Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Insect & Pest Control Newsletter

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Contents

To Our Readers

Aedes *spp. mosquito emerging from the pupal stage to become a flying adult standing on water (from top left to top right, and from bottom left to bottom right).* Aedes *spp. females can transmit a number of viral and other diseases, including dengue, chikungunya, yellow fever, Zika and others. In response to the recent Zika emergency in Brazil and increasingly other countries in Latin America and the Caribbean, there have been many requests to FAO and IAEA from Member States in this region to accelerate the validation in pilot projects of the Sterile Insect Technique as a "multivaccine" approach that can contribute to population suppression as part of an integrated vector management focused on villages, towns and eventually cities (photo credit J. Reyes/A. Rodriguez).*

A year ago, in NL 85, we reported on the increasing demands from our FAO and IAEA Member States to expand our focus from developing and transferring the sterile insect technique (SIT) for major crop and livestock insect pests to major disease-transmitting mosquitoes.

Since the mid-2000s, there have been several IAEA General Conference resolutions requesting the Joint FAO/IAEA Insect Pest Control Subprogramme to develop a complete "SIT package" for major mosquito species to be used as a component of area-wide integrated vector management (IVM) approaches. The first resolutions focussed on the malaria vector *Anopheles arabiensis*, but since 2010, also the dengue and chikungunya vectors *Aedes aegypti* and *Ae. albopictus* were included.

In view that the traditional chemical-based vector control strategies were facing serious challenges due to increased resistance of mosquitoes to insecticides and increased public concern of insecticide use in urban areas, there was a clear need for novel methods and complementary approaches to manage mosquito populations in an effective and more environmentally friendly and sustainable way. Furthermore, due to the absence of effective vaccines and drugs against some of these diseases, vector suppression approaches are widely seen as the most effective means to reduce these mosquito-transmitted diseases that pose an enormous economic and social burden, and whose incidence has increased drastically in recent years with the spread to new regions.

In early 2016, when the dimension and impact of the Zika outbreak in Brazil and later throughout the tropical Americas became known, demands for the SIT to contribute to vector control strategies increased significantly. During IAEA Director General Yukiya Amano's February 2016 travel in Latin America, several countries requested capacity building and technical support in this area. The Agency responded rapidly and effectively to the requests and a new off-cycle regional technical cooperation project for the Latin American and the Caribbean region (RLA/5/074) was approved by the IAEA Board of Governors in March 2016. The project aims to support the transfer of integrated vector management approaches with an SIT component with a focus on capacity building, mosquito surveillance, mass-rearing, sex separation, irradiation, handling, transport and release methods, and monitoring, including pilot trials in some Member States. Financial contributions were provided by the Governments of France, Japan and the USA to support this regional project.

In addition, a new *Peaceful Uses Initiative* (PUI) project was simultaneously approved to increase support to the mosquito research and technology transfer activities at the Insect Pest Control Laboratory (IPCL) of the FAO/IAEA Agriculture and Biotechnology Laboratories in Seibersdorf to be able to provide the technical support for the above and other regional TC mosquito projects and to better respond to the increasing demands for the development and application of SIT-based approaches for the management of Zika and other disease-transmitting *Aedes* species. Generous financial contributions were provided by the Governments of Japan and the USA to support the expansion of mosquito activities at the IPCL and particularly its support to the RLA/5/074 off-cycle project.

As reported in NL 85, much progress has been made over the last ten years in developing the SIT package for mosquitoes (over 100 publications in peer-reviewed journals), even though funding and resources have been quite limited at the IPCL, with only one permanent researcher staff and one technical staff dedicated to mosquito activities. These were of course supported by coordinated research projects, as well as by collaborating and visiting scientists, cost-free experts, fellows and interns. The additional space, staff and funds are therefore very welcome to be able to expand the mosquito activities in order to address the growing expectations of our Member States.

There is clearly no "silver bullet" for suppressing mosquito vector populations. All available tools and strategies are potentially useful, not as stand-alone tactics, but as part of an integrated vector management approach. Nevertheless issues of stability, sustainability, biosecurity and regulation have to be addressed. In the case of self-limiting mosquito suppression methods such as the SIT, releasing only males is an absolute prerequisite to avoid any possibilities of disease transmission by accidentally released females, and increasing at the same time effectiveness and cost efficiency of mass-rearing and release operations. In the current absence of an efficient and reliable sex separation method at a larger scale, the safest and most responsible solution for mosquito population suppression is the integration of the SIT with other genetic approaches such as *Wolbachia*-induced cytoplasmic incompatibility (incompatible insect technique, IIT).

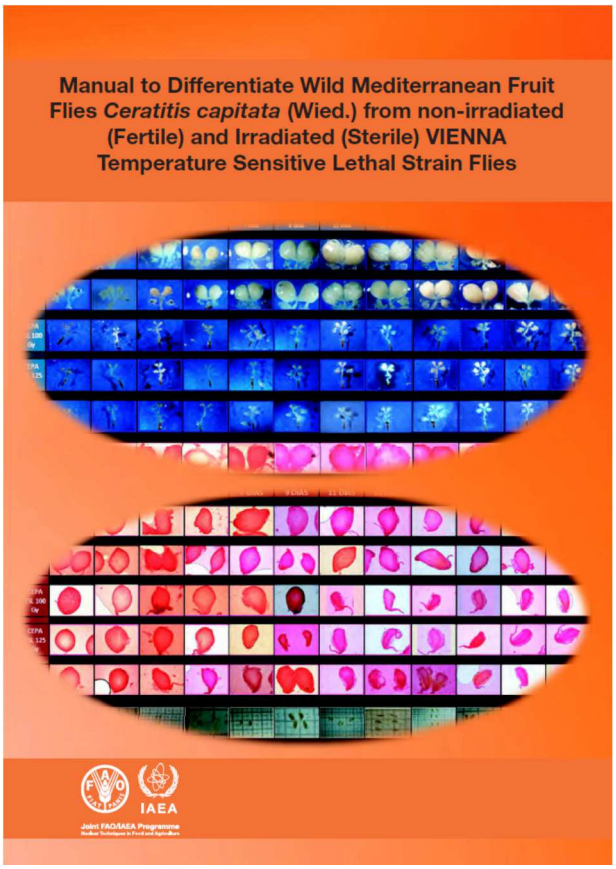
This combination of IIT and SIT strategies, developed by FAO/IAEA (see recent review on page 36), is the most responsible and safe approach as any accidentally released females cannot transfer the disease due to the presence of *Wolbachia* bacteria. In addition, the females will be completely sterile due to a low-dose irradiation treatment before release, and thus cannot become established in the natural population. This prevents the loss of the IIT tool and the irreversible replacement of the wild population, which may have unforeseen consequences with regards to mosquito vectorial capacity. Also in the case of transgenic mosquitoes, the risk of releasing any fertile or biting females in the field, as well as transgene horizontal transfer, can be avoided by an irradiation treatment that ensures complete sterility of the released males and females. The often repeated argument that mosquitoes, unlike other Diptera such as fruit flies and screwworm flies, cannot tolerate the radiation treatment is of course a fallacy and is incorrectly used by promoters of transgenic (i.e. genetically engineered) approaches.

A critical challenge and essential component of any programme releasing insects, and especially those that release mosquitoes, is public relations. Campaigns need to be prepared and deployed at various levels to educate the public to engage in the removal of mosquito breeding sites and to support SIT activities. One example (see below) is a brief animated infographic for the general public on mosquito SIT http://www-naweb.iaea.org/nafa/resources-nafa/SIT-Mosquitoes-LR.mp4 that was produced with graphic animation experts at FAO headquarters to make the potential contribution of the SIT to integrated vector management more easily understandable to the general public.

FAO animated infographic on the integration of the Sterile Insect Technique for disease-transmitting Aedes *mosquitoes more easily understandable by the wider general public.*

In response to another challenge in relation to the aerial mosquito release, the Remotely Operated Mosquito Emission Operation (ROMEO) concept was developed by FAO/IAEA, and constructed in collaboration with the German drone manufacturer Height Tech. ROMEO was one of two IAEA-supported projects submitted to the "***2016 United Arab Emirates Drones for Good Award"*** competition. This innovative concept that associates drone and new release device technologies won fourth place in the competition, which received over 1000 entries from more than 160 countries.

With respect to publications, I would like to highlight the recently published "*Manual to Differentiate Wild Mediterranean Fruit Flies* Ceratitis capitata *(Wied.) from Non-irradiated (Fertile) and Irradiated (Sterile) VIENNA Temperature Sensitive Lethal Strain Flies*". This manual nicely illustrated with many colour plates is a product of recent studies on the effect of gamma radiation on testes and ovaries of the Mediterranean fruit fly VIENNA temperature sensitive lethal (*tsl*) genetic sexing strains, which are being used in most Mediterranean fruit fly mass-rearing facilities in the world. It includes standardised and updated procedures to determine the fertility or sterility of adults of these strains. Consequently, this is a very useful document to support SIT-based area-wide integrated pest management programmes against the Mediterranean fruit fly VIENNA *tsl* strains.



Finally I would like to inform you that I will be retiring at the end of September 2016, after having served the FAO and the IAEA in various capacities and locations for over 28 years. I am very thankful to my mentors Dieter Enkerlin, Jorge Gutierrez Samperio, Carrol Calkins and Don Lindquist, and for an enjoyable and thrilling career, which started in the 1970s with the initiation of the Moscamed Programme in Mexico. Science can be exciting, but also challenging when applied in operational programmes to solve real socioeconomic problems in developing countries; but the resulting achievements make it all very worthwhile. I'm grateful to our collaborators across the globe for their generosity, interest and understanding. My special thanks to all my colleagues at FAO/IAEA and elsewhere for your support, encouragement and friendship over many decades. I am leaving very pleased that the construction of a new and modern Insect Pest Control Laboratory in Seibersdorf is now fully funded and has finally been initiated making this dream a reality; it is scheduled to be completed in late 2017. Furthermore, I will be handing over to a strong and experienced team that will continue to thrive to help making pest and vector management in the world more environmentally friendly and therefore more sustainable.

With gratitude, Jorge Hendrichs

Head, Insect Pest Control Section

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Forthcoming Events (2016-2017)

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

First RCM on Improved Field Performance of Sterile Male Lepidoptera to Ensure Success in SIT Programmes. 31 August–4 September 2016, Durban, South Africa.

Third RCM on Exploring Genetic, Molecular, Mechanical and Behavioural Methods of Sex Separation in Mosquitoes. 10–14 October 2016, Tapachula, Mexico.

Second RCM on Comparing Rearing Efficiency and Competitiveness of Sterile Male Strains Produced by Genetic, Transgenic or Symbiont-based Technologies. 12–16 December 2016, Panama City, Panama.

Second RCM on Mosquito Handling, Transport, Release and Male Trapping Methods. 24-28 April 2017, Valencia, Spain.

Fourth RCM on Use of Symbiotic Bacteria to Reduce Mass-rearing Costs and Increase Mating Success in Selected Fruit Pests in Support of SIT Application. 17–21 May 2017, Vienna, Austria.

Third RCM on Dormancy Management to Enable Mass-rearing and Increase Efficacy of Sterile Insects and Natural Enemies. 27–31 May 2017, Vienna, Austria.

First RCM on Integration of the SIT with Biocontrol for Greenhouse Insect Pest Management. 3-7 July 2017, Vienna, Austria.

Fourth RCM on Enhancing Vector Refractoriness to Trypanosome Infection. 27 November – 1 December 2017, Pretoria, South Africa.

II. Consultants and Expert Meetings

FAO/IAEA Consultants Meeting on Mass-rearing Colony Management. 17–21 May 2017, Vienna, Austria.

III. Other Meetings/Events

XXV International Fruit Fly Course. National Fruit Fly Programme DGSV-SENASICA-SAGARPA (in support to TC Project RLA5070). 20 June–8 July 2016. Metapa de Dominguez, Chiapas, Mexico.

FAO/IAEA First Coordination Meeting of Interregional Project Sharing Knowledge on the Sterile Insect and Related Techniques for the Integrated Area-Wide Management of Insect Pests and Human Disease Vectors (under Regional TC Project INT5155). 4–8 July, 2016, Tapachula, Mexico.

FAO/IAEA Regional Workshop on 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). 9–11 July 2016, Tapachula, Mexico.

FAO/IAEA Regional Training Course on Taxonomy and Identification of Fruit Fly Pest Species for Southeast Asia (under Regional TC Project RAS5067). 11–15 July 2016, Bangkok, Thailand.

FAO/IAEA First 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). 25–29 July, 2016, Maputo, Mozambique.

FAO/IAEA Second Coordination Meeting of Regional Project Integrating Sterile Insect Technique for Better Cost-Effectiveness of Area-Wide Fruit Fly Pest Management Programmes in Southeast Asia (under Regional TC Project RAS5067). 14–19 August, 2016, Kuala Lumpur, Malaysia.

First Meeting of the Tephritid Workers of Asia, Australia, and Oceania (TAAO), 15–18 August 2016, Kuala Lumpur, Malaysia.

FAO/IAEA First Coordination Meeting of Europe Regional Project Establishing Genetic Control Programmes for *Aedes* Invasive Mosquitoes (under Regional TC Project RER5022). 22–26 August, 2016, Vienna, Austria.

Workshop to Standardize Sampling and Bioassay Methods for Assessing Field Performance of Sterile Male Lepidoptera. 29–30 August 2016, Durban, South Africa.

Meeting of the Technical Panel on Phytosanitary Treatments (TPPT), International Plant Protection Convention FAO. 29 August – 2 September 2016, Tokyo, Japan.

