomal inversions

The absence of 100% reliable sex separation approaches and / or GSS for *Aedes aegypti* limits the application of the SIT for its control. Identifying naturally occurring mutations and using them for the construction of GSS can support existing sexing strategies or, depending on their efficiency, can be applied as a stand-alone approach.

During the last years staff of the IPCL have been using naturally occurring morphological markers for the construction of a first generation GSS. To do so, these markers must be either naturally linked with the sex chromosomes or artificially linked through the induction of chromosomal rearrangements (translocations). Ideally, the wild type allele of a mutation of interest must be linked with the M factor, i.e. the male determining region on chromosome I. The close genetic linkage among the marker and the M locus enhances the genetic stability of the strain.

However, the presence of high recombination frequencies in *Aedes aegypti* males (comparable with recombination frequencies of females) compromises the genetic stability of such strains. To enhance their genetic stability, we are in search of recombination suppressors, focusing on chromosomal inversions. Inversions are known to reduce recombination within their range and this effect can be extended to neighboring genomic areas.

Therefore, selecting the appropriate inversions (see Figure) could reduce or even eliminate recombination between the two loci of interest (M locus and selectable marker S) and provide a GSS of higher genetic stability (2nd generation GSS).



Hypothetical scheme, representing chromosome pair I of Aedes aegypti*, presenting the maleness locus (M) and a selectable marker (S). M/m individuals are males. A: both chromosomes (M and m) have the same orientation. B: chromosome M has an inverted region (red part), compared to chromosome m. Thick black arrows indicate the inversion breakpoints. Green arrows indicate the genetic distance among the loci of interest.*

Two strategies are currently followed to isolate such recombination suppressors. In the first approach, considering that inversions can be frequently found in natural populations, we are screening laboratory colonies deriving from different geographic areas available at the IPCL.

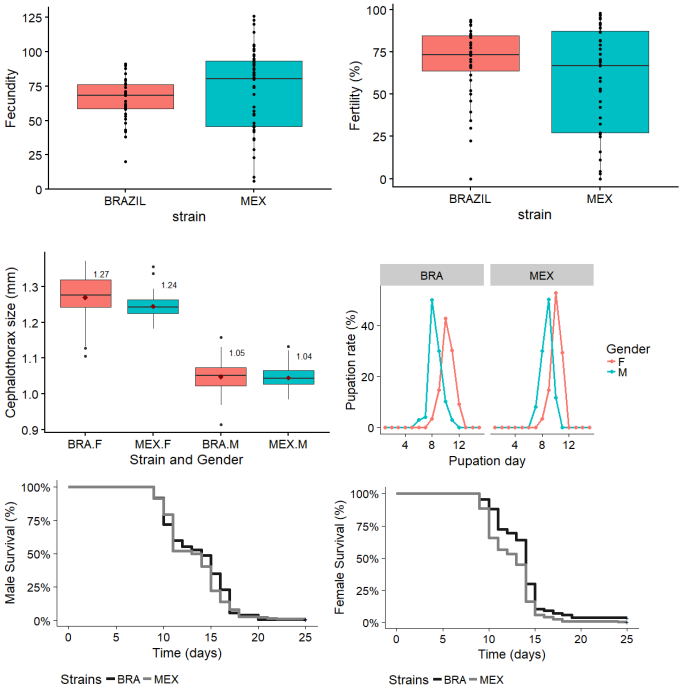
The second approach involves the induction of chromosomal rearrangements through irradiation and the identification and isolation of inversions with the desirable recombination-reducing characteristics. In both approaches, screening is performed based on reduction of recombination among the loci of interest (sex determining region and selectable markers).

Quality control analysis of *Aedes aegypti* under small-scale rearing conditions

There are ongoing intense efforts to develop strains, including GSS, suitable for SIT-based approaches to suppress *Aedes aegypti* populations. The strain selected for SIT-based applications should be of adequate quality with respect to its productivity and male mating competitiveness.

We recently evaluated two populations of *Aedes aegypti* maintained under small rearing conditions, one originating from Brazil and another from Mexico, with respect to their productivity (fecundity and fertility), cephalothorax size, pupation curve and longevity.

Our analysis indicated that, with respect to the fecundity, there was no statistically significant difference between the populations from Brazil and Mexico with an average of about 65 and 72 eggs per female, respectively. Similarly, there was no significant difference with respect to the fertility with an average of about 69% for Brazil and 58% for Mexico. With respect to the cephalothorax size, there was a small statistical difference between the populations with both males and females from Brazil being larger than those from Mexico. There was no difference with regards to the pupation curve, with most of the males being pupated on day eight for Brazil and day nine for Mexico, while most of the females from both populations pupated on day ten after hatching. The two populations did not differ with respect to the longevity of males with 50% of them being able to survive up to 18 days. However, there was a significant difference between the two populations with 50% of the Brazil females surviving up to 19 days, while the equivalent 50% of the Mexico females survived only up to 16 days.



Comparative analysis of two populations of Aedes aegypti*, one from Brazil and the other from Mexico, with respect to fecundity (A), fertility (B), cephalothorax size (C), pupation curve (D), male longevity (E), and female longevity (F).*

PLANT PESTS

FAO/IAEA/USDA phytosanitary treatment projects

The phytosanitary research under the FAO/IAEA/USDA collaborative agreement, "Harmonization of phytosanitary treatments for exotic fruit flies", has continued to evaluate whether low-oxygen conditioning can increase the radiation tolerance of third instar larvae of *Bactrocera dorsalis* and *Ceratitis capitata* reared in mandarins.

Preliminary results have shown that six hours of low-oxygen conditioning (~0.2% O_2, ~21.9% CO_2) does not increase the survival of insects irradiated with lethal doses of gamma radiation. There were no survivors in 5 400 low-oxygen conditioned *B. dorsalis* larvae irradiated with doses of 116 Gy and 150 Gy, nor in 2 000 low-oxygen conditioned *C. capitata* larvae irradiated at a dose of 100 Gy. Large-scale confirmatory testing continues with the ultimate goal of irradiating at least 30 000 third instar larvae under low-oxygen conditioning. The results of this research might contribute to the revision of restrictions applied by regulatory agencies to phytosanitary irradiation under modified atmosphere.

Dissection of mandarins infested by Anastrepha fraterculus.

Research comparing cold tolerance of four morphotypes of the *Anastrepha fraterculus* complex at 1.1°C for 8, 9, 10, and 15 days continues using naturally infested mandarins and nectarines (see Figure). The results generated by this research may help guide regulatory decisions to proactively avoid any resulting trade barriers from the description of new species out of the *A. fraterculus* complex.

Potential use of inactive bacteria as a protein source for the mass-production of fruit flies of economic importance

Studies on the development of new larval diets for the mass-rearing of Mediterranean fruit fly indicated that using inactivated bacteria of the genus *Enterobacter* sp. as a replacement for the routinely used brewer's yeast increased larval production and the quality of the larvae, pupae and the adults.

These studies clearly demonstrated that the quality of the protein originating from bacteria is equal or superior to that of the protein present in brewer's yeast. In the future, benefit-cost analyses will be carried out to determine the viability of this approach on an industrial scale.

Drosophila suzukii

As reported previously, the IPCL has been an active counterpart in the SUZUKILL international project. One of the objectives of this project is to develop alternative and innovative approaches for the biological control of *Drosophila suzukii*, a serious invasive pest, infesting soft summer fruit early during the ripening stage in temperate climates. The IPCL aims at developing the 'SIT package' for this pest and to assess the feasibility of its use in confined areas such as greenhouses.

To be able to implement the SIT for this pest, studies on irradiation/biology of the target insect are required. More specifically, the optimal dose that sterilizes the males without compromising the quality and performance of the released sterile insects in the field is needed. Recently we have completed the dose-response studies for both male and female *D. suzukii*.

Good progress has also been made with the development of an oviposition system that is composed of an oviposition panel made from netting that simulates the oviposition system used to mass-rear other tephritid fruit fly species of economic importance. A practical oviposition system is critical for the mass-production of large numbers of eggs.

The current system allows the eggs to be washed from the oviposition panel, easily cleaned, quantified and incubated. The success of this research will contribute to the development of environment-friendly and practical solutions to better manage the threat of *D. suzukii*.

Adult of Drosophila suzukii *(spotted wing drosophila).*

Further work is ongoing to improve and further fine-tune procedures into an optimal economic mass-rearing system. Production of a larger number of pupae will also allow further work on irradiation dose response curves and irradiation protocols.

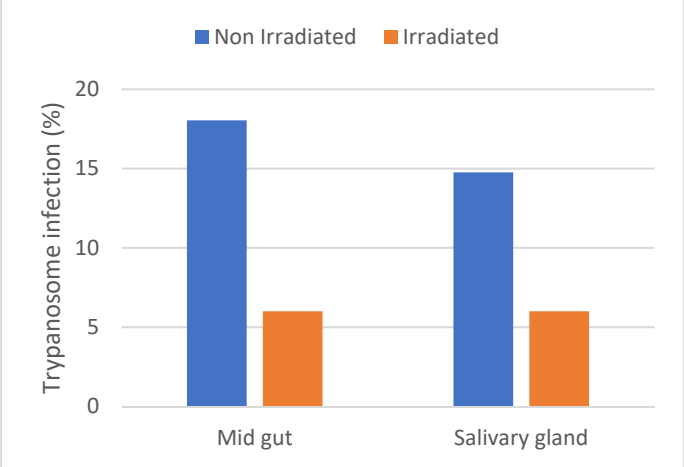
LIVESTOCK PESTS

Impact of ionizing radiation on tsetse vectorial capacity for Trypanosomes

Tsetse flies are competent vectors of trypanosomes, the causative agents of sleeping sickness in humans and nagana in animals. Despite the decrease in the prevalence of human sleeping sickness in the last decade, nagana remains a serious problem for agriculture in much of sub-Saharan Africa.

Sterile tsetse fly males are blood-feeding, thus when released in large quantities for SIT implementation, they are fed trypanocides before release to prevent them becoming potential vectors. This risk needs to be further eliminated in areas where human sleeping sickness is endemic. However, the impact of irradiation on the vectorial capacity of sterile males remains poorly understood. Therefore, we assessed it for the tsetse fly *Glossina morsitans morsitans* and *Trypanosoma brucei brucei* in collaboration with Linda De Vooght and Jan Van Den Abbeele of the Institute of Tropical Medicine, Antwerp, Belgium.

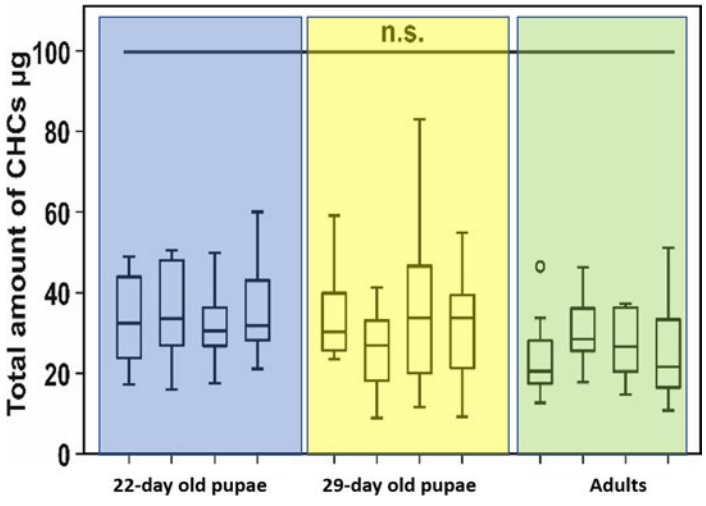
The results indicate that, whereas a prevalence of 18 and 14% was observed in the midgut and salivary glands of non-irradiated flies, an irradiation treatment of 110 Gy reduced the trypanosome infection rate in the salivary glands and midgut to 6%.



Impact of irradiation on the tsetse fly's susceptibility towards trypanosome Trypanosoma brucei brucei *infection (determined by light microscope observation of trypanosomes at 100x magnification).*

Impact of ionizing radiation on tsetse fly cuticular hydrocarbons (CHCs) profiles

Released sterile male flies need to be as competitive as wild males to be able to successfully implement an SIT programme. Irradiation might affect the performance of sterile male insects through reduced survival and changes in the male associated microbiota. It also might have an effect on the cuticular hydrocarbon (CHCs) profiles, but this effect is still poorly understood.



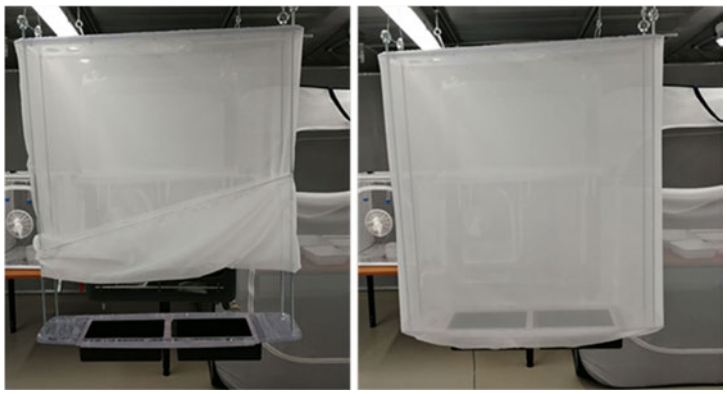
Impact of different doses of irradiation (0, 20, 50 and 110 Gy) administered to 22 and 29-day old pupae and to adults of G. m. morsitans *on the CHCs; n.s.: indicates no significant difference between different treatment.*

The CHCs are ubiquitous and both structurally and functionally diverse in insects. Although the primary function of CHCs is the protection of the insect from water loss, they have secondarily adopted a multitude of functions in intra- and interspecific communication in a solitary as well as social context. In particular, CHCs play an important role in mate attraction, species and sex recognition, courtship, and mate choice in many insect species. We investigated the impact of irradiation treatment (0, 20, 50 and 110 Gy) on *Glossina morsitans morsitans* pupae and adult males, and the results indicated that irradiation itself had no effect on the CHC amount (see Figure).

HUMAN DISEASE VECTORS

Improved mass-rearing cage for *Aedes* mosquito species

Mass-rearing is an important component of any pest or vector control programme that requires the release of a large number of insects. In the framework of the United States Department of State grant 'Surge Expansion of Sterile Insect Technique (SIT) to Control Mosquito Populations that Transmit the Zika Virus' that was awarded to the IPCL in 2016, an innovative design of adult mosquito rearing cage has been under development and evaluation. The new mass-rearing cage was designed for cost-efficiency and is 75% cheaper when compared to the standard adult mass-rearing cage.



New design of an Aedes *mass-rearing cage that is being evaluated at the IPCL.*

The cage can be easily manufactured locally in the Member States and all the plans will be made available on our website. The cage size is adjustable and can be loaded with a maximum of 20 000 *Aedes* pupae. Several hundred thousand eggs can be collected per week following two blood feeds. During the rearing, all manipulations can be done from the outside, which minimizes the risk of mosquitoes escaping, as there is no need for intervention inside the cage.

Preliminary tests showed that the new cage prototype yields a greater number of eggs as compared to the standard cage, without affecting egg hatch. The potential of the new cage for *Aedes* mosquito species mass-rearing is very promising and will therefore contribute to the expansion of the SIT package against the vectors of the Zika virus.

Effect of mass-rearing stress conditions on life history traits and genetic stability of the *Aedes aegypti* genetic sexing strain

The SIT relies on the release of an adequate number of sterile males. However, a fully reliable method to separate male from female mosquitoes on a large scale is still required in mosquitoes and therefore, the development of a GSS is another important component for the development of the SIT for disease transmitting mosquitoes.

In the framework of the same United States Department of State grant, new *Aedes* GSS candidates are under development. One of the candidates is being evaluated under mass-rearing conditions and the following parameters are being assessed: larval development, pupation rate, pupal emergence rate, egg production, survival and recombination rate that conditions the stability of the strain.

Preliminary tests showed that the life history traits were similar to those of the wild-type *Aedes aegypti* strain. Moreover, females of the new GSS candidate produced a greater number of eggs per female as compared with the wild-type strain, both under stress and no-stress conditions. In addition, the candidate GSS showed good genetic stability after the first generation. The evaluation of this new strain will continue for a few more generations.

Longevity of mass-produced and packed sterile males of *Anopheles arabiensis* and *Aedes aegypti* under semi-field conditions

The implementation of the SIT requires the mass-production of sterile males of adequate biological quality, able to survive long enough to participate in mating swarms (for *Anopheles*) and compete with wild males for mating with females. Therefore, it is of utmost importance to determine to what extent procedures such as mass-rearing, irradiation, chilling and packaging can impact the longevity of the adult males under semi-field conditions.

