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Nuclear Techniques in Food and Agriculture

Insect Pest Control Newsletter

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To Our Readers

Participants of the Third International Conference on Area-wide Management of Insect Pests: Integrating the Sterile Insect and Related Nuclear and Other Techniques, held from 22-26 May 2017 in Vienna, Austria.

Over the past months staff of the Insect Pest Control subprogramme was very occupied with preparations for the *Third FAO/IAEA International Conference on "Area-wide Management of Insect Pests: Integrating the Sterile Insect and Related Nuclear and Other Techniques"*, which was successfully held from 22-26 May 2017 at the Vienna International Centre, Vienna, Austria. The response and interest of scientists and governments, as well as the private sector and sponsors were once more very encouraging. The conference was attended by 360 delegates from 81 countries, six international organization, and nine exhibitors. As in previous FAO/IAEA Area-wide Conferences, it covered the area-wide approach in a very broad sense, including the development and integration of many non-SIT technologies.

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. This concept is presented in the brief animated infographic posted on the web (https://www.youtube.com/watch?v=p8kzxgYeAqQ&feature=youtu.be; you will find the same video in Arabic, Chinese, French and Spanish at http://www-naweb.iaea.org/nafa/resources-nafa/multimedia.html). 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, un-coordinated 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 used pesticides. On the other hand, an AW-IPM approach adopts an often preventive rather than a reactive strategy, whereby all individuals of the pest population are targeted in time and space, requiring fewer inputs in the longer term and resulting in more cost-effective and sustainable pest management.

In June 1998 and May 2005 FAO and IAEA sponsored, respectively, the First and the Second *International Conferences on Area-wide Management of Insect Pests Integrating the Sterile Insect and Related Nuclear and other Techniques*. 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 rapidly evolving field are increasingly relevant to a majority of Member States, justifying a third conference after 12 years:

- Increasing insect pest problems due to intensification of crop / livestock production systems.
- Increasing invasions of non-native agricultural pests and disease vectors into new regions due to globalisation and their survival in previously inhospitable areas due to climate change.
- Increased outbreaks of diseases (e.g. dengue, Chikungunya, Zika) that are transmitted by mosquitoes.
- Increasing public demand for more efficient, sustainable and environment-friendly pest management methods.
- Increasing resistance of pest insects to insecticides
- Ever stricter application of sanitary / phytosanitary trade regulations for countries to be able to access international export markets with their agricultural products.
- Increasing potential to improve biologically-based pest management methods in view of recent major developments in molecular genetics and microbiology, leading to new biotechnological tools and a better understanding of the role of symbionts and other microbiota in insects.

The Third Area-wide Conference was structured into selected plenary lectures, six theme-specific sessions with keynote addresses, 55 oral presentations and 206 posters, as well as three panel discussions. The six theme-specific sessions were:

- Operational area-wide insect pest management programmes
- Mosquitoes and human health
- Animal health
- Regulatory issues and socio-economic impact
- Climate change, global trade and invasive species
- New developments and tools for area-wide integrated pest management

On the last day of the conference, three panels of experts guided open discussions on the following subjects:

- Short term political will / vision and stakeholder support versus long term sustainability of area-wide programmes
- Opportunities and risks for area-wide control of mosquito-borne diseases
- How will new developments, products and technologies affect the way we control insect pests?

IAEA Director General Yukiya Amano stated during his opening remarks that "I greatly value the work done by the experts gathered here for this Conference to tackle harmful insect pests. You are helping to strengthen food security for many millions of people. The IAEA, working closely with the FAO, is pleased to be your partner in helping countries to develop capacities for area-wide pest management. I have seen for myself in visits to many countries what a difference successful pest control makes to countless families and communities." Also at the opening, the FAO Assistant Director General Ren Wang emphasized the importance of effective pest control programmes in meeting future challenges and the Sustainable Development Goal on Zero Hunger. "Effective and sustainable pest management methods are integral components of national strategies to raise productivity to assure future global food security," he said during his opening remarks.

Area-wide integrated pest control programmes are logistically complex and managerially intensive. They require an effective management and a broad coalition of stakeholders committed, often over many years, to ensure success. Critical issues, whether technical, operational or managerial, often determine success or failure of area-wide programmes: whereas the area-wide integration of various technologies is effective in some countries, major problems have occurred when implemented against the same pest insect in others. Therefore the main focus of this third conference was to review lessons learned in implementing AW-IPM programmes, addressing both the technical and managerial components of these operational programmes and review how recent developments and tools can contribute to increased efficiency of these programmes.

The majority of area-wide programmes have so far been implemented by governmental organizations, with or without some financial participation from the direct beneficiaries. Although they often address a public good, in the long run this may not be sustainable. Many of the presentations included success stories of pest and disease suppression or elimination from around the world. Experts also shared information and exchanged ideas related to the regulatory, sustainability and development aspects of AW-IPM.

I would like to thank all conference participants and government delegates for their enthusiastic participation and the high quality of oral and poster presentations, as well as the IAEA Conference Services staff, the Joint FAO/IAEA Programme staff, the Department of Technical Cooperation and other sponsors, for the effective organization and support, contributing to a very fruitful and enjoyable event. A new text book will now be prepared that is based on most of the oral presentations, some relevant poster presentations, as well as some invited papers of other AW-IPM related programmes. The text book will be published by an outside publisher and will hopefully be available as of late 2018.

The construction activities of the new Insect Pest Control Laboratory (IPCL) under the ReNuAL project are progressing as planned. The concrete shell has been completed, the out-side walls have been finished (insulated, painted, etc.), and the inside walls and the floors on the ground and first floor have been started. In addition, construction has started of a climate controlled greenhouse that will be linked with the new IPCL at the south-eastern side of the building.

On a different note I would like to inform you that there have been various staff changes in our Insect Pest Control Laboratory in Seibersdorf. These include the departure of Jeremie Gilles who guided for seven years the Human Disease Vectors (HDV) group of the Insect Pest Control subprogramme during a very intensive and productive period involving the early development of the SIT package for mosquitoes. We would like to thank Jeremie for his dedicated support to the Insect Pest Control subprogramme during these critical years.

Our colleague and former CIRAD staff member, Jeremy Bouyer, was appointed as the new leader of the HDV group. Jeremy has extensive experience with AW-IPM programmes and the SIT and has worked in tsetse projects in Burkina Faso, Senegal and Ethiopia. Additionally, Jeremy has been active in the development of mosquito control strategies, as well as serving as expert in several missions to Member States.

In addition, the HDV group was reinforced with the appointment of Hanano Yamada, who has been supporting this group as a consultant. She was selected as professional staff in a new position (Entomologist) created to support the development of the SIT package for mosquitoes and the transfer of this technology to Member States that are initiating pilot projects to suppress mosquito populations. We all welcome Jeremy Bouyer and Hanano Yamada to the Insect Pest Control subprogramme and wish them much success in their new positions.

Also recently, four young professionals joined the HDV group to conduct work under the United States Department of State grant that was awarded in 2016 (*"Surge Expansion of Sterile Insect Technique (SIT) to Control Mosquito Populations that Transmit the Zika Virus"*). They are: Danilo Carvalho (Molecular Biologist); Antonios Avgoustinos (Geneticist), Hamidou Maiga (Medical Entomologist), and Wadaka Mamai (Medical Entomologist - rearing). Their contribution to research and development activities in the area of *Aedes* vectors, as well as their support to technology transfer, is expected to contribute to the effective implementation of this extrabudgetary project.

Finally, I would like to let you know that as of 1 May 2017 I was appointed Head of the Insect Pest Control Section. In collaboration with all my IPC colleagues and our numerous external stakeholders and collaborators, I will strive to contribute effectively to the successful development and integrated application of the SIT by the FAO/IAEA Insect Pest Control subprogramme.

Rui Cardoso Pereira

Head, Insect Pest Control Section

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Forthcoming Events (2017-2018)

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

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, Tanga, Tanzania.

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

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

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

First RCM on Colony Management of Insects for Sterile Insect Technique Application. 2–6 July 2018, Vienna, Austria.

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

II. Other Meetings/Events

Meeting of the Technical Panel on Phytosanitary Treatments (TPPT), International Plant Protection Convention FAO. 17–21 July 2017, Vienna, Austria.

FAO/IAEA Regional Workshop on Geographical Information Systems, Databases and Information Analysis (under Regional Latin America Project RLA5070). 7–11 August 2017, Belmopan, Belize.

FAO/IAEA Latin America 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 Latin America Project RLA5074). 16–18 August 2017, Vienna, Austria.

FAO/IAEA Europe Regional Training Course on Field Procedures for Mosquito Population Surveillance, Detection and Quantification (under Regional Europe Project RER5022). 4–15 September 2017, Tirana, Albania.

FAO/IAEA Regional Training Course on Non-native Fruit Flies of Quarantine Significance (under Regional Asia Project RAS5076). 11–15 September 2017, Seibersdorf, Austria.

Training Course on Fruit Fly Integrated Pest Management Including the Sterile Insect Technique and Biological Control. Moscamed Programme Brazil, 19–28 September 2017, Juazeiro, Brazil.

FAO/IAEA Regional Training Course on Fruit fly Detection, Surveillance, and Databases and Data Analysis in Africa (under Regional Africa Project RAF5074). 2–6 October 2017, Nairobi, Kenya.

FAO/IAEA Regional Training Course on Quarantine and International Standards for Phytosanitary Measures for Fruit Flies in Southeast Asia (under Regional Asia Project RAS5067). 16–20 October 2017, Hanoi, Viet Nam.

FAO/IAEA Third Project Coordination Meeting on Integrating Sterile Insect Technique for better Cost-Effectiveness of Area-wide Fruit Fly Pest Management Programmes in Southeast Asia (under Regional Asia Project RAS5067). 23–25 October 2017, Vienna, Austria.

FAO/IAEA Africa Regional Workshop on the Use of the Sterile Insect Technique Within an Integrated Approach to Control Populations of Mosquito Vectors with Special Reference to Dengue (under Interregional Project INT5155). 23–27 October, Mauritius.

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 Technical Cooperation Project INT5155). 6 November–1 December 2017, Metapa de Dominguez, Chiapas, Mexico and Antigua / El Pino, Guatemala.

FAO/IAEA Europe Regional Workshop to Present Respective Experiences with Fruit Fly Activities and Synergize Future Activities (under Regional Europe Project RER5021). 13–17 November 2017, Vienna, Austria.

14th Workshop of the IOBC Global Working Group on Mass Rearing and Quality Assurance, 14–17 November 2017, Mérida, Mexico.

FAO/IAEA Regional Training Course on Operation and Maintenance of Remotely Piloted Aerial System for the Release of Sterile Males of Tsetse Flies (under Regional Africa Project RAF5077). 20–24 November 2017, Entebbe, Uganda.

FAO/IAEA Europe Regional Workshop on Establishing Genetic Control Programmes for *Aedes* Invasive Mosquitoes (under Regional Europe Project RER5022). 4–6 December, Crete, Greece.

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

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

Past Events (2017)

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

Second RCM on Comparing Rearing Efficiency and Competitiveness of Sterile Male Strains Produced by Genetic, Transgenic or Symbiont-based Technologies. 27–31 March 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. 29 May–2 June 2017, Vienna, Austria.