FAO/IAEA Regional Training Course on Fruit Fly Detection, Surveillance and Area-Wide Integrated Pest Management for Balkans and Eastern Mediterranean (under Regional TC Project RER5021). 5–9 September 2016, Opuzen, Croatia.

FAO/IAEA Southeast Asia Regional Workshop on Sterile Insect Technique-based Approaches to Control Populations of Mosquito Disease Vectors: with Special Reference to Dengue, Chikungunya and Zika Vectors (under Regional TC Project RAS5066 and INT5155). 5–9 September 2016, Kuala Lumpur, Malaysia.

FAO/IAEA Workshop on Surveillance Systems against Non-native Fruit Fly Pests and Emergency Response Capacity (under TC Project MOR5035). 5–9 September 2016, Rabat, Morocco.

FAO/IAEA Workshops on Identification of Non-native Fruit Flies of Quarantine and Economic Significance (under TC Project MOR5035). 28-30 September 2016, Rabat, Morocco.

Ninth Meeting of the Tephritid Workers of the Western Hemisphere (TWWH), 16–22 October 2016, Buenos Aires, Argentina.

FAO/IAEA Regional Latin America Training Course on Mass-rearing, and SIT-related Activities for the Control of *Aedes* Mosquitoes, the Major Vectors of dengue, chikungunya and Zika (under Regional TC Project RLA5074). 7-11 November 2016, Juazeiro, Brazil.

Third FAO/IAEA International Conference on Area-wide Management of Insect Pests: Integrating the Sterile Insect and Related Nuclear and Other Techniques. 22–26 May 2017, Vienna, Austria.

FAO/IAEA Europe Regional Workshop to Present Respective Experiences with Fruit Fly Activities and Synergize Future Activities (under Regional TC Project RER5021). 22–26 May 2017, Vienna, Austria.

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). 31 July – 25 August 2017, Metapa de Dominguez, Chiapas, Mexico and Antigua / El Pino, Guatemala.

Past Events (First Semester 2016)

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

Second RCM on Dormancy Management to Enable Mass-rearing and Increase Efficacy of Sterile Insects and Natural Enemies. 18–22 April 2016, Stellenbosch, South Africa.

Third RCM on Enhancing Vector Refractoriness to Trypanosome Infection. 6–10 June 2016, Lyon, France.

II. Consultants and Expert Meetings

FAO/IAEA Consultants Meeting on Integration of the SIT with Biocontrol for Greenhouse and Other Confined Insect Pest Management. 14–18 March 2016, Vienna, Austria.

III. Other Meetings/Events

FAO/IAEA Regional Latin America Training Course and Workshop on Supporting Capacity Building for Evaluation of Feasibility of a Progressive Control Programme for New World Screwworm (under Regional TC Project RLA5067). 11–15 January, 2016, Juazeiro, Brazil.

FAO/IAEA First Coordination Meeting of Regional Latin America 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). 4–8 April, 2016, Guatemala City, Guatemala.

Eleventh Session of the Commission on Phytosanitary Measures, International Plant Protection Convention, FAO. 4–8 April 2016, Rome, Italy.

Third Meeting of the Tephritid Workers of Europe, Africa and the Middle East (TEAM), 11–14 April 2016, Stellenbosch, South Africa.

Workshop on Dormancy Management to Enable Insect Mass-rearing. 15–17 April 2016, Stellenbosch, South Africa.

Workshop on Bioinformatics Approaches for Microbiota Profiling Based on Amplicon Sequencing Data. 30 May–1 June 2016, Lyon, France.

Workshop on Tissue Localization and Analysis of Insect Endosymbionts by Fluorescence Microscopy: Theoretical Background and Practical Applications. 2–4 June 2016, Lyon, France.

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*)	Stephen Leak
Botswana	BOT5013	Using the Sterile Insect Technique Integrated with Other Suppression Methods for Managing *Bactrocera dorsalis*	Rui Cardoso Pereira
Burkina Faso	BKF5012	Collecting Baseline Data and Implementing Fruit Fly Suppression in Mango Fruit	Rui Cardoso Pereira
Burkina Faso	BKF5018	Improving Agro-Forestry and Agro-Pastoral Production through the Use of Nuclear Technologies	Adly Abdalla Rafael Argiles
China	CPR5020	Integrating the Sterile Insect Technique (SIT) for Area-Wide Integrated Pest Management of Tephritid Fruit Flies	Rui Cardoso Pereira
Ecuador	ECU5029	Improving Integrated Fruit Fly Management in Fruit and Vegetable Production Areas	Walther Enkerlin Carlos Cáceres
Ethiopia	ETH5019	Enhancing Livestock and Crop Production through Consolidated and Sustainable Control of Tsetse and Trypanosomosis to Contribute to Food Security	Rafael Argiles Andrew Parker Adly Abdalla
Fiji	FIJ5001	Examining Options for the Management of Fruit Flies	Rui Cardoso Pereira
Guatemala	GUA5019	Strengthening National Capabilities for the Control of Agricultural Pests Using Nuclear Technologies	Walther Enkerlin
Israel	ISR5020	Developing a Strategy to Counteract *Bactrocera zonata*	Walther Enkerlin
Libya	LIB5011	Enhancing Area-Wide Integrated Management of Fruit Flies	Walther Enkerlin
Marshall Islands	MHL5001	Strengthening national capacities for the early and rapid detection of Zika virus infections in the Marshall Islands	Hanano Yamada Jeremie Gilles Kostas Bourtzis
Mexico	MEX5031	Using the Sterile Insect Technique to Control Dengue Vectors	Kostas Bourtzis Hanano Yamada
Morocco	MOR5035	Implementing the Sterile Insect Technique in the Souss Valley	Walther Enkerlin Carlos Cáceres

Mauritius	MAR5019	Supporting a Feasibility Study Using the Sterile Insect Technique (SIT) for the Integrated Control of Mosquitoes	Hanano Yamada Jeremie Gilles
Mauritius	MAR5022	Reducing Insecticide Use and Losses to Melon Fly (*Bactrocera cucurbitae*) through Environment-Friendly Techniques to Increase Production in Different Areas, Phase II	Jorge Hendrichs Rui Cardoso Pereira
Panama	PAN5025	Expanding and Strengthening the Phytosanitary Surveillance System for Fruit Fly, Emphasizing Exotic Species of Quarantine Importance, and Exploring the Use of Nuclear Techniques for Post-Harvest Treatment as a Complementary Action	Walther Enkerlin
Papua New Guinea	PAP5001	Supporting a Feasibility Study on Using the Sterile Insect Technique against the Cocoa Pod Borer	Marc Vreysen
Philippines	PHI5033	Building Capacity in Using the Sterile Insect Technique against Dengue and Chikungunya Vectors	Jeremie Gilles Hanano Yamada
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)	Rui Cardoso Pereira
South Africa	SAF5014	Assessing the Sterile Insect Technique for Malaria Mosquitos in a South African Setting, Phase II	Hanano Yamada Jeremie Gilles
Senegal	SEN5037	Supporting the National Programme to Control Tsetse and Trypanosomosis	Marc Vreysen Rafael Argiles Andrew Parker
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	Jeremie Gilles Hanano Yamada
Sudan	SUD5038	Implementing the Sterile Insect Technique for Integrated Control of *Anopheles arabiensis*, Phase II	Jeremie Gilles Hanano Yamada Adly Abdalla
Thailand	THA5052	Developing Sustainable Management of Fruit Flies Integrating Sterile Insect Technique with other Suppression Methods	Rui Cardoso Pereira
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	Stephen Leak
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	Stephen Leak

		Regional Projects	
Regional Africa	RAF5069	Supporting a Feasibility Study to Eradicate Tsetse from Southern Mozambique, South Africa and Swaziland	Marc Vreysen Rui Cardoso Pereira
Regional Africa	RAF5070	Supporting Area-Wide Tsetse and Trypanosomosis Management to Improve Livestock Productivity and Enable Sustainable Agriculture and Rural Development (Phase II)	Rafael Argiles Stephen Leak
Regional Africa	RAF5072	Exploring the Use of Sterile Insect Technique as a Novel Technique for Control of Vector Mosquito for Chikungunya and Dengue (*Aedes albopictus*) in the Indian Ocean Region (PHASE I - 2014-2015)	Jeremie Gilles Hanano Yamada
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	Rui Cardoso Pereira
Regional Africa	RAF5077	Supporting Area-Wide Tsetse and Trypanosomosis Management to improve Livestock Productivity, Phase III	Rafael Argiles Andrew Parker
Regional Asia	RAS5066	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	Kostas Bourtzis Hanano Yamada
Regional Asia	RAS5067	Integrating Sterile Insect Technique for Better Cost-Effectiveness of Area-Wide Fruit Fly Pest Management Programmes in Southeast Asia	Rui Cardoso Pereira
Regional Asia (ARASIA)	RAS5076	Harmonising 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 Europe	RER5021	Supporting the Management of Fruit Flies in the Balkans and the Eastern Mediterranean	Rui Cardoso Pereira
Regional Europe	RER5022	Establishing Genetic Control Programmes for *Aedes* Invasive Mosquitoes	Kostas Bourtzis Hanano Yamada
Regional Latin America	RLA5067	Supporting Capacity Building for Evaluation of Feasibility of a Progressive Control Programme for New World Screwworm	Walther Enkerlin
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	Kostas Bourtzis Hanano Yamada Jeremie Gilles
		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	Jeremie Gilles Hanano Yamada Rui Cardoso Pereira

Highlights of Technical Cooperation Projects

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

Director General of the IAEA visits the National Institute for Communicable Diseases

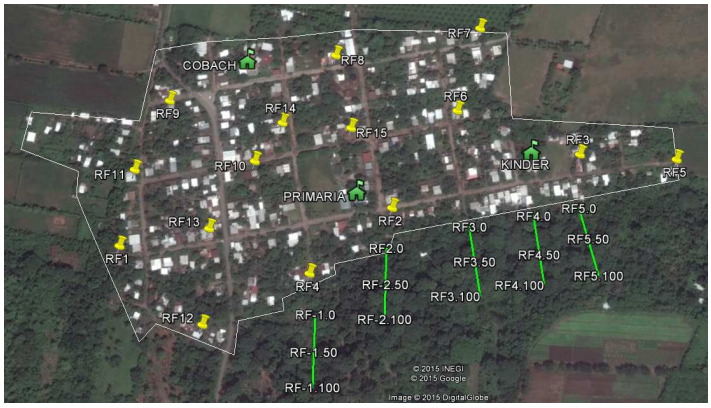
The Director General of the IAEA, Mr Yukiya Amano, visited the National Institute for Communicable Diseases (NICD) on 10 May 2016. He was accompanied by a delegation from South Africa's Department of International Relations & Co-operation. Mr Amano visited the NICD in order to view progress on the Sterile Insect Technique (SIT) feasibility project currently being conducted by a team of researchers from the Vector Control Reference Laboratory of the Centre for Opportunistic, Tropical & Hospital Infections and the Wits Research Institute for Malaria. This project, supported by the IAEA and other donor agencies, aims to establish the feasibility of integrating mass-produced, irradiation-sterilised male mosquitoes of a major malaria vector species, *Anopheles arabiensis*, as a non-insecticide method of malaria vector control. Mr Amano was impressed by the progress of the project to date and pledged to continue supporting the current phase of the project over the next few years. He was also impressed by the NICD's insectary facilities and the number of *Anopheles* species and strains in culture.

Director General of the IAEA visits the National Institute for Communicable Diseases (Johannesburg, South Africa).

The South African Malaria SIT feasibility project is funded by the International Atomic Energy Agency, the Industrial Development Corporation and the South African Nuclear Energy Corporation (NECSA) through its Nuclear Technologies in Medicine and the Biosciences Initiative (NTeMBI)–a national platform funded by the Department of Science and Technology and the Global Diseases Detection.

Using the Sterile Insect Technique to Control Dengue Vectors (MEX5031)

The goal of this project is to develop and implement a feasibility study integrating sterile insect based approaches to control *Aedes aegypti* (the primary vector) and *Aedes albopictus* (potential secondary vector) transmitting dengue, chikungunya and, recently, Zika viruses in Southern Mexico, where a significant number of disease cases have been reported during the last few years. This is a 3 years project started in January 2016 and the Mexican counterparts, Centro Regional de Investigación en Salud Pública (CRISP) and El Colegio de la Frontera Sur (ECOSUR) have made a very promising start to the planned SIT feasibility study against *Aedes aegypti*, the major local disease vector.



A potential pilot site in Ejido Río Florido, Tapachula, Chiapas identified for control of Aedes *mosquitos with the surveillance sites mapped.*

Efforts have already started to collect and analyze baseline entomological data. Ovitraps have been placed weekly in each of two villages, Rio Florida (23 ha) and Ejido Hidalgo (30 ha), two villages about 3.5 km apart and ~5 km from Tapachula, which will be used as sites for the pilot releases for population suppression. An insectary is available at CRISP and used for hatching eggs from ovitraps, species identification and sample collection. A further two rooms in the same building have been identified for colony establishment and to further support the field work. The production of mosquitoes is currently being scaled up while a new colony (from wild material) is to be established soon and will be used for mark-release-recapture (MRR) experiments.

The MRR experiments will be performed in both dry and rainy seasons thus providing answers about the dispersal capacity of *Ae. aegypti* males in the sites as well as migration into these two sites from the surrounding areas. These results will definitely provide valuable information about the adult populations and their survival in the field. In addition, the counterpart has access to all the necessary expertise and facilities for irradiation, leaving only the logistics of the workflow (rearing-irradiation-release) to be finalized.