For the evaluation, sterile males were packed in small canisters, chilled at 6 °C for 6 hours and then exposed to rainy season conditions as available in Khartoum (Sudan) and Juaneiro (Brazil) for *Anopheles arabiensis* and *Aedes aegypti,* respectively.

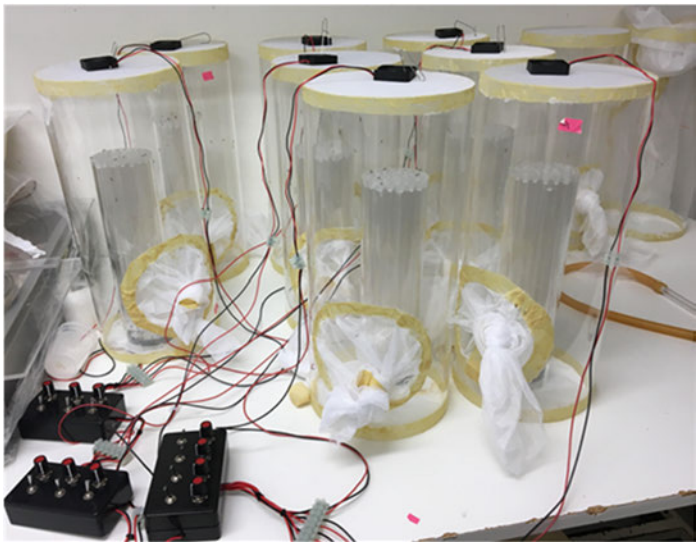
Longevity of sterile males exposed to daily fluctuating field conditions simulated in climatic chambers was lower in comparison to those exposed to laboratory conditions for both *An. arabiensis* and *Ae. aegypti* mosquitoes. Packing conditions significantly reduced the longevity of *An. arabiensis* only. However, the combination of irradiation and the chilling-packing process significantly reduced longevity in both species. Longevity of *An. arabiensis* was significantly lower following an early morning release in comparison to late afternoon. *An. arabiensis* appeared to be more sensitive to the packing process and timing of the release as compared to *Ae. aegypti*.

These results are important parameters to be considered for optimizing pre-release conditions and selecting the desired release ratio relative to wild male populations.

A new quality control tool for mosquito SIT

Insect flight ability is one of the most reliable measures of insect quality. Despite the availability of standardized tools for other insects used in programmes involving sterile insects, there is currently no adequate quality control tool in place to assess mosquito quality.

As previously reported, two new quality control tools have been developed to measure male competitiveness by observing mosquito flight ability. These tools required introduction of pupae into individual wells beneath clear plastic tubes. In recent months, colleagues at the IPCL have redesigned one of these devices to allow direct introduction of adult mosquitoes into the flight test device. Results are obtained in only two hours.



A series of flight test devices to measure the flight ability of Aedes aegypti *following exposure to a stress treatment such as irradiation, chilling or compaction.*

A series of experiments were carried out in which *Ae. aegypti* and *Ae. albopictus* were exposed to various stress treatments, such as irradiation, immobilization and compaction. Flight ability was assessed post-exposure and compared with survival and insemination potential as reference methods.

In all stress treatments, we found that survival and insemination rates could be accurately predicted by the results of the flight ability test. These results are extremely encouraging and pave the way for this novel tool to become a standardized method to evaluate cumulative stress throughout the process of mass-rearing, handling, transport and release of sterile mosquitoes and its impact upon final sterile male mosquito quality.

Reports

Participants of the 10th International Symposium on Fruit Flies of Economic Importance (Tapachula, Mexico).

10th International Symposium on Fruit Flies of Economic Importance, 23–27 April 2018, Tapachula, Mexico

The International Symposium on Fruit Flies of Economic Importance (ISFFEI) is the global fruit fly symposium, held every four years. The 10th edition was successfully held from 23–27 April 2018 in Tapachula, Chiapas, Mexico. It was organized by El Colegio de la Frontera Sur (ECOSUR), with the support of the Servicio Nacional de Sanidad Inocuidad y Calidad Agroalimentaria (SENASICA), the Asociación Agrícola Local de Fruticultores del Soconusco (AALFS) of Chiapas, Mexico and the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture.

The symposium was attended by 289 fruit fly researchers, plant protection officials, fruit industry representatives, fruit fly control companies and exhibitors from 62 countries. There were 59 oral and 134 poster presentations during the symposium that covered the following 10 sessions: (1) Biology, Ecology, Physiology and Behavior, (2) Taxonomy and Morphology, (3) Genetics and Biotechnology, (4) Chemical Ecology and Attractants, (5) Risk Assessment, Quarantine and Post-harvest, (6) Sterile Insect Technique, (7) Natural Enemies and Biological Control, (8) Other Control Methods and New Developments, (9) Area-wide IPM and Action Programs, (10) Social, Economic and Policy Issues of Action Programs.

Many oral and poster presentations covered various aspects related to area-wide integrated application of the SIT against fruit fly pests, such as mass-rearing, field release, genetic sexing strains, quality control, etc. The success stories on SIT application were shared in the symposium, including the tri-national Guatemala-Mexico-USA Medfly Program, the Mediterranean fruit fly eradication in the Dominican Republic, as well as Moscafrut Program in Mexico. These highlight that the SIT is a cost-effective, environmentally sustainable and publicly accepted method for the integrated management of fruit fly pests.

Highlights of the symposium were new knowledge and developments regarding the chemical ecology of fruit flies that contribute to make control methods more specific and efficient, the use of models to better understand and predict population dynamics, and new knowledge on microbial symbionts associations. In addition, the audience very well received research on social aspects regarding farmers' perceptions and education on fruit fly problems and management options.

Three field trips took place during the mid-week to 1) the mass-rearing facility of Moscafrut Program in Metapa, 2) the mango production and exporting process, release of sterile flies and mango packing center for export, and 3) surveillance of Mediterranean fruit fly, field operations and the coffee plantations.

The participation of thirty-five participants from Africa, Latin America and the Caribbean, and Asia and the Pacific were supported under ongoing IAEA Technical Cooperation projects.

Kick-Off Meeting for the SIT Project 2 against Mosquitoes on the Island of La Réunion, 29–31 January 2018, La Réunion, France

A meeting of the second phase of this project that aims to control *Aedes albopictus* mosquitoes on La Réunion reviewed the progress made so far on the development of the SIT package. Three components, namely mass-rearing, field site characterization (mosquito population size, dispersion in three sites) and stakeholder engagement were discussed. Special attention was given to the last one as no regulation for the release of sterile male mosquitoes is yet available in Europe (including La Réunion).

A communication strategy for stakeholders was developed and a final document was submitted for review and approval to the Ethics Committee of the French 'Institut de Recherche pour le Développement' (IRD). The SIT team on La Réunion requires funds to increase their production capacity to be able to release in three pilot sites. A 100 m^2

area was offered by CYROI (Cyclotron Réunion Océan Indien) to build a mass-rearing facility. CYROI is also hosting the SIT programme and research activities.

Common Aedes albopictus *breeding site in La Réunion, France.*

The discussions with the working group were useful and allowed defining a strategy for at least one pilot field trial. A follow-up project outline was also developed for submission to funding bodies for larger releases in pilot SIT trials against *Ae. albopictus* in La Réunion.

World Trade Organization (WTO) Sanitary and Phytosanitary (SPS) Committee Thematic Session on Pest Free Areas (PFA), 26–28 February 2018, Geneva, Switzerland

A Thematic Session on Pest Fee Areas (PFA) was organized by the WTO. Delegates from more than 30 countries attended the session which was chaired by Christine Wolff, WTO Counsellor of the Agriculture and Commodities Division. Other relevant participants included Jay Mitchell, International Trade Specialist, APHIS-IS, Washington DC, USA; Cong Linye, Deputy Director, Import and Export Food Safety Bureau, AQSIQ, Beijing, China; Naoko Kokuho, Deputy Director, International Standards Office Food Safety Policy Division, MAFA Tokyo, Japan; and Sergio Balderas Rodriguez, Deputy Director for Sanitary and Phytosanitary Measures and Competition Policy, Ministry of Economy, Mexico City, Mexico.

The Thematic Session included extensive presentations and discussions of the provisions of the SPS Agreement on PFA and relevant guidelines (Article 6), including International Plant Protection Convention (IPPC) standards on PFA. The representative of the Joint FAO/IAEA Division delivered a presentation entitled 'Area-wide IPM with the Sterile Insect Technique as a Tool for Establishing and Maintaining PFA'. The role of the Joint Division in research and development, and in supporting technology transfer to Member States through technical cooperation projects was discussed. The support provided by the Joint Division to the standard-setting for fruit fly pests through drafting of International Standards for Phytosanitary Measures (ISPMs) and preparing procedures manuals and guidelines was highlighted. A discussion session on PFA and the use of area-wide SIT was conducted with representatives of UN Member States, mostly trade specialists.

Discussions were held on the recognition of the concept of '*Regionalization*', including violations of Article 6 such as not recognizing the concept of regionalization and failure to adopt SPS measures. Another topic was the issue on '*Undue delay*' of petitions for recognition of PFA, which should not be left to the discretion of the Member State. Consequently, the possibility was raised of IPPC formally recognizing PFA at a country or regional level, as is the case of OIE with pests and diseases affecting livestock. The conclusion from IPPC members attending the session was that this role was not foreseen as part of the mandate of the IPPC, rather it is a bilateral issue of interest to the NPPOs. Issues related to complexity and lack of funds for such an endeavor were also discussed.

Delegates of the SPS Committee Thematic Session on Pest Free Areas (PFA).

The opportunity to expose representatives of Member States to the WTO with the area-wide application of the SIT as a tool for establishing and maintaining PFA and areas of low pest prevalence (ALPP), was very valuable. Also, representatives became acquainted about the role and contributions of the IAEA and its Joint FAO/IAEA Division in support of these phytosanitary schemes to facilitate trade. It is very rewarding to see how the ISPMS to establish and maintain PFA and ALPP, especially those developed for fruit fly pests, are being implemented and increasingly used in Member States to facilitate international trade of horticultural commodities.

Thirteenth Session of the Commission on Phytosanitary Measures (CPM), International Plant Protection Convention, 16–20 April 2018, Rome, Italy

The Secretary of the International Plant Protection Convention (IPPC), Jingyuan Xia, presented the major achievements of the IPPC in 66 years. He stressed that the entire IPPC community should be very proud of these achieve-

ments, and should be also well prepared for moving towards 2020 to celebrate the International Year of Plant Health, and towards 2030 to contribute to achieving UN Sustainable Development Goals (SDGs).

The CPM approved the '*Reorganization and Harmonization of International Fruit Fly Standards*'. Contracting parties acknowledged the IPPC Technical Panel on Pest Free Areas and Systems Approaches for Fruit Flies (TPFF) for its work. The new organization of the standards is presented on pages two and three of this newsletter (under the section To Our Readers) and is now simplified to three ISPMs:

- ISPM 26: *Establishment of pest free areas for fruit flies (Tephritidae)*
- ISPM 35: *Systems approach for pest risk management of fruit flies (Tephritidae)*
- ISPM 37: *(Determination of host status of fruits to fruit flies (Tephritidae)*

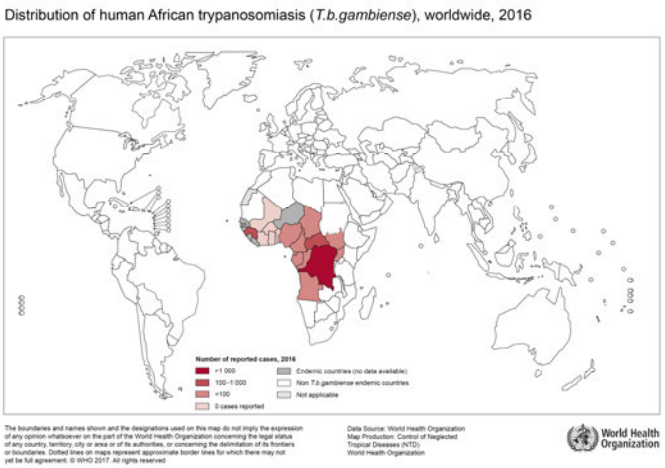
The major change was the inclusion of the former ISPM 30 (*Establishment of Areas of Low Pest Prevalence for Fruit Flies (Tephritidae)*) as Annex 1 of ISPM 35. Also, a new Annex of ISPM 28 (Phytosanitary treatments for regulated pests) on '*Vapour Heat Treatment for* Bactrocera dorsalis *on* Carica *papaya*' was adopted.

Third WHO Stakeholders Meeting on *gambiense* Human African Trypanosomiasis (g-HAT) Elimination, 18–20 April 2018, Geneva, Switzerland

The third WHO meeting on g-HAT elimination was held at WHO headquarters, with good progress being reported towards elimination of g-HAT. About 1 500 new g-HAT cases were detected in 2017, as compared to 2 163 detected cases in 2016. This is an enormous reduction knowing that in 2000, there were still 32 000 newly detected cases.

Every year, around two million people are actively screened by 1 370 centres that have the facilities to screen for g-HAT, a number that has increased from 700 centres in 2013. In addition, there are now more than 600 centres available that provide treatment for g-HAT. Although there are still cases reported in 17 countries, 80% of all the cases are found in the Democratic Republic of the Congo (see Figure).

The WHO reported that the number of people at risk of contracting the disease has however, increased from 56 million in 2000–2004 to 61 million in 2006–2010 and in 2012–2016. This is however mainly due to an increase in the total size of the African population. Important however, is that there is a significant reduction in number of people at high/very high risk, i.e. from 5.8%, to 2.2% and to 0.8% in the periods 2000–2004, to 2006–2010 and to 2012–2016, respectively.



Countries still infested with gambiense sleeping sickness in 2016 (Source WHO).

There seemed to be a consensus in the meeting that, as g-HAT cases continue to decrease, the goal of elimination of g-HAT as a public health problem by 2020 (and eliminating transmission by 2030) will only be possible when vector control programmes will be incorporated in the overall disease containment approach.

WHO Vector Control Advisory Group (VCAG) and the Combined Sterile Insect Technique / Incompatible Insect Technique, 14–16 May 2018, Geneva, Switzerland

As reported in the IPC Newsletter 90, the combined sterile and incompatible insect technique (SIT/IIT) approach against *Ae. aegypti* and *Ae. albopictus* was presented at the 5th WHO Vector Control Advisory Group meeting which was held 2–4 November 2016 in Geneva, Switzerland and received the following conclusions and recommendations (http://apps.who.int/iris/bitstream/10665/255824/1/WHO-HTM-NTD-VEM-2017.02-eng.pdf):

(a) The combined SIT/IIT technology has potential for long-term control of *Ae. aegypti* and *Ae. albopictus* mosquitoes and (b) VCAG strongly recommends further entomological and epidemiological field trials be conducted to validate the use of this intervention and its claims of efficacy against disease.

The Insect Pest Control Subprogramme presented updates on all the components of the combined approach at a WHO Vector Control Advisory Group meeting which was held at the WHO headquarters. The updates included progress achieved on the development and evaluation of several strains suitable for SIT-based approaches, and emphasized progress with the development of genetic sexing strains, mass-rearing, irradiation protocols, packing / transport / release, quality control, design of mass-rearing facilities, public awareness as well as implementation of small scale pilot trials.

Status Report Released on the New World Screwworm in Latin America

A status report (in Spanish) on the New World screwworm (NWS) has just been released by participants of an IAEA project, presenting the current state of the NWS in Latin America, together with future activities and expected benefits of the project.

The New World screwworm *Cochliomyia hominivorax* (Coquerel) is a cause for myiasis, a parasitic infestation of the body which affects humans and animals. The most devastating effect is on livestock production, through mortality and reduced milk and meat yield. Wildlife, especially endangered species, are also threatened. Due to climate change, the insect can also spread into new geographical areas formerly free from infestation, or re-infest areas where NWS had been eradicated.

For these reasons, the governments of Argentina, Brazil, Chile, Ecuador, Panama, Paraguay, Peru and Uruguay requested assistance from the IAEA to help control this pest problem. A TC project was started in 2014 with the support of the Joint FAO/IAEA Programme, delivering expertise, equipment procurement and training, supporting capacity building in disease diagnosis, assessing geographical boundaries of the pest and supporting educational campaigns.

Participants at the regional meeting, 12–16 December 2016, Vienna, Austria (Photo: J. Krickl/IAEA).