II. Consultants and Expert Meetings

Consultants Meeting on Development of a Protocol for the Planning and Implementation of a Pilot Trial Using the Sterile Insect Technique against Codling Moth in Selected European Target Areas. 13–17 February 2017, Vienna, Austria.

Consultants Meeting on Improvement of Colony Management in Insect Mass-rearing for SIT Applications. 17–21 May 2017, Vienna, Austria.

III. Other Meetings/Events

FAO/IAEA Regional Training Course on Mosquito Identifications, Surveillance and Trapping Methods for Area-wide Integrated Mosquito Management in the European Area (under Regional Europe Project RER5022). 23–27 January 2017, Vienna, Austria.

FAO/IAEA Regional Workshop on the Practical Use of GPS/GIS to Improve Management of Fruit Fly Trapping Networks (under Regional Asia Project RAS5076). 30 January–2 February 2017, Arava, Israel.

83rd Annual Meeting of American Mosquito Control Association. 13–17 February 2017, San Diego, California, USA.

FAO/IAEA Regional Training Course on Free Open Source Software for Geographic Information System (GIS) and Data Management Applied to Fruit Flies in Southeast Asia (under Regional Asia Project RAS5067). 6–10 March 2017, Bangkok, Thailand.

Seventh Annual Chapman Phytosanitary Irradiation Forum. 21–22 March 2017, Orange, California, USA.

FAO/IAEA Regional Workshop on Establishment and Harmonization of Fruit Fly Trapping Surveillance Networks and Quality Control (under Regional Latin America Project RLA5070). 27–31 March 2017, Santiago de Chile, Chile.

FAO/IAEA Regional Training Course on Mosquito Detection, Surveillance, Data Recording and Analysis for Area-wide Integrated Mosquito Management in the European Area (under Regional Europe Project RER5022). 3–7 April 2017, Valencia, Spain.

Twelfth Session of the Commission on Phytosanitary Measures, International Plant Protection Convention, FAO. 5–11 April 2017, Incheon, Republic of Korea.

FAO/IAEA Workshop on Development of a Rearing System and an Artificial Diet for the Cocoa Pod Borer in Papua New Guinea (under PAP5001). 24–28 April 2017, Rabaul, Papua New Guinea.

Meeting on Breeding Invertebrates for Next Generation Bio Control (BINGO). 18–22 May 2017, Vienna, Austria.

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 Regional Workshop on Identification of Non-Native Fruit Flies of Quarantine Significance (under Technical Cooperation Project PAN5025). 18–22 June 2017, Panama City.

Technical Cooperation Field Projects

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

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

Country	Project Number	National Projects	Technical Officer
Angola	ANG5012	Supporting Feasibility Studies for using Sterile Insect Techniques as part of Area-wide Integrated Pest Management for Control of Tsetse Flies (*G. morsitans centralis*)	Rafael Argiles
Botswana	BOT5013	Using the Sterile Insect Technique Integrated with Other Suppression Methods for Managing *Bactrocera dorsalis*	Rafael Argiles
Burkina Faso	BKF5012	Collecting Baseline Data and Implementing Fruit Fly Suppression in Mango Fruit	Rafael Argiles
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
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
Mexico	MEX5031	Using the Sterile Insect Technique to Control Dengue Vectors	Danilo Carvalho
Morocco	MOR5035	Implementing the Sterile Insect Technique in the Souss Valley	Walther Enkerlin Carlos Cáceres
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	Wadaka Mamai
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
Senegal	SEN5037	Supporting the National Programme to Control Tsetse and Trypanosomosis	Marc Vreysen Rafael Argiles
Seychelles	SEY5009	Suppressing Melon Fruit Fly Species through Environment-Friendly Techniques to Enhance Food Security	Rui Cardoso Pereira
Sri Lanka	SRL5047	Establishing a National Centre for Research, Training and Services in Medical and Molecular Entomology for Vector-borne Disease Control	Antonios Avgustinos
Sudan	SUD5038	Implementing the Sterile Insect Technique for Integrated Control of *Anopheles arabiensis*, Phase II	Adly Abdalla
Thailand	THA5052	Developing Sustainable Management of Fruit Flies Integrating Sterile Insect Technique with other Suppression Methods	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	Rafael Argiles
Viet Nam	VIE5021	Integration of the Sterile Insect Technique with Other Suppression Methods for Control of *Bactrocera* fruit flies in Dragon Fruit Production	Rui Cardoso Pereira
Zimbabwe	ZIM5023	Improving Crop and Livestock Production through the Eradication of Bovine and Human Trypanosomiasis in Matusadona National Park	Rafael Argiles

		Regional Projects	
Regional Africa	RAF5074	Enhancing Capacity for Detection, Surveillance and Suppression of Exotic and Established Fruit Fly Species through Integration of Sterile Insect Technique with Other Suppression Methods	Rui Cardoso Pereira Rafael Argiles
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
Regional Asia	RAS5067	Integrating Sterile Insect Technique for Better Cost-Effectiveness of Area-wide Fruit Fly Pest Management Programmes in South-east 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	Jeremy Bouyer
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	Hanano Yamada
		Interregional Project	
Interregional	INT5155	Sharing Knowledge on the Sterile Insect and Related Techniques for the Integrated Area-wide Management of Insect Pests and Human Disease Vectors	Jeremy Bouyer Rui Cardoso Pereira

Highlights of Technical Cooperation Projects

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

The IAEA through its Joint FAO/IAEA Division and Technical Cooperation Department has been providing technical assistance for Mediterranean fruit fly (medfly) area-wide integrated management to the Middle East Region including Israel, Jordan and Palestinian Territories.

Staff from the Pest Control Division of the Jordanian Ministry of Agriculture releasing sterile medflies from paper bags.

Currently, assistance is being provided through the Regional Middle East Technical Cooperation Project RAS5076, aimed at capacity building for area-wide medfly control utilizing an integrated pest management approach, including the sterile insect technique (SIT) in the Middle East. In addition, surveillance networks for early detection of entries of exotic fruit fly species of quarantine significance are being strengthened and capacity for emergency response is being developed.

Jordan has substantially benefited from this technical cooperation. A pilot medfly SIT project is ongoing in the Jordan Valley where citrus and stone fruits, including apricots and peaches, are produced. In this area, medfly damage to commercial fruit production has been reduced through the weekly releases of sterile medflies supplied by a mass rearing and sterilization facility located in Israel.

Sterile pupae are shipped from Israel to Jordan, where they are packed and released over medfly-infested areas in the valley. Moreover, insecticide sprays have been minimized protecting human health and the environment. Jordan has also benefited from an improved surveillance network and emergency response plan against other non-native fruit fly species such as the peach fruit fly already present in nearby countries.

Technology transfer to the Ministry of Agriculture has been implemented through individual fellowships and scientific visits, as well as workshops for training of professional staff and expert missions to the country. In addition, specialized fruit fly trapping and laboratory equipment has been timely delivered. Furthermore, under the IAEA Technical Cooperation Programme, regional transboundary-cooperation has been possible and fruitful.

Integrating Sterile Insect Technique for Better Cost-Effectiveness of Area-wide Fruit Fly Pest Management Programmes in Southeast Asia (RAS5067)

Regional Training Course on Free Open Source Software for GIS and Data Management Applied to Fruit Flies in Southeast Asia

This Regional Training Course was organized under the TC project RAS5067 *"Integrating Sterile Insect Technique for Better Cost-Effectiveness of Area-wide Fruit Fly Pest Management Programmes in Southeast Asia"* and was attended by 10 participants from 7 countries (Bangladesh, Indonesia, Malaysia, Myanmar, Philippines, Thailand and Vietnam). The course was held at the Palace Hotel & Convention, Bangkok, Thailand from 6-10 March 2017.

Participants of the regional training course on Free Open Source Software for GIS and Data Management Applied to Fruit Flies in Southeast Asia (Bangkok, Thailand).

The programme of the training course consisted of theoretical lectures, demonstrations and practical exercises, including a field visit, and covered the following main topics:

- Introduction to GIS
- Basics of QGIS (project toolbar, loading layers, vector vs raster layers, map navigation toolbars, layer properties, symbology, labels, visibility, etc.)
- Editing layers (creating and editing vector layers, creating a grid, etc.)

- Editing attribute tables (adding fields, calculating area and length, adding coordinates, etc.)
- Useful graphic operations (append, buffer, join, etc.)
- Adding data from various sources
- Introduction to databases
- Coordinate systems (CRS, re-projection, etc.)
- Field recording information (GPS and QFIELD)
- Composing maps
- Working with raster data.

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 (RLA5070)

Regional workshop on the establishment and harmonisation of traps system and quality control

The workshop was held under the framework of the Regional Latin America Technical Cooperation Project 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"*. The event was organized by the National Fruit Fly Programme of the Servicio Nacional Agricola y Ganadero (SAG) of Chile from 27 to 31 March 2017.

Participants from Latina America and the Caribbean to the fruit fly trapping workshops in Santiago de Chile, Chile, March 2017.

The workshop was attended by 28 participants from 17 countries from Latin America and the Caribbean: Argentina, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Dominican Republic, Guatemala, Jamaica, Mexico, Panama, Paraguay, Honduras, Peru and Nicaragua. It consisted of theoretical lectures and practical field exercises.

The topics that were addressed where:

- International phytosanitary standards and procedures manuals related to fruit fly surveillance networks and emergency response capacity.
- Establishment and management of fruit fly trapping networks based on risk factors.
- Geographical information system in support of data analysis and decision making for fruit fly surveillance networks
- Practical implementation of emergency response plans, including delimiting trapping and phytosanitary measures to eliminate pest entries.

Through the knowledge acquired participating member countries should be able to strengthen their national surveillance networks against non-native fruit fly pests. It was also useful to continue with the process of regional harmonization of fruit fly detection and monitoring systems following IPPC International Standards.

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

A workshop was organised on "The development of a rearing system and an artificial diet for the cocoa pod borer, *Conopomorpha cramerella* (CPB), in Papua New Guinea (PNG)" that was held in Rabaul, PNG from 24-28 April 2017, and supported by TC project PAP5001. The meeting was hosted by the Cocoa and Coconut Research Institute (CCI) and held at the National Agricultural Research Institute (NARI). The meeting was locally organised by Arnold Parapi, CCI, assisted by George Otto of the IAEA National Liaison Office in Port Moresby.

The CPB was first detected in PNG in 2006 and available data seem to indicate multiple entry points. Cocoa is a highly important export commodity in PNG, 80% of which comes from smallholders dependent on it for their livelihoods. There is plenty of room to expand cocoa production in PNG, as it is estimated that only 2% of the land that is suitable for cocoa production is actually planted with cocoa trees.

In the last 10 years, PNG has experienced a reduction in cocoa production from 50,000 to 30,000 tons, mainly due to CPB. The Government of PNG has set a very ambitious goal of reaching a production/export volume of 300,000 tons per year by 2030, and all stakeholders seem to agree that this will not be possible without adequate management of the CPB. As part of the management strategy of CPB, the NARI has been quite successful in developing new breeds/strains of cocoa that better resist the CPB.