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 in Latin America (RLA5070)

The first project coordination meeting was held in Guatemala City from 4 to 8 of April 2010. So far, nineteen countries from the region have adhered to the project. Countries participating in the meeting were: Argentina, Belize, Brazil, Costa Rica, Colombia, Dominican Republic, Ecuador, El Salvador, Guatemala, Jamaica, Mexico, Panama, Paraguay and Peru.

Opening ceremony first coordination meeting of regional Latin America fruit fly project (Guatemala City, Guatemala).

The results obtain from the meeting are the following:

1. Project work plan finalized and integrated with the Organismo Internacional Regional de Sanidad Agropecuaria (OIRSA) fruit fly regional project work plan.
2. Synthesis of the fruit fly situation by country finalized.
3. Preparation of operational plan by country.
4. Draft document on the organization and use of International Standards on Phytosanitary Measures (ISPMs) for fruit flies of quarantine and economic significance.
5. Current situation of the surveillance networks against non-native fruit flies and response capacity.
6. List of specific topics of interest by country.
7. Table of trapping material needs by country as well as GIS/GPS needs.
8. Information on current status of trapping systems including trap types, attractants and service frequency.

With some exceptions, it was determined that there is a marked deficiency in the Latin American Region on surveillance networks against non-native fruit flies as well as in response capacity. Apart from this central topic, other topics of interest are technology transfer on mass-rearing processes, sterile fly release and adult and larvae identification through molecular techniques. Given the transboundary nature of fruit fly pests, it was agreed to address the problem at a regional level.

Suppressing Melon Fruit Fly Species through Environment-Friendly Techniques to Enhance Food Security (SEY5009)

Although Seychelles has managed to keep dangerous non-native fruit fly species at bay, these efforts should continue to prevent the introduction of *Bactrocera dorsalis*, the major threat to Seychelles horticulture. The country remains at high risk of its introduction through commercial consignments or introduction of infested fruits by individuals when arriving at the country by air or by sea.

With the objective of preventing the incursion and possible establishment of non-native species into the Seychelles, the quarantine infrastructure has recently received special attention–capabilities have been improved with new equipment and staff training. As a result, no fruit fly entry or incursion has been detected in Seychelles despite the interception of some infested fruits by the quarantine services at the port of entry. Since 2000, six interceptions occurred in fruits and vegetables imported to Seychelles: *Bactrocera zonata* in 2000, and *Ceratitis cosyra* and *B. dorsalis* in 2006, all in mango (*Mangifera indica*); *Dacus ciliatus*, in 2010 and 2013, respectively in courgette (*Cucurbita pepo*) and musk melon (*Cucumis melo*); and in 2014 *Zeugodacus tau (*known previously as *Bactrocera tau)* in courgette (*C. pepo*). The immediate response included the intensification of surveillance by installation of a specific trapping network in the vicinity of the ports of entry, and an increase of fruit sampling.

The project also helped to strengthen fruit fly detection and identification, pest risk analysis and the establishments of an emergency action plan, as well as implementation of a melon fly suppression study in a pilot area. This was conducted for 3 months (the cucumber crop cycle) on Mahe Island during 2014. The study area was about 8 km^2 in extent, and the following suppression methods were integrated: (1) sanitation; (2) male annihilation technique (MAT) blocks baited with cuelure (CUE); (3) bait spay with GF-120 (spinosad); and (4) mass-trapping with GF-120. To evaluate the impact of the suppression, a network of 41 Tephri traps with CUE as attractant was installed and fruit sampling for larval infestation was conducted before and during the pilot trial. Adult populations captured in CUE traps decreased from about 6 flies per trap per day (FTD) to <1 FTD, and fruit infestation decreased from about 90% at commencement to 20% during the trial. Farmers' incomes increased due to an increase in marketable cucurbits.

Project team installing traps during the melon fly pilot suppression study conducted in Mahe Island.

The promising results of the suppression pilot, showed the importance of integrating several fruit fly management methods, and emphasized the advantages of an area-wide approach to population control rather than the field-by-field approach. A follow-up study to combine the above suppression methods with the sterile insect technique (SIT) is planned for initiation as soon as sterile melon flies are available.

Using the Sterile Insect Technique Integrated with Other Suppression Methods for Managing *Bactrocera dorsalis* (BOT5013)

This new project was approved for 2016-2019 with the main objective to help manage fruit fly populations in Botswana to below economic thresholds. So far there is scarce baseline data available, however an effort to compile the data from the Ministry of Agriculture and the Universities was made and data will be made available. However, it is known that Oriental fruit fly, *B. dorsalis*, invaded Botswana in 2010 in Chobe district (northern Botswana). Since then, the fruit fly has spread towards the south, causing major economic problems to Botswana farmers due to the damage caused to the fruits and the quarantine restrictions imposed for international trade. Under the BONAZAZI FAO project (with participation of Botswana, Namibia, Zambia and Zimbabwe, from 2014 to 2015) a pilot suppression study was conducted in Chobe district, however the data were not conclusive.

On the positive side are the relatively low *B. dorsalis* populations (below 1 fly/trap/day (FTD) and their occurrence only during part of the year (mainly from January to April), which coincides with marula (*Sclerocarya birrea*) fruit maturation and the wet season.

On the other hand, although the damage caused on the fruit production (mainly citrus) still appears very limited and of relative minor importance, the spread of *B. dorsalis* to all the country is of major concern for the Botswana fruit production.

Supporting a Feasibility Study on Using the Sterile Insect Technique against the Cocoa Pod Borer (PAP5001)

Cocoa is an important agricultural commodity in Papua New Guinea (PNG) and 80% of the export is produced by smallholders, who are dependent on it for their livelihoods. The cocoa pod borer (CPB) *Conopomorpha cramerella*, was first detected in PNG in 2006, and available data seem to indicate multiple entry points. The CPB is now considered one of the most serious threats to the global cocoa industry. In East New Britain cocoa production plummeted by 82% between 2008 and 2012, i.e. from 25,000 tons to 4,000 tons. National cocoa production dropped from 50,000 tons in 2008 to 34,000 tons in 2014. There is plenty of room to expand cocoa production on PNG, and it is estimated that only 2% of the land that is suitable for cocoa production is actually planted with cocoa trees. The Government of PNG has set a very ambitious goal of reaching a production/export volume of 300,000 tons per year by 2030. All stakeholders seem to agree that this will not be possible without adequate management of the CPB.

Cocoa fruits in a well-managed orchard.

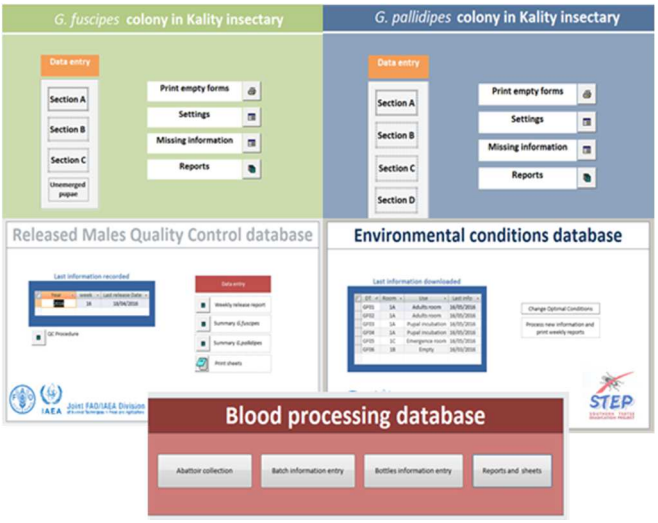
The TC project PAP5001 "Supporting a Feasibility Study on Using the Sterile Insect Technique against the Cocoa Pod Borer" will be providing support to a feasibility study to assess whether the SIT can be developed against the CPB. This will entail developing rearing techniques, with special emphasis on an artificial larval diet. Some expertise is already available in the region (e.g. Indonesia, Malaysia) and it is proposed that a workshop be organized to bring all this expertise together and to jointly develop a strategy to the rearing of the CPB.

Supporting Biological Control of Stable Flies (*Stomoxys calcitrans*, L) through the Use of Parasitoids Reproduced on Fruit Flies (COS5030)

The stable fly (*Stomoxys calcitrans* Walker) affects Costa Rican livestock industry causing animal stress with the ultimate loss of productivity and decrease in milk production. In recent years proliferation of the stable fly in residues from pineapple farms and other crops has become a serious problem. A technical cooperation project was implemented to develop capacities at the National Institute of Agricultural Technology Research (INTA) for biological control of the pest through the parasitoid *Spalangia endius* L. The most important outputs achieved were: (1) Key knowledge on the pest behaviour and habits in the field, (2) The process to mass-rear the parasitoid wasp (*S. endius*) in irradiated larvae of its real host as well as in larvae of the Mediterranean fruit fly, and (3) A rearing facility to produce *Spalangia parasitoids* was established. With these actions, Costa Rica has now viable tools to apply a biological control strategy for the stable fly in a sustainable manner using a nuclear component.

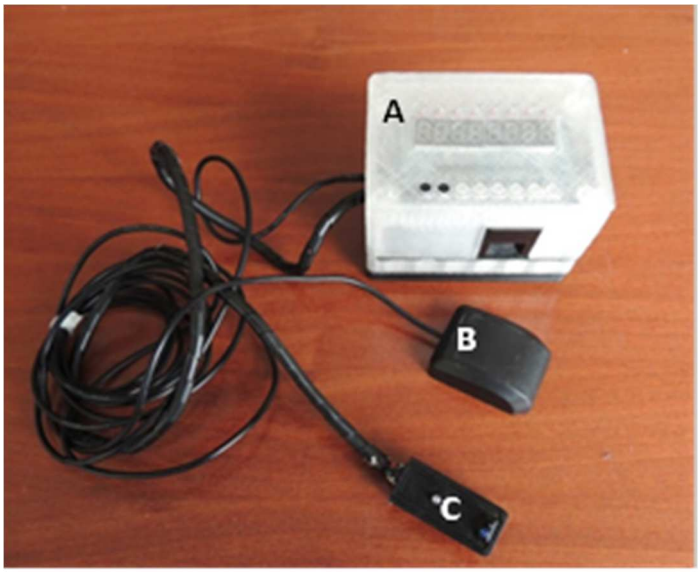
Enhancing Livestock and Crop Production through Consolidated and Sustainable Control of Tsetse and Trypanosomosis to Contribute to Food Security (ETH5019)

An information system covering all the activities conducted at the tsetse insectary in Kality, Ethiopia has been developed and implemented. The system relies on a set of databases for each of the different sections of the project, including mass-rearing of the colonies, blood processing, environmental conditions in the rearing rooms, male handling and release, and quality control procedures.



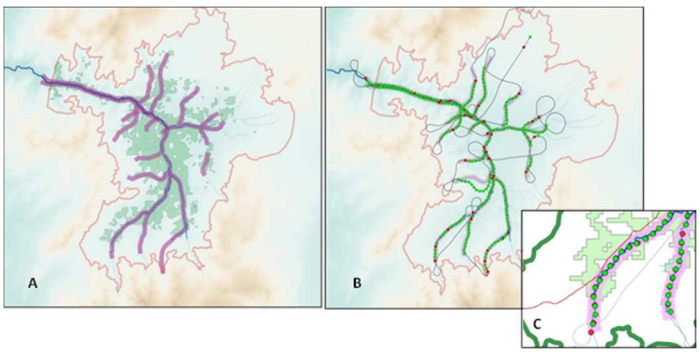
Interfaces of some of the databases developed in Kality, Ethiopia.

The databases have been tailored to the specific working procedures of the insectary and therefore are suitable for the technical and managerial staff. When fed regularly with daily information by the project technicians, the system, stored in the central server, provides comprehensive and standardized analysis of the project status, enabling the managerial staff to apply an adaptive management based on informed decisions. Shortcomings are detected earlier and corrective actions can be promptly applied.



Electronic release counter. A: Display of main unit. B: GPS antenna. C: Optic sensor to be fixed at the end of the bottom chute of the air plane.

The releases of sterile males have also been enhanced by the development of a GPS-based electronic counter that allows the drop of carton boxes containing the sterile males at precise intervals. In addition, a distribution prediction model has been produced using the specialized Maxent software which has led to improvements in the release sections and to the intensification of the monitoring in the most suitable habitat. As a result, the apparent density of wild flies in the Deme Valley has decreased to extremely low levels and the over-flooding ratio has experienced a sustained increase, reaching values above 1:40 in the most recent surveys.



A: Predicted distribution developed with Maxent (green area) and improved released sections (purple lines). B: Map of a specific release. C: Partial map showing actual box drop (green dot) and missed drop (red dot).

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

Project Number	Ongoing CRPs	Scientific Secretary
D4.10.24	Use of Symbiotic Bacteria to Reduce Mass-rearing Costs and Increase Mating Success in Selected Fruit Pests in Support of SIT Application (2012-2017)	Carlos Cáceres
D4.20.15	Enhancing Vector Refractoriness to Trypanosome Infection (2013-2018)	Adly Abd Alla
D4.40.01	Exploring Genetic, Molecular, Mechanical and Behavioural Methods of Sex Separation in Mosquitoes (2013-2018)	Jeremie Gilles 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 Jeremie Gilles
D4.10.26	Improved Field Performance of Sterile Male Lepidoptera to Ensure Success in SIT Programmes (2016-2021)	Marc Vreysen
	New CRP	
D4.10.27	Integration of the SIT with Biocontrol for Greenhouse Insect Pest Management (2017-2022)	Andrew Parker

Second RCM of the CRP on *Dormancy Management to Enable Mass-rearing and Increase Efficacy of Sterile Insects and Natural Enemies*. 15–22 April 2016, Stellenbosch, South Africa

The Research Coordination Meeting (RCM) was successfully held with the participation of 23 research agreement and contract holders, and observers from 13 countries. Good progress is being made in understanding dormancy responses and temperature biology of a number of insect species. Also very encouraging results are being obtained in manipulating the seasonal biology of some pests to facilitate their mass-rearing as a result of understanding the three phases of diapause (induction, maintenance and termination) plus any related quiescence responses, all of which can be influenced by temperature.