The status report provides an update of the regional status of the presence or absence of the pest, challenges and expected project benefits, such as the availability of base-line information for a future area-wide intervention using the SIT, feasibility studies and technology. The report was drafted with the contributions of IAEA project counterparts, invited experts and partners, as well as the United States Department of Agriculture and the International Regional Organization for Plant and Animal Health.

A new TC project for the 2018–2020 programme is foreseen to continue strengthening surveillance systems and emergency response capacities in Member States in Central and North America, which are pest-free, and to continue supporting capacity building that could lead to pilot-scale interventions using SIT in South America and in the Caribbean.

IAEA Supports Successful Test of Drones in Brazil in the Fight Against Disease-Transmitting Mosquitos

The International Atomic Energy Agency (IAEA) and its partners have successfully tested releasing sterile mosquitos from drones as part of efforts to use a nuclear technique to suppress the insect that spreads Zika and other diseases.

The IAEA, in partnership with the Food and Agriculture Organization of the United Nations (FAO), has worked with the Swiss-American non-profit group WeRobotics for the last year to develop a drone-based mosquito release mechanism for use in the application of the Sterile Insect Technique (SIT) to control insect pests. Testing of the system was carried out in Brazil in March 2018.

The SIT, a form of insect birth control, uses radiation to sterilize male mosquitos, which are then released to mate with wild females. As these do not produce any offspring, the insect population declines over time.

“The release mechanism for mosquitos has until now been a bottleneck in the application of SIT to control human diseases,” said Jeremy Bouyer, medical entomologist at the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. “The use of drones is a breakthrough, and paves the way for large-scale and cost-efficient releases, also over densely populated areas.”

The technique requires the uniform release of large numbers of insects in good condition over a given area. *Aedes* mosquitos, responsible for the spread of diseases, do not disperse for more than 100 meters in their lifetime, creating a challenge for the effective application of SIT over large areas. They are also fragile, and high-altitude releases by airplanes – often used in the application of the technique for other insects – may damage their wings and legs.

"The biggest challenge in designing this mechanism was keeping the mosquitos healthy and competitive while transporting and releasing them at cool temperatures" said Adam Klaptocz, co-founder of WeRobotics. "We're pleased with initial tests that show less than 10% mortality through the entire chilling, transport and aerial release process."

Until now, sterile mosquitos have been released using time-consuming and labour-intensive ground methods. “With the drone, we can treat 20 hectares in five minutes,” said Bouyer. Weighing less than 10 kilograms, the drone can carry 50 000 sterile mosquitos per flight. At 10 000 Euro per drone, its use also reduces the cost of releasing mosquitos by half.

Brazil plans to start using the drone-based system in selected urban and rural areas from January 2019, at the peak of the summer and mosquito season. “We are hopeful about the application of SIT for the control of *Aedes aegypti* in Brazil with the results from the drone tests,” said Jair Virginio, Director of Brazil-based Moscamed, a recently-designated IAEA Collaborating Centre.

The IAEA and its partners are now working to reduce the drone's weight and to increase its capacity to carry up to 150 000 mosquitos per flight. The development of the drone was supported by a grant from the United States Agency for International Development.

The SIT has been used for over 50 years to fight agricultural pests such as the Mediterranean fruit fly, and has only recently been adapted for disease-transmitting mosquitos. The insect control method can be particularly useful against vectors that are difficult to manage using conventional techniques, such as nets impregnated with insecticide, or when there is a need to reduce the use of pesticides.

The push for the development of SIT to control mosquitos became more urgent as the Zika epidemic unfolded in Brazil and Latin America in 2015–2016. Through its Technical Cooperation Programme, the IAEA provided assistance to affected countries to rapidly diagnose the disease and to boost regional capacity to apply SIT against the vector of diseases.

Moscamed Brasil Receives IAEA Collaborating Centre Designation

Moscamed Brasil has been designated as an IAEA Collaborating Centre for the period 2018–2022 in relation to its programmes to combat the disease-carrying *Aedes* mosquitoes. Brazil, one of the countries that was severely affected by the mosquito transmitted Zika virus outbreak in 2015, has been working for several years on the development of genetic technologies to control *Aedes aegypti*, the vector of this and other diseases such as dengue. Moscamed Brasil, with the support of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture has become one of the pioneer institutions worldwide in the application of the sterile insect technique for the control of the *Aedes* mosquito.

Collaborating Centre Designation Ceremony at Moscamed Brasil, with Dazhu Yang - IAEA Deputy Director General Technical Cooperation Department (holding plaque left) and Jair Virginio - Director Moscamed Brasil (holding plaque right).

Mr Dazhu Yang, Deputy Director General of the IAEA and Head of the Department of Technical Cooperation, delivered a plaque commemorating the Collaborating Centre designation to Mr Jair Virginio, Director of Moscamed Brasil, on 21 March 2018. "With the funding of the Ministry of Health and the technical support of the IAEA and FAO, we have initiated a programme to control the vector mosquito through the release of sterile male mosquitoes in the state of Bahia," said Mr Virginio. "We are upscaling our production capacity to 4 million sterile male mosquitoes per week of a local mosquito strain that will be released on a continuous basis as of January 2019".

Moscamed Brasil has a long history of collaboration with the Joint FAO/IAEA Division on the sterile insect technique for fruit flies and mosquitoes. Since 2011, seven regional training courses, three research coordination meetings and some 30 fellowships and scientific visits have been hosted at their facilities.

Centro Agricoltura Ambiente 'Giorgio Nicoli' in Italy Receives IAEA Collaborating Centre Designation

The Centro Agricoltura Ambiente, Bologna, Italy has been designated as an IAEA Collaborating Centre for the period 2017–2021 in relation to its programme to suppress the disease-carrying *Aedes albopictus* mosquitoes. This centre has in the past few years been leading the research on mass-rearing *of A. albopictus*, including the development of relevant equipment, and the implementation of pilot trials, to test the effectiveness of the sterile insect technique. It has also supported the Joint FAO/IAEA Division in terms of providing capacity building and expertise to other projects in the region and elsewhere. Furthermore, the Centro Agricoltura Ambiente has been supporting the FAO/IAEA by hosting several research coordination meetings and several training courses in the past few years.

Collaborating Centre Designation Ceremony, with Paolo Ceccardi - President of Centro Agricoltura Ambiente 'Giorgio Nicoli' (holding plaque right) and Rui Cardoso Pereira - Joint FAO/IAEA Division on Nuclear Applications in Food and Agriculture (holding plaque left).

In the last two years the Centro Agricoltura Ambiente has also been rearing and shipping *A. albopictus* mosquitoes for pilot releases in Albania and Germany. With the support of FAO/IAEA, it has become one of the pioneer institutions worldwide in the application of the sterile insect technique for the control of the *A. albopictus*.

Announcements

Call for Submission of Research Proposals for a new FAO/IAEA Coordinated Research Project (CRP) on *Assessment of Simultaneous Application of SIT and MAT to Enhance* Bactrocera *Fruit Fly Management*

Background:

The SIT, which is an environment-friendly technique, involves the mass-rearing of male insects, sterilizing them by ionizing radiation and releasing them in the target area in numbers large enough to outcompete their wild counterparts. Sterile male matings with wild females result in no off-spring and the release of sterile males in adequate sterile to wild male over-flooding ratios suppresses the wild population in the targeted area. In certain cases, this population suppression can lead to eventual eradication of the target population. Furthermore, as the SIT acts in an inverse density dependent manner, it becomes more effective when the wild population is reduced.

The male annihilation technique (MAT) has been used to suppress *Bactrocera* pest species as part of an integrated pest management approach, and even successfully applied to eradicate populations in some isolated situations such as islands or after recent outbreaks. Integration of the MAT with the SIT has so far been sequential, rather than simultaneous, with the SIT applied after a significant reduction of the wild population with the MAT; the reason being to avoid the mass-trapping of the released sterile males in the lured traps with the semiochemical methyl eugenol, which would significantly reduce the efficacy of the SIT.

Objectives:

The objective of the new CRP 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:

- The development of cost-effective semiochemical treatments and delivering systems that improve sterile male sexual performance and reduce their response to MAT formulations so that MAT and SIT can be integrated simultaneously.
- Assessment of the effect of exposure of selected *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.
- Evaluation of key parameters in large field cages such as degree of lure response of sterile flies, sterile to wild over-flooding ratio, wild fly sex ratio and bisexual release to determine their influence on the effectiveness of simultaneous MAT and SIT application.
- Field evaluation of simultaneous MAT and SIT within a pilot or operational setting that includes compatible management practices.

Main Activities:

The CRP will address all factors that should allow the simultaneous and effective application of SIT and MAT to enhance *Bactrocera* fruit fly management:

- Determine the minimum amount of semiochemical required by males to reduce their lure response for a significant portion of their lifetime in the field.
- Establish the best means to confirm that adequate semiochemical delivery has been achieved physiologically, including analysis of haemolymph, rectal gland contents, and pheromone composition.
- Establish the means to minimize responsiveness to traps
- Identify alternative semiochemicals for pre-release treatment, but recognizing that the best lure for a particular fruit fly species may not be the best semiochemical for pre-release treatment.
- Compare the mating age and behavior of males fed semiochemicals only or in combination with other pre-release treatments (e.g., methoprene, dietary supplements).
- Determine whether pre-release treatments of fruit flies diminish their performance, such as survival, flight, dispersal, and mating ability.
- Determine the best means of semiochemical delivery that is compatible with existing fly emergence and release systems.
- Establish the relative field response of different fruit fly species to male lures using standardized protocols.

Duration:

The expected duration of the CRP is 5 years (2019–2023) and the first Research Coordination Meeting is planned for 15–19 July 2019 in Vienna, Austria.

Applications:

Scientist and researchers who are interested in collaborating in this new CRP should contact Carlos Cáceres (C.E.Caceres-Barrios@iaea.org) or Rui Cardoso Pereira (R.Cardoso-Pereira@iaea.org). Information on the IAEA Coordinated Research Programme and how to apply for research contracts and research agreements can be found at http://cra.iaea.org/. Applications should be submitted by **31 October 2018** to research.contracts@iaea.org.

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

Context: Food insecurity is inherently linked to pests and diseases. The losses caused by diseases and pests at both the pre- and post-harvest levels average at 30-40% of agricultural outputs. This is a very inefficient use of agricultural investments in land, seeds, water, fertilizer, animal feed, labour and other inputs available to feed the growing human population.

Current reliance on pesticides and drugs is not sustainable, impairing the natural balance and causing outbreaks of secondary pests, contaminating the environment and leaving residues on food commodities, and leading to the development of resistance to pesticides used.

In addition, because of increasing crop and animal movement and trade, as well as climate change, there is an unprecedented increase of invasive animal and plant pests with dire socio-economic consequences.

An area-wide integrated approach that targets the management of total populations of major pest insects, although management-intensive and logistically more complex, can contribute in most situations to a more effective and sustainable control.

Purpose of the Course: The purpose of this four-week interregional course is to provide a broad overview on the application of nuclear-related techniques, within the context of area-wide integrated insect pest management programmes, to managers of insect control programmes, animal health and plant protection officials and applied research entomologists.

The course will include radiation-induced sterility, the sterile insect technique (SIT), F-1 sterility, other methods of insect control, integration of control methodologies for area-wide insect management, the biology, ecology and dynamics of pest insect populations subjected to control, economic analysis of area-wide programmes and reviews of successful and ongoing area-wide programmes with an SIT component.

The aim is to widen the knowledge and horizon of current and future decision makers to a broader list of major insect pest problems, including pests or vectors of diseases that are currently not yet established in the participants' countries.

Participants: The course is directed at top-level disease vector and pest control management personnel that are or will likely become high level decision makers and senior managers of pest control programmes or campaigns. A key aspect of this training is to develop good pest control managers in Member States with the broad background and skills required to conduct complex area-wide programmes. There is a need to transfer technology while also developing the required managers of projects to effectively integrate the SIT. Future decision makers need to be made aware of upcoming risks, develop a sense of preparedness and be trained on preventive and management strategies against potential new major pests and disease vectors.

Application Procedure: Nominations should be submitted on the standard IAEA application form for training courses (https://www.iaea.org/technicalcooperation/How-to-take-part/train-course/index.html). Completed forms should be endorsed by and submitted through the official channels established (either the Ministry of Foreign Affairs, the National Atomic Energy Authority, the Office of the United Nations Development Programme, the Office of the FAO Resident Representative or the Ministry of Agriculture). **(Deadline for nominations: 28 February 2019).**

Participants' Qualifications: The course is open to about 24 participants from IAEA and FAO Member States in all geographical regions. Preference will be given to qualified candidates from developing countries. Applicants must have at least a Bachelor of Science degree or equivalent in entomology or a related biological field. As the course will be conducted in **English**, participants must have an adequate working knowledge of that language.

Preference will be given to those in pest control policy-formulating positions or involved in preparing applied pest control programmes, or who have had at least several years of practical experience in applied research or teaching on pest control. The key criterion is the candidate's actual participation in operational area-wide pest control programmes or the potential when he/she has returned home to provide leadership in area-wide pest management and the use of the SIT in future programmes.

Dashboard for Managers on Process Control for Fruit Fly Rearing Facilities that Mass-Produce Insects for Sterilization and Release

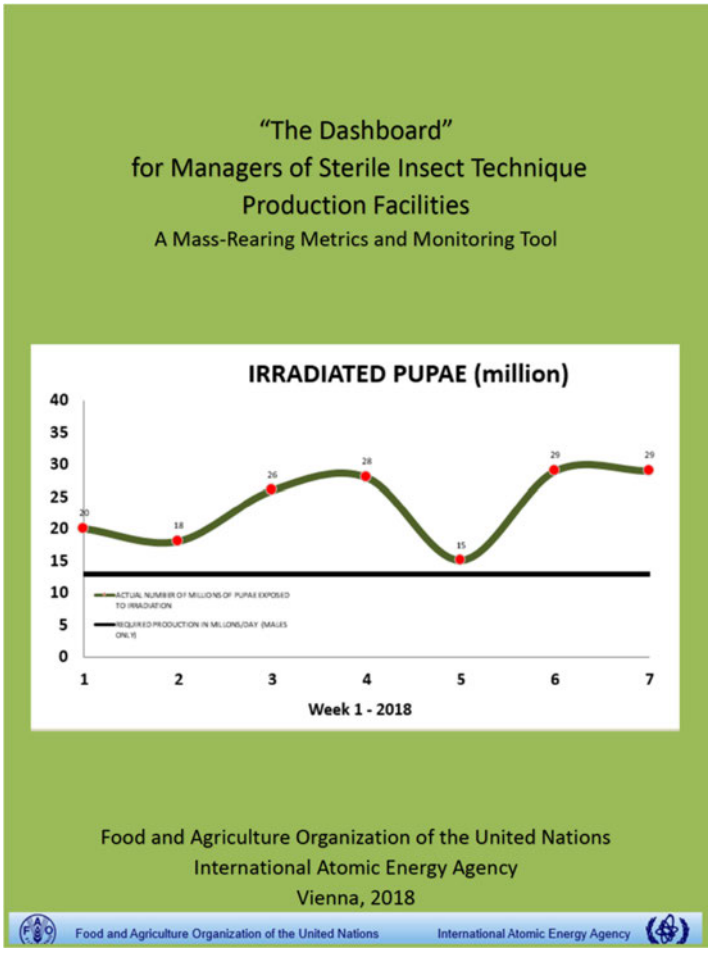
The Dashboard on Process Control for Fruit Fly Rearing Facilities is composed of an Excel spreadsheet and graphic display and has been designed as a working tool, primarily for managers and staff at mass-production facilities to monitor insect rearing operations.

Managers and rearing technicians can be easily overwhelmed by the large volume of information generated by various production processes. Presenting production trends in an organized, dashboard-style manner brings a lot of value to facility and programme managers.

It can also be used to monitor performance of small-scale colonies and for strain comparisons. This mass-rearing metrics and monitoring tool allows managers to monitor their daily production performance in a dashboard format. This Excel monitoring system and graph display 'dash-

board' can also be used to predict or model different production scenarios and compare them with actual operations.

By definition a dashboard is a visual display of data collected to monitor conditions and to facilitate understanding of the processes described. Dashboards are commonly used in industrial production and are suited to monitor insect production. They display key performance parameters showing production and quality trends in simple, easy to interpret graphs.