Cocoa pod showing damage caused by the cocoa pod borer.

The TC project PAP5001 is providing support to a feasibility study to assess whether the SIT can be developed against the CPB. It is obvious that rearing of CPB will be challenging, as it is a micro Lepidoptera from the family Gracillariidae, which are in general challenging to culture.

The aim of the workshop was to bring together all available knowledge in the region (Malaysia, Indonesia, Philippines) on the development of artificial diets and rearing systems for CPB. Most of the progress has been made with the development of an artificial diet in Malaysia, and the workshop participants were all in agreement that the Malaysian diet should be used by all groups as a starting point for further development.

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

Customized Information System of Networked Databases to Manage Tsetse SIT Activities

A comprehensive information system customized to the Southern Rift Valley Tsetse Eradication Project (STEP) has been developed by FAO/IAEA and transferred to the technical staff of the National Institute for the Control and Eradication of Tsetse and Trypanosomosis (NICETT) in Ethiopia. The system consists of a set of networked databases, one for each of the teams involved in SIT activities (*G. fuscipes* team, *G. pallidipes* team, Blood team, Males Release team and Field team).

The databases are extremely user friendly and enable technicians and team leaders to collect and store the information daily even without any previous skills in databases. In addition, the databases offer the possibility to print prefilled labels and customized recording sheets for the rearing activities. They also offer a full set of standard analyses (more than 100 graphs and reports) that can also be accessed by the managerial staff of the project through a central database stored in the server with live links to the rest of the files. This enables the Insectary Manager to supervise in real time the progress of the different teams, early detect problems and diagnose their cause, which is essential to implement an adaptive management approach.

A similar information management system has been adapted and transferred to the Insectary of Bobo Dioulasso in Burkina Faso under the TC Project BKF5018.

Some of the standard charts available in the information system of the G. f. fuscipes *colony.*

Supporting Area-wide Tsetse and Trypanosomosis Management to Improve Livestock Productivity (RAF5077)

Workshop on Strengthening National Planning in the Formulation and Implementation of Tsetse and Trypanosomosis Intervention Programmes in Member States of the ECOWAS

The workshop was held during 24-28 April 2017 and was hosted by the PATTEC-Burkina Faso office, Bobo Dioulasso, Burkina Faso and was attended by eighteen participants from nine countries (Burkina Faso, Benin, Cote d'Ivoire, Ghana, Mali, Niger, Nigeria, Senegal and Togo) and two lecturers from FAO and AU-PATTEC. The workshop aimed to:

(i) assist Member States in the ECOWAS Sub-region to develop sound project proposals for Tsetse & Trypanosomosis (T&T) interventions that could be submitted to the

IAEA TC programme for technical and financial support and

(ii) contribute to the development of an integrated ECOWAS Sub-regional level strategy for mainstreaming T&T interventions in the sub region's regular/normative programmes.

The first two days were devoted to country presentations and the remaining three days were allocated to discuss and draft a Regional TC Project to be submitted to the IAEA's Department of Technical Cooperation. During the workshop, the common preparatory activities were identified that need to be addressed to initiate T&T interventions using the phased conditional approach and the progressive control programme pathway proposed by the IAEA and FAO. The draft proposal focussed on the following outcomes:

(i) national capacities in entomology, parasitology, and GIS reinforced,

(ii) national and regional tsetse & African Animal Trypanosomosis distribution maps of West Africa generated,

(iii) friction maps and isolated tsetse populations for sustainable SIT implementation identified, and

(iv) suppression pilot projects to eliminate isolated tsetse populations using the SIT in the frame of AW-IPM conducted.

Participants of the Workshop on "Strengthening National Planning in the Formulation and Implementation of Tsetse and Trypanosomosis Intervention Programmes in Member States of the ECOWAS".

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

Significant progress has been achieved in the frame of this mosquito project which aims to develop sterile insect-based approaches as part of an integrated approach to suppress populations of *Aedes* mosquitoes transmitting dengue, Chikungunya and Zika viruses in a pilot study in Tapachula, southern Mexico.

The Mexican counterparts, Centro Regional de Investigación en Salud Pública (CRISP) and El Colegio de la Frontera Sur (ECOSUR) have already selected the pilot sites, two villages, Rio Florido and Ejido Hidalgo, about 3.5 km apart and 5 km from Tapachula respectively.

Using ovitraps, baseline entomological data have been collected for more than 12 months. Mosquito rearing protocols have been established, and the rearing will take place in a new rearing facility constructed for the pilot study. In addition, irradiation protocols for mosquito sterilization have been developed.

The counterparts have also carried out public engagement and public education activities (see picture) followed up by mark-release-recapture experiments to acquire important information about the density of the wild populations, migration phenomena as well as the survival and the dispersal capacity of the male mosquitoes.

Demonstration that SIT male mosquitoes neither bite nor blood-feed, and they do not transmit pathogens. Photo credit: Erika Dominguez.

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

The IAEA Regional TC Project RER5022 was designed to support European regional issues related to the surveillance and control of invasive *Aedes* mosquitoes through the promotion of technical knowledge sharing and the provision of support to initiate area-wide integrated mosquito control pilot programmes integrating a Sterile Insect Technique component.

During the initial workshop that was the official start of the project (22–26 August, 2016, Vienna, Austria), the participants agreed on the need to develop and implement competence and capacity for effective mosquito vector control and surveillance methods.

According to these recommendations, the IAEA started procurement and training activities in order to provide the basic technologies and equipment for effective mosquito surveillance and to establish appropriate laboratories. Training courses were carried out in 2017 that improved skills and competencies for surveillance and identification

methods (23–27 January, 2017, Vienna, Austria), and for field data collection, recording and analysis (3–7 April, 2017, Valencia, Spain) in order to setup effective mosquito pilot control activities and to create or reinforce networking among specialists within participating Member States in the European region.

Expert missions in the different Member States are also under implementation together with the preparation of the annual coordination meeting and new training activities developed in agreement and coordination with the scientific counterparts of Member States.

Supporting Capacity Building for Evaluation of Feasibility of a Progressive Control Programme for New World Screwworm (RLA5067)

Review and Planning Meeting

Participants of the Regional Screwworm Meeting, 12-16 December, Vienna, Austria.

The meeting was held at the IAEA Headquarters in Vienna, Austria, from 12 to 16 December 2016. Participants included project counterparts and experts from the following countries: Argentina, Brazil, Cuba, El Salvador, Ecuador, Mexico, Panama, Paraguay, Peru, Uruguay, and USA. So far outputs of this regional Latin America project include:

- Technicians of participating countries trained on the diagnosis of the New World Screworm (NWS) and myiasis,
- Technical document on a retrospective study of the epidemiology of the NWS available,
- Harmonized methodology for NWS sampling developed and available in participating countries,
- Kit for NWS sampling delivered to Ecuador, Paraguay, Peru and Uruguay,
- Technical document on NWS geographical barriers available,
- Harmonized procedures to implement mating compatibility studies between populations of different geographical origin available,
- Harmonized methodology to conduct studies on socio-economic impact available, and
- Document on socioeconomic impact of NWS in Cuba available to decision makers.

During the meeting it was agreed to extend the project one more year (to 2017) and a list of activities was discussed and agreed. The logical frame work matrix for the new technical cooperation project starting in 2018 was reviewed and finalized. The following recommendations were drawn:

- To increase communication and follow-up activities between the national counterparts and IAEA responsible project officers,
- To increase awareness among the governmental and non-governmental institutions in participating countries, on NWS socioeconomic impact,
- To establish the NWS myiasis obligatory report at national level in both animal and humans in order to improve the knowledge about its epidemiology and effective control methods,
- To engage more countries in Central and South America to actively participate in project RLA5067, in view of the severe economic damage inflicted by the pest to the countries' livestock industries, and the risk to neighbouring NWS-free countries next to the NWS sterile fly biological barrier in the Darien Gap between Panama and Colombia, and
- To incentivize a more active participation of international and regional organizations such as L'Organisation mondiale de la santé animale (OIE), Organismo Internacional Regional de Sanidad Agropecuaria (OIRSA), Inter-American Institute for Cooperation on Agriculture (IICA) and the Pan American Health Organization (PAHO) in project implementation. Meeting participants confirmed the importance of continuing national and regional preventive efforts in NWS-free Central and North American countries, and progressive control in infested Caribbean and South American countries.

Implementing the Sterile Insect Technique for Integrated Control of *Anopheles arabiensis*, Phase II (SUD5038)

Consultative meeting on preparation for SIT mosquito field operation

The counterpart of the project the Project SUD5038 participated in the consultative meeting, held in Vienna from 27 February to 3 March, with the Project Manager Officer (PMO), Technical Officers (TOs), the mosquito staff of the Insect Pest Control section and laboratory to discuss the progress and the future plan for this *Anopheles arabiensis* project in northern Sudan.

The meeting was attended also by the Sudanese National Liaison Officer (NLO), the managers of the rearing facility and the field team of this project.

The first day of the meeting was devoted to presentations by the PMO and project counterpart, Badria Babiker El-Sayed, who reviewed past activities and presented an overview of the project current situation and progress made, in particular the initiation of the construction of the mosquito mass-rearing facility, in Soba, Khartoum. The expected date for completing the construction is January 2018.

Participants of the Consultative Meeting on Preparation for SIT Mosquito Field Operation for the Project SUD5038 "Implementing the Sterile Insect Technique for Integrated Control of Anopheles arabiensis*, Phase II" 27 February- 3 March 2017, Vienna, Austria.*

Fayz Ali, the manager of the mass-rearing facility and Tellal Ageep, the manager of the field team, presented the advances in mass-rearing and field activities, respectively.

The staff of the Human Disease Vectors group of the FAO/IAEA Insect Pest Control Laboratory (IPCL) reviewed recent developments in mosquito mass-rearing technologies. The second day was allocated to discussing the needs and future plans of activities for this project.

The managers for the mass-rearing facility and the field team then spent two days at the IPCL in Seibersdorf to get acquainted with the latest development in mosquito rearing. Furthermore, the staff of the IAEA Procurement Services had a meeting with the Sudanese delegation to discuss the future plan for purchasing a gamma cell irradiator (GC220) and the discussion concluded that the best option in the light of the available funds from the Islamic Development Bank is to refurbish an old machine and use it.

Construction of the Anopheles arabiensis *mosquito mass-rearing facility in Soga, Khartoum, Sudan.*

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)	Kostas Bourtzis Jeremy Bouyer
D4.10.25	Dormancy Management to Enable Mass-rearing and Increase Efficacy of Sterile Insects and Natural Enemies (2014-2019)	Rui Cardoso Pereira
D4.20.16	Comparing Rearing Efficiency and Competitiveness of Sterile Male Strains Produced by Genetic, Transgenic or Symbiont-based Technologies (2015-2020)	Kostas Bourtzis
D4.40.02	Mosquito Handling, Transport, Release and Male Trapping Methods (2015-2020)	Rafael Argiles
D4.10.26	Improved Field Performance of Sterile Male Lepidoptera to Ensure Success in SIT Programmes (2016-2021)	Marc Vreysen
D4.30.03	Integration of the SIT with Biocontrol for Greenhouse Insect Pest Management (2017-2022)	Andrew Parker

Second RCM of the CRP on *Comparing Rearing Efficiency and Competitiveness of Sterile Male Strains Produced by Genetic, Transgenic or Symbiont-based Technologies.* 27-31 March 2017, Panama City, Panama

The Second Research Coordination Meeting of this FAO/IAEA CRP was held at the Holiday Inn, Panama City, Panama. The meeting was attended by 14 scientists from Argentina, Australia, Brazil, China, Germany, Greece, Guatemala, Italy, Mexico, Panama, Thailand and United States of America. In addition, five observers from Australia, Brazil, Italy and Mexico attended this meeting.