The long-term goals on diapause manipulation are to:

(1) eliminate the obligate diapause of target species to facilitate mass-rearing programmes to support the development of new biological-control programmes;

(2) induce diapause to stockpile produced biological control agents, and then terminate diapause on demand to synchronize availability of agents with need in the field; and

(3) provide insights that would improve modelling the field phenology of pests and beneficial organisms.

But understanding thermal biology can also contribute to improve mass-rearing and storage of insects by:

(1) treatment conditions and manipulations that improve insect cold tolerance;

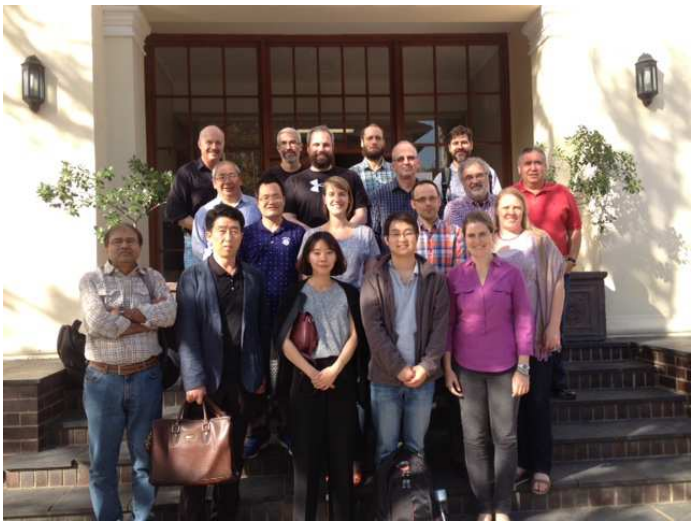
(2) facilitation and enhancement of survival and performance under long-term cold storage, including cryopreservation;

(3) enhancement of the thermal performance of insects destined for release; and

(4) manipulation of thermal biology to cause ‘ecological suicide’ in a pest control context.

The RCM was held in conjunction with a workshop on "Dormancy Management to Enable Insect Mass-rearing". The workshop was focused on methods for studying insect dormancy and cold hardiness at the Applied Physiological Ecology Laboratory in the Department of Entomology and Conservation Biology at Stellenbosch University headed by John Terblanche. This workshop included lecture sections by the four instructors, Daniel Hahn, Brent Sinclair, John Terblanche, and Leigh Boardman, and hands-on activities that included training in insect respirometry with a focus on dormancy phenotyping, use of thermal monitoring equipment including thermocouples, thermistors, and infrared cameras for thermal biology by imaging.

Additional activities included learning methods for estimating supercooling points and proper application of cooling baths for estimating lethal time and temperature relationships. Each day of the workshop also included a structured session where instructors and participants worked together on experimental design and methods for inference to facilitate the success of participants in completing their CRP goals.



Participants of the Second RCM of the CRP on Dormancy Management to Enable Mass-rearing and Increase Efficacy of Sterile Insects and Natural Enemies (Stellenbosch, South Africa).

Third RCM of the CRP on *Enhancing Vector Refractoriness to Trypanosome Infect* 6 – 10 June 2017, Lyon, France

This third meeting was hosted by the 'Institute National des Sciences Appliquées de Lyon" (INSA-Lyon, France), with the arrangement made by Abdelaziz Heddi the director of the research unit 'Biologie Fonctionelle Insectes et Interactions' (BF2I). Nineteen participants from sixteen countries attended the meeting together with one consultant from Kenya and three observers (see group photo below). The first two days of the meeting were devoted to presentations by agreement and contract holders and a consultant, whereas during the reminder of the meeting the participants discussed in two working groups follow-up research on tsetse on tsetse symbionts, parasites and pathogens.

Participants discussed and emphasised the need for detailed studies on the impact of irradiation treatments on the host and associated symbionts and parasites through the analysis of their impact: (i) on the vectorial capacity of tsetse fly for the trypanosome infection, (ii) on the cuticular hydrocarbons, (iii) on the symbiont bacteria using FISH Fluorescence In Situ Hybridization. Working groups were formed to conduct these research activities.

During the meeting the publishing of a special issue on the research activities and results achieved during this coordinated research project was discussed. It was agreed to publish in the *Frontiers in Microbiology* journal and participants were encouraged to submit their scientific papers to this journal once an agreement for this special issue has reached.

Participants of the Third RCM of the CRP on Enhancing Vector Refractoriness to Trypanosome Infection (Lyon, France).

In addition the group recommended standardizing the detection tools (PCR conditions) and sharing the standardized protocols among the participants using the webpage http://www.tsetse-symbiosis.net/ established by George Tsiamis for this purpose. The group discussed also several ideas for a possible new CRP focussed on the improving colony management for SIT application.

Prior to the RCM, two workshops on:

- "The Characterization of Symbionts of Tsetse Flies via Bioinformatic Approaches" and on
- "Microbiota Detection from Natural Tsetse Species by the Fluorescence Microscopy"

were conducted at the same institute. They were attended by ten participants and four lecturers from twelve countries. Several oral presentations were given that provided an overview on general principles of bioinformatics tools and fluorescence microscopy.

Several practical sessions were organized on hands on practice of bioinformatics tools for analysing sequence data with both windows and Linux software, i.e. Quantitative Insights Into Microbial Ecology (QIIME) in analysing the gut microbios and bacterial identification using 16SrDNA sequence analysis and blast tools. Also the preparation of samples for fluorescence in situ hybridization (FISH) and image analysis was conducted.

Consultants' Group Meeting on "Integration of the SIT with Biocontrol for Greenhouse and Other Confined Pest Insects", 14–18 March 2016, Vienna, Austria

Five consultants met in Vienna from 14-18 March 2016 to advise the Joint FAO/IAEA Division on the potential and requirement for the development of the sterile insect technique (SIT) for the control of pests in confined environments, including greenhouses, storage houses and bee hives. The consultants were drawn from research, regulatory and the greenhouse biocontrol industry to give a wide perspective on the issue.

The major pests of greenhouse culture were analysed for their potential to disrupt the biocontrol environment when pesticides have to be used to control outbreaks, leading to mortality of pollinators and biocontrol agents. The consultants considered the economic importance (current distribution, host range, existing biocontrol options), whether the pest was a disease vector, the mode of reproduction (sexual/asexual) and the current information on mass-rearing and SIT for each species or group. Many of the pests are successfully controlled by current biocontrol, but the spread of pests into new regions was identified as a primary risk, as in many circumstances the associated biocontrol agents are not present in the new range and could not be imported from the origin of the pest. Identifying acceptable control agents in the new area may take a considerable time and, in the meantime, losses to the new pest could be considerable.

The consultants identified three groups of greenhouse pest as potential targets for SIT:

Drosophila suzukii in closed and semi-closed systems

Drosophila suzukii has spread in recent years rapidly around the world and is now causing considerable losses in many berry crops. Current control relies heavily on pesticide application late in fruit development, with the associated risks of residues remaining at the time of consumption. The high reproductive rate of this species and constant re-invasion from outside as often the berry crops are grown in semi-closed systems may make SIT difficult, but the economic losses caused and lack of alternative non-chemical control may make it worthwhile investigating.

Spodoptera and *Helicoverpa*

These species are generally managed using egg parasitoids, but the efficacy is often low as the period for egg parasitization is short. SIT for area wide pest management of these species has been developed in the past but these were never operational. The reasons why are not clear and need to be looked into as there are opportunities for SIT against these pests in greenhouses, particularly in conjunction with egg parasitoids as the sterile eggs form a useful resource to promote the parasitoids.

Bell pepper greenhouse production using high technology.

Tuta absoluta and *Neolucinoides elegantalis*

Tuta absoluta is native to South America but has invaded and is spreading in Europe, North Africa and the Middle East and causing up to 100% losses in Solanaceous crops, increasing tomato prices, bans on the trade of tomato including seedlings, an increase in synthetic insecticide applications, disruption of integrated management programmes of other tomato pests and an increase in the cost of crop protection. It can be controlled by mirid bugs in Europe, but the mirids could not be transferred to other regions outside their native ranges if the pests spreads to North America or Asia. *Neolucinoides elegantalis* is another pest of Solanaceous crop from South and Central America. It is absent from other regions, but is considered a threat due to the importance of tomato and other Solanaceous fruit crops in many other regions. SIT could, therefore reduce pesticide usage in the current distribution of both these pests and also provide a means to control further spread.

The consultants also noted that many stored product pests are routinely reared in considerable numbers for research and as food for parasitoids, but that SIT is not applied to control them in storage. They suggested that it would be worthwhile investigating why SIT is not used for this group of pests. Another potential target would be the small hive beetle, *Aethina tumida* but further information from specialists in apiculture is needed. It was considered, however, that SIT would not be useful against livestock pests as they are all either disease carriers or nuisances themselves.

The consultants concluded that there is potential for the SIT to be used in greenhouse environments to complement biocontrol in some situations and recommended that a Co-ordinated Research Projects be proposed in this area.

Developments at the Insect Pest Control Laboratory (IPCL)

INSECT GENETICS AND MOLECULAR BIOLOGY

Adaptation of natural insect populations to laboratory conditions

As discussed in previous newsletters, adaptation of natural populations of SIT targeted insect species to laboratory and/or mass-rearing conditions can influence a variety of parameters crucial for their rearing efficiency and mating competitiveness. These changes can be attributed to both genetic structure and symbiotic communities' changes. At the IPCL, we have initiated the analysis of the structure of the gut symbiotic community of various laboratory strains of different Tephritidae species, which differ also in the degree of adaptation and rearing practices. Our results demonstrate the presence of few dominant *Enterobacteriaceae* genera. The sampling protocols established, focusing on different developmental stages and ages clearly show that symbiotic communities, although with rather restricted diversity, are quite dynamic. The origin of the host and the differences of rearing, both in feeding and oviposition substrates, clearly play a role in the current structure of these symbiotic communities.

One of the main problems of studies in the laboratory is that a direct comparison with the wild populations can rarely be performed. To address changes occurring in the gut symbiotic communities, wild *Ceratitis capitata* populations from Greece were recently introduced in the IPCL and maintained on two types of larval diet for more than 12 generations. Analysis of their gut symbiotic communities in different generations clearly demonstrate that a) medfly populations entering the laboratory have quite diverse symbiotic communities and, b) different parameters, such as the degree of adaptation (generations in the lab), rearing substrates, age and developmental stage influence the structure of the gut symbiotic community.

Progress in the cytogenetics of targeted Tephritidae species and species complexes

The availability of polytene chromosomes in Diptera has greatly facilitated genetic studies for many decades. In Tephritidae, cytogenetics has supported the construction and characterization of genetic sexing stains. In addition, comparative cytogenetics has provided insight in the resolution of cryptic species, which is of vital importance prior to the development and application of SIT strategies for the control of insect pests. In this respect, and following previous studies in different *Bactrocera* and *Ceratitis* species, in collaboration with the group of Emeritus Professor Antigone Zacharopoulou (Department of Biology, University of Patras, Greece), the cytogenetic analysis of *Bactrocera tau* and *B. correcta* is ongoing. *B. tau* is of special interest, as it is believed to be a complex of species and also belongs to the *Zeugodacus* subgenus, which is currently under discussion for its possible elevation to genus level. Preliminary analysis of mitotic (Figure 1) and polytene chromosomes (Figure 2) of a colony derived from China shows that *B. tau* shares many common characteristics with the only other analyzed *Zeugodacus* species (*Bactrocera (Z.) cucurbitae*). These characteristics seem to differentiate *Zeugodacus* species from the other *Bactrocera* species.

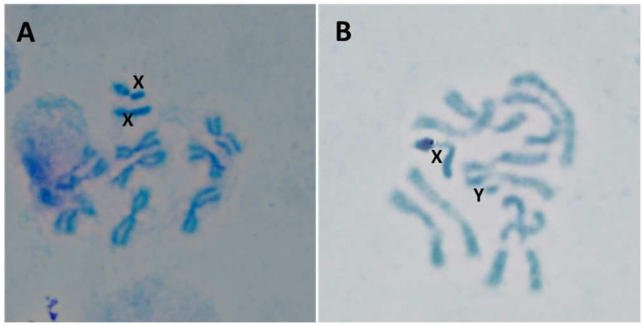


Figure 1: The mitotic karyotype of female (A) and male (B) 3rd instar larvae derived from B. tau *from China.*

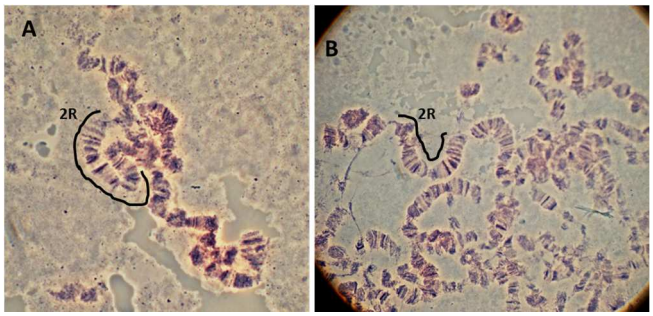


Figure 2: Polytene chromosomes derived from 3rd instar larvae from the B. tau *from China. A characteristic region (2R) is indicated.*

Bactrocera correcta is another species of economic importance with interest for the development of SIT applications. Cytogenetics could support such applications and the development of polytene chromosome maps has started (Figure 3).