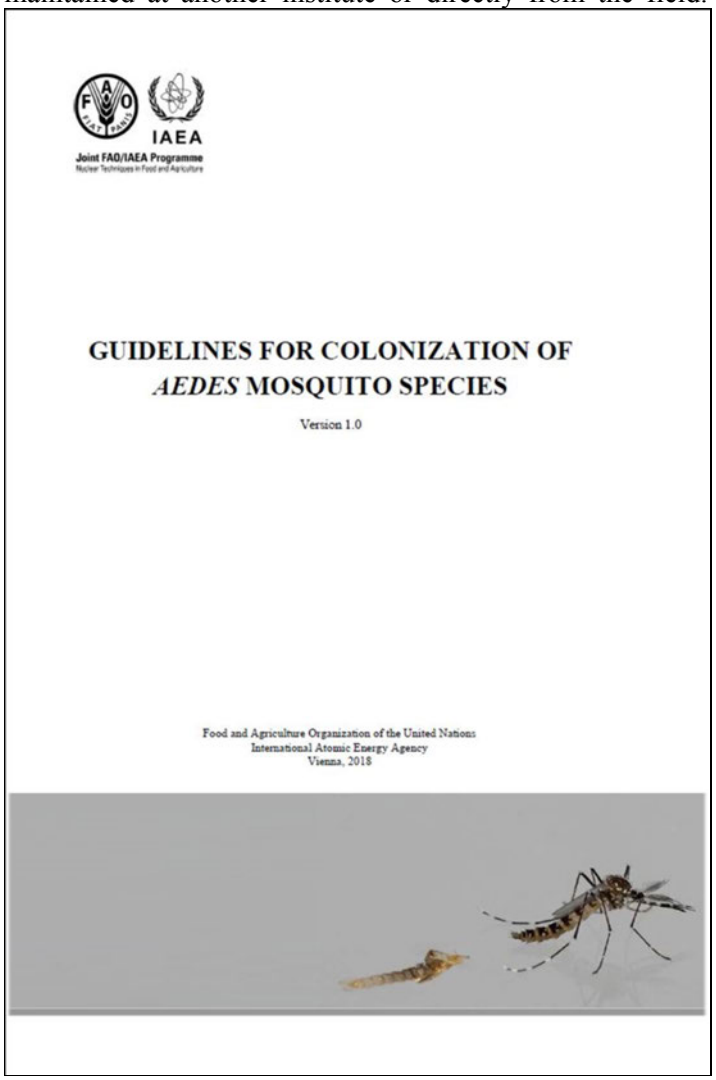


The monitoring of operation activities helps to quickly identify production problems, take corrective actions, and measure their impact in improving processes. Monitoring also strengthens process planning and implementation, use of resources, supervision in general and invites participation by staff at all levels of the insect rearing operation, as well as all operations linked to SIT application. A stable production process with known performance measurements provides better control over production output, leading to reduced overall operational costs.

Feedback from users regarding potential improvements of the dashboard is encouraged to achieve greater utility. This software and procedures manual is available at: http://www-naweb.iaea.org/nafa/ipc/public/manuals-ipc.html.

Guidelines for Colonization of *Aedes* Mosquito Species

This document provides a description of procedures required for the establishment of *Aedes aegypti* and *Ae. albopictus* colonies in an insectary or laboratory. *Aedes* material for the establishment of a new colony may be retrieved from an already established laboratory colony routinely maintained at another institute or directly from the field.



These guidelines present a summary of the necessary steps such as collecting material from the field, transferring material (such as eggs) from an already established colony, identifying species, and adapting your wild colony to laboratory conditions and artificial rearing procedures.

The Guidelines can be visited at: http://www-naweb.iaea.org/nafa/ipc/public/Guidelines-for-colonisation-of-Aedes-mosquito-species-v1.0.final.pdf.

Manual para diferenciar moscas de *Anastrepha ludens* (Loew) silvestres y criadas de cepa normal ("bi-sexual") y cepa sexada genéticamente (Tapachula-7), irradiadas y sin irradiar

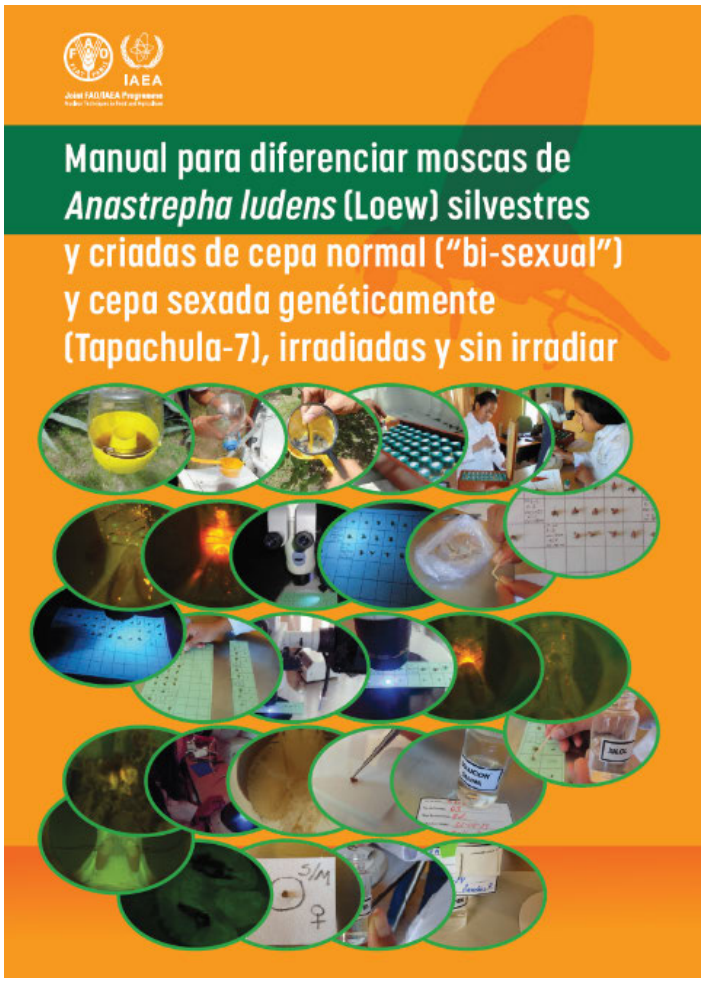
Manual to differentiate Mexican fruit fly, *Anastrepha ludens* (Loew), wild and artificially reared, from irradiated and non-irradiated bisexual strain and a genetic sexing strain (Tapachula-7)

This manual is specific for Mexican fruit fly (*Anastrepha ludens*), a pest of citrus in its native geographical area that includes Mexico, Southern USA, as well as some countries in Central America. In Mexico and the USA, it has been possible to establish areas free of this pest, as well as areas of low pest prevalence through national programmes that apply an integrated pest management approach which includes the sterile insect technique (SIT).

Important components of the SIT implementation include the release of sterile insects, as well as their subsequent monitoring of their performance in the field. Therefore, the correct identification as well as differentiation between the sterile released and the wild insects is fundamental to maintain the phytosanitary conditions of an area.

The manual presents the necessary procedures to accurately differentiate specimens of wild *A. ludens* from those reared in a laboratory, irradiated and non-irradiated from a normal bisexual strain, as well as from the genetic sexing strain (*Tapachula-7*).

The manual is a result of extensive studies conducted to measure the effects of irradiation on testis and ovaries of these fruit fly strains. The studies were partially funded by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. The Mexican National Fruit Fly Campaign (SENASICA-SAGARPA) was instrumental by providing financial support, facilitating the identification laboratories and providing the biological materials for the study.



It is the first manual of its kind for this fruit fly species and presents standardized procedures. Therefore, it is a valuable tool for area-wide operational programmes against *A. ludens* that apply the SIT. The manual is available at: http://www-naweb.iaea.org/nafa/ipc/public/Manual-para-diferenciar-moscas.pdf.

In Memoriam

Maurice Desmond Proverbs (1921–2018)

Maurice Desmond ('Jinx') Proverbs passed away with his family by his side 18 May 2018 at the age of 96. He will be sadly missed by his loving wife Muriel (nee Peart), daughters Joan (Bob), Kathy (Ron), Patricia (Kim), and Dianne, and grandchildren Jennifer, Keith, James, Alex, Laura, Stephanie, and Darren. Desmond was the son of Gordon and Nellie Proverbs of Barbados and was predeceased by his brother Keith. Desmond was born and raised in Barbados. He attended The Imperial College of Tropical Agriculture in Trinidad and then continued at McGill University (Macdonald College) in Ste. Anne de Bellevue, Quebec where he earned a BSc, MSc and PhD in agriculture (entomology). At McGill he met Muriel and together they had 70 happy years together in Summerland, British Columbia.

Desmond's life work was as a research scientist developing the original sterile codling moth control program in the Okanagan Valley. His work at the Summerland Research Station from 1947 to 1980 is recognized as a significant part of the original research of the sterile insect technology now used internationally as an environment-friendly insect pest control method. As result of his outstanding contributions, in 1975 he was named a Fellow of the Entomological Society of Canada and in 1978 he received a major Canadian Public Service Merit Award.

He loved life in Trout Creek and the beautiful view across Okanagan Lake. After retirement he enjoyed spending winters in Barbados, where he had many close friends and family. Desmond had an incredible knowledge of nature and was an avid fisherman, cultivator of roses, and birder. He was an enthusiastic golfer, gardener and a man of the sea. Desmond will be remembered for his sharp intellect, hearty laugh and fascinating life stories.

Source: Okanagan Valley Newspaper Group, 26 May 2018

Ernest J. Harris (1928–2018)

Ernest James Harris passed away at his home in Kaneohe, Hawaii on February 20, 2018 just 3 months short of his 90th birthday, following a battle with cancer.

He was the son of an African-American cotton farmer. From elementary through high school, Ernie started each school year more than two months late because he and his five brothers and sisters needed to help his father pick cotton on a five-acre family farm near Little Rock, Arkansas. He attended an all-black high school in the segregated South, graduating magna cum laude.

Ernie was among the first African-Americans who volunteered to become U. S. Marines. As a result of his military service he received financial support from the GI Bill to attend college. Ernie then graduated from the University of Arkansas at Pine Bluff, and obtained a Master's degree in entomology from the University of Minnesota.

After many attempts to land a job after college, he finally received a positive response from USDA's Agricultural Research Service (ARS) with an invitation to work on solving problems with fruit flies in Hawaii and the Mariana Islands, starting in January 1962. Ernie became one of their first African-American research scientists.

During his 44-year ARS research career, his assignment was to develop information on the biology, field ecology, detection, and monitoring of tephritid fruit flies and parasitoid species for large area control by population suppression or eradication with the SIT, male annihilation, or augmentative parasitoid releases.

During the early 1960's in the western Pacific, Ernie was part of the pioneering Hawaii team led by Loren Steiner to demonstrate the use of the SIT and male annihilation for eradication of fruit flies. Even today these technologies form the backbone of area-wide treatments in California, Florida and other U.S. mainland states for the eradication

of frequent introductions of fruit flies, to keep them free of these invasive pests and avoid costly quarantines that would interfere with millions of dollars' worth of agricultural exports. These technologies are not only used nationally, but also internationally. In 1975 while still working for ARS, Ernie obtained his PhD from the Entomology Department in the College of Tropical Agriculture and Human Resources under the direction of Wallace C. Mitchell. During his research career, Ernie published over 120 peer-reviewed articles.

Although he encountered much discrimination during his career, Ernie remained the positive, kind, gentle and humble man for which he will always be remembered. He has been a role model for African-American scientists. Ernie has received significant national and international recognition for his research efforts, with recognition also for his accomplishments in having to work through racial biases against African Americans.

He received Certificates of Merit from USDA-ARS for both the transfer of research technology to the California Mediterranean fruit fly eradication program efforts (1983) and for outstanding research effort in developing the laboratory adapted strain of *Biosteres arisanus*. He was inducted into the Royal Entomological Society of London (1989) and received an official commendation from the government of Chile for his help in fruit fly eradication that helped Chile to export fruits (1996).

The Ernest James Harris Ph.D. Scholarship has been established by the Mu Beta Lambda Chapter of the Alpha Phi Alpha Fraternity. He, also, was recently (November 2016) awarded a Congressional Gold Medal, the highest civilian award bestowed by the Congress of the United States. This award was given to him in recognition of his unwavering perseverance and courage and that of his fellow Montford Point Marines, that inspired change in the Marine Corps. The award recognizes the Montford Point Marines' contributions to the Marine Corps and the United States of America from 1942 to 1949.

Most recently, in September 2017, Dr. Ernest James Harris was inducted into the ARS Science Hall of Fame. Ernie has certainly left behind a legacy and serves as a role model for others to look up to and follow. His colleagues at USDA, ARS, and DKI-PBARC are immensely proud of Ernie's accomplishments and will miss him greatly.

Source: Roger I. Vargas, USDA-ARS.

Rubén Leal Mubarqui (1961–2018)

Rubén started releasing sterile fruit flies by air in 1995, using the paper bag system and constituting the Mubarqui Corporation. In 1998 he opened the Mexican fruit fly *Anastrepha ludens* packing and release centre in Tamaulipas, Mexico, and in 1999 he created a research unit that developed a fruit fly adult diet, as well as a chilled adult release machine with a capacity to release 5 million sterile *A. ludens* and *A. obliqua* per flight. Together with his team he designed a Quality Assurance System for SIT application, including an interactive web platform. He also designed the Mubarqui tower for sterile fly emergence and holding, used in Mexico for *Anastrepha spp* and *Ceratitis capitata.*

By invitation of the IAEA, a tsetse fly release machine was designed and donated to the program in Senegal. He created the concept of the high precision "Smart Release Machine", which was latter applied to all fruit fly release machines used in Mexico. Together with his team, he collaborated with Croatia on the control of *C. capitata* in Neretva Valley, where they fully adopted the Mubarqui method. Many of these developments are an important part of the FAO/IAEA Guideline for Packing, Shipping, Holding and Release of Sterile Flies in Area-wide Fruit Fly Control Programmes, first (2007) and second (2017) editions.

He participated in the development of the parasitoid *Diachasmimorpha longicaudata* packing and release system, and of the method and equipment for sterilized mosquito vector release. He also developed a release system using drones under the principle of "Precision Release". His latest contributions were the establishment in Mexico of a rearing facility for *Tamarixia radiata,* parasitoid of the Asian citrus psilid *Diaphorina citri.*

On the human side, the most important thing was his family and close collaborators. His character was inventive and entertaining, however, strict and disciplined as well. Motivated by his altruistic and humanitarian spirit, he created the Mubarqui Foundation 'Salud Para Un Bienestar Social', a health clinic for the most vulnerable. His passion for nature took him to create on his property a real bird, fish and mammal sanctuary, as well as greenhouses for cultivation of exotic plant cultivars.

Source: Roberto Angulo, Mubarqui Corporation.

Other News

Plant and Food Research, New Zealand, Develops New Weapon against Most Feared Pests

New Zealand scientists have found a new hope against a tide of invasive pests threatening to invade our borders, with hundreds of millions of dollars at stake.

Bioprotection scientists have begun a trial targeting some of our most feared threats, including the brown marmorated stink bug, the Korean pumpkin fly, the European grapevine moth, and spotted wing drosophila. If they became established, the species could wreak havoc in orchards and vineyards. Plant and Food Research's bioprotection team was looking to target the potential invaders with a chemical-free approach called the 'sterile insect technique'.

The 'sterile insect technique' is being used against the codling moth in Hawke's Bay. Photo / Simon Winkley & Ken Walker, Museum Victoria/CC.

It was already being used in one promising Hawke's Bay trial, in which hundreds of thousands of sterile male Canadian moths were being dropped by drone to combat codling moths that attacked apple, pears and walnuts. Overseas, the tactic had proven effective by eradicate the pink bollworm moth in California.

As world trade and travel increase, so too does the risk, senior plant pathologist Nick Waipara said. Ministry for Primary Industries figures showed that between 2003 and 2014 air passenger numbers increased 47%, sea containers 37% and parcels 216%. "Like many of our traditional trading partners we are also trading with new markets and that means we are being exposed to new pests from both new and traditional trading partners."