Seventeen scientific papers and related scientific presentations were presented and reviewed on the performance of sterile males produced by classical genetic, transgenic or symbiont-based technologies to address the increasing demand for environment-friendly and sustainable integrated pest management approaches for insect pests of agricultural, veterinary or public health importance. During the discussion it was concluded that this CRP is extremely useful since there are several strains available for population suppression of insect pests and disease vectors produced by different technological platforms and there is a need to comparatively evaluate them in respect to their rearing efficiency and male mating competitiveness.

Participants of the Second Research Coordination Meeting of the FAO/IAEA Coordination Research Project on Comparing Rearing Efficiency and Competitiveness of Sterile Male Strains Produced by Genetic, Transgenic or Symbiont-based Technologies, Panama City, Panama.

The CRP has been very productive so far since a significant number of strains from all three technological platforms (classical genetics, transgenic, symbiont-based) and from different target species of agricultural, veterinary and public health importance have already been evaluated.

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

The Second Research Coordination Meeting was held at the Instituto Valenciano de Investigaciones Agrarias (IVIA) and was attended by 20 scientists from Australia, Brazil, Burkina Faso, China, France, French Polynesia, Germany, Indonesia, Italy, Mexico, Philippines, Senegal, South Africa, Spain, Sweden, Thailand, United Kingdom and United States of America.

Participants of the Second RCM of the CRP on "Mosquito Handling, Transport, Release and Male Trapping Methods" (Valencia, Spain).

During the first two days, 22 presentations with the research results since the last RCM were delivered by the participants. During the discussions, it was concluded by the participants that significant progress has been made in the last 18 months, among which we can highlight a new marking method for large amounts of mosquitoes, good progress with sound lures, passive traps and smart traps, and the development of several mosquito release device prototypes, both from the air and from the ground. It was noted that there is a need to produce standard operating procedures to assess the quality of released mosquitoes in order to evaluate the developed prototypes and to harmonise trapping protocols to be able to test the same trapping systems in different environmental settings.

Fourth RCM of the CRP 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

The fourth and final RCM was held at the Vienna International Centre and thirty two participants, including six observers, from eighteen countries attended the RCM. The systematic study of the symbionts associated with pest Tephritid species has resulted in several important breakthroughs:

- The bacteria associated with major tephritid pests have been identified for the first time
- The role of bacteria in mass-rearing facilities has been elucidated for several key pest species
- The effect of sterilizing radiation on the microbiota of several mass-reared species has been documented
- The use of symbionts as probiotic supplements to improve larval rearing and adult quality has been studied in several species of *Anastrepha, Bactrocera*, and *Ceratitis capitata*
- The utility of harnessing symbiotic associations towards the reproductive manipulation and suppression of target populations has been investigated. Specifically, the effect of *Wolbachia* infection on *Ceratitis capitata* has been studied, revealing the practical potential for introducing this bacterium into mass-reared and wild populations
- An online portal has been established describing protocols and techniques for culture-dependent and independent approaches (PCR protocols, symbiont screening, etc.)
- An online tool for calculating distribution of operational taxonomic units generated from new generation sequencing approaches has been developed (Rbplot)
- A computerized database of all microorganisms identified during the CRP has been established and is available online.

Participants of the Fourth RCM on the Use of Symbiotic Bacteria to Reduce Mass-rearing Costs and Increase Mating Success in Selected Fruit Pests in Support of SIT Application and the Consultants Meeting on Improvement of Colony Management in Insect Mass-rearing for SIT Applications. Vienna, Austria.

Overall, the research performed under this CRP has resulted in 22 publications in peer reviewed journals, numerous presentations in international and national scientific meetings, and several theses written by undergraduate and graduate students. Outcomes from the CRP sponsored research are being implemented in the major mass-rearing facilities world-wide. Finally, the collaborative research undertaken has forged lasting interdisciplinary working groups, bridging basic and applied approaches, engaged in furthering the research initiated during the CRP. It is expected that some of the more important research topics of this CRP will have follow-up in a potential new CRP on Improvement of Colony Management in Insect Mass-rearing for SIT Applications. A Special Issue with the results of this CRP is in preparation for publication in a peer-reviewed scientific journal.

Consultants Meeting on *Improvement of Colony Management in Insect Mass-rearing for SIT Applications.* 17-21 May 2017, Vienna, Austria

Five consultant and two observers met in Vienna from 17-22 May 2017 to advise the joint FAO/IAEA Division on the potential and the requirement for improving colony management of insect for sterile insect technique application. Based on their research and experience, the consultants reviewed the major problems encountered during insect colonization and mass-rearing. These problems are:

- poor genetic diversity, pathogen presence, and low performance regularly encountered during insect colonization and adaptation to rearing conditions
- loss of genetic diversity and important symbiotic organisms under continuous mass-rearing often leads to the loss of mating competitiveness, predator avoidance and longevity, and change in circadian rhythm, resulting in colony deterioration
- loss of strain stability or purity of specially designed or selected strains during continuous mass-rearing, resulting in colony deterioration
- colonies in insect mass-rearing facilities frequently threatened by infection or build-up of microbial and viral pathogens, which is exacerbated by the lack of pathogen detection tools
- in the case of human diseases vectors, potential human health issues related to disease transmission.

The consultants concluded that development of improved colony management methods and protocols for insect mass-rearing could mitigate the loss of genetic and symbiotic diversity, enhance insect strain stability, prevent outbreak of insect diseases, and reduce staff health risks at the rearing facilities. This research has important potential to make colony management more sustainable, resulting in more cost-effective SIT programmes. Therefore, they strongly recommended the initiation of a coordinated research project on insect colony management for SIT application.

Third RCM of the CRP on *Dormancy Management to Enable Mass-rearing and Increase Efficacy of Sterile Insects and Natural Enemies.* 29 May–2 June 2017, Vienna, Austria

The Research Coordination Meeting (RCM) was successfully held with the participation of 30 research agreement and contract holders, as well as observers. 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.

Rhagoletis cingulata, *one of the species subject to research under the CRP on Dormancy Management to Enable Mass-rearing and Increase Efficacy of Sterile Insects and Natural Enemies.*

The major achievements by the end of the third RCM included:

- Identified treatments including thermal regimes that use brief warm pulses interspersed with longer periods of dormancy-inducing cold, fluctuating thermal regimes, that enhance the shelf life of beneficial pollinators (e.g., the bee *Megachile rotundata*) and also pest insects targeted for sterile insect technique (e.g., the invasive fly *Drosophila suzukii*).
- Identified dietary components that experimentally enhanced the freeze-tolerance of a tropical fruit fly that does not normally tolerate freeze, *Drosophila melanogaster*, opening up new avenues for using dietary additives to enhance cold storage of tropical fruit flies of economic importance, including those used in sterile insect programmes.
- Identified environmental and pharmacological treatments that can reduce or extend the dormant period in several insects from fruit flies of economic importance (e.g., *Rhagoletis cerasi*, *Rhagoletis pomonella* and *Bactrocera minax*) to beneficial pollinators (e.g., *Osmia bicornis*).
- Identified thermal treatments that increased the efficiency of a natural enemy, the parasitoid wasp *Trichogramma achaeae*, in parasitizing hosts.
- Produced a review paper on insect thermal biology targeted towards less-experienced practitioners and regulators to allow them to better understand and use common approaches in arthropod biology, from performing field experiments on cold temperature tolerance and dormancy to predicting the potential survival range for released arthropods.
- Identified several engineered hormone analogues that can potently terminate seasonal dormancy in two species of economically important moths that can be used to develop novel methods for pest insect control by manipulating dormancy to induce “ecological suicide”.

Developments at the Insect Pest Control Laboratory (IPCL)

LIVESTOCK PESTS

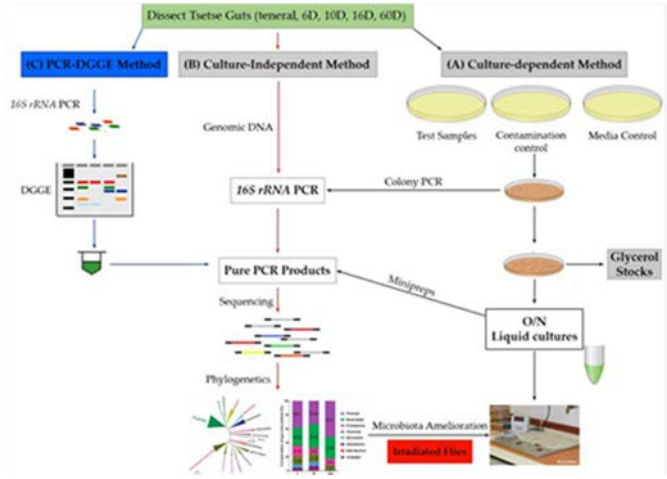
Identification of cultivable tsetse gut microbiota and their effects on fly performance

Tsetse flies are competent vectors of human (sleeping sickness) and animal (nagana) trypanosomoses, a group of neglected tropical diseases that, despite the decrease in prevalence of human sleeping sickness in the last few decades, remains a serious problem for agriculture in much of sub-Saharan Africa.

Tsetse flies harbour three symbiont bacteria (*Wigglesworthia glossinidia*, *Sodalis glossinidius* and *Wolbachia pipientis*), and numerous gut microbiota, in addition to a pathogenic virus (salivary gland hypertrophy virus (SGHV)).

The sterile insect technique (SIT) has proven to be an effective method for integration in area-wide integrated pest management (AW-IPM) progammes that aim to eradicate tsetse fly populations. The SIT involves irradiation-induced sexual sterilization of male flies, a procedure that potentially damages the gut epithelial cells and gut-inhabiting microbiota. This could reduce the biological quality (sexual performance and competitiveness) of the sterile males, and thereby have a negative impact on the success and operational costs of the SIT component.

The beneficial traits conferred to insect hosts by their gut-inhabiting microbiota makes these microorganisms potential agents for improving the quality of the sterile males. The gut microbiota of tsetse flies can be exploited not only to reduce the vectorial capacity to transmit trypanosomes, but also to enhance the quality of the sterile males.