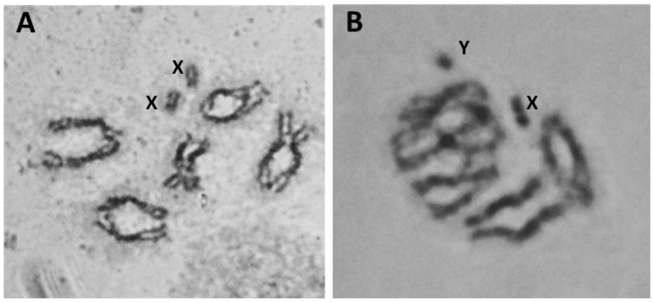


Figure 3: The mitotic karyotype of female (A) and male (B) 3rd instar larvae derived from a B. correcta *colony.*

PLANT PESTS

Impact of chemotherapy, hormonal treatment and diet on post-copulatory behaviour of *Bactrocera dorsalis* and *Bactrocera cucurbitae*

Post-teneral treatment of fruit fly males before release has proven useful in improving their sexual performance. Specifically, post-teneral treatments including addition of protein to the adult food, plant essential oils, topical applications of juvenile hormone mimics (e.g. methoprene), feeding or exposure to methyl eugenol (ME) can boost male sexual competitiveness. It is known that the combined effect of ME and protein increases male *Bactrocera dorsalis* mating performance. However, it is less understood how post-teneral treatments such as ME can impact a males' ability to transfer sperm and inhibit females from remating. The efficiency of the SIT could increase if wild females are prevented from remating with a wild male after mating with a sterile male. Mating inhibition is achieved through the ejaculate. Proteins produced in the male accessory glands and transferred to females during mating have important repercussions on female post-mating behaviour such as host location, oviposition and can act as anti-aphrodisiacs.

Martha Reyes-Hernández of Mexico was hosted at the IPCL to assess the effect of ME on the post-copulatory behaviour and ejaculate transfer of *B. dorsalis*. Ms Reyes evaluated remating of *B. dorsalis* females which had previously been injected with accessory glands from males fed protein and ME, or sugar and ME, only protein or only sugar. In addition, she evaluated the effect of these post-teneral treatments on the size of the male accessory glands and the number of sperm transferred to females during copulation. Preliminary results show that injection of accessory gland fluid from treated males to virgin females did not prevent copulation, while females that naturally mated with treated males where effectively inhibited from remating. Analyses of the number of sperm transferred and the size of the accessory glands is ongoing.

Comparison of the mass-rearing profile and quality characteristics of genetic sexing strains of the Mediterranean fruit fly

Colleagues of the Department of Developmental Biology, Georg-August-University in Göttingen, Germany have developed a transgenic sexing system for *C. capitata* based on female-specific embryonic lethality. The transgenic approach consists of the expression of female lethality at the embryo stage when female adults of this strain are deprived of tetracycline, therefore producing male-only progeny. Females that are provided with the tetracycline produce equal proportions of males and females. Due to the fact that the sexing system kills female flies at the early development stage, it seems to hold promise, although not likely for the Mediterranean fruit fly as for this species a very good non-transgenic sexing system is available that is based on the sensitivity of the female flies to higher temperatures. This strain is currently being used in all operational programmes against Mediterranean fruit fly that have an SIT component. However, there have been requests to evaluate and compare the systems.

The IPCL hosted a visiting scientist, Salvador Meza from Moscafrut/Moscamed, Mexico who compared at the semi mass-rearing level, the quality profile of the VIENNA-8 temperature sensitive lethal strain where the females carry a homozygous viable inversion D53, the VIENNA-8 temperature sensitive lethal strain but without the inversion D53, and the transgenic strain that expresses Female Specific Embryo Lethality (FSEL) "FSEL-32". Preliminary results showed that the FSEL-32 had a similar or better production and quality profile as compared with the VIENNA-8 sexing strains, regardless whether they carried the inversion or not. Although this transgenic system will most likely not be used for Mediterranean fruit fly, this evaluation shows that similar transgenic sexing system approaches could be used for other insect species where sexing systems are desirable or mandatory for the utilization of the SIT.

X rays to induce egg sterility in different fruit flies species

Irradiation studies were carried out with the fruit fly species *Bactrocera tryoni*, *Anastrepha fraterculus* and *Anastrepha ludens* and adult males were exposed to X rays in a RadSource RS-2400 irradiator (Rad Source Technologies) or to gamma rays in a ^{60}Co gamma Cell 220. The treated males were allowed to mate with non-irradiated females. Untreated female *B. tryoni* that had mated with males treated with X rays or gamma rays showed similar levels of sterility for the same dose. However, untreated *A. fraterculus* females mated with gamma irradiated males had a slightly higher egg hatch (0.67%) as compared with females who had mated with males exposed to X rays (0.25%). Females *A. ludens* that had mated with males irradiated by gamma rays at 80 and 60 Gy, showed similar egg hatch (0.47 and 0.48% respectively). Likewise, females mated with males irradiated by X rays at 80 and 60 Gy showed 0.08 and 0.24% egg hatch respectively. However, females mated with males irradiated by gamma and X rays at 40 Gy showed much higher egg hatch (0.88 and 2% respectively).

Drosophila suzukii

In collaboration with the Institute de Recherche et de Développement en Agroenvironnement (IRDA) in Québec, Canada, research is underway to develop rearing methods for the spotted wing Drosophila (*Drosophila suzukii*) and to establish radiation dose response curves and irradiation protocols. This research is part of an assessment whether the SIT could potentially be integrated with other control tactics in greenhouses against this invasive pest.

Fabiana Sassu from Italy is being recruited as a PhD student at the University of Natural Resources and Life Sciences (BOKU), Vienna, under the project "Suzukill", i.e. a multidisciplinary and international research project funded by the French Research Agency (ANR) and the Austrian Science Fund (FWF). She will be based at the IPCL to conduct pilot experiments on the development of the SIT against *D. suzukii* together with visiting scientists Gustavo Taret (Argentina) and Silvana Caravantes (Guatemala). Also Ms Katerina Nikolouli from Greece was recruited as a PhD student to work under the same project on developing Incompatible Insect Technique (IIT) for *D. suzukii* and test it in combination with the SIT.

Anastrepha fraterculus complex

The IPCL hosted three visiting scientists from Argentina (María Laura Juárez, Francisco Devescovi and Diego Segura) from July to November 2015. They further explored the role of the male sex pheromone of different morphotypes of *Anastrepha fraterculus*. Experiments were carried out in field cages to 1) determine if females show different attraction to the pheromones of males from their own morphotype or other morphotype using artificial leks; 2) determine the hetero-specific mate recognition system by long and short distance attraction between males and females from the different morphotypes/populations; 3) describe the temporal pattern of calling and mating behaviour for each morphotype/population. In addition, volatiles were collected from calling males of the different populations for further bioassays.

Female Anastrepha fraterculus *used in the experiments (photo by Salvador Mesa).*

The three experiments involved populations from Castelar (Argentina), Vacaria and Piracicaba (Brazil) all of them belonging to the Brazilian-1 morphotype and one population from Mexico which belonged to the Mexican morphotype. Volatiles collections involved these populations and one from Peru. Data analysis of all experiments is in progress.

Phytosanitary treatment research

Recent research under the USDA/IAEA collaborative agreement, "Development of phytosanitary treatments for exotic tephritid fruit flies" continues with cold treatments. The 3rd instar has been identified as the most cold-tolerant stage for *Anastrepha grandis* and that research has been terminated and is being prepared for publication. The egg and other larval stages were very similar in cold tolerance. In general the 3rd instar has most often been found to be the most cold-tolerant stage for tephritids.

The research comparing cold tolerance of populations of *C. capitata* from Argentina, Australia, and Spain is coming to a conclusion and again the 3rd instar seems to be the most cold-tolerant for all three populations. The three populations do not seem to differ significantly in cold tolerance.

Research completed earlier on cold tolerance among *Bactrocera carambolae, B. correcta, B. cucurbitae, B. tryoni, B. zonata,* and 4 populations of *B. dorsalis* from different countries has been analysed and is being prepared for publication. There were no significant differences in cold tolerance among the 4 populations of *B. dorsalis.*

Bactrocera cucurbitae was more cold tolerant than the other species studied, while all of the other species required approximately the same time (at 2.0 °C) to control. *Bactrocera cucurbitae* is in a different subgenus (*Zeugodacus*) than the other species, which are all in the same subgenus (*Bactrocera*). This research points to the possibility of more broadly applicable cold treatments by taxonomic group that would save member countries resources and time in the development of treatments and facilitate trade.

LIVESTOCK PESTS

Impact of GpSGHV infection on productivity of *Glossina fuscipes fuscipes*

Many tsetse species are infected with a salivary gland hypertrophy virus (SGHV). The virus infection in most species is asymptomatic but in *Glossina pallidipes* the virus infection can be converted to a symptomatic infection which causes salivary gland hypertrophy symptoms that are associated with reduced fly fecundity and colony collapse. The symptomatic infection of SGHV in other tsetse species seems to be scarce and requires further investigation.

Although virus prevalence is low in wild tsetse flies, we injected adults of other tsetse species with the virus from *G. pallidipes* (GpSGHV) and the results indicate that the virus can successfully replicate in all tested species except *G. brevipalpis*.

The *Glossina fuscipes fuscipes* colony maintained at the National Institute for Control and Eradication of Tsetse and Trypanosomosis (NICETT) facility, Ethiopia, suffered recently from poor performance and declined in colony size. In order to explain the poor performance of this colony, we

assessed the impact of the GpSGHV on the productivity of *G. f. fuscipes* challenged with the virus by injection. Non-injected flies and flies injected with PBS were used as control. Challenged flies were maintained for 120 days and productivity and mortality were recorded. The results showed that the injection process significantly reduced fly productivity. Therefore the virus might be one of the reasons of the decline of the colony in the NICETT facility and the virus management procedures developed will have also to be applied to this colony.

HUMAN DISEASE VECTORS

ROMEO: A New Concept for Aerial Release of Sterile Mosquitoes

ROMEO takes flight during the UAE's Drones for Good competition in Dubai (above), and (below) the team ROMEO at the UAE's Drones for Good competition (standing, second from left is Ms Nicole Culbert, of the IPCL).

ROMEO (*Remotely Operated Mosquito Emission Operation*) is a collaborative project between the Human Disease Vectors (HDV) group of the IPCL and the German drone manufacturer Height Tech. Together an unmanned aerial release vehicle (UAV) was designed that is capable of transporting and releasing sterile male mosquitoes by air (see Figure above). Saving lives through controlling the populations of disease-carrying mosquitoes is the mission of ROMEO, an innovative concept using a customised drone. ROMEO's compact size and specially-developed components offer a new alternative to conventional release approaches. In contrast to conventional methods, ROMEO's specialized GPS software and tailor-made release mechanisms allow it to be used remotely to blanket a village or town with sterile males or to carefully home in on a site for targeted releases. With a substantial carrying capacity and a flight time of up to 30 minutes, the drone can cover about a square kilometre releasing about half a million sterile mosquitoes. This offers a quick and cheap release option, and allows for optimal distribution, particularly in difficult to access terrains.

The ROMEO concept, together with another IAEA-supported project, was submitted to the 2016 United Arab Emirates (UAE) *Drones for Good Award* competition. From over 1,000 entries submitted from 165 countries, both IAEA-supported projects were selected as two of the 10 semi-finalists. The ROMEO team was invited to travel to Dubai to give a live presentation and demonstration to a panel of international judges and the general public and placed 4th overall. Our collaboration with Height Tech continues and testing of the release cassettes is already underway. In the coming months, we intend to carry out more extensive tests with the drone itself with the aim of having ROMEO ready to deploy sterile males in the not too distant future.

Optimizing Fluorescent Marking Methods for Sterile Male *Anopheles arabiensis* Mosquitoes

Prior to releasing sterile male mosquitoes during a ground or aerial release, they must first be marked in order to make them easily identifiable upon recapture. There are several methods in which to make adult sterile male mosquitoes distinguishable from their wild counterparts. For mass release purposes, when potentially millions of males are being released on a weekly basis, it is necessary to identify a low-cost, low-effort and long-lasting method of marking which imposes little or no effect upon the survival or behaviour of the insect itself.

One common method of marking insects is to use fluorescent dust. This technique allows insects to be marked in a range of visible colours, is low-cost and is relatively easy to apply. We have been working to standardise a method for mass-marking sterile male mosquitoes using this technique whilst investigating any subsequent effect upon survival.

The optimal quantity of dust necessary to mark a known number of males has been assessed by using various dust quantities and comparing subsequent survival (see Figure). The persistence of the mark has also been evaluated, with

dust still present after several weeks. Chilling marked males did not affect the persistence of the dust and there was no transfer of dust between marked and unmarked males or females. Different colours of fluorescent dust were investigated with no difference in survival noted between colours. The most efficient method of applying the dust is still being investigated with competitive studies planned for the coming months to ensure marked males are able to compete with unmarked males for females under semi-field conditions.

Fluorescence under UV light after a sample of 100 males Anopheles arabiensis *were marked with 0.005g of fluorescent dust.*

Effect of cage size, blood meal source and adult *Anopheles arabiensis* density on productivity

Anopheles arabiensis is one of the major malaria vectors that put millions of people in endemic countries at risk. Mass-rearing of this mosquito is crucial for strategies that integrate the sterile insect technique to suppress vector populations. We addressed the question of whether egg production would be affected by the size of the adult holding cages, the source of the blood meal and the total number of pupae that could be loaded into the cages and finally, the impact of daily pupae addition on egg production.