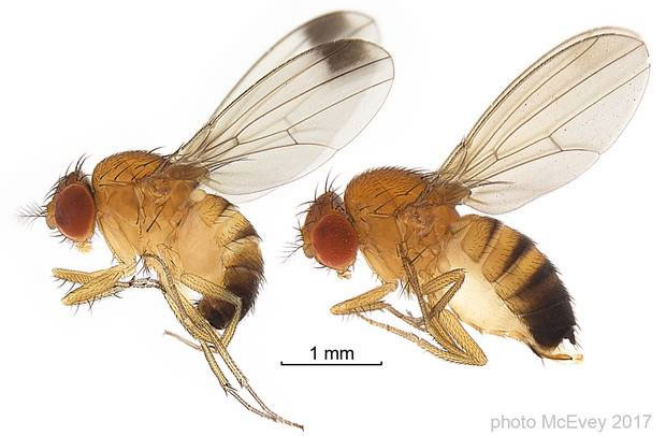
Max Suckling, who heads the bioprotection team, said the global eradication and response database, GERDA, showed the rate at which pest insects were 'going global' was accelerating. New Zealand, meanwhile, was experiencing a third wave of migration. "First there was the original flora and fauna, then people arrived with the animals and plants they wanted to grow, and now we seem to be getting fast-moving super pests," Suckling said.

The multi-agency effort to eradicate the painted apple moth outbreak in New Zealand cost $65 million. Estimates of the cost to the economy if that moth established here ranged up to $290 million, while the cost saved by interceptions, and eradication programmes to date, ranged from $100 million to as much as $1 billion.

Suckling said new technology was also likely to make detection and tracking more efficient. New super-sensitive electronic sniffers, capable of detecting airborne compounds well below one part per billion, would help detect pests at the border. Similar electronic sensors could be deployed with pheromone traps tailored to target species to provide live monitoring and reporting, when necessary. "If a new pest arrives we could deploy prototype traps and link them up to quickly build a picture of spread and density in different areas," Suckling said.

Traps baited with artificial pheromones helped eradicate the European grapevine moth around Napa, California – a pest which spread across 2 800 square kilometres in Chile, and costing its table grape industry NZ$70m a year.

Pheromone traps were also in regular heavy use in New Zealand orchards at this time of year – not as part of an eradication programme but as a management tool. Orchards are much livelier with insect activity today than in the days of regular and heavy spray use. Orchardists and farmers monitor pest numbers and spray only when they cross a certain threshold.



The spotted wing drosophila, a type of fruit fly. Photo / Shane F. McEvey, Australian Museum/CC.

This formed the cornerstone of the integrated pest management system (IPM) that Plant and Food Research designed together with growers. Today, there were now virtually no chemical residues on our export apples, meaning they could be exported to more than 70 countries - more than any other apple exporting nation.

A new generation of insect lures was also showing promise. When insects ate foliage, volatile chemicals were released from the plant that attracted more insects to the feast. Suckling said lures based on those chemicals would be simpler and cheaper to prepare. They also attracted broad classes of pest insects – and their predators – not just individual species. They could be combined with pheromones to attract specific species, as work in that field continues to advance. "There is no doubt that more insect pests will arrive here," Suckling said.

The brown marmorated stink bug. Photo / Hectonichus/CC.

"Increasing contact with the rest of the world means we are engaged in a never-ending battle to protect our horticulture and native ecology against new threats.

"We have had good success against some of these fast-moving super pests already and now we are developing new tools and international collaborations to take on the next challengers."

Source: Jamie Morton, NZ Herald, 17 December 2017.

Local Focus: Sterile Pink Moths to Fight Codling Infestation of Apples

Pink moths are opening markets for New Zealand apples. A million of the sterile moths, both male and female, were imported this season for a pilot programme to control the codling moth in Central Hawke's Bay.

Over three years the programme has slashed its pest population by 98 %, and total elimination would improve New Zealand's export-market access. Plant and Food Entomologist, Jim Walker said the programme had led to decreasing use of insecticide: "bit we've also increased our use of sex-pheromone technology disrupting the mating of codling moth".

"The sterile insect technique, on top of these other measures, is really an intention overall to control or eliminate the codling moth locally within these orchards," he said. Sterilized in Canada, the imported moths were dropped by drone over orchards so the local population will invariably breed with the sterilized moths, drastically reducing the resident population. "On a 100 ha orchard – this orchard we are standing in – there was just one adult codling moth captured – male – all season in all of their pheromone traps," Dr. Walker said.

As larvae, they are fed a red dye which gives their bodies a pink hue when pressured, for easy identification. 80 000 are chilled each week to 1°C to settle them down for the 36-hour flight over the Pacific Ocean.

Initially the release of codling moths caused harm to humans because the scientists released them by hand from mountain bikes requiring one-handed riding that resulted in too many crashes. A remote-control fixed-wing plane was also used for the release but now a drone is taking over duties for greater precision. For more detail see the video at: https://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=12017028.

The moth sterilization technique has been approved by Biogrow, enabling an organic apple orchard to be incorporated in the Central Hawke's Bay trial. Plant & Food Research Science Group Leader for Biosecurity, Max Suckling said the technology could be rolled out further, especially if there was an incursion of a new pest.

Source: Patrick O'Sullivan, NZH Local Focus, 22 March 2018.

Unmanned Drones are Dropping Sexy, Sterile Moths on Okanagan Orchards

Kelowna, Canada. A new way to drop sterilized moths on Okanagan orchards could make a job that used to take an entire day take less than 45 minutes. Melissa Tesche is acting general manager of the sterile insect release program in the Okanagan-Kootenay region.

A specially designed drone for dropping sterilized moths on infested orchards is being tested in the Okanagan. The device can hold enough moths for around 40 acres, which it can cover in 8 minutes. Image Credit: M3 Consulting Group.

Three years ago, an American company, M3 Consulting Group, approached Okanagan-Kootenay Sterilized Insect Release Program (OKSIR) with drone technology they said was working well on large cotton fields. “They wanted to try on another size of moth as well, and asked ‘would you guys be willing to give us moths to test?” Tesche says. “As we watched the test we started thinking this could really work for us.”

Cydia pomonella, *Codling Moth. Image Credit: Wikipedia.*

According to the OKSIR website, the codling moth population has decreased by around 90 per cent since they started releasing sterilized moths into the population in 1992. Wild moths mate with the sterile moths, but produce no offspring. “It’s a fine balance between giving them just enough radiation to make them sterile, but still letting them be sexy” Tesche says.

Three years ago, equipped with a few thousand donated, sterilized codling moths from Osoyoos, the organization was able to drop a known quantity out of a specially-equipped unmanned aerial vehicle (UAV) along a predetermined route. The first test was a success. They came back the next year to see if drones might work better than the current method of using all-terrain vehicles (ATVs).

Tesche’s hope is that the GPS-guided drones will prove faster and cheaper than ATVs and plans to spend this season working out the operational details and extending the test over a longer time. Although Transport Canada requires an operator and spotter be present, the drones do much of the work themselves.

Using open source software, the operator can also program the drone to drop a large quantity all at once or avoid areas like animal pens and property lines. Tesche says they haven’t had anyone deny them access to their orchards yet, and hope to continue testing the entire 22-week codling moth season.

The UAV currently being used can hold enough moths for about 40 acres, and can cover that in less than ten minutes. The average ATV operator covers an average of 150 acres per day. An ATV costs between $10 000 and $15 000, whereas the drone being used, including guidance system, batteries and release device, comes in under $14 000. “It’s got a lot of potential,” Tesche says. "It could really change things."

Source: Adam Proskiw, InfoTel News Ltd, 13 April 2018.

District Outlines Program to Target One Species of Disease-Carrying Mosquito

The Lee County Mosquito Control District is preparing to implement a new program on Captiva island, as well as the north end of Sanibel, aimed at reducing the population of one disease-carrying insect. At the Captiva Community Panel meeting on April 10, representatives from the district provided information on its sterile insect (SIT) program. The program will target the *Aedes aegypti* mosquito, which is an invasive exotic species that is a transmitting carrier for a variety of viruses. The list includes yellow fever, dengue fever, the chikungunya virus and the Zika virus.

"Which is why we're targeting just them," Assistant Director David Hoel said. If successfully implemented, the program will greatly reduce the population of the species, which currently poses a serious public health risk. He noted that the insect has few natural predators due to its preferred breeding habitat, so reducing the population will not significantly impact the food chain.

"There's no benefits to the human population," Hoel said, explaining that other species of mosquitoes such as the salt water mosquito are sources of food for fish and other wildlife. "Not so with these guys."

David Hoel, assistant director of Lee County Mosquito Control District, discusses at Captiva Community Panel meeting on April 10 the SIT program, expected to be operational in 2019 (credit Tiffany Repecki).

Introduced to America by way of slave ships from North Africa, the *Aedes aegypti* mosquito is an "urban mosquito," meaning that is breeds around homes - inside water-holding containers, tires, bird baths, potted plants, gutters, cans and bottles, even storm drains - and prefers to feed on humans.

The species is difficult to control by conventional means, like insecticide applications and source reduction, due to its cryptic behavior and daytime biting habits, which only the

females take part in. "These are hard mosquitoes to control," he said.

The process for sterilization requires no genetic manipulation, only gamma rays or X-rays. "There's no radioactive residue," he said. "It's perfectly safe." The sterile males will then be released to mate with the wild population. "The (lab-reared) females won't be released," Jackson said. Any female mosquitoes accidentally released will also be sterile, so of little concern.

Rachel Morreale, applied science and technologies manager for the Lee County Mosquito Control District, talks about trapping one type of mosquito in preparation for the upcoming SIT program (credit Tiffany Repecki).

The district began trapping the species in June across Captiva and on part of Sanibel island. "We have an idea of the mosquito density for the island because of the trappings," Hoel said.

Eric Jackson, spokesman for the district, explained that the initial numbers will be used as a baseline to analyze the effectiveness of the program once the releases begin, which are set for winter of 2019. Captiva is a prime location because of the species' size and abundance on the island.

The trapped mosquitoes are also being harvested for their eggs. Once the lab-grown mosquitoes reach the pupae stage in their life, X-rays will be used to render them sterile for when they hit adulthood.

According to Hoel, the SIT is not a new technology. Its first use in the United States took place on Sanibel in 1951 to eliminate the screwworm fly. Recently, sterile screwworm flies were released successfully in the Florida Keys to control one outbreak. SIT is used in agriculture to control fruit flies, moths and tsetse flies.

Source: Tifany Repecki, Island Reporter, Captiva Current, Sanibel-Captiva Islander, 13 April 2018.

The Ground-breaking Australian Technology Hoping to Combat Fruit Fly Outbreaks

Scientists hope to know by as early as next season whether Australia's new SIT is an effective weapon in controlling fruit fly outbreaks. Millions of specially bred sterile fruit flies were released in South Australia this month in an attempt to stop wild flies breeding and eventually reduce the numbers of the Queensland Fruit Fly, which is native only to Australia.

As part of the plan to control the pest, Hort Innovation teamed up with other stakeholders including state governments and research institutes. After some international collaboration it was decided that a facility would need to be built capable of producing 50 million sterile males a week, which was established in Port Augusta.

"SIT is a technique where you want to use all other methods to smash the fruit fly population where there is an outbreak and the coup de gras is swamping them with steriles," Hort Innovation CEO John Lloyd said. "So there are very few wild females available, and when you swamp them with steriles, you overwhelm what small population there is after all the other methods have been carried out."

Mr Lloyd says this research has attracted widespread interest across the industry, as there has been many outbreaks in horticulture production areas that have not previously had the pest.

Hort Innovation SITPlus Director Dan Ryan and South Australia Biosecurity's Will Zacharin.

"There have been some outbreaks in South Australia, and there have been some well publicized outbreaks in Tasmania, which is of great concern because Tasmania has always been considered as fruit fly free," he said. "The big breakthroughs that we have had is around the standalone research we have done around diet. We are the first country to move from a stock-feed based diet, or a mash, to a pure gel based diet, which is much more efficient."

Mr Lloyd added that this new technology could be a major game changer for the horticulture industry, with fruit flies one of the biggest barriers to trade. Not only does the fruit fly cause domestic losses, but non-infected fruit that is grown in the area is prevented from being exported because of the risks associated with it.

Australia is on the cusp of many new export opportunities, but in most cases protocols have to be met, and Hort Innovation says it can prove costly for growers and producers. "Apart from tariffs, the fruit fly is the number one barrier to trade and at a high cost we are ensuring that we remain fruit fly free," he said.

Queensland Fruit Fly pupae maturation.

"We are uniquely positioned in the world, with 400–500 air freight capable flights leaving Australian capitals each week going to Asia, capable of taking instant fresh produce to enter the stores tomorrow. So the opportunity is huge, and while there are other pests to worry about, fruit fly is the biggest."

While the sterile fly numbers are not at 50 million yet, Hort Innovation says there are still a number of areas that need further development. It is still working on developing a male only strain, as the current release that includes sterilised females is less efficient. But Mr Lloyd says the feedback from growers is that they are relieved that there is light at the end of the tunnel.

"If we can get this technology right, if we can move to a male only line in the first instance, then they have a very powerful tool," he said. "Not only to defend areas that are currently free of fruit fly but also roll fruit fly out of areas that have become infested. But it's still early days."

Plans are also underway to introduce the female self-limiting gene into the Mediterranean fruit fly, which has affected areas of Western Australia.

"We are at the start of a long journey here, and from a technology perspective, there are some tremendously exciting developments we are looking at," Mr Lloyd said.

Source: Matthew Russell, freshplaza.com, 10 April 2018.

European Cherry Fruit Fly, a New Invasive Species in North America

The European cherry fruit fly (ECFF), *Rhagoletis cerasi*, is the most serious pest of cherries in Europe. The principal hosts are cherry, particularly sweet cherry (*Prunus avium*), and honeysuckle (*Lonicera* spp.). In response to a photograph submitted to the Canadian Food Inspection Agency in February 2016 by an amateur entomologist, a survey was initiated in June 2016 and confirmed as ECFF.

Subsequent surveys confirmed infestations in several locations along Lake Ontario near Niagara Falls. Survey efforts in the U.S. in Niagara County, New York, in 2016 did not find ECFF, but expanded efforts in 2017 confirmed ECFF in traps hung on wild honeysuckle and wild sweet cherry trees on state and public lands along the Niagara River. These detections in Ontario and New York are the first detections of ECFF in North America; however, no detections have occurred in either country in commercial cherry orchards. ECFF has one generation a year, with adults typically emerging from May to July when females deposit one egg beneath the skin of host fruits.

Both countries are concerned about the potential for ECFF to be unintentionally moved to sweet cherry production areas of the Pacific Northwest and have begun restricting the movement of fruit from east to west.

Adult European cherry fruit fly (Biopix, S.D. Lund, www.biopix.com*).*

At this point Canada considers ECFF to be widely established on wild honeysuckle throughout Ontario and non-eradicable. APHIS-PPQ is working closely with the Canadian Food Inspection Agency (CFIA) to assess its options for eradication, but currently plans to continue delimitation trapping and employ bait sprays and soil treatments to eliminate the infestation similar to the strategy it uses against other Tephritid fruit flies when the SIT isn't available.

Source: Kenneth Bloem, Fruit Fly, USDA-APHIS-PPQ, NAPPO Newsletter, November 2017.

Relevant Published Articles

Screwworm (Diptera: Calliphoridae) in the United States: Response to and Elimination of the 2016–2017 Outbreak in Florida

Steven R. Skoda,[1] Pamela L. Phillips,[1] and John B. Welch[2]

[1]*USDA-ARS-KBUSLIRL, Screwworm Research, Kerrville, TX, USA.*
[2]*USDA-APHIS-IS, Action Programs, USDA, ARS, College Station, TX, USA.*

Abstract

Eradicating screwworm, *Cochliomyia hominivorax* (Coquerel), from continental North American via the sterile insect technique has provided huge economic benefit to livestock producers by eliminating screwworm myiasis. After confirmatory identification of fly samples from infested deer by the USDA National Veterinary Services Laboratory on September 30, 2016, an alert was issued that screwworm myiasis was discovered in the Florida Keys. Personnel from USDA Animal and Plant Health Inspection Service, Agricultural Research Service, the State of Florida, U.S. Fish and Wildlife Service and local officials responded to the outbreak focus on Big Pine Key. After witnessing infested Key deer (*Odocoileus virginianus clavium* Barboyr & Allen), screwworm adult sampling was initiated at 0930 h on October 5, 2016 using nets to collect flies arriving at putrid liver, with the first female collected within 1 h. Larval samples were collected from infested animals for DNA analyses and to develop a "Florida outbreak" colony to test mating compatibility with the mass-produced strain used for sterile fly releases. Ground release chambers for sterile screwworm releases were placed in favorable habitats based on satellite image analyses. Sterile pupae were first placed in the chambers on October 11, 2016. Further liver trapping showed that 13 Keys were infested. One case, presumably through animal movement, occurred near Homestead on the Florida mainland. Ultimately there were 35 sterile fly release stations, including 4 located around Homestead, but no further cases were identified. About 188 million sterile flies were released until successful eradication was declared on March 23, 2017. Containing the outbreak prevented economic losses to livestock producers and other wildlife on the mainland and kept eradication costs to a minimum.