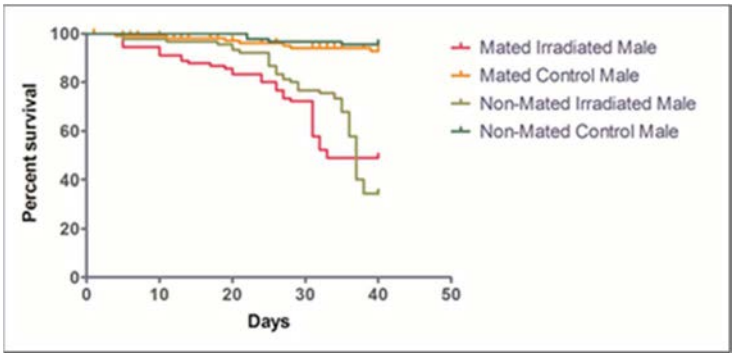
Flow chart for identification of tsetse gut microbiota and assessment of their potential to improve the quality of sterile males used in SIT programmes. The primary approach is culture-dependent (A), which is supplemented with culture-independent approaches (B and C).

We are using culture-dependent and independent approaches (see figure) to identify and characterize gut microbiota that can be used as probiotics to improve the performance of tsetse sterile males. Culture-dependent aerobic and anaerobic cultivation was used to identify the cultivable tsetse gut microbiota. Of the several cultivable major species identified so far, representatives from *Providencia*, *Acinetobacter*, *Enterobacter*, *Serratia* and *Sphingobacterium* species are being evaluated for their probiotic potential.

Preliminary quality control results indicate that blood meals supplemented with high concentration of bacterial isolates (108 CFUs/ml of blood) caused high mortality, especially in females and reduced pupae production. Lower concentrations did not result in high mortality and bioassays are currently on-going to assess the effects on pupae production. This work is conducted by Henry Kariithi, a consultant from Kenya.

Impact of irradiation on longevity of *Glossina morsitans morsitans*

The implementation of SIT requires the production of sterile males of adequate biological quality to be able to survive and compete with wild males for mating with wild females. In past and current tsetse programmes that have an SIT component, the males are sterilized by irradiating the adults or late stage pupae. Recent attempts to separate male from female pupae using a near infra-red sorter device indicates the possibility of separation the male from female pupae when 22-days old. Therefore the impact of irradiating 22-day old pupae on survival of the adults was assessed. The results indicate that female *G. m. morsitans* emerged from pupae exposed to 110 Gy showed no significant difference in survival rate, irrespective whether the females were mated or not. Males, however, that emerged from pupae treated in the same way showed a significantly lower survival rate as compared with untreated control males (see figure). This work was conducted by Güler Demirbas, a consultant from Turkey.

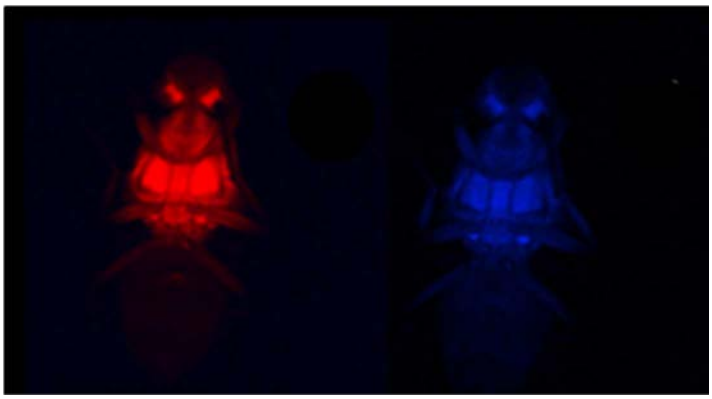


Impact of irradiation on longevity of Glossina morsitans morsitans.

PLANT PESTS

Antioxidant enzymes to mitigate radiation-induced oxidative stress to improve mating performance of sterile male Caribbean fruit fly

Vanessa Simões Dias, a PHD student from Brazil (TC project RLA5070) has been conducting research at the University of Florida to assess the quality and biological profile of transgenic Caribbean fruit fly (*Anastrepha suspensa*) strains. Although SIT has proven to be effective against several fruit fly species, improving the efficacy of the technique and decreasing its costs could promote greater adoption of the SIT. Sterilization of the male flies using radiation can reduce their competitiveness, and increased oxidative stress in living tissues through the production of free radicals during and/or after irradiation is one of the reasons for this reduced quality.



Gene expression of the fluorescent protein markers, DsRed (red) and AmCyan (blue), in transgenic Caribbean fruit flies.

This study is being carried out to assess the effects of increased levels of a key antioxidant enzyme, the mitochondrial superoxide dismutase (MnSOD), an antioxidant enzyme, in Caribbean fruit flies on the quality of the male flies, through a better understanding of the effects of oxidative stress and the potential mitigating effects of antioxidants. By overexpressing MnSOD in *A. suspensa*, it is possible to test whether increasing antioxidant capacity will decrease oxidative stress and increase mating success after irradiation sterilization. Therefore seven transgenic *A. suspensa* lines that overexpress MnSOD were produced.

Preliminary results indicate that these transgenic strains have a higher capacity to increase superoxide dismutase enzymatic activity as compared with normal non-transgenic flies. Small-scale experiments indicated that irradiated flies of two transgenic strains showed greater mating success than irradiated non-transgenic flies.

Currently, tests are being conducted in larger walk-in field cages (that allows males to form leks) to assess the mating competitiveness of sterile males of transgenic Caribbean fruit flies that overexpress mitochondrial SOD as compared with flies that do not overexpress mitochondrial SOD. The ultimate goal of this research is to increase the quality of the sterile males produced.

Anastrepha suspensa *male releasing sexual pheromone and calling females, important aspects of its sexual behavior.*

Assessing the effect of semiochemicals, food supplements and hormone analogue to improve sexual competitiveness of sterile males of the Oriental fruit fly

The effects of protein supplements, methyl eugenol (ME) and juvenile hormone analogue on the mating success of a genetic sexing strain (GSS) of male *Bactrocera dorsalis* were assessed under laboratory conditions. In addition, their optimal age of peak sexual maturity was likewise assessed to determine the appropriate age of sterile males to be released for SIT application. The results showed that protein supplements significantly increased the males' mating success, with more than 50% of the protein-fed males achieving a mating as of day 5. In comparison, males fed on sugar only needed more than 14 days to achieve a similar mating success. Application of juvenile hormone analogue didn't accelerate the males' sexual maturity and ME did also not enhance male mating success. Five to 7 day old *B. dorsalis* GSS males were competitive with 14 day old males in walk-in field cages.

Phytosanitary treatment research

This research is supported under the USDA/IAEA collaborative agreement, "Development of phytosanitary treatments for exotic tephritid fruit flies". The overall objective is to develop broadly applicable phytosanitary treatments against fruit infesting tephritids using the tephritid resources at the IPCL as well as collaborations with other researchers and institutions worldwide.

The development of broadly applicable vapour heat treatments is hampered by the uncertainty over whether populations of the same tephritid species differ in heat tolerance. Research comparing tolerance to vapour heat among 3 populations of *Bactrocera dorsalis* was finished and found no significant differences at the 95% level of confidence, which may help the development of broadly applicable treatments against this pest.

Research comparing cold tolerance of populations of the *Anastrepha fraterculus* complex has been initiated. This research will help guide regulatory decisions that may result from the description of new species out of that complex and help avoid trade obstructions.

Large-scale confirmatory testing continues at 1.1°C for 20 days to develop a phytosanitary cold treatment against *Bactrocera tau* in mandarins. The objective is to kill 30,000 third instars (the most tolerant stage) with no surviving larvae 1 day after termination of treatment.

HUMAN DISEASE VECTORS

Towards the standardization and optimization of irradiation methods for pupae of *Aedes aegypti, Ae. albopictus* and *Anopheles arabiensis*

Several studies have been initiated to develop standardized methods for the sexual sterilization of male mosquitoes for sterile male releases. Dose-response curves for males of the three species in the presence and absence of oxygen have been mapped and clear differences in the induced sterility are observed when irradiated under hypoxic versus normoxic conditions. Further effects of irradiation at sub-sterilizing doses on F_1 progeny are also being investigated. Impending results will contribute to the guidelines for the SIT package for mosquitoes.

Automated mosquito larval counter

Achieving an optimal and synchronized development rate of mosquito immature stages is essential to maximize the productivity and optimize male sorting in a mass-rearing facility. In order to maintain a consistent and standardized larval density and larval diet supplement, it is necessary to control the initial number of larvae present in each larval tray.

The mosquito larvae counter (MLC) is an automated tool capable of counting newly hatched mosquito larvae (L_1 stage) evenly distributed in a water solution. The system consists of

i) a larvae dispenser,

ii) an electronic counting unit, and

iii) a PC control software (see figure).

The mosquito larvae are introduced into the counter through the upper loading funnel and flow out at the bottom of the counter by gravity.

The water flow is controlled and the corresponding number of larvae processed as larvae/sec, which is displayed on the connected PC control unit. The MLC can stop the flow of water automatically when the pre-selected number of larvae has been counted. The present prototype of the MLC has one single counting channel but can be scaled up easily to support and control a maximum of 120 channels.

When newly emerged larvae are processed in a 500 ml water solution free of particles and debris at a density of 10 larvae per ml, a single channel MLC is able to count larvae in about one minute with an accuracy of the measurement < 5% without damaging the larvae. This automatic mosquito larval counter is therefore a useful instrument to standardize and automate enlarged mass-rearing procedures.

The automated mosquito larval counter. The left panel shows a general view of the larval counter, the top right a detailed view of the larvae dispenser and the bottom right the digital display of the larvae counts.

Development of optimal larval diets to mass-rear *Anopheles arabiensis*, *Aedes aegypti* and *Aedes albopictus*

The diets available at the IPLC for the rearing of *Anopheles arabiensis*, *Aedes aegypti* and *Aedes albopictus* are based on bovine liver powder (BLP), tuna meal (TM) and brewer's yeast (BY). These diets are all rather costly and not always available in all Member States, which compromises the efficiency and sustainability of the SIT for mosquitoes. Especially, the BLP is the most expensive as it costs more than 78 times the TM, and more than 6 times the BY.

Efforts have been devoted to improve the cost-efficacy of these diets. Four diet mixtures including TM, BY and chickpea (CP) and 0-25% of BLP are now available for *An. arabiensis* rearing, which entail a 40-92% reduction in costs. Furthermore, investigations into using bacteria dry mass as a nutritional source did improve the diets for the rearing of *Anopheles* and *Aedes* species. Finally, effective insect-based larval diets that including insect proteins without any addition of BLP have been developed for *An. arabiensis*, *Ae. aegypti* and *Ae. albopictus*.

Larval food dispenser

The daily larval feeding procedures that provide the optimal amount of liquid diet to immature mosquito stages are challenging and laborious, but are essential for every mosquito mass-rearing operation required for a sterile insect technique (SIT) programme. The need to produce large quantities of insects encourages the development of automated mass-rearing technologies to improve efficiency and to optimize and standardize labour-intensive rearing procedures.

The larval food dispenser (LFD) is a new device built for the automatic feeding of mosquito larvae cultured inside trays stacked into larval rearing racks (see figure). The LFD is composed of a reservoir tank and a pump system capable of administering with high accuracy (± 5ml) the desired quantity of liquid diet to each tray. The LFD is capable to optically identify the position of the trays stacked

inside the rack and to dispense automatically the correct amount of diet to the different trays.

The new automated larval food dispenser.