Two mass-production cages of different size, two blood meal sources (bovine and pig) and two pupal densities (15,000 and 20,000 pupae) were tested with respect to eggs produced/cage or per female. Adult mosquitoes were placed in the cages where they had access to 5% sugar solution and were offered blood meals using a Hemotek membrane feeding system. Eggs were collected from daily to twice a week.

Neither cage size nor blood meal source affected egg production per cage and per female. However, under high-density rearing conditions (20,000 pupae) the number of eggs produced/cage and per female decreased significantly. These results demonstrated that under the test conditions 15,000 is near to the optimal number of pupae to be loaded into the *Anopheles* mass-production cages that allows the production of 120,000 eggs/cage/day. Feeding females with bovine or pig blood in big or small aforementioned cages did not affect egg production.

Effect of mass-rearing procedures on sexual competitiveness of sterile male *Anopheles arabiensis* in semi-field cages

A successful SIT programme requires the mass-production of good quality sterile insects for release into a target area. This study aimed to assess the effect of mass-rearing processes on sterile male sexual competitiveness in semi-field cages, as compared with males reared using conventional laboratory-rearing methods (see Figure below). Mosquitoes were reared using the rack system (mass-rearing scale) and in small trays (laboratory-rearing system) before being irradiated with 75 Gy in a GammaCell 220.

Mass-rearing system (rack with larval trays, left) and conventional laboratory rearing system (small trays, right).

Mass-rearing of *Anopheles arabiensis* immature stages using the rack system, did not affect sterile male life history traits or their competitiveness as measured in semi-field cages.

Dose response curve for *Aedes* spp. from different geographic locations

A dose response curve of *Aedes aegypti* from Brazil was established using a ^{60}Co GammaCell 220. Male and female pupae were irradiated with different doses to assess their fertility and fecundity when mated with their non-irradiated counterparts. Standardized gamma irradiation procedures were also used to assess the radiation sensitivity of *Ae. aegypti* and *Ae. albopictus* populations from different geographic locations. No difference in radiation sensitivity between males from different geographic locations could be detected. The effect of water during irradiation of *Ae. aegypti* pupae from Brazil and *Ae. albopictus* from Italy was also assessed. This information is being used to develop guidelines for pupae irradiation for our Member States.

Reports

Participants of the Tephritid Workers of Europe, Africa and the Middle East (TEAM) meeting (Stellenbosch, South Africa).

The Third International Symposium of TEAM (Tephritid Workers of Europe, Africa and the Middle East) took place in Stellenbosch, South Africa from 11-14 April 2016. TEAM is a regional network of researchers dealing with different aspects of tephritid fruit fly (Diptera: Tephritidae) work. These symposia are organized every four years and this was the first that took place on the African continent (previous two were in Spain and Greece).

In total 144 delegates from 34 countries registered and participated, including 110 delegates from 20 African countries, as well as 30 student delegates. The high number of African delegates was a novel event and demonstrates the awareness and importance given by several national governments to research on this group of agricultural pests. The relatively high number of students (the majority of which were presenting their research results) also shows that a new generation of fruit fly researchers is being groomed for the future. The attendance of these two groups was also only possible because of the intensive sponsorship by different players from both the public and private sector, through which travel and accommodation could be paid for a large number of them and the total price for registration could be kept low and at an affordable level to a larger community.

The programme of the symposium consisted of plenary speakers, and talks grouped in nine different sessions, over a period of three days, covering all major research aspects. Poster presentations were displayed throughout the whole duration of these three days in an adjacent room. A special afternoon was specifically earmarked for poster viewing (with the request of authors being present near their posters in order to reply to questions), but could be consulted throughout the whole duration of the symposium. In total, 49 oral presentations (including three plenary talks) were given during the three days, and 61 posters were on display. The complete book of abstracts can be downloaded at: http://teamfly2016.co.za/abstracts/.

The fourth day provided the optional possibility to partake in one of two choices of excursions in the Cape region. Both excursions included visits to horticultural farms (vineyards, citrus growers), post-harvest packaging facilities and demonstration of control measures (including SIT).

Members of the local organizing committee will edit the proceedings of the symposium, which will be published in a separate issue of a peer review journal (Journal of Applied Entomology).

IAEA Board of Governors Approves 2.3 Million Euro Project to Help Combat Zika

At the request of Member States in Latin America and the Caribbean, the IAEA Board of Governors decided to approve a new 2.3 million Euro initiative that will help countries in the region to fight the Zika virus with a nuclear technique that has been used to suppress various insect pests.

"The project will strengthen national and regional mechanisms for control of the *Aedes* mosquito population," said IAEA Director General Yukiya Amano. The initiative complements immediate IAEA support provided to countries in the region in the wake of the Zika outbreak to help rapid detection of the virus.

The IAEA will transfer the sterile insect technique (SIT), a form of pest control that uses ionizing radiation to sterilize male insects mass-produced in special rearing facilities. The IAEA, in partnership with the Food and Agriculture Organization of the United Nations (FAO), spearheads global research in the development and application of the SIT.

Under the new regional project, sterilized male mosquitoes will be released over pilot areas, where they will mate with wild females, which will not produce any offspring. This will contribute to reduce mosquito populations and disease transmission.

The *Aedes* mosquito is the carrier of the Zika, Chikungunya and Dengue viruses. So far, Zika has spread to 31 countries and territories in the Americas. The World Health Organization (WHO) has declared it a public health emergency of international concern, predicting that Zika could infect three to four million people in the Americas this year. The virus may be associated to neurological disorders and it has no immediate cure.

IAEA Deputy Director General and Head of the Department of Nuclear Sciences and Applications Aldo Malavasi (centre) at the meeting in Brasilia organized by the Brazilian Ministry of Health.

The IAEA will train local staff on integrated vector management, including SIT, and help strengthen knowledge and information exchange between countries, building on IAEA projects already running in the region, said Luis Longoria, Director for Latin America and the Caribbean. The project builds on the recommendations of an international experts' meeting that took place in Brazil to discuss the use of the technique as part of a comprehensive approach to controlling mosquito populations.

The four-year project, is scheduled to start in April this year. It will be implemented in coordination with the WHO, the Pan American Health Organization (PAHO) and national health authorities, and will integrate all relevant insect management approaches.

Containing and Eradicating the Mediterranean Fruit Fly from Dominican Republic through Integrating the Sterile Insect Technique (SIT)

A large outbreak of the Mediterranean fruit fly (medfly), one of the worst horticultural pests, was detected in early 2015 in the Province of Altagracia located in the eastern part of the Dominican Republic. Given the magnitude of the event, a quarantine response from trading partners resulted in the closure of the markets for exports of some fruits and vegetables including peppers, avocado and citrus. As a result of the outbreak, an estimated US $40 million were lost in export revenue in just 10 months.

Mediterranean fruit fly containment and eradication actions in Dominican Republic.

In support of the Dominican Republic, a multi institutional coordinated emergency response was organized aimed at containing the expanding pest outbreak. This was followed by a major containment and eradication campaign that is being supported by IAEA Technical Cooperation Project RLA5070 and the FAO/IAEA Division, as well as by USDA, OIRSA and IICA, including the weekly release of millions of sterile medflies supplied by the Moscamed Programme in Guatemala. Moreover, the IAEA was requested to support the containment and eradication effort through integrating a Technical Advisory Committee (TAC) of SIT experts which have been reviewing progress and providing technical advice.

The TAC met from 25 to 29 January 2016 in Alta Gracia Province and Santo Domingo, providing technically valuable recommendations, including the urgent need for implementing area-wide aerial release of sterile males. If this coordinated effort had not been implemented, the economic losses would have been of a much greater order of magnitude and the risk for the whole region would have been more substantial due to the transboundary nature of the pest with high dispersal capacity, without recognition of borders as well as the increasing movement of people and goods in the region. The government efforts through the Moscamed-Dominican Republic programme has resulted in the lifting by USDA of the export ban in 23 of 30 provinces within only ten months.

Technical Advisory Committee members of the campaign to contain and eradicate the Mediterranean fruit fly from Dominican Republic.

So far the Government of the Dominican Republic has invested an estimated US $1.5 million dollars in infrastructure and operation of the containment and eradication programme. Intensive eradication actions integrating area-wide SIT will continue for several more months, until the last medfly hotspots left in Punta Cana, at the eastern most part of the country, are eradicated.

Containing the spread of the infestation in Dominican Republic has prevented large economic losses throughout the Caribbean, but also mainland countries including Mexico and the USA.

Annual Meeting of the EU Project "Breeding Invertebrates for Next Generation BioControl Training Network" (BINGO), 19–21 January 2016, Valencia, Spain

The second annual scientific meeting of the EU project BINGO took place in IVIA, Valencia, Spain between 19-21 January 2016. BINGO is an EU-funded Innovative Training Network (ITN) in the frame of Marie Sklodowska-Curie Actions, which aims to advance current knowledge in biocontrol practice. In the frame of BINGO, 13 early stage researchers (ESRs) have been recruited as PhD students and will be trained in biocontrol practice, through a variety of scientific and technological platforms in different institutions, universities, research centers and other international organizations (CABI) from eight countries.

On the first day, the BINGO Workshop on "Genetics to improve biocontrol?" took place and included the following scientific presentations: "General introduction to BINGO" (Bart Pannebaker), "Fine tuning behaviour for better biological control" (Louise Vet), "Integrating sterile insect technique and insect symbiosis for the control of insect pests and disease vectors" (Kostas Bourtzis), "Towards safer biological control: How much risk is acceptable?" (Tim Haye), "Performance" (Tom Groot), "Natural genetic variation for life history traits: opportunities and constraints" (Bas Zwaan), "Prospects of biological control of pests in the XXI century: What have we learned from mistakes in the past?" (Alberto Urbaneja) and "The genetic selection of natural enemies, an opportunity to connect both projects (*Orius laevigatus* against pesticides)" (Pablo Bielza).

Participants of the second annual meeting of BINGO (Breeding Invertebrates for Next Generation BioControl Training Network) held at IVIA (Valencia, Spain).

On the second day, all 13 ESRs presented the progress of their research PhD projects. Each presentation was followed by Q&A and an open discussion about how each PhD project could be improved. On the third day, the meeting focused on the overall progress achieved in the frame of the first year of BINGO with an emphasis on the deliverables and milestones as well as on the training programme. The 2nd BINGO summer school (BSS) will take place 4-8 July 2016 in Netherlands and will be organized by Koppert while the 3rd BSS will take place in May 2017 in Vienna in conjunction with the FAO/IAEA International Conference on "Area Wide Management of Insect Pests".

Meeting of the Project "Managing Cold Tolerance and Quality of Mass-produced *Drosophila suzukii* Flies to Facilitate the Application of Biocontrol through Incompatible and Sterile Insect Techniques (SUZUKILL)", 1–2 March 2016, Vienna, Austria

The first meeting of SUZUKILL was organized on 1-2 March 2016 in Vienna and Seibersdorf (Austria) with all partners. The first day at the Vienna International Centre (IAEA Headquarters) was dedicated to scientific presenta-

tions and discussions. The next day, the group visited the IPCL in Seibersdorf.

The project aims to develop alternative approaches to fight *Drosophila suzukii* through innovative biotechnology, such as mass-release of sterile insects. Sterile insects can be generated by irradiation (Sterile Insect Technique, SIT) or by *Wolbachia*-induced cytoplasmic incompatibility (Incompatible Insect Technique, IIT). These innovative methods represent a major breakthrough in pest management and have proved to be successful in controlling various invasive and/or pest species. However, these environmentally-friendly technologies require the development of mass-rearing of competitive insects at an industrial scale, as well as the ability to stockpile, handle and ship insects usually under stressing low temperature.

Participants of the first meeting of SUZUKILL (Vienna, Austria).

The objective of the SUZUKILL project is to develop an alternative avenue for controlling *D. suzukii*, initially in greenhouses, through the release of sterile insects produced via SIT and IIT. Protocols for mass-rearing and sterilization of *D. suzukii*, as well as the adaptation of current quality control procedures for tephritid fruit flies, will be developed and validated in this project. Critical elements of cold tolerance to better control this trait and develop quality management (including assessment of the genetic diversity and mating competiveness) will be identified in order to facilitate the implementation of these environmentally-friendly control methods.

Sixth Annual Chapman Phytosanitary Irradiation Forum, 23-24 March 2016, Orange, CA, USA

The Sixth Annual Chapman Phytosanitary Irradiation Forum was held at Chapman University in Orange, California, USA 23-24 March 2016. The objective of the Forum is to increase understanding and use of irradiation as a phytosanitary treatment to enhance global trade while preventing the transport of invasive pests. It is co-hosted by the Joint FAO/IAEA Programme, the US Department of Agriculture Animal and Plant Health Inspection Service (USDA-APHIS), and Chapman University, Orange CA, USA.

Attended by over 100 participants from many different countries, the discussions included latest developments in the commercial application of phytosanitary irradiation, research, equipment, trade, and regulations. Updates and hands-on-experience in this area were provided by a series of presentations and discussion sessions comprising representatives of plant protection organizations, other regulation agencies, growers, the food industry, irradiation facility operators, and irradiation equipment providers.

Participants of the Sixth Annual Chapman Phytosanitary Irradiation Forum (Orange, California, USA).

The commercial use of phytosanitary irradiation (PI) increases every year, exceeding 25,000 tons of guava, mango, dragon fruit, tomato, sweet potato, manzano pepper, lychee, rambutan, and other products in 2015. Some products, such as guava and rambutan, had not been shipped out of quarantined areas before PI became commercially available.