The full paper was published in: Journal of Medical Entomology, (in press, doi: 10.1093/jme/tjy049).

Survival ability of Mexican fruit fly males from different strains in presence of the predatory orb-weaving spider *Argiope argentata* (Araneae: Araneidae)

Ariane Dor[1] and Pablo Liedo[2]

[1]*Consejo Nacional de Ciencias y Tecnologías commissioned to El Colegio de la Frontera Sur, Tapachula, Chiapas, Mexico.*
[2]*El Colegio de la Frontera Sur, Tapachula, Chiapas, Mexico.*

Abstract

The sterile insect technique (SIT) is a key element for the integrated management of pest populations of the Mexican fruit fly, *Anastrepha ludens*, in Mexico. Its success depends on the survival of mass-reared sterile males and their ability to mate with wild females. However, colonization and mass-rearing conditions can adversely affect their ability to avoid predators. To test if colony management strategies could contribute to improve field survival abilities of mass-reared flies, we compared the survival of males exposed to the orb-weaver spider *Argiope argentata*. Males compared originated from three strains with different colonization strategies: (a) a colony started from field-collected wild flies (replacement), (b) a colony started by hybridizing wild males with mass-reared adapted females (hybrid) and (c) a colony started with mass-reared males selected on the basis of their survival ability and mating competitiveness in field cages (selected). Mass-reared males and wild males were used as controls. Males were exposed to spiders under laboratory cage conditions. Overall, wild males showed better survival ability than mass-reared males. Regarding the colonization approach, wild males survived better than a hybrid, replaced and selected males. We conclude that mass-rearing conditions have a strong negative effect on the ability of males to escape spiders. The colonization systems evaluated did not counter this effect. The lower survival of males from the selected colony suggests that the selection over one generation did not contribute to improve males' predator avoidance and escape abilities and probably needs to be modified. Possible explanations for this and implications on colonization and colony management for SIT purpose are discussed.

The full paper was published in: Bulletin of Entomological Research, 1-8 (in press, doi:10.1017/S0007485318000275).

Rates and Patterns of Laboratory Adaptation in (Mostly) Insects

Ary A. Hoffmann and Perran A. Ross

Bio21 Institute, School of BioSciences, The University of Melbourne, Victoria, Australia.

Abstract

Insects and other invertebrates can readily adapt to a range of environmental conditions and these include conditions used in artificial rearing. This can lead to problems when mass rearing insects and mites for release as biocontrol agents or in sterile insect control programs, and when using laboratory strains to understand field population dynamics. Laboratory adaptation experiments also help to understand potential rates of trait evolution and repeatability of evolutionary changes. Here, we review evidence for laboratory adaptation across invertebrates, contrasting different taxonomic groups and providing estimates of the rate of evolutionary change across trait classes. These estimates highlight rapid changes in the order of 0.033 (median) haldanes and up to 2.4 haldanes, along with proportional changes in traits of more than 10% per generation in some cases. Traits tended to change in the direction of increased fitness for Coleoptera, Diptera and Hymenoptera, but changes in Lepidoptera were often in the opposite direction. Laboratory-adapted lines tend to be more sensitive to stress, likely reflecting relaxed selection for stress-related traits. Morphological traits show smaller changes under laboratory conditions than other types of traits. Estimates of evolutionary rates slowed as more generations were included in comparisons, perhaps reflecting nonlinear dynamics although such patterns may also reflect variance differences among trait classes. The rapid rate of laboratory adaptation in some cultures reinforces the need to develop guidelines for maintaining quality during mass rearing and highlights the need for caution when using laboratory lines to represent the performance of species in vulnerability assessments.

The full paper was published in: Journal of Economic Entomology, XX(X), 2018, 1–9, (in press, doi: 10.1093/jee/toy024).

Effects of Irradiation Dose on Sterility Induction and Quality Parameters of *Drosophila suzukii* (Diptera: Drosophilidae)

Alexandra Peter Krüger,[1] Daniele Cristine Hoffmann Schlesener,[1] Liliane Nachtigall Martins,[2] Jutiane Wollmann,[1] Maríndia Deprá,[3,4] and Flávio Roberto Mello Garcia[1,2]

[1]*Programa de pós graduação em Fitossanidade, Universidade Federal de Pelotas, Pelotas, Brazil.*
[2]*Programa de pós graduação em Entomologia, Universidade Federal de Pelotas, Pelotas, Brazil.*
[3]*Programa de pós graduação em Biologia Animal, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil.*
[4]*Programa de pós graduação em Genética e Biologia Molecular, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil.*
[5]*Corresponding author, e-mail: alexandra_kruger@hotmail.com.*

Abstract

Drosophila suzukii (Matsumura, 1931) (Diptera: Drosophilidae) is a widely distributed pest of soft-skinned and stone fruits that is controlled mainly with pesticides. An alternative to the chemical control is the sterile insect technique (SIT), an ecologically friendly method of pest management that could be used against *D. suzukii*. The objective of the present study was to evaluate the effects of gamma radiation on reproductive sterility, ovarian morphometry, and quality parameters of *D. suzukii*. Full female sterility was achieved at 75 Gy, while an adequate level of male sterility (99.67%) was obtained at 200 Gy. The ovarian size showed an exponential decay in function of irradiation dose increase. There was no significant influence of irradiation dose on the quality parameters evaluated. Our data suggest that gamma radiation can be recommended to be used in an SIT program for *D. suzukii*.

The full paper was published in: Journal of Economic Entomology, XX(X), 2018, 1–6, in press, doi: 10.1093/jee/tox349).

Papers in Peer Reviewed Journals

In Press

AUGUSTINOS, A.A., M. VREYSEN, A. PARKER, A. ABD-ALLA and K. BOURTZIS. A nuclear, mitochondrial and *Wolbachia*-based approach for the rapid and accurate identification of tsetse species. BMC Microbiology (in press).

BOUYER, J. and R. LANCELOT. Using genetic data to improve species distribution models. Infection, Genetics and Evolution (in press).

BOUYER, J. and E. MAROIS. Genetic Control of Vectors. In: Smallegange R, Takken W, Bouyer J, Garros C, (Ed.). Prevention and control of pests and vector-borne diseases in the livestock industry Emerging pests and vector-borne diseases in Europe. The Netherlands: Wageningen Academic Publishers (in press).

CARTER, N., P. BOULEY, S. MOORE, M. POULOS, J. BOUYER et al. Climate change, cattle disease, and the future of lions. Conservation Biology (in press).

DEMIRBAS-UZEL G., A.G. PARKER, M.J.B. VREYSEN, J. VAN DEN ABBEELE, A.M.M. ABD-ALLA et al. Combining paratransgenesis with SIT: Impact of ionizing radiation on the prevalence of *Sodalis glossinidius*. BMC Microbiology (in press).

DEMIRBAS-UZEL G., A.G. PARKER, M.J.B. VREYSEN, J. BOUYER, A.M.M. ABD-ALLA et al. Impact of *Glossina pallidipes* salivary gland hypertrophy virus (GpSGHV) on a heterologous tsetse fly host, *Glossina fuscipes fuscipes*. BMC Microbiology (in press).

DOUDOUMIS, V., A. AUGUSTINOS, A. PARKER, A.M.M. ABD-ALLA, K. BOURTZIS et al. Different laboratory populations similar bacterial profile? The case of *Glossina palpalis gambiensis*. BMC Microbiology (in press).

ENGL, T., V. MICHALKOVA, B.L. WEISS, G.D. UZEL, A.M.M. ABD-ALLA et al. Effect of antibiotic treatment and gamma-irradiation on cuticular hydrocarbon profiles and mate choice in tsetse flies (*Glossina m. morsitans*). BMC Microbiology (in press).

GEIGER, A., I.I. MALELE, A.M.M. ABD-ALLA and F. NJIOKOU. Trypanosoma-tsetse fly interactions: current and potential future research directions. BMC Microbiology (in press).

GIMONNEAU, G, J.B. RAYAISSE and J. BOUYER. Integrated control of trypanosomosis. In: Smallegange R, Takken W, Bouyer J, Garros C, (Ed.). Prevention and control of pests and vector-borne diseases in the livestock industry Emerging pests and vector-borne diseases in Europe. The Netherlands: Wageningen Academic Publishers (in press).

KARIITHI, H.M., I.K. MEKI, D.I. SCHNEIDER, DE VOOGHT, A.M.M ABD-ALLA et al. Enhancing Vector Refractoriness to Trypanosome Infection: Achievements, Challenges and Perspectives. BMC Microbiology (in press).

KARIITHI, H.M., D.G. BOUCIAS, M.J.B. VREYSEN, A.M.M. ABD-ALLA, J.M. VLAK et al. Coevolution of Hytrosaviruses and Host Immune Responses. BMC Microbiology (in press).

MARIE J., D. PERERA, H. GARSTANG, H.C. BOSSIN and K. BOURTZIS. Exploring mosquito fauna of Majuro Atoll (Republic of Marshall Islands) in the context of Zika outbreak. Journal of Medical Entomology (in press).

MEKI, I.K., H.M. KARIITHI, A.G. PARKER, M.J.B. VREYSEN, A.M.M. ABD-ALLA et al. Hytrosavirus genetic diversity and eco-regional spread in *Glossina* species. BMC Microbiology (in press).

MEKI, I., H.M. KARIITHI, A.G. PARKER, M.J.B. VREYSEN, A.M.M. ABDALLAH et al. RNA interference-based antiviral immune response against the salivary gland hypertrophy virus in *Glossina pallidipes*. BMC Micobiology. (in press).

OUEDRAOGO, G.M.S., A. AVGOUSTINOS, A.G. PARKER, M.J.B. VREYSEN, K. BOURTZIS, A.M.M. ABD-ALLA et al. Prevalence of trypanosomes, salivary gland hypertrophy virus and *Wolbachia* in wild populations of tsetse flies from West Africa. BMC Microbiology (in press).

SCHNEIDER, D.I., A.G. PARKER, A.M.M. ABD-ALLA and W.J. MILLER. High-sensitivity detection of cryptic Wolbachia in the African tsetse fly (*Glossina* spp.). BMC Microbiology (in press).

SCOLARI, F., G.M. ATTARDO, G. SAVINI, A.M.M. ABD-ALLA, A.G. PARKER et al. Exploring the effect of symbiotic microbes on gene expression in tsetse male reproduction. BMC Microbiology (in press).

WAMITI, L.G., F.M. KHAMIS, A.M.M. ABD-ALLA, F.L.O. OMBURA, S. SUBRAMANIAN et al. *Metarhizium anisopliae* infection reduces Trypanosoma congolense multiplication in *Glossina fuscipes fuscipes* and its ability to acquire or transmit the pathogen. BMC Microbiology (in press).

2018

BOUYER, J., M.J.B. VREYSEN (2018). Vectors: Tsetse flies. In: Infectious Diseases of Livestock, JAW Coetzer, GR Thomson, NJ Maclachlan, M-L Penrith and A Michel (Ed.). Anipedia (www.anipedia.org).

DEMIRBAS-UZEL G., H. KARIITHI, A.G. PARKER, M.J.B. VREYSEN, A.M.M. ABD-ALLA et al. (2018). Susceptibility of Tsetse Species to *Glossina pallidipes* Salivary Gland Hypertrophy Virus (GpSGHV). Frontiers in Microbiology 9:701.

HAQ I.U, C. CÁCERES, J.S. MEZA, J. HENDRICHS and M.J.B. VREYSEN (2018). Different methods of methyl eugenol application enhance the mating success of male Oriental fruit fly (Dipera: Tephritidae). Scientific Reports 8:6033.

NIKOLOULI K., F. SASSU, C. CÁCERES, R. PEREIRA, K. BOURTZIS et al. (2018). Sterile insect technique and *Wolbachia* symbiosis as potential tools for the control of the invasive species *Drosophila suzukii*. Journal of Pest Science 91(2):489-503.

ORLOV I., R. DRILLIEN, D. SPEHNER, M. BERGOIN, A.M.M. ABD-ALLA et al. (2018). Structural features of the salivary gland hypertrophy virus of the tsetse fly revealed by cryo-electron microscopy and tomography. Virology 514:165-169.

PERCOMA, L., A. SOW, S. PAGABELEGUEM, A.H. DICKO, O. SERDEBEOGO, J. BOUYER et al. (2018). Impact of an integrated control campaign on tsetse populations in Burkina Faso. Parasites & Vectors 11:270.

2017

AUGUSTINOS, A.A., A. TARGOVSKA, E. CANCIO-MARTINEZ, C. CÁCERES, A. ZACHAROPOULOU, K. BOURTZIS et al. (2017). *Ceratitis capitata* genetic sexing strains: laboratory evaluation of strains from mass-rearing facilities worldwide. Entomologia Experimentalis et Applicata 164:305-317.

BALESTRINO, F., A. PUGGIOLI, M. CARRIERI, J. BOUYER and R. BELLINI (2017). Quality control methods for *Aedes albopictus* sterile male production. PLoS Neglected Tropical Diseases 11:e0005881.

BASSÈNE, M.D., M.T. SECK, S. PAGABELEGUEM, M.J. VREYSEN, J. BOUYER et al. (2017). Competitiveness and survival of two strains of *Glossina palpalis gambiensis* in an urban area of Senegal. PLoS Neglected Tropical Diseases 11:e0006172.

BIMBILÉ-SOMDA, N. S., K.R. DABIRE, H. MAIGA, H. YAMADA, W. MAMAI, J. BOUYER, J.L. GILLES et al. (2017). Cost-effective larval diet mixtures for mass-rearing of *Anopheles arabiensis* Patton (Diptera: Culicidae). Parasites & Vectors 10:619.

CHAKROUN S., P. REMPOULAKI, K. LEBDI-GRISSA and M.J.B. VREYSEN (2017). Gamma irradiation of the carob or date moth *Ectomyelois ceratoniae*: dose–response effects on egg hatch, fecundity, and survival. Entomologia Experimentalis et Applicata 164:257-268.

CHIKOWORE, G., A.H. DICKO, P. CHINWADA, M. ZIMBA, J. BOUYER et al. (2017). A pilot study to delimit tsetse target populations in Zimbabwe. PLoS Neglected Tropical Diseases 11(5):e0005566.

CULBERT, N.J., R.S. LEES, M.J. VREYSEN, A.C. DARBY and J.R. GILLES (2017). Optimised conditions for handling and transport of male *Anopheles arabiensis*: effects of low temperature, compaction, and ventilation on male quality. Entomologia Experimentalis et Applicata 164:276-283.

DE BEER, C.J., P. MOYABA, S.N. BOIKANYO, H. YAMADA, M.J. VREYSEN et al. (2017). Evaluation of radiation sensitivity and mating performance of *Glossina brevipalpis* males. PLoS Neglected Tropical Diseases 11(3):e0005473.

DIALL, O., G. CECCHI, R. ARGILÉS-HERRERO, M.J.B. VREYSEN, J. BOUYER et al. (2017). Developing a progressive control pathway for African animal trypanosomosis. Trends in Parasitology 33:499-509.

DIEVAL, F., J. BOUYER and J.-F. FAFET (2017). An improved extraction method for surface dosage of insecticides on treated textile fabrics. Malaria Journal 16(1):14.

DOHINO, T., G.J. HALLMAN, T.G. GROUT, A.R. CLARKE, R. PEREIRA et al. (2017). Phytosanitary treatments against *Bactrocera dorsalis* (Diptera: Tephritidae): Current situation and future prospects. Journal of Economic Entomology 110(1):67-79.

DOUDOUMIS V., F. BLOW, A.G. PARKER, A.M.M. ABD-ALLA, K. BOURTZIS et al. (2017). Challenging the *Wigglesworthia*, *Sodalis*, *Wolbachia* symbiosis dogma in tsetse flies: *Spiroplasma* is present in both laboratory and natural populations. Scientific Reports 7:4699.

DROSOPOULOU, E., C. PANTELIDOU, A. GARIOU-PAPALEXIOU, A.A. AUGUSTINOS, K. BOURTZIS et al. (2017). The chromosomes and the mitogenome of *Ceratitis fasciventris* (Diptera: Tephritidae): two genetic approaches towards the *Ceratitis* FAR species complex resolution. Scientific Reports 7:4877.

ENKERLIN, W.R., J.M. GUTIÉRREZ RUELAS, C. CÁCERES BARRIOS, J. REYES FLORES, J. HENDRICHS et al. (2017). The Moscamed Regional Programme: review of a success story of area-wide sterile insect technique application. Entomologia Experimentalis et Applicata 164:188-203.