The LFD has a high-precision dosing capacity and at the current setting can deliver the diet in 10-12 minutes for a fully stacked rack (50 trays, at 100 ml of diet per tray).

Larval pupal separator

Mass-rearing procedures proposed for the production of *Aedes* mosquito males include the need of effective separation methods for life stages and sexes based on their size characteristics. The present method is based on the use of adjustable glass plates that grades larvae and pupae according to their size, and although laborious, is to date considered the most effective method for the separation of *Aedes* life stages and sexes.

Building further on this approach, a new filter device has been developed at the IPCL. The aluminium filter described here is composed of several filter units that can be connected and separated at various distances by calibrated washers (see figure). The filter units have a characteristic V shape that allows the insect to be easily guided between the filter elements to be selected based on its size. Using a filtering distance of 0.8 mm, this sieve successfully separated *Aedes* larvae and pupae. Different washer spacers will be tested to define the most appropriate filtering distance to successfully separate *Aedes* male and female pupae.

This new tool may improve the laborious and time consuming procedures needed to select the male pupae during mass-rearing procedures.

One step closer to aerial releases of sterile mosquito males

Towards the end of 2016, IPC colleagues, together with the NGO WeRobotics, successfully secured an award of 400 000 USD from the United States Agency for International Development (USAID) under a call for addressing *"Combatting Zika & Future Threats: A Grand Challenge for Development"*. Our proposal, entitled *"Fighting Future Threats Using Autonomous Aerial Robotics"*, will focus on designing a mechanism to be deployed with an unmanned aerial vehicle (UAV) to release sterile male mosquitoes.

The aim is to develop a continuous release system which can release around 200 000 mosquitoes during a 20-30 minute flight. In order to design the holding container, we first need to determine the maximum column height or highest tolerable level of compaction we can impose on immobile mosquitoes. This was calculated by compacting several thousand immobile mosquitoes inside prisms designed to replicate a prototype holding container and then exposing them to varying weights of particles above them, intended to replicate different quantities or column heights of mosquitoes. Each prism was then held at 8°C for 1 hour inside an incubator, and thereafter, mosquitoes were split into two cages, depending on whether they had been in the top or bottom layer whilst compacted. A small sample was taken from both layers for all prisms and mosquitoes were screened under a stereomicroscope for damaged or missing wings and legs.

Additionally, longevity was assessed in each cage until all mosquitoes had died. The next step will be to check the mating competitiveness of mosquitoes from each prism that will allow a final assessment on the maximum tolerable level of compaction we can impose on immobile mosquitoes. From experiments performed thus far at the IPCL, the procedure of immobilization does not appear to impact subsequent survival. When held immobile for up to 24 hours at 4-10°C, although slightly reduced, survival is not significantly lower than that of controls.

Finally, in March 2017 the first release mechanism prototype was tested indoors at the IPCL and the impact on damage, longevity and flight ability investigated. Based upon the results of these tests, further modifications will be made to the release mechanism.

Additionally, IPC colleagues with the help of the Nuclear Science & Instrumentation Laboratory (NSIL) team have also designed and 3D printed a separate release mechanism, based on existing systems used for aerial release of other sterile insects. This system will be tested in the coming weeks. The most suitable prototype release system will be field tested in pilot sites in Peru in late 2017 with a hexacopter UAV.

Quality control methods for mosquito SIT

The ability of released sterile males to survive, disperse, compete with wild males and inseminate wild females is an essential prerequisite to be evaluated in any mosquito suppression programme that includes an SIT component.

Adequate quality control tests supported by standardized procedures need to be developed to measure these parameters and to identify and adjust rearing, handling and release methods affecting the overall male quality.

The ability of insects to fly is one of the most direct and reliable indicators of insect quality and the ability of an insect to fly out from simple flight tube devices is a standard quality control procedure regularly used in many operational SIT programmes.

New filter device allowing larvae / pupae separation. Left, details of V shaped filter units. Right, overview.

Two novel quality control devices have been developed and designed to measure, compare and infer the sterile male mosquito competitiveness by observing their flight ability (see figure).

Survival and insemination potential of irradiated males were successfully predicted using their ability to fly out of narrow plastic tubes (flight organ device) or after aspiration stress exposure (aspirator device).

These simple and cheap tools are practical instruments to identify and correct sub-optimal rearing and handling procedures and to evaluate single and cumulative stress during male production, which may affect the final male quality and their field performance.

The availability of easy and standardized quality control tests could facilitate the adoption of international procedures for evaluation and comparison of mosquito strains and to assess strain suitability for effective mosquito genetic control applications.

Various systems developed to measure mosquito flight ability. Top, aspirator device used to impose an aspiration stress exposure to mosquitoes; bottom left, 40 cm high flight organ device used to test the quality of adults emerging from pupae; bottom right, flight organ device used to test the quality directly of adults.

INSECT GENETICS AND MOLECULAR BIOLOGY

Development of strains for the suppression of *Aedes aegypti* populations using the combined SIT / IIT approach

The transmission of major human pathogens, such as dengue, yellow fever, Chikungunya and Zika, by the mosquito species *Aedes aegypti* and *Aedes albopictus* is quite alarming, due to both the increased number of countries reporting these diseases and the number of people affected by them.

Increased risk is also associated with factors such as insecticide-resistance, climate change, rapid spread due to globalization and the human population´s disregard for eliminating potential breeding sites, as well as the low efficiency of conventional methods caused by the precariousness of the offered services.

The IPCL has been developing the SIT package for the population suppression of both *Aedes aegypti* and *Aedes albopictus*, which is based on the mass-production, sterilization and release of sterile males which will compete with wild males for mating with wild females in the field. Through the continuous release of sterile males in adequate over-flooding ratios, the target population will be suppressed.

Although the basic mosquito SIT package has been developed and is constantly being refined, a critical step for its implementation in the field is the sex separation since male-only releases should be performed given that female mosquitoes, bite, blood feed and can transmit the human pathogens. Until now, there is no efficient sex separation system which can accurately eliminate all female mosquitoes ensuring male-only releases.

For this reason, and until an efficient sex separation method or a genetic sexing strain is developed, the IPCL recommends the combination of the SIT with the incompatible insect technique (IIT), which is based on the *Wolbachia*-induced cytoplasmic incompatibility (a kind a male sterility). Mosquito-*Wolbachia* symbiosis has another interesting property in that in many cases, the symbiont can block the transmission of major human pathogens including dengue, yellow fever, Chikungunya and Zika. So, by combining SIT with IIT, even if a few females are inadvertently released, these females will be fully sterile due to the irradiation treatment and they will be unable to transmit the pathogens due to the *Wolbachia* infection. As a result, male sterility is induced both from the irradiation treatment and the *Wolbachia* infection.

The proof-of-concept of the combined SIT/IIT has been tested against *Aedes albopictus* in collaboration with Zhiyong Xi (Michigan State University, USA) and it is now being expanded against *Aedes aegypti*, using the *Wolbachia*-infected WB2 strain (wAlbB infection) produced in Prof. Xi's laboratory.

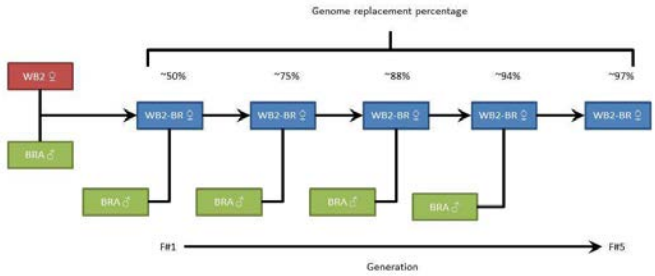
The origin of the mosquito strains is another critical factor associated with the release of sterile mosquitoes. Using populations derived from different geographic origins may put the effectiveness of such approaches at risk due to:

(1) potential reduced mating competitiveness in the field,

(2) increased concerns about the vectorial capacity in case of unintentional release of females (even if they are sterile), or

(3) potential development of genetic admixture (in case of accidental release of mosquitos that are not sterile).

Therefore, introducing the available mosquito strain into the local genetic background is a standard approach before any field application. For example if we want to use the *Wolbachia*-infected WB2 strain for a field trial in Brazil, the genetic background of this *Ae. aegypti* strain needs to be replaced with the Brazilian genetic background through continuous backcrossing of *Wolbachia*-infected females with Brazilian males (line called WB2-BRA) as shown in the figure. Every new generation, the percentage of Brazilian genetic background increases, theoretically reaching around 99% in the 7th generation.



Representation of the crosses for genetic background replacement of WB2 into a Brazilian genetic background.

This genomic introgression might have an impact on the fitness of the new strain (positive or negative). Therefore, the properties of both the *Wolbachia* in the new host and of the newly infected host must be assessed. Different quality control parameters can be measured to evaluate potential fitness enhancement / cost in comparison to a wild-type (control) strain.

We are currently running a comparative analysis of such an introgressed line called WB2-BRA, with the genetic background donor line BRA. Parameters such as fecundity, fertility, longevity and mating competitiveness are being assessed with the objective to determine if there are any statistically significant differences between the lines that can be attributed to the presence of *Wolbachia*.

The effect of irradiation using X- and gamma-rays will also be evaluated to determine the minimum radiation dose required for complete female sterility, both for the *Wolbachia*-infected (WB2_BRA) and uninfected (BRA) laboratory populations of *Ae. aegypti*.

Reports

Consultants Meeting on *Development of a Protocol for the Planning and Implementation of Pilot Trials Using the Sterile Insect Technique against Codling Moth in Selected European Target Areas.* 13-17 February, Vienna, Austria

A consultants meeting was held during 13–17 February 2017 at the IAEA headquarters in Vienna, Austria to develop a detailed protocol for the use of the sterile insect technique (SIT) in pilot trials against codling moth (CM), *Cydia pomonella* (L.) in selected target areas of Europe. The codling moth is a key pest of most pome fruit (apple, pear and quince) and some walnut orchards in the temperate regions of the world. Infestation in neglected apple and pear orchards can reach 60-80%. Up to today, management of the CM still relies in many areas of Europe on the intensive use of broad-spectrum insecticides, which has led to the development of resistance and cross-resistance to most traditionally used organophosphate and pyrethroid insecticides and even in some areas to Insect Growth Regulators (IGRs). The application of these insecticides has in addition resulted in the disruption of the natural control of the secondary pest complex.

Participants of the Consultants Meeting on the SIT for Codling Moth in Europe.

In view of increased awareness of the negative consequences of the use of insecticides and the withdrawal and banning of a number of essential insecticides because of increasing environmental and human health concerns, as well as increasingly resistance to the codling moth granulosis virus, the growers have been facing serious challenges to effectively manage CM in their orchards and to place their pome production on international markets. This has given rise to the need for alternative control tactics of which the sterile insect technique (SIT), which is effectively being applied in Canada, bears great potential.

Twelve international consultants (Austria, Canada, France, Germany, Greece, Italy, Netherlands, UK and USA) participated in the meeting that had the objective to develop a protocol to facilitate the effective implementation of pilot programmes that would rely on the release of sterile insects to manage CM in pome fruit and walnut orchards.