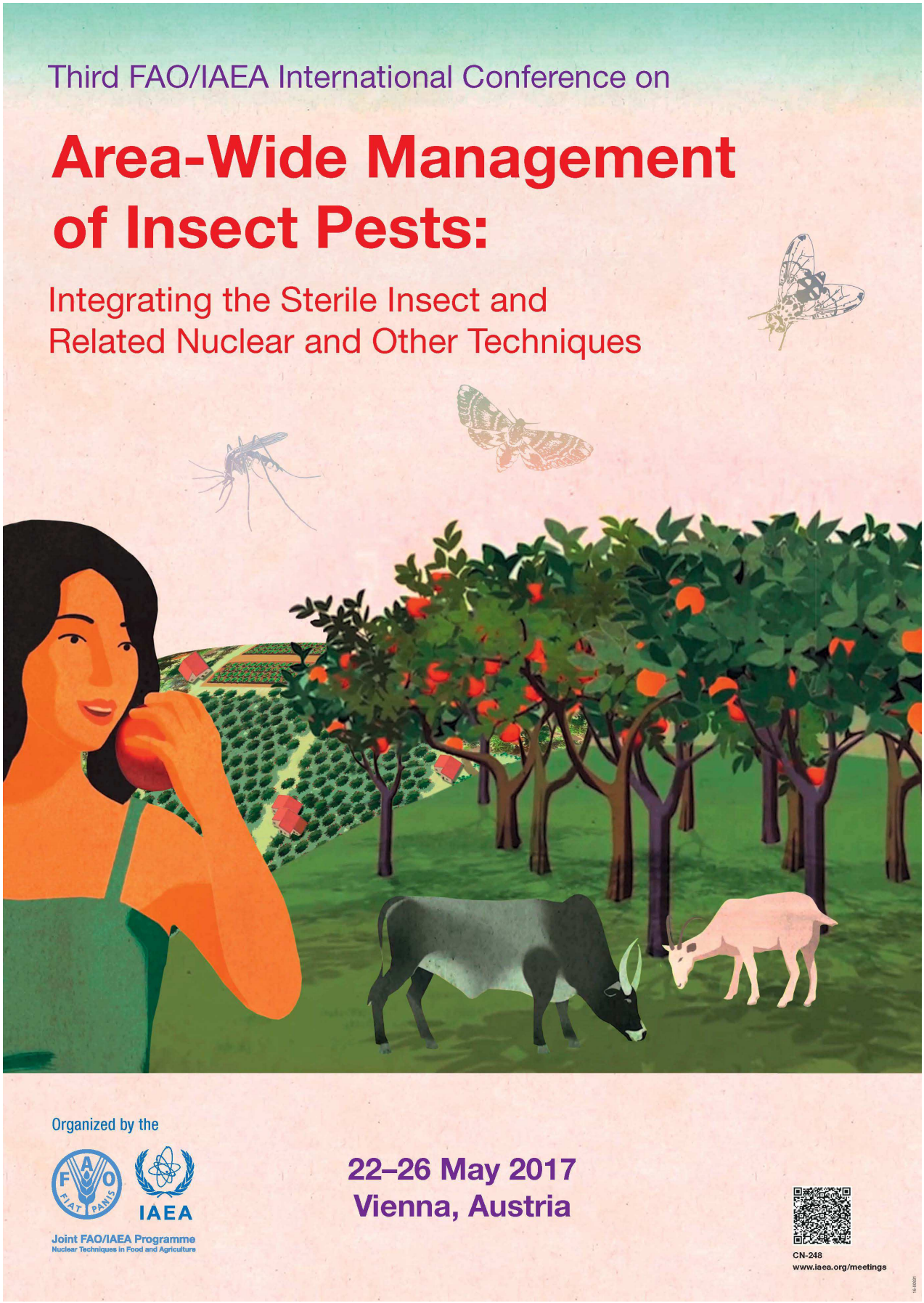
The USA has historically consumed 95% of produce irradiated for phytosanitary purposes, but the process is increasingly accepted in other importing countries, such as Malaysia, Mexico and New Zealand. Consumer acceptance has not proven to be an issue in USA, and this has not gone unnoticed by retail grocery chains and other countries. PI is enabling Australian exports to Indonesia, Malaysia, New Zealand, the USA, and Viet Nam. Some irradiated produce is also traded within Australia to meet phytosanitary requirements between the different states and territories.

There are two phytosanitary irradiation facilities in Mexico that are authorized to treat food for export to the USA. A purpose-built PI facility is responsible for much of this trade; over 12,000 tonnes of irradiated produce from the Benebión facility were exported in 2015.

Irradiation is being used commercially to overcome pest restrictions on trade in fresh fruits and vegetables. Not all countries have approved food irradiation facilities but this should not be a barrier. For example, over the past few years, modest volumes of mangoes from Pakistan have been shipped to the USA and irradiated on arrival according to USA rules.

Research conducted through the FAO/IAEA Coordinated Research Project D62008 on the Development of Generic Irradiation Doses for Quarantine Treatments that terminated in 2014 (Special Issue in *Florida Entomologist* in 2016) has led to the support for further PI treatments that are being proposed to plant protection organizations. This will allow for broader economical and feasible commercial application of the process.

Announcements



Third FAO/IAEA International Conference on Area-wide Management of Insect Pests: Integrating the Sterile Insect and Related Nuclear and Other Techniques, 22-26 May 2017, Vienna, Austria

Background: The successful implementation of area-wide pest management programmes integrating the use of sterile insects with other control technologies against a number of key plant, veterinary, and medical insect pests, such as various species of fruit flies, moths, screwworms, tsetse flies and, more recently, disease-transmitting mosquitoes, clearly demonstrates a peaceful application of nuclear technology. The Food and Agriculture Organization of the United Nations (FAO) and the International Atomic Energy Agency (IAEA) have over the last 50 years played, and will continue to play, a critical role in supporting their Member States in the development and application of these environmentally friendly pest management methods.

The concept of area-wide integrated pest management (AW-IPM), in which the total population of a pest in an area is targeted, is central to the effective application of the sterile insect technique (SIT) and is increasingly being considered for related genetic, biological and other pest suppression technologies. Insect movement, occurring sometimes over long distances, is generally underestimated. As a consequence, most conventional pest management is implemented as a localized or field by field, uncoordinated action against segments of a pest population, resulting very often in an unsustainable spiral of insecticide application and eventual resistance of the pest against the pesticides used. On the other hand, an AW-IPM approach involves a preventive rather than a reactive strategy, whereby all individuals of the pest population are targeted in time and space, requiring in the longer term fewer inputs and resulting in more cost-effective and sustainable pest management.

In June 1998 and May 2005, FAO and the IAEA organized, respectively, the First and the Second International Conferences on Area-wide Control of Insect Pests: Integrating the Sterile Insect and Related Nuclear and Other Techniques with the participation of, in each case, around 350 participants from close to 70 Member States and 5 international organizations. Both events greatly increased awareness about area-wide approaches for managing important insect pests. Since then, many new technical innovations have emerged and are being validated, such as the development of the SIT package for mosquitoes, and a better regulatory framework is being adopted for integrating the SIT with other pre- and post-harvest pest management methods. In addition, the driving forces in this field are increasingly relevant to a majority of Member States, justifying a third conference after 12 years.

Objectives: The purpose of the conference is to familiarize participants with new developments, trends and challenges related to insect pest management, both in the fields of agriculture and public health, and to foster a broad exchange of information between sanitary and phytosanitary regulatory authorities, operational AW-IPM programme managers, scientists, human, animal and plant protection specialists, pest management experts, public health practitioners, medical personnel and epidemiologists, as well as the private sector.

The conference and its deliberations and conclusions will provide useful feedback to the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and, in particular, to its future programme to address Member States' needs in the rapidly evolving field of insect pest management, which is exposed to such drivers as those described in Section A above. It will also highlight the challenges faced by Member States, such as new emerging pest and disease problems, and the global spread and outbreaks of invasive species in new regions.

Format and Topics: The structure of the conference will be based on selected plenary lectures, thematic sessions with keynote addresses, contributions, in the form of oral presentations and posters, as well as panel discussions. A limited amount of space will be available for commercial vendors' displays/exhibits during the conference.

A series of plenary sessions will address the topics listed below, and the conference programme will include invited keynote speakers from academia and industry, oral presentations and panel discussions. There will be ample time for viewing of posters, and for discussion and interaction among the participants. A final round table session will discuss the main conclusions drawn in the plenary sessions and will summarize recommendations for future development.

The scope of the conference is meant to cover, but is not limited to, the following topical areas:

- Operational AW-IPM programmes
- Economic impact and regulatory issues
- Mosquitoes and human health
- Animal health
- Climate change, global trade and invasive species
- Tools for integrated programmes, geographic information systems and new developments

Detailed information on administrative matters, including registration, paper submission and grants, is provided on the conference web page:

http://www-pub.iaea.org/iaeameetings/50813/Third-FAO-IAEA-International-Conference-on-Area-wide-Management-of-Insect-Pests-Integrating-the-Sterile-Insect-and-Related-Nuclear-and-Other-Techniques

To obtain further information please contact us via e-mail: AWConf2017@iaea.org

Call for Submission of Research Proposals for a new FAO/IAEA Coordinated Research Project on Integration of the SIT with Biocontrol for Greenhouse Insect Pest Management

The importance of food production in greenhouses is growing and will become increasingly significant in developing countries in the future. Biological control has been developed very successfully for the control of many of the pests of greenhouses, but there are occasions when an outbreak of a particular pest gets out of control, necessitating the use of chemical pesticides to bring it back under control. The use of pesticides disrupts pollination and biocontrol, leaves residues in the produce and is potentially harmful to the workers.

Three groups of pests have been identified with the potential to disrupt biocontrol: the spotted wing drosophila, *Drosophila suzukii* (see page 19); the cutworms *Spodoptera* and *Helicoverpa*; and the solanaceous pests *Tuta absoluta* and *Neolucinoides elegantalis*. For some of these pests considerable relevant information is already available but the sterile insect technique (SIT) and inherited sterility (IS) have not been developed in greenhouses. For others there is less information available and the SIT and IS need to be developed.

The SIT has been used successfully against some key pest species and offers the possibility of controlling these outbreak pests without the need for chemical pesticides. A new CRP will, therefore, be implemented to investigate and develop the potential of SIT and IS for pest control in greenhouses. This will include:

- Identifying the pest likely to cause disruption to the biocontrol environment
- Identifying the constraints to the adoption of SIT and IS in greenhouses
- Collecting and generating data on rearing, diet, irradiation and utilization for the various potential targets
- Testing SIT and IS in large scale trials and under commercial growing conditions.

The expected duration of the CRP is 5 years (2017-2022) and the first Research Coordination Meeting is planned for **3-7 July 2017 in Vienna, Austria.**

Scientists and researchers who are interested in collaborating in this new CRP should contact Andrew Parker (a.parker@iaea.org). Information on the IAEA Coordinated Research Programme and how to apply for research contracts and research agreements can be found at http://www-crp.iaea.org/. Applications should be submitted by **31 January 2017** to Official.Mail@iaea.org.

Interregional Training Course on the Use of the Sterile Insect and Related Techniques for the Integrated Area-wide Management of Insect Pests 31 July–25 August 2017, 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, as a result 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 vector disease 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/workshops (downloadable from: http://www-tc.iaea.org/tcweb/participion/astrainee/default.asp). 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: 30 April 2017).**

Participants' Qualifications: The course is open to about 22 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.

Announcement of FAO/IAEA Regional Training Courses

- Regional Training Course on *Taxonomy and Identification of Fruit Fly Pest Species for Southeast Asia* (under Regional TC Project RAS5067). 11–15 July 2016, Bangkok, Thailand.
- FAO/IAEA Regional Training Course on Fruit Fly Detection, Surveillance and Area-Wide Integrated Pest Management for Balkans and Eastern Mediterranean (under Regional TC Project RER5021). 5–9 September 2016, Opuzen, Croatia.

Other News

UN Ready to Irradiate Mosquito Sperm to Combat Zika Virus

A new method to render male mosquitoes infertile by nuclear radiation could help reduce populations of the insect carrying the Zika virus that is linked to thousands of birth defects in Brazil, the U.N. atomic agency said on Tuesday.

Experts from the Vienna-based International Atomic Energy Agency (IAEA) are to meet Brazilian officials on February 16 to discuss how best to roll out the so-called Sterile Insect Technology (SIT) in the host country of the 2016 Summer Olympics.

"If Brazil released a huge number of sterile males, it would take a few months to reduce the population, (but) it has to be combined with other methods," IAEA Deputy Director General Aldo Malavasi told reporters.

Besides SIT, the spread of the Zika virus, which the World Health Organization has declared an international public health emergency, could be fought by more intense sanitation efforts, the use of insecticides and traps.

The SIT, adapted from decades-old methods used to slash populations of other insects such as fruit flies, involves exposing males of the *Aedes aegypti* mosquito to X or gamma rays to render their sperm sterile.

Such laboratory-bred male mosquitoes could then be released in the wild to mate with the females of the species who then bear eggs that never hatch, thus reducing the number of insects in a given area without killing any animals or using chemicals.

"It's family planning for insects," which offers the technological know-how to interested member countries for free so they can design and run their own SIT programme. The sterile males, one generation of which takes about a month to breed, must outnumber the indigenous males by a factor of 10 or 20 to make their mark in a mosquito population. This requires millions of males, making the method more likely to be used in villages or towns, rather than large cities, Malavasi said.

In test runs running over several months in Italy, SIT helped cut mosquito populations by around 80 percent and in China the success rate was as high as 100 percent.

Apart from Brazil, other countries such as Mexico, Guatemala, Indonesia and Singapore have also requested the technology from the IAEA to control their mosquito populations.