FELDMAN, U., S.G.A. LEAK, and J. HENDRICHS (2017). Assessing the feasibility of creating tsetse and trypanosomosis-free zones. International Journal of Tropical Insect Science 38(1):77-92.

FLORES S., E. GÓMEZ, S. CAMPOS, F. GÁLVEZ, R. PEREIRA et al. (2017). Evaluation of Mass Trapping and Bait Stations to Control *Anastrepha* (Diptera: Tephritidae) Fruit Flies in Mango Orchards of Chiapas, Mexico. Florida Entomologist, 100(2):358-365.

GARZIERA, L., M. C. PEDROSA, F. ALMEIDA DE SOUZA, M. GOMEZ and D. OLIVEIRA CARVALHO (2017). Effect of interruption of over-flooding releases of transgenic mosquitoes over wild population of *Aedes aegypti*: two case studies in Brazil. Entomologia Experimentalis et Applicata 164:327-339.

GOMEZ-SIMUTA, Y., E. HERNANDEZ, P. LIEDO, A. ESCOBAR-LOPEZ, P. MONTOYA, G.J. HALLMAN et al. (2017). Tolerance of Mango cv. 'Ataulfo' to Irradiation with Co-60 vs. Hydrothermal Phytosanitary Treatment. Radiation Physics and Chemistry 139:27-32.

HALLMAN, G.J. (2017). Process control in phytosanitary irradiation of fresh fruits and vegetables as a model for other phytosanitary treatment processes. Food Control 72(B):372-377.

HALLMAN, G.J., E.I. CANCIO MARTÍNEZ, C.E. CÁCERES, M.J.B. VREYSEN, V. WORNOAYPORN et al. (2017). Phytosanitary cold treatment against *Anastrepha grandis* (Macquart) (Diptera: Tephritidae). Florida Entomologist 100:29-31.

HIEN, N.T.T, L.D. KHANH, V.V. THANH, V.T.T. TRANG, R. PEREIRA et al. (2017). Influence of adult diet and exposure to methyl eugenol in the mating performance of Bactrocera correcta. Nuclear Science and Technology 7:42-48.

KARIITHI, H.M., I.K. MEKI, D.G. BOUCIAS and A.M. ABD-ALLA (2017). Hytrosaviruses: Current Status and Perspective. Current Opinion in Insect Science 22:71-78.

KARIITHI, H.M., X. YAO, F. YU, P.E. TEAL, C.P. VERHOEVEN and D.G. BOUCIAS (2017). Responses of the housefly, *Musca domestica*, to the Hytrosavirus replication: Impacts on host's vitellogenesis and immunity. Frontiers in Microbiology 8:583.

KYRITSIS, G.A., A.A. AUGUSTINOS, C. CÁCERES and K. BOURTZIS (2017). Medfly gut microbiota and enhancement of the sterile insect technique: similarities and differences of *Klebsiella oxytoca* and *Enterobacter* sp. AA26 probiotics during the larval and adult stages of the VIENNA 8D53+ genetic sexing strain. Frontiers in Microbiology 8:2064.

LANOUETTE G., J. BRODEUR, F. FOURNIER, M. VREYSEN, C. CACERES et al. (2017). The sterile insect technique for the management of the spotted wing drosophila, *Drosophila suzukii*: Establishing the optimum irradiation dose. PLoS ONE 12(9):e0180821.

MAIGA, H., N. S. BIMBILE-SOMDA, H. YAMADA, W. MAMAI, F. BALESTRINO, J.R.L. GILLES et al. (2017). Enhancements to the mass-rearing cage for the malaria vector, *Anopheles arabiensis* for improved adult longevity and egg production. Entomologia Experimentalis et Applicata 164:269-275.

MAMAI, W., N.S. BIMBILE-SOMDA, H. MAIGA, J.G. JUAREZ, J.R.L. GILLES et al. (2017). Optimization of mosquito egg production under mass-rearing setting: effects of cage volume, blood meal source and adult population density for the malaria vector, *Anopheles arabiensis*. Malaria Journal 16:41.

MAMAI W., H. MAIGA, N.S BIMBILÉ-SOMDA, H. YAMADA, R.S, LEES et al. (2017). Reverse osmosis and ultrafiltration for recovery and reuse of larval rearing water in *Anopheles arabiensis* mass-production: Effect of water quality on larval development and fitness of emerging adults. Acta Tropica 170:126-133.

MCINNIS, D.O., J. HENDRICHS, T. SHELLY, W. BARR and W. ENKERLIN (2017). Can polyphagous invasive tephritid pest populations escape detection for years under favorable climatic and host conditions? American Entomologist 63 (2):89-99.

RAS, E., L.W. BEUKEBOOM, C. CÁCERES, K. BOURTZIS (2017). Review of the role of gut microbiota in mass-rearing of the olive fruit fly, *Bactrocera oleae*, and its parasitoids. Entomol. Exp. Appl. 164:237-256.

SCHUTZE, M.K., K. BOURTZIS, S.L. CAMERON, A.R. CLARKE, J. HENDRICHS et al. (2017). Taxonomic authority without peer-review versus integrative taxonomy: the case of the Oriental fruit fly, *Bactrocera dorsalis* (Tephritidae). Systematic Entomology 42:609-620.

SOMA, D.D., H. MAIGA, W. MAMAI, H. YAMADA, J.R.L. GILLES et al. (2017). Does mosquito mass-rearing produce an inferior mosquito? Malaria Journal 16(1):357.

SOMDA, N.S.B., H. MAIGA, H. YAMADA, W. MAMAI, J. BOUYER et al. (2017). Cost-effective larval diet mixtures for mass-rearing of *Anopheles arabiensis* Patton (Diptera: Culicidae). Parasites & Vectors 10:619.

SHELLY T.E., D.M. SUCKLING, K. BLOEM, W. ENKERLIN, J. HENDRICHS et al. (2017). To Repeat: Can polyphagous invasive tephritid pest populations remain undetected for years under favorable climatic and host conditions? American Entomologist 63:224-231.

SCHUTZE, M.K., K. BOURTZIS, S.L. CAMERON, A.R. CLARKE, J. HENDRICHS et al. (2017). Taxonomic authority without peer-review versus integrative taxonomy: the case of the Oriental fruit fly, *Bactrocera dorsalis* (Tephritidae). Systematic Entomology 42:609-620.

SUCKLING, D.M., J.E. CARPENTER, D. CONLONG, P. RENDON, M.J.B. VREYSEN et al. (2017). Global range expansion of pest Lepidoptera requires socially acceptable solutions. Biological Invasions 19:1107-19.

TOLEDO J., P. LIEDO, W. ENKERLIN, S. FLORES and A. VILLASEÑOR (2017). Pathogenicity of three formulations of *Beauveria bassiana* and efficacy of autoinoculation devices and sterile fruit fly males for dissemination of conidia for the control of *Ceratitis capitata*. Entomologia Experimentalis et Applicata 164:340-349.

VIRGINIO, J.F., M. GOMEZ, A.M. PINTO, G.G. ANIELY, C. CÁCERES et al. (2017). Male sexual competitiveness of two *Ceratitis capitata* strains, tsl Vienna 8 and OX3864A transgenics, in field cage conditions Entomologia Experimentalis et Applicata 164:318-326.

ZACHAROPOULOU, A., A. AUGUSTINOS, E. DROSOPOULOU, K. TSOUMANI, K. BOURTZIS et al. (2017). A review of more than thirty years of cytogenetic studies of Tephritidae in support of sterile insect technique and global trade. Entomologia Experimentalis et Applicata 164:204-225.

ZHANG, D.J., M.C. ZHANG, Y. WU, J.R.L GILLES, H. YAMADA et al. (2017). Establishment of a medium-scale mosquito facility: Optimization of the larval mass-rearing unit for *Aedes albopictus* (Diptera: Culicidae). Parasites & Vectors 10:569.

2016

ABD-ALLA, A.M., H.M. KARIITHI, F. COUSSERANS, A.G. PARKER, M.J. VREYSEN (2016). Comprehensive annotation of the *Glossina pallidipes* salivary gland hypertrophy virus from Ethiopian tsetse flies: A proteogenomics approach. Journal of General Virology 97:1010-1031.

AHMAD, S., I.U. HAQ, P. REMPOULAKIS, C. CÁCERES, M.J.B. VREYSEN et al. (2016). Artificial rearing of the olive fruit fly *Bactrocera oleae* (Rossi) (Diptera: Tephritidae) for use in the Sterile Insect Technique: improvements of the egg collection system. International Journal of Industrial Entomology 33:15-23.

AUGUSTINOS, A.A., I.U. HAQ, A. TARGOVSKA, C. CÁCERES, K. BOURTZIS A.M. ABD-ALLA et al. (2016). Cryopreservation of embryos of the Mediterranean fruit fly *Ceratitis capitata* Vienna 8 genetic sexing strain. PLoS One 11(8):e0160232.

BAKRI, A., J. REYES, R. PEREIRA and J. HENDRICHS (2016). How can we better communicate among fruit fly fans?, in: Sabater-Muñoz, B., Vera, T., Pereira, R. and Orankanok, W., (Eds.), Proceedings of the 9th International Symposium on Fruit Flies of Economic Importance. pp. 127-134.

BALESTRINO, F., F. SCHAFFNER, D.L. FORGIA, A.I. PASLARU, P.R. TORGERSON, et al. (2016). Field evaluation of baited traps for surveillance of *Aedes japonicus japonicus* in Switzerland. Medical and Veterinary Entomology 30:64-72.

BALESTRINO, F., A. MATHIS, S. LANGS and E. VERONESI (2016). Sterilization of *Hulecoeteomyia japonica japonica* (= *Aedes japonicus japonicus*) (Theobald, 1901) by high-energy photon irradiation: implications for a sterile insect technique approach in Europe. Medical and Veterinary Entomology 30:278-285.

BARCLAY, H.J., R. STEACY, W. ENKERLIN and P. VAN DEN DRIESSCHE (2016). Modeling diffusive movement of sterile insects released along aerial flight lines. International Journal of Pest Management 62(3):228-244.

BJELIS, M., L. POPOVIC, M. KIRIDZIJA, G. ORTIZ and R. PEREIRA (2016). Suppression of Mediterranean fruit fly using the Sterile Insect Technique in Neretva River Valley of Croatia, in: Sabater-Muñoz, B., Vera, T., Pereira, R. and Orankanok, W., (Eds.), Proceedings of the 9th International Symposium on Fruit Flies of Economic Importance. pp. 29-45.

BOURTZIS, K., R.S. LEES, J. HENDRICHS and M.J.B. VREYSEN (2016). More than one rabbit out of the hat: Radiation, transgenic and symbiont-based approaches for sustainable management of mosquito and tsetse fly populations. Acta Tropica 157:115-130.

BOUYER, J., F. CHANDRE, J. GILLES and T. BALDET (2016). Alternative vector control methods to manage the Zika virus outbreak: more haste, less speed. The Lancet. Global health 4(6):e364.

DE BEER, C.J., G.J. VENTER, K. KAPPMEIER GREEN, J. ESTERHUIZEN, M.J.B. VREYSEN et al. (2016). An update of the tsetse fly (Diptera: Glossinidae) distribution and African animal trypanosomosis prevalence in north-eastern KwaZulu-Natal, South Africa. Onderstepoort Journal of Veterinary Research 83(1):a1172.

DOGAN, M., F. GUNAY, A. PUGGIOLI, F. BALESTRINO, C. ONCU et al. (2016). Establishment of a satellite rearing facility to support the release of sterile *Aedes albopictus* males. I. Optimization of mass-rearing parameters. Acta Tropica 159:62-68.

ENKERLIN W., A. VILLASEÑOR, S. FLORES, D. MIDGARDEN, E. LIRA et al. (2016). Descriptive analysis of the factors affecting population fluctuation of the Mediterranean fruit fly (*Ceratitis capitata*, Wied.) in coffee areas located in Guatemala and its implications in IPM Strategies. in: Sabater-Muñoz, B., Vera, T., Pereira, R. and Orankanok, W., (Eds.), Proceedings of the 9th International Symposium on Fruit Flies of Economic Importance. pp. 46-63.

ENKERLIN, W., P. RENDÓN, A. VILLASEÑOR, Á. VALLE and R. CASTAÑEDA (2016). Integrating bait stations as an IPM component in area-wide fruit fly operational programmes, in: Sabater-Muñoz, B., Vera, T., Pereira, R. and Orankanok, W., (Eds.), Proceedings of the 9th International Symposium on Fruit Flies of Economic Importance. pp.162-171.

FLORES, S., P. MONTOYA, L. RUIZ-MONTOYA, A. VILLASEÑOR, W. ENKERLIN et al. (2016). Population fluctuation of *Ceratitis capitata* (Diptera: Tephritidae) as a function of altitude in eastern Guatemala. Environmental Entomology 45(4):802-11.

GARIOU-PAPALEXIOU, A., M.C. GIARDINI, A.A. AUGUSTINOS, C. CÁCERES, K. BOURTZIS et al. (2016). Cytogenetic analysis of the South American fruit fly *Anastrepha fraterculus* (Diptera:Tephritidae) species complex: Construction of detailed photographic polytene chromosome maps of the Argentinian Af. sp.1 member. PLoS One 11(6):e0157192.

GIMONNEAU, G., Y. ALIOUM, B. CENE, H. ADAKAL and J. BOUYER et al. (2016). Insecticide and repellent mixture pour-on protects cattle against animal trypanosomosis. PLoS Neglected Tropical Diseases 10(12):e0005248.

HALLMAN, G.J. (2016). Generic phytosanitary irradiation treatment for "true weevils" (Coleoptera: Curculionidae) infesting fresh commodities. Florida Entomologist 99(S2):197-201.

HALLMAN, G.J. (2016). Generic phytosanitary irradiation dose of 300 Gy for the Insecta excluding pupal and adult Lepidoptera. Florida Entomologist 99(S2):206-210.

HALLMAN, G.J., D. ZHANG and V. ARTHUR (2016). Generic phytosanitary irradiation dose for phytophagous mites (Sarcoptiformes: Acaridae; Trombidiformes: Eriophyidae, Tarsonemidae, Tenuipalpidae, Tetranychidae). Florida Entomologist 99(S2):202-205.

HALLMAN, G.J., J.C. LEGASPI and DARMAWI (2016). Phytosanitary irradiation of *Diatraea saccharalis*, *D. grandiosella*, and *Eoreuma loftini* (Lepidoptera: Crambidae). Florida Entomologist 99(S2):182-185.

HALLMAN, G.J., Y.M. HÉNON, A.G. PARKER and C.M. BLACKBURN (2016). Phytosanitary irradiation: An overview. Florida Entomologist 99(S2):1-13.

HALLMAN, G.J. and D.L. CHAPA (2016). Phytosanitary irradiation of Diaphorina citri (Hemiptera: Liviidae). Florida Entomologist 99(S2):150-152.

HALLMAN, G.J. (2016). Phytosanitary irradiation of Heliothis virescens and Helicoverpa zea (Lepidoptera: Noctuidae). Florida Entomologist 99(S2):178-181.

HALLMAN, G.J. (2016). Phytosanitary irradiation of the invasive herbivorous terrestrial snail *Cornu aspersum* (Stylommatophora: Helicidae). Florida Entomologist 99(S2):156-158.

HALLMAN, G.J. and P. LOAHARANU (2016). Phytosanitary irradiation - Development and application. Radiation Physics and Chemistry 129:39-45.

HALLMAN, G.J. and C.M. BLACKBURN (2016). Phytosanitary irradiation. Foods 5:8.

HAQ, I., M.J.B. VREYSEN, M. SCHUTZE, J. HENDRICHS and T. SHELLY (2016). Effects of Methyl eugenol feeding on mating compatibility of Asian population of *Bactrocera dorsalis* (Diptera: Tephritidae) with African population and with *B. carambolae*. Journal of Economic Entomology 109(1):148-153.

KARIITHI, H.M., S. BOEREN, E.K. MURUNGI, J.M. VLAK and A.M.M. ABD-ALLA (2016). A proteomics approach reveals molecular manipulators of distinct cellular processes in the salivary glands of *Glossina m. morsitans* in response to Trypanosoma b. brucei infections. Parasites & Vectors 9:424.

KARIITHI, H.M., I.A. INCE, S. BOEREN, I.K. MEKI, A.M.M. ABD-ALLA et al. (2016). Comparative analysis of salivary gland proteomes of two *Glossina* species that exhibit differential hytrosavirus pathologies. Frontiers in Microbiology 7:89.