The following issues were deemed important and have been included in the protocol: collection of essential base line data, handling of sterile moths, selection of control tactics, experimental designs, release strategies, monitoring strategies, import of moths, regulatory issues, quality control aspects, public relations, farmer collaboration, staffing, and funding. It is hoped that the protocol will provide some guidance to those parties that are interested in implementing pilot project against CM that have an SIT component.

83rd Annual Meeting of the American Mosquito Control Association, 13-17 February 2017, San Diego, California, USA

The 83rd Annual Meeting of the American Mosquito Control Association took place 13-17 February 2017 at the Town and Country Resort and Convention Center, San Diego, California, USA. The meeting was attended by almost 1000 participants. About 120 oral presentations were presented in 17 different sessions and symposia.

One symposium was devoted on the sterile insect technique (SIT) and how the SIT and related technology could be used to suppress mosquito populations, and particularly of *Aedes* mosquito vector populations transmitting dengue, Chikungunya and Zika.

The meeting also included poster sessions and was characterized by the strong participation of industry, which presented its different products for mosquito control in a large exhibition area.

At the end of the meeting, it was decided that the 84th Annual Meeting of the American Mosquito Control Association will take place in the Sheraton Crown Center, Kansas City, Kansas, USA, 26 February - 2 March 2018.

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)", 10 March 2017, Vienna, Austria

The SUZUKILL is a bilateral (Austria – France) research project which aims to develop new approaches for the population suppression of *Drosophila suzukii* that has become a major fruit crop pest in many countries and is a serious economic threat to soft summer fruit. The annual meeting of SUZUKILL took place at the Vienna International Centre with the participation of researchers from

ECOBIO/Rennes, LBBE/Lyon, IFFF/BOKU Vienna, and the Joint FAO/IAEA Insect Pest Control subprogramme.

Logo of SUZUKILL project.

Oral presentations and discussions focused on four major topics being researched in the project:

(a) the development of sterile insect technique (SIT), including the mass-rearing of this major pest, for greenhouse pilot projects;

(b) the development of the incompatible insect technique (IIT) or combined SIT/IIT approaches;

(c) the study of cold tolerance and its potential exploitation in support of SIT and / or IIT approaches; and

(d) the monitoring of genetic changes which may be occurring during the laboratory domestication in support of mass-rearing and SIT and / or IIT population suppression strategies.

7th Annual Phytosanitary Irradiation Forum, 21-22 March 2017, California, USA

The 7th Annual Phytosanitary Irradiation (PI) Forum was held at Chapman University, California, USA, 21-22 March 2017. The FAO/IAEA is a co-organizer of this event, which brings together industry, regulators, and researchers to discuss the progress and potential use of ionising radiation as a phytosanitary treatment. The FAO/IAEA presented the published results of a Coordinated Research Project (CRP) on generic PI doses which is freely available at http://journals.fcla.edu/flaent/issue/view/4278. The new International Database on Commodity Tolerance created by the Joint Division was introduced and a live demonstration given. It is available at https://nucleus.iaea.org/sites/naipc/IDCT/Pages/default.aspx.

Other presentations covered PI technology and efficacy, highlighting a new dose that USDA-APHIS approved: 290 Gy for tortricid eggs and larvae. Also covered was the important topic of PI of commodities in modified atmosphere storage. It was concluded that only oxygen is the issue, while carbon dioxide levels can be ignored. Further research will aim to more precisely define the threshold where reduction in oxygen level is not of concern.

Industry representatives from Australia and the USA gave an informative combined talk about consumer acceptance of PI-treated produce. They have seen a big growth in irradiated produce in the past 2 years and predict greater growth in the near future. They say that convincing stores to carry irradiated products is the biggest hurdle, and once the product is available consumers buy it.

Several USDA-APHIS speakers gave talks on market access, negotiation of requirements, pre-clearance, export programme, port of entry irradiation, and operational activities. USDA-APHIS also reported on pre-clearance imports using PI. Viet Nam has increased imports greatly in the past 2 years to 5,500 tons. Viet Nam is second behind Mexico for export to USA; Mexico shipped 12,000 tons of guavas to the USA in 2016. In the first 2 months of 2017 Mexico has already shipped over 6,000 tons of guavas. Irradiated Mexican guavas are now available in 3,300 retail stores in the US. Three different maturity classes are marketed.

Mexico has also starting shipping irradiated dragonfruit, pitahaya (yellow dragon fruit), and figs. Thailand has the 3rd largest export programme to the USA with 2 facilities. India now has 3 facilities, doubled their mango export, and started shipping pomegranates. Several new port of entry (USA) irradiation facilities are in the works for the Texas-Mexico border and New Jersey.

India has begun shipping irradiated mangoes to Australia this year. Australia is in the 3rd year of shipping irradiated mangoes to the USA. Thirty percent of all exported Australian mangoes are treated with PI.

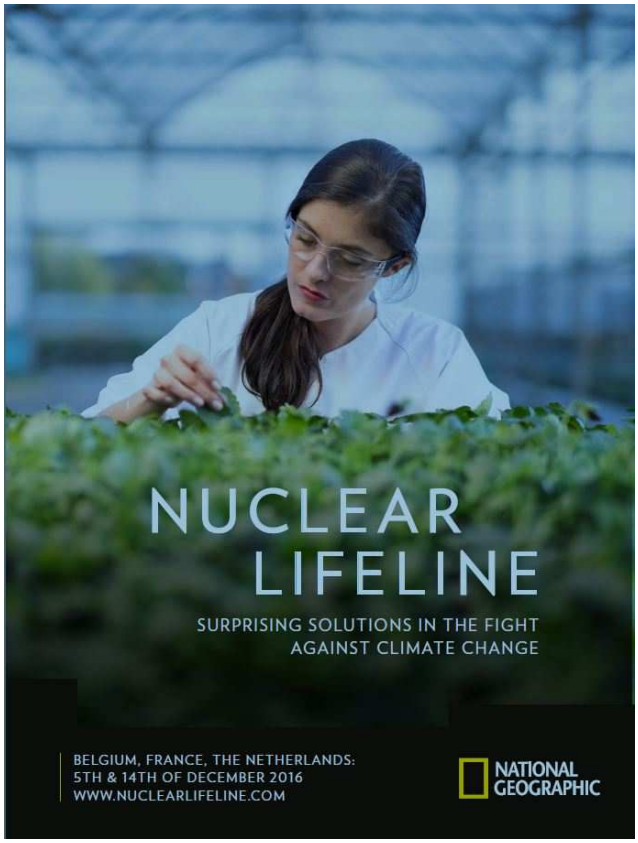
Some conclusions from this meeting are:

- Phytosanitary irradiation (PI) is steadily increasing in volumes, countries, commodities, and pests covered.
- The FAO/IAEA International Database on Commodity Tolerance is a very valuable contribution to implementation of PI.
- The research conducted by the FAO/IAEA CRP on Generic PI Doses will result in many new doses being scheduled for PI.

IPCL featured in National Geographic Documentary: Nuclear Lifeline

The Belgian Nuclear Forum collaborated with National Geographic to develop two documentaries entitled: Nuclear Lifeline: Surprising Solutions in the Fight against Climate Change. The objective was to demonstrate the crucial role nuclear technologies play in the areas of human health, nutrition, agriculture, water etc. The Insect Pest Control Laboratory (IPCL), together with the Programa Moscamed (Guatemala, Mexico and USA) was featured in one of the

episodes entitled: "The utility of nuclear research in several global challenges such as food, agriculture and climate change". The episode was aired in December 2016 in Belgium, the Netherlands and France. The link to download the English version of the episode: https://www.youtube.com/watch?v=6vIAqqxrzms&t=9s or refer to the website of the Nuclear Forum for other languages: https://www.nucleairforum.be/actualiteit/nieuws/de-nucleaire-technologie-in-de-schijnwerpers-in-twee-afleveringen-van-national-geographic https://www.forumnucleaire.be/actus/nouvelle/national-geographic-illustre-la-technologie-nucleaire.



The documentary emphasised that, as a result of rapid growth in travel, trade and globalisation, exotic insect pests are increasingly introduced into new areas and continents. In addition, due to changes in climate, newly introduced insects pests can become established in areas where they could not survive before. As a result, insect pests are expanding their ranges into new latitudes and to higher elevations, causing increased damage to crops, livestock, and especially, exposing more and more people to mosquitoes and other disease-carrying vectors.

The IPCL has been developing with many partners the sterile insect technique (SIT) against some key insects for several decades, and many technologies that were developed in this laboratory are being used in large programmes such as the Programa Moscamed, whose activities are also shown in the documentary.

The documentary recently received a "*Cuckoo Award*", i.e. an award that honours excellence in creativity, strategy, response/results and content in marketing campaigns. The Cuckoo Awards are given to campaigns that have the power to change business with each winner having the perfect combination of visionary strategy, extraordinary content, compelling creativity and breakthrough results.

We congratulate the Belgian Nuclear Forum and the producers of the documentary to this award.

Twelfth Session of the Commission on Phytosanitary Measures (CPM), International Plant Protection Convention, 5-11 April 2017, Incheon, Republic of Korea

The Secretary General of the World Customs Organization (WCO), Mr Kunio Mikuriya, welcomed the CPM members to FAO and emphasized the importance of the International Plant Protection Convention (IPPC) mission to protect the world's plant resources from pests and facilitate safe trade in plants and plant products. Furthermore, his keynote address greatly helped raising awareness on trade facilitation and clearly demonstrated the need for the IPPC to work with the WCO, among other stakeholders, regarding this important issue.

The CPM adopted 8 Annexes of ISPM 28 (Phytosanitary treatments for regulated pests):

- Cold treatment for *Ceratitis capitata* on *Citrus sinensis*
- Cold treatment for *Ceratitis capitata* on *Citrus reticulata* × *C. sinensis*
- Cold treatment for *Ceratitis capitata* on *Citrus limon*
- Cold treatment for *Ceratitis capitata* on *Citrus paradise*
- Cold treatment for *Ceratitis capitata* on *Citrus reticulata*
- Cold treatment for *Ceratitis capitata* on *Citrus clementina*
- Vapour heat treatment for *Ceratitis capitata* on *Mangifera indica*
- Vapour heat treatment for *Bactrocera tryoni* on *Mangifera indica*

Also, the "*Reorganization and Harmonization of Fruit Fly Standards*" was presented to the plenary. From the discussion after the presentation, most contracting parties are in favour of the reorganization, and several applauded the IPPC Technical Panel on Fruit Flies (TPFF) for its work.

Nevertheless, the Comité de Sanidad Vegetal (COSAVE), which is the Regional Plant Protection Organization for the Southern Cone, expressed its concern that Areas of Low Pest Prevalence (ALPP) would become mandatory under a systems approach if ISPM 30 would be moved from a stand-alone Standard to an Annex of ISPM 35.

Announcements

Call for Submission of Research Proposals for a new FAO/IAEA Coordinated Research Project (CRP) on *Colony Management of Insects for Sterile Insect Technique Application*

Sterile Insect Technique (SIT) applications against major insect pests and disease vectors rely on the cost-effective production of high quality sterile males. This largely depends on the optimal management of target pest colonies by maximizing the benefits provided by a genetically rich and pathogen-free mother colony, the presence of symbiotic microorganisms, and an efficient domestication and rearing process that mitigates colony deterioration, while at the same time minimizing or even eliminating the outbreak of viral or microbial pathogens (bacteria, fungi, microsporidia), as well as the use of hazardous chemicals.