According to the WHO, the Zika virus is "spreading explosively" and could infect as many as 4 million people in the Americas. The Pan American Health Organization says Zika has spread to 24 nations and territories in the Americas.

Source: http://www.reuters.com (2 February, 2016).

Sterile Moth Technology to Target Navel Orangeworm in Tree Nuts

To combat one of its major insect pests, the Californian pistachio industry would like to take a page from the playbook of cotton growers and their highly successful pink bollworm (PBW) eradication programme.

The nut growers' target – it also plagues walnuts and almonds – is the Navel orangeworm (NOW), *Amyelois transitella*, a vector for aflatoxin that is under increased scrutiny from pistachio processors.

The objective of a NOW control pilot project would be to do what the pink bollworm programme has done, rearing and sterilization of massive numbers of moths per day. The project is in "the very preliminary stage," said Bob Klein, manager of the California Pistachio Research Board.

The PBW programme has been a resounding success; there have been no native pink bollworm detections since spring 2012. Klein said there is disagreement among researchers as to whether sterile NOW moths could be produced and in high numbers as is done with the PBW. Their physiology is, of course, different.

Sterile releases for NOW will start in this spring

The strategy, proponents say, is "to suppress moth mating in each generation so after a number of years, fertile NOW moths numbers are very minor or even cease to exist, as with PBW."

The PBW programme has been so successful that the Phoenix, Arizona facility is no longer needed, except to sustain a very small population of PBW in case eradication becomes necessary again in the future.

If the NOW effort works, the plan would house production of sterile NOW moths in part of the Phoenix facility that would be shared with production of sterile PBW moths. It would likely save some jobs at the facility, Klein said.

Some scientists believe NOW can successfully be reared in massive numbers, sterilized, and distributed by air in the same way the PBW moths are. Jeff Gibbons, plant and grower relations manager with Setton Pistachio in Terra Bella, is among those on a pistachio industry task force who is a firm believer in the project's chances for success.

Gibbons said releases of millions of sterile NOW moths would be "another tool in the toolbox to battle such a difficult and aggressive pest." He pointed out that the NOW pest is particularly problematic since most pistachios are sold in-shell, and what the pest does to the unseen kernel could end up in a consumer's mouth literally leaving a bad taste.

Some pistachio growers believe almond growers–and possibly walnut growers–would join funding in rearing and releasing moths. Gibbons said releases should cover wide areas since almond, pistachio, and walnut orchards are often contiguous. He added the pest also damages figs and pomegranates.

Millions of sterile NOW moths would be delivered daily on the orchards as soon as moths emerge around March 1 when insect levels are at their lowest. Release of the sterile moths would continue for several months later than sprays and pheromones in the fall to help reduce over-wintering populations until approximately October 1. Gibbons said the sterile moth programme would complement pheromone mating disruption using puffers since the use of the sterile moths is most effective with low populations, and puffers can keep populations low.

Differences between the NOW programme and PBW programme is that there would be, of course, no "plow down" directive with the NOW releases. NOW has multiple food sources, are better flyers than the PBW, and have different mating habits.

The PBW facility was rearing and distributing 28 million moths per day at cost of less than $1 for a thousand moths.

The NOW programme would be aimed more at suppression than eradication, Gibbons said. He added that NOW damage costs pistachio growers around $400 million annually. The hope is that an IPM programme integrating the sterile moths could reduce this cost by 10 percent or more.

Gibbons said the cost of the sterile insect programme would cost about $20 million or $15 an acre, "less than the cost of one spray." Premium and bonus programmes offered by processors would help offset those costs.

Source: http://westernfarmpress.com (17 February 2016).

The Plan to Drop Thousands of Tsetse Flies from a Drone to Tackle Disease

A drone about to drop something is typically a cue for widespread destruction. But that's not the case with this F300 fixed-wing and its unusual cargo: Instead of unleashing catastrophe, the automated machine is designed to do good by releasing a swarm of tsetse flies.

This may seem peculiar at first, especially given the tsetse fly's reputation. This African insect harbours harmful parasites called trypanosomes, spreading them to humans and animals through its bite. In humans, the resulting disease, trypanosomiasis, causes "sleeping sickness," a potentially fatal condition that attacks the central nervous system and, as the name suggests, afflicts people with an uncontrollable urge to sleep. In livestock, it brings on "nagana," which causes muscle wasting, paralysis, and eventual death. Losing cattle, particularly, has knock-on effects for agriculture and food security.

Now Spanish drone company *Embention* is part of an unlikely solution in Ethiopia, where the disease ravages livestock: eradicating trypanosomosis using the very culprits responsible for its spread. To do it, the heroically-titled project *Drones against Tsetse* combines drone technology with a biological control method known as the Sterile Insect Technique (SIT).

The SIT works by exposing male insects to radiation, which sterilises them and thus destroys their ability to

breed offspring. It's garnered attention in recent years as a possible tool for controlling the spread of malaria via mosquitoes; now in Ethiopia it's being applied to hundreds of thousands of male tsetse flies reared at facilities in Addis Ababa, where the project's research headquarters lie.

The work is supported by the Ethiopian Ministry of Livestock, the United Nations Food and Agricultural Organisation, and the International Atomic Energy Agency, an organisation that promotes the peaceful use of nuclear technologies in scientific research and is pioneering SIT research in many countries. The researchers have so far shown that when released into the wild, the radiated tsetse males fail to have offspring with females, effectively erasing the next generation and undermining the population. That leaves fewer tsetse flies around to infect humans and animals.

Embention's drone prototype—so far trialled in Spain and awaiting approval for use in Ethiopia—comes in as a way to seed the wild populations with their sterilised brethren.

The radiated flies will be loaded into boxes enclosed within long chambers that sit below the drone's wings, explains Javier Espuch, one member of the five-strong team who developed the drone. Flying autonomously, the machine follows pre-set coordinates that pinpoint areas known to be infested with the insects: "When the drone reaches that area it automatically drops the flies," says Espuch. The biodegradable, open-sided boxes free the insects as they fall.

For humans, the risk of contracting trypanosomiasis is declining in many countries. But in places like Ethiopia where livestock feel the brunt of its impact, disease-ridden animals can drastically undermine agricultural production because farmers rely on cattle to till the land. Agriculture accounts for 43 percent of Ethiopia's GDP and provides 85 percent of its employment, so it's a risk worth fighting.

Until now, the project has relied on people to manually drop the fly boxes from an airplane over Ethiopia's Deme River Basin, a 1,000 km^2 tsetse fly hotspot. But the drone will make this process cheaper, safer, and—since it flies just 300 meters above ground—more precise, said Espuch. "To be effective, they need to fly every day, so the cost involved in it decreases a lot, because you don't really need a trained pilot for this," he said.

When the prototype receives approval and hopefully reaches Ethiopian skies in coming months, it will be capable of raining down 5,000 sterile insects per flight. As for the tsetse flies, they might not be its only passengers: "The same release system can be used for sterile mosquitoes. If all goes well, malaria could be the drone's next frontier.

Source: http://motherboard.vice.com (28 March 2016).

USDA to Upgrade Sarasota "Fruit Fly" Operation to Protect Florida Citrus

For 17 years, Sarasota has been Florida's top processing centre for fruit flies.

"I was very surprised, I mean the building's been there for quite a few years, and you drive by it every day and don't realize what really goes on inside it," says Reed Giasson, VP of operations at Halfacre Construction. "But the science that's behind it is pretty impressive."

Halfacre Construction is the local contractor in charge of moving USDA's sterile insect release programme from a warehouse south of University Parkway, to a new facility just north of the Sarasota/Bradenton International Airport.

"This brand new facility is going to facilitate the process a lot more efficiently," says Giasson. "They're handling over 100 million sterile fruit flies a week, so we have to make sure the building is state-of-the-art."

Mediterranean fruit flies enter the country with foreign produce. They feed and reproduce on harvest-ready citrus. Sarasota is handling sterile male flies that halt population growth in infested regions.

"With the citrus and other fruit crops being one of our major sources of income in the state, it's imperative we get this off and running quickly," says Giasson.

Source: http://www.mysuncoast.com (10 May 2016).

Relevant Published Articles

Male-killing bacteria as agents of insect pest control

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Abstract

1. Continual effort is needed to reduce the impact of exotic species in the context of increased globalization. Any innovation in this respect would be an asset.
2. We assess the potential of combining two pest control techniques: the well-established sterile insect technique (SIT) and a novel male-killing technique (MKT), which comprises inoculation of a pest population with bacteria that kill the infected male embryos.
3. Population models are developed to assess the efficiency of using the MKT for insect pest control, either alone or together with the SIT. We seek for conditions under which the MKT weakens requirements on the SIT.
4. Regarding the SIT, we consider both non-heritable and inherited sterility. In both cases, the MKT and SIT benefit one another. The MKT may prevent the SIT from failing when not enough sterilized males are released due to high production costs and/or uncertainty on their mating ability following a high irradiation dose. Conversely, with already established SIT, pest eradication can be achieved after introduction of male-killing bacteria with lower vertical transmission efficiency than if the MKT was applied alone.
5. For tephritid fruit flies with non-heritable sterility, maximal impact of the SIT is achieved when the released males are fully sterile. Conversely, for lepidopterans with inherited sterility, maximal impact of the SIT is achieved for intermediate irradiation doses. In both cases, increasing vertical transmission efficiency of male-killing bacteria benefits the SIT; high enough vertical transmission efficiency allows for pest eradication where the SIT is absent or induces only pest suppression when used alone.
6. Synthesis and applications. While both techniques can suppress or eliminate the pest on their own, combined application of the male-killing technique and the sterile insect technique substantially increases pest control efficiency. If male-killing bacteria are already established in the pest, any assessment of the sterile insect technique needs to account for their presence; otherwise, management recommendations could be exaggerated and unnecessarily costly.

The full paper was published in: Journal of Applied Ecology (in press, early view)

Hygienic food to reduce pathogen risk to bumblebees

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Abstract

Bumblebees are ecologically and economically important pollinators, and the value of bumblebees for crop pollination has led to the commercial production and exportation/importation of colonies on a global scale. Commercially produced bumblebee colonies can carry with them infectious parasites, which can both reduce the health of the colonies and spillover to wild bees, with potentially serious consequences.

The presence of parasites in commercially produced bumblebee colonies is in part because colonies are reared on pollen collected from honey bees, which often contains a diversity of microbial parasites. In response to this threat, part of the industry has started to irradiate pollen used for bumblebee rearing. However, to date there is limited data published on the efficacy of this treatment.

Here we examine the effect of gamma irradiation and an experimental ozone treatment on the presence and viability of parasites in honey bee pollen. While untreated pollen contained numerous viable parasites, we find that gamma irradiation reduced the viability of parasites in pollen, but did not eliminate parasites entirely. Ozone treatment appeared to be less effective than gamma irradiation, while an artificial pollen substitute was, as expected, entirely free of parasites.

The results suggest that the irradiation of pollen before using it to rear bumblebee colonies is a sensible method which will help reduce the incidence of parasite infections in commercially produced bumblebee colonies, but that further optimisation, or the use of a nutritionally equivalent artificial pollen substitute, may be needed to fully eliminate this route of disease entry into factories.

The full paper was published in: Journal of Invertebrate Pathology: 136: 68-73 (2016).

More than one rabbit out of the hat: Radiation, transgenic and symbiont-based approaches for sustainable management of mosquito and tsetse fly populations

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Abstract

Mosquitoes (Diptera: Culicidae) and tsetse flies (Diptera: Glossinidae) are bloodsucking vectors of human and animal pathogens. Mosquito-borne diseases (malaria, filariasis, dengue, chikungunya and Zika) cause severe mortality and morbidity annually, and tsetse fly-borne diseases (African trypanosomes causing sleeping sickness in humans and nagana in livestock) cost Sub-Saharan Africa an estimated US$ 4750 million annually. Current reliance on insecticides for vector control is unsustainable: due to increasing insecticide resistance and growing concerns about health and environmental impacts of chemical control there is a growing need for novel, effective and safe biologically-based methods that are more sustainable. The integration of the sterile insect technique has proven successful to manage crop pests and disease vectors, particularly tsetse flies, and is likely to prove effective against mosquito vectors, particularly once sex-separation methods are improved. Transgenic and symbiont-based approaches are in development, and more advanced in (particularly *Aedes*) mosquitoes than in tsetse flies; however, issues around stability, sustainability and biosecurity have to be addressed, especially when considering population replacement approaches. Regulatory issues and those relating to intellectual property and economic cost of application must also be overcome. Standardised methods to assess insect quality are required to compare and predict efficacy of the different approaches. Different combinations of these three approaches could be integrated to maximise their benefits, and all have the potential to be used in tsetse and mosquito area-wide integrated pest management programmes.

The full paper was published in: Acta Tropica 157: 115-130 (2016).

Determination of the sterile release rate for stopping growing age-structured populations

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Abstract

A freely-growing age-structured population was modelled for growth and control by sterile male releases. Equilibrium populations yield critical sterile male release rates that would hold the population at equilibrium. It is shown here that these rates may be different from the release rates required to stop a growing population and bring it to an equilibrium.

A computer simulation was constructed of this population and a parameter sensitivity analysis graphed the effects on the required sterile male release rate of fertility, mating delay in adult females, net juvenile survivorship, three adult survivorship curves, the time spent in the juvenile stages, and total life span.

The adult survivorship curves had the greatest effect on the required sterile release rate for population elimination. The required release rate was also determined for *Ceratitis capitata* (Wiedemann) using survivorship and fertility data from a laboratory strain. The concepts of over-flooding ratio and release ratio were discussed and quantified for the cases above.

The full paper was published in: International Journal of Pest Management: 62(1):40-54 (2016).

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