KHANH, L.D., L.Q. KHAI, N.T.T. HIEN, V.V. THANH, R. PEREIRA et al. (2016). Area-wide suppression of Bactrocera fruit flies in dragon fruit orchards in Binh Thuan, Viet Nam, in: Sabater-Muñoz, B., Vera, T., Pereira, R. and Orankanok, W., (Eds.), Proceedings of the 9th International Symposium on Fruit Flies of Economic Importance. pp. 93-100.

KHOURY, H.J., K. MEHTA, V.S. DE BARROS, P.L. GUZZO and A.G. PARKER (2016). Dose assurance service for low energy X ray irradiators using an alanine-EPR transfer dosimetry system. Florida Entomologist 99(S2):14-17.

MAÏGA, H., D. DAMIENS, A. DIABATÉ, R.S. LEES, J.R.L. GILLES et al. (2016). Large-scale *Anopheles arabiensis* egg quantification methods for mass-rearing operations. Malaria Journal 15:72.

MAMAI, W., R.S. LEES, H. MAIGA and J.R.L. GILLES (2016). Reusing larval rearing water and its effect on development and quality of *Anopheles arabiensis* mosquitoes. Malaria Journal 15:169.

MORAN, Z.R. and A.G. PARKER (2016). Near infrared imaging as a method of studying tsetse fly (Diptera: Glossinidae) pupal development. Journal of Insect Science 16(1):72.

MUNHENGA, G., B.D. BROOKE, J.R. GILLES, K. SLABBERT, A. KEMP et al. (2016). Mating competitiveness of sterile genetic sexing strain males (GAMA) under laboratory and semi-field conditions: Steps towards the use of the Sterile Insect Technique to control the major malaria vector *Anopheles arabiensis* in South Africa. Parasites & Vectors 9:122.

MYERS, S.M., E. CANCIO-MARTINEZ, G.J. HALLMAN, E.A. FONTENOT and M.J.B. VREYSEN (2016). Relative tolerance of six *Bactrocera* (Diptera: Tephritidae) species to phytosanitary cold treatment. Journal of Economic Entomology 109(6):2341-2347.

PAGABELEGUEM, S., S. RAVEL, M.J. VREYSEN, A. PARKER, J. BOUYER et al. (2016). Influence of temperature and relative humidity on survival and fecundity of three tsetse strains. Parasites & Vectors 9:520.

PAGABELEGUEM, S., G. GIMONNEAU, M.T. SECK, M.J.B. VREYSEN, J. BOUYER et al. (2016). A molecular method to discriminate between mass-reared sterile and wild tsetse flies during eradication programmes that have a sterile insect technique component. PLoS Neglected Tropical Diseases 10(2):e0004491.

PAPANICOLAOU, A., M.F. SCHETELIG, P. ARENSBURGER, P.W. ATKINSON, K. BOURTZIS et al. (2016). The whole genome sequence of the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), reveals insights into the biology and adaptive evolution of a highly invasive pest species. Genome Biology 17(1):192.

REMPOULAKIS, P., G. TARET, I.U. HAQ, C. CÁCERES and M.J.B. VREYSEN et al. (2016). Evaluation of quality production parameters and mating behavior of novel genetic sexing strains of the Mediterranean fruit fly *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae). PLoS One 11(6):e0157679.

SABATER-MUÑOZ B, T. VERA, R. PEREIRA, and W. ORANKANOK, Proceedings of the 9th International Symposium on Fruit Flies of Economic Importance. 2016: xiii + 440.

SALOU, E., J.B. RAYAISSE, D. KABA, V. DJOHAN, J. BOUYER et al. (2016). Variations in attack behaviours between *Glossina palpalis gambiensis* and *G. tachinoides* in a gallery forest suggest host specificity. Medical and Veterinary Entomology 30(4):403-409.

SCHETELIG, M.F., A. TARGOVSKA, J.S. MEZA, K. BOURTZIS and A.M. HANDLER (2016). Tetracyclinesuppressible female lethality and sterility in the Mexican fruit fly, Anastrepha ludens. Insect Molecular Biology 25(4):500-8.

SCOLARI, F., J.B. BENOIT, V. MICHALKOVA, E. AKSOY, A.M.M. ABD-ALLA et al. (2016). The spermatophore in *Glossina morsitans morsitans*: Insights into male contributions to reproduction. Scientific reports 6:20334.

SOMDA, M.B., S. CORNELIE, Z. BENGALY, F. MATHIEU-DAUDÉ, J. BOUYER et al. (2016). Identification of a Tsal152-75 salivary synthetic peptide to monitor cattle exposure to tsetse flies. Parasites & Vectors 9(1):1-12.

SUCKLING, D.M., J.E. CARPENTER, D. CONLONG, K. BLOEM, M.J.B. VREYSEN et al. (2016). Global range expansion of pest Lepidoptera requires socially acceptable solutions. Biological Invasions 19:1107-19.

SUCKLING, D.M., J.M. KEAN, C. CÁCERES, J. HENDRICHS, J. REYES-FLORES, and B. C. DOMINIAK (2016). Eradication of Tephritid Fruit Fly Pest Populations: Outcomes and Prospects. Pest Management Science 72:456-465.

VAN NIEUWENHOVE, G.A., A.V. OVIEDO, J. PEREZ, M.J. RUIZ, G.J. HALLMAN et al. (2016). Gamma radiation phytosanitary treatment for *Hemiberlesia lataniae* (Hemiptera: Diaspididae). Florida Entomologist 99(S2):134-137.

VAN NIEUWENHOVE, G.A., A.V.F. OVIEDO, Y.M. DALTO, J. PEREZ, G.J. HALLMAN et al. (2016). Gamma radiation phytosanitary treatment against *Trialeuroides vaporariorum* (Hemiptera: Aleyrodidae). Florida Entomologist 99(S2):130-3.

VREYSEN, M.J.B., W. KLASSEN and J.E. CARPENTER (2016). Overview of technological advances toward greater efficiency and efficacy in sterile insect-inherited sterility programs against moth pests. Florida Entomologist 99(S1):1-12.

ZHANG, D., R.S. LEES, Z. XI, K. BOURTZIS and J.R.L. GILLES (2016). Combining the Sterile Insect Technique with the Incompatible Insect Technique: III-Robust mating competitiveness of irradiated triple *Wolbachia*-Infected *Aedes albopictus* males under semi-field conditions. PLoS One 11(3):e0151864.

Other Publications

2018

FAO/IAEA (2018). Trapping guidelines for area-wide fruit fly programmes, Second edition, by Enkerlin, W.R. and Reyes-Flores, J. (eds). Rome, Italy. 65 pp. http://www-naweb.iaea.org/nafa/ipc/public/Trapping-guideline-(002).pdf.

FAO/IAEA (2018). The Dashboard for Managers of Insect Production Facilities A Mass-Rearing Metrics and Monitoring Tool, by Rendon, P., Aldana, A. and Caceres, C. (eds). Vienna, Austria, 18 pp. http://www-naweb.iaea.org/nafa/ipc/public/MANUAL-MASS-REARING-METRICS-AND-MONITORING-TOOL-Ver-1.pdf.

FAO/IAEA (2018). Manual para diferenciar moscas de *Anastrepha ludens* (Loew) silvestres y criadas de cepa normal ("bi-sexual") y cepa sexada genéticamente (Tapachula-7), irradiadas y sin irradiar. Guillen Aguilar J.C., Lopez Muñoz L., Lopez Villalobos E.F. y Soto Garcia D. N. Roma, Italia, 95 pp. http://www-naweb.iaea.org/nafa/ipc/public/Manual-para-diferenciar-moscas.pdf.

FAO/IAEA (2018). Guidelines for Colonization of *Aedes* Mosquito Species. Version 1.0. Vienna, Austria, 12 pp. http://www-naweb.iaea.org/nafa/ipc/public/Guidelines-for-colonisation-of-Aedes-mosquito-species-v1.0.final.pdf

2017

FAO/IAEA (2017). Fruit Sampling Guidelines for Area-Wide Fruit Fly Programmes, Enkerlin WR, Reyes J and Ortiz G (eds.), Food and Agriculture Organization of the United Nations. Vienna, Austria. 45 pp. http://www-naweb.iaea.org/nafa/ipc/public/fruit-sampling-guidelines.pdf.

FAO/IAEA (2017). Guidelines for Mature Tsetse Sterile Male Pupae Packaging for Long Distance. Joint FAO/IAEA Programme, Vienna, Austria. 7 pp. (http://www-naweb.iaea.org/nafa/ipc/public/Long-distance-shipment-tsetse-pupae.pdf).

FAO/IAEA (2017). Guidelines for Standardised Mass-Rearing of *Anopheles* Mosquitoes.Version 1.0. http://www-naweb.iaea.org/nafa/ipc/public/Guidelines-for-standardised-mass-rearing-of-Anopheles-mosquitoes-v1.0.pdf.

FAO/IAEA (2017). The Guidelines for Routine Colony Maintenance of *Aedes* Mosquito Species.Version 1.0. http://www-naweb.iaea.org/nafa/ipc/public/guidelines-for-routine-colony-maintenance-of-Aedes-mosquito-species-v1.0.pdf.

FAO/IAEA (2017). Guideline for packing, shipping, holding and release of sterile flies in area-wide fruit fly control programmes. Joint FAO/IAEA Programme, Vienna, Austria. 144 pp. (http://www-naweb.iaea.org/nafa/ipc/public/Guideline-for-Packing.pdf).

MEHTA, K. (2017). Technical Specification For An X-Ray System For The Irradiation Of Insects For The Sterile Insect Technique And Other Related Technologies, Vienna, Austria. 11 pp. (http://www-naweb.iaea.org/nafa/ipc/public/X-Ray-system-sit.pdf).

2016

FAO/IAEA (2016). Guidelines for the Use of Mathematics in Operational Area-wide Integrated Pest Management Programmes Using the Sterile Insect Technique with a Special Focus on Tephritid Fruit Flies. Barclay H.L., Enkerlin W.R., Manoukis N.C. and Reyes-Flores J. (eds.), Food and Agriculture Organization of the United Nations. Rome, Italy. 95 pp. (http://www-naweb.iaea.org/nafa/ipc/public/tephritid-fruit-flies-manual.pdf).

FAO/IAEA (2016). Standard Operating Procedures for Preparing and Handling Sterile Male Tsetse Flies for Release. Argiles-Herrero R. and Leak S. (eds.). Joint FAO/IAEA Programme, Vienna, Austria. 37 pp. (http://www-naweb.iaea.org/nafa/ipc/SOP-sterile-male-tsetse-shipment-handling-release.pdf).

FLORIDA ENTOMOLOGIST (2016). Volume 99, Special Issue 1. Toward Greater Efficiency and Efficacy in Sterile Insect - Inherited Sterility Programs against Moth Pests. Vreysen M.J.B., Klassen, W. and Carpenter J.E. (eds.). Florida Entomological Society. (http://journals.fcla.edu/flaent/issue/view/4271).

FLORIDA ENTOMOLOGIST (2016). Volume 99, Special Issue 2. Development of Generic Phytosanitary Irradiation Dose for Arthropod Pests. Hallman G.J., Parker A., Klassen W., Blackburn C. and Hénon, Y.M. (eds.). Florida Entomological Society. (http://journals.fcla.edu/flaent/issue/view/4278).

GUILLEN-AGUILAR J.C., L.L. MUÑOZ, E.P. ESPINOZA, E.F. LÓPEZ VILLALOBOS, V.H. MARROQUÍN SOLÓRZANO et al. (2016). Manual to Differentiate Wild Mediterranean Fruit Flies *Ceratitis capitata* (Wied.) from Non-irradiated (Fertile) and Irradiated (Sterile) VIENNA Temperature Sensitive Lethal Strain Flies (Ed. by J. Reyes-Flores). IAEA, Vienna, Austria. 60 pp. (http://www-naweb.iaea.org/ nafa/ipc/public/Cc-Differentiation.pdf).

2015

ZOOKEYS (2015). Volume 540, Special Issue of FAO/IAEA Coordinated Research Project on Resolving Cryptic Species Complexes of Major Tephritid Pests to Enhance SIT Application and Facilitate International Trade. J. Hendrichs, M.T. Vera, M. De Meyer and A.R. Clarke (eds.). Pensoft Publishers, Sofia, Bulgaria. (http://zookeys.pensoft.net/browse_journal_issue_documents.php?issue_id=763).

2014

BMC GENETICS (2014). Volume 15 (Suppl. 2), Special Issue of an FAO/IAEA Coordinated Research Project on Development and Evaluation of Improved Strains of Insect Pests for Sterile Insect Technique Applications. Bourtzis, K. and Hendrichs J. (eds.). (http://www.biomedcentral.com/bmcgenet/supplements/15/S2).

INTERNATIONAL JOURNAL OF TROPICAL INSECT SCIENCE (2014). Volume 34, Supplement 1:S1-S153. Special Issue of an FAO/IAEA Coordinated Research Project on Development of Mass-rearing for African, Asian and New World Fruit Fly Pests in Support of the Sterile Insect Technique. Vreysen, M.J.B., Hendrichs J. and Cáceres C. (eds.). (http://journals.cambridge.org/action/displayIssue?decade=2010&jid=JTI&volumeId=34&issueId=S1&iid=9377479).

ACTA TROPICA (2014). Volume 138 Supplement: S1-S93. Special Issue of an FAO/IAEA Coordinated Research Project on Applying GIS and Population Genetics for Managing Livestock Insect Pests: Case Studies on Tsetse and Screwworm Flies. Ready, P.D., Feldmann U. and Berzins K. (eds.). (http://www.sciencedirect.com/science/journal/0001706X/138/supp/S).

SHELLY, T., N. EPSKY, E.B. JANG, J. REYES-FLORES and R.I. VARGAS (eds.). (2014). Trapping and the Detection, Control, and Regulation of Tephritid Fruit Flies: Lures, Area-wide Programs, and Trade Implications. Springer, The Netherlands, 638 pp.

FAO/IAEA/USDA (2014). Product Quality Control for Sterile Mass-reared and Released Tephritid Fruit Flies, Version 6.0. IAEA, Vienna, Austria. 164 pp. (http://www-naweb.iaea.org/nafa/ipc/public/QualityControl.pdf).

ACTA TROPICA (2014). Volume 132, Supplement: S1-S187. Special Issue of an FAO/IAEA Coordinated Research Project on Biology and Behavior of Male Mosquitoes in Relation to New Approaches to Control Diseases Transmitting Mosquitoes. Lees, R.S., Chadee D.D. and Gilles J.R.L. (eds.). (http://www.sciencedirect.com/science/journal/0001706X/132/supp/S).

2013

FAO/IAEA (2013). Using Open Source GIS Techniques in Insect Pest Control Programmes. Tutorial DVD. IAEA, Vienna, Austria.

ABD-ALLA, A.M.M. and ARIF B. (eds.) (2013). Special Issue of an FAO/IAEA Coordinated Research Project on Improving SIT for Tsetse Flies through Research on their Symbionts and Pathogens Improvement of Codling Moth SIT to Facilitate Expansion of Field Application. Journal of Invertebrate Pathology. 112 (Supplement 1): S1-S147. (http://www.sciencedirect.com/ science/journal/00222011/112/supp/S1).

CÁCERES-BARRIOS, C., P. RENDÓN and A. JESSUP, (2013). The FAO/IAEA Spreadsheet for Designing and Operation of Insect Mass-Rearing Facilities. FAO, Rome, Italy. 48 pp.

HENDRICHS, J. and R. PEREIRA, (eds.) (2013). Special Issue of an FAO/IAEA Coordinated Research Project on Improving Sterile Male Performance in Fruit Fly Sterile Insect Technique (SIT) Programmes. Journal of Applied Entomology 137 (Supplement 1): S1-S259. (http://onlinelibrary.wiley.com/doi/10.1111/jen.2013.137.issue-s1/issuetoc).

For copies of unpriced publications, please contact Svetlana Piedra Cordero (S.Piedra-Cordero@iaea.org), or the Insect Pest Control subprogramme, Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture, IAEA (http://www-naweb.iaea.org/nafa/ipc/index.html).

Impressum

Insect Pest Control Newsletter No. 91

The Insect Pest Control Newsletter is prepared twice per year by the Insect Pest Control Section, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and FAO/IAEA Agriculture and Biotechnology Laboratories, Seibersdorf

International Atomic Energy Agency
Vienna International Centre, PO Box 100, 1400 Vienna, Austria
Printed by the IAEA in Austria, July 2018

18-02873