The optimization of the colony management for different SIT target insects will ensure a standardized high quality mass-rearing process and the cost-effective production of sterile males with enhanced field performance and male mating competitiveness.

This proposed CRP aims to develop best practices for sustainable insect colony management for the cost-effective production of high quality sterile males for SIT applications against major insect pests and disease vectors through a multidisciplinary approach involving entomologists, geneticists, ecologists, microbiologists, pathologists, virologists, and mass-rearing experts to

(i) prevent or minimize colony deterioration by maintaining a mother colony under relaxed semi-natural conditions,

(ii) prevent or minimize loss of field performance, and

(iii) identify and conserve potential symbionts that enable the insect to combat pathogens and succeed upon field release.

Effective colony management is essential for insect mass-rearing and the successful application of sterile insect techniques. The CRP will address five major problems encountered during insect colonization and insect mass-rearing:

- Poor genetic diversity, pathogen presence, and low performance are regularly encountered during insect colonization and adaptation to rearing conditions.
- Loss of genetic diversity and important symbiotic organisms under continuous mass-rearing often leads to the loss of mating competitiveness, predator avoidance and longevity, and change in circadian rhythm, resulting in colony deterioration.
- Loss of strain stability or purity of specially designed or selected strains are major concerns during continuous mass-rearing, resulting in colony deterioration.
- Colonies in insect mass-rearing facilities are frequently threatened by infection or build-up of microbial and viral pathogens, which is exacerbated by the lack of pathogen detection tools.
- In the case of human disease vectors, potential human health issues related to disease transmission.

The expected duration of the CRP is 5 years (2018-2023) and the first Research Coordination Meeting is planned for **2-6 July 2018 in Vienna, Austria.**

Scientists and researchers who are interested in collaborating in this new CRP should contact Adly Abdalla (a.m.m.abd-alla@iaea.org) or Carlos Caceres (c.e.caceres-barrios@iaea.org). Information on the IAEA Coordinated Research Programme and how to apply for research contracts and research agreements can be found at http://wwwcrp. iaea.org/. Applications should be submitted by **31 December 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,* 6 November–1 December 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, ani-

mal 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.

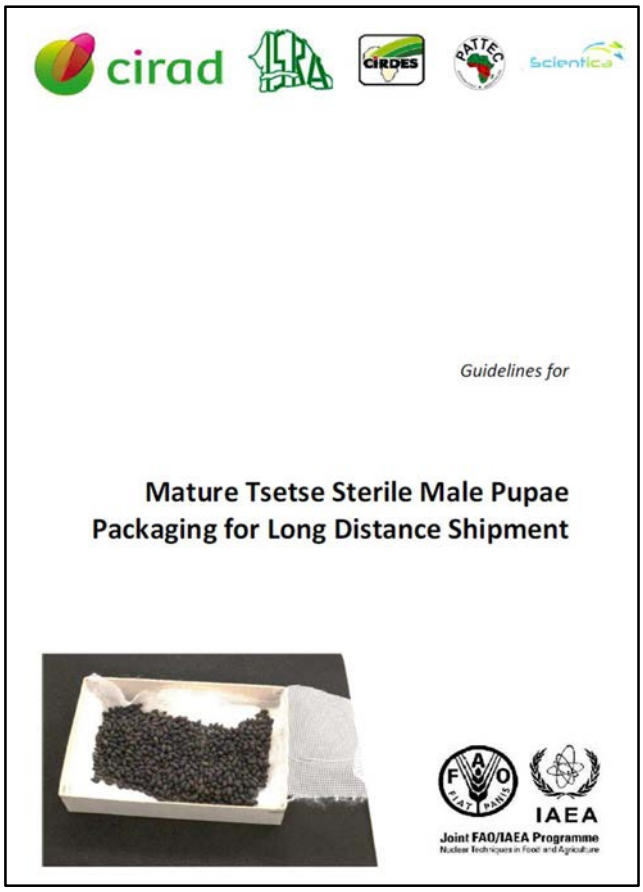
Application Procedure: Nominations should be submitted on the standard IAEA application form for training courses/workshops (downloadable from: http://www-tc.iaea.org/tcweb/participion/astrainee/default.asp). Completed forms should be endorsed by and submitted through the official channels established (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: 31 July 2017).**

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

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

Mature Tsetse Sterile Male Pupae Packaging for Long Distance

Guidelines for the long-distance transport of irradiated male tsetse pupae were recently developed as a result of collaboration between the FAO/IAEA Insect Pest Control Laboratory, Centre International de Recherche-Developpement Sur l'Elevage en Zone Subhumide (CIRDES) in Burkina Faso, Institut Senegalais de Recherches Agricoles (ISRA) in Senegal, Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) and the Slovak Academy of Sciences. The shipment procedure includes the use of a) phase change material packs for temperature stabilization, b) humidity control packs, and c) packing material allowing limiting mechanical shocks and vibrations received by the pupae. The protocol was tested as part of the tsetse eradication programme in Senegal. It was applied to the transport of pupae from Burkina and Slovakia to Senegal, trying to minimize the impact of the long-distance shipment on the quality of sterile males. It is available on the IPCS website (http://www-naweb.iaea.org/nafa/ipc/public/Long-distance-shipment-tsetse-pupae.pdf).



In Memoriam

Donald O. McInnis (1951-2017)

It is with great sadness that we inform you that we and the fruit fly community have lost our great friend and colleague, Don McInnis. After a brief illness, Don passed away at home on June 8, surrounded by his family.

Don obtained his PhD in genetics at North Carolina State University and initiated his career at USDA-ARS as a geneticist to assist the New World Screwworm eradication programme in the USA and northern Mexico. After the eradication of the pest from the USA he became a fruit fly researcher at USDA-ARS in Honolulu, where for nearly 30 years he worked in the area of population genetics, SIT, rearing and area-wide management.

Don (and colleagues) had a major impact on our understanding of the SIT. He developed a system to score mating competiveness in sterile insects, was one of the first to report behavioural resistance of medfly in the field to sterile insects, demonstrated the importance of sexing strains, and developed a pupal colour strain of melon fly. He also did many behavioural field cage studies to assess strains and was a pioneer of large scale open field evaluations of medfly genetic sexing strains and SIT application.

Don served on the California Medfly Science Advisory Panel and was instrumental in maintaining to this day California free of this and other major polyphagous fruit flies. He also served in various other advisory groups for other major pest action programmes, as well as in support of FAO and IAEA.

After his retirement from ARS, Don continued to be active in the fruit fly community, consulting and helping out on expert missions, training courses and field cage mating evaluations in various countries.

Those of us who were lucky enough to have known Don will always remember him as a great scientist and wise technical advisor, but even more for his great friendship, generosity of heart, and his positive and, most assuredly, good nature and humour.

Don loved travelling as well as his sports, being an avid soccer, basketball and football fan. Never the 'shy' one, Don made sure that meetings were never boring and was one of the star performers in "buggy-buggy-bye-bye" performance at the ISFFEI global fruit fly meeting in Salvador, Brazil.

The only thing Don loved more than fruit flies was his family. They were #1 in his life. Don and his wife Peggy raised three wonderful children, Brian, Julie and Megan on Oahu were they became "locals" in the community.

A hui hou [Good-bye, until we meet again]

E pili mau na pomaika`i ia `oe [May blessings ever be with you]

Other News

USDA Announces Eradication of New World Screwworm in Florida

USDA's Animal and Plant Health Inspection Service (APHIS) is announcing the successful eradication of the New World screwworm (NWS) from Florida.

"I want to personally thank our many collaborating partners at the Federal, State, and local levels," said Dr. Jack Shere, USDA Chief Veterinarian. "Through their dedication and professionalism close to 154 million sterile flies have been released, 16,902 animals have been inspected at checkpoints, and almost 430 hours of active surveillance in the Keys and 250 hours of active surveillance on the mainland have been completed. Their tireless work has allowed us to eliminate New World screwworm from the United States once again."

Animal health checkpoints, or interdiction stations, were closed on Saturday. The last sterile fly releases in Homestead, FL took place on Tuesday and fly releases are scheduled to end on 25 April 2017 in the Florida Keys.

*Myiasis caused by New World Screwworm in Key deer (*Odocoileus virginianus clavium*) in Florida Keys.*

APHIS considers an area to be screwworm-free through surveillance which includes trapping flies and visually inspecting animals for signs and symptoms of NWS infestation. No new cases of NWS have been reported in Florida since January 10. Science shows that, when sterile flies are released, elimination of NWS is achieved three life cycles after the last detection.

The flies have on average a 21-day life cycle and they continue to circulate in the area for three weeks beyond each release. In the Keys, APHIS will complete five life cycles beyond the last positive screwworm detection. Out of an abundance of caution, APHIS also released flies in the Homestead area for three completed life cycles.

APHIS and Florida Department of Agriculture and Consumer Services (FDACS) will continue passive surveillance to ensure any new findings are quickly identified. This surveillance includes veterinarians reporting any suspicious cases, wildlife surveillance, concerned citizens that see suspicious wounds on animals or even on a person, and continued communication with the parks and the National Key Deer Refuge.

APHIS began releasing sterile flies in October 2016, as part of aggressive eradication effort undertaken in collaboration with the U.S. Fish and Wildlife Service, FDACS, and local partners. More information about the screwworm response can be found here: https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/animal-disease-information/cattle-disease-information/nws.

Source: USDA Animal and Plant Health Inspection Service sent this bulletin at 03/23/2017 02:05 PM EDT.

Tweaking Pepper Weevil Reproduction. Tiny Bug a Massive Problem for Ontario Pepper Growers

"Cobalt-60 and the Pepper Weevils". It could be a great name for a fusion punk band, or the basis for scientific research related to miniscule doses of nuclear radiation to control agricultural pests. In this case, it's the latter.

Radiation has been used for decades to control insect pests. It's called sterile insect technique, and it's very complicated and quite simple at the same time. It has to do with mating.

University of Guelph School of Environmental Sciences professor Cynthia Scott-Dupree is looking into using it as a kind of birth control method for the pepper weevil, a tiny, hairy-looking bug that burrows into peppers and devours them from the inside. It's a big, devastating problem for pepper growers in Ontario and beyond.

"In Ontario, we grow a lot of peppers in fields and greenhouses, and thus the concern about it in our agriculture sector in the province," she said in an interview.

Scott-Dupree, who holds the Bayer CropScience Chair in Sustainable Pest Management, said she has entered into a multi-year study in conjunction with Bruce Power in Tiverton, ON, and Nordion, a supplier of medical isotopes, to use Cobalt-60 to sterilize pepper weevils.

"Sterile insect technique, which is basically the birth control method I'm working with for these particular insect pests, was developed in the 50s, initially to control screwworms in cattle," she said. "It has proven very successful wherever it has been used."

There is a successful program using Cobalt-60 that controls codling moth, an apple pest, in the Okanagan Valley.

While this kind of thing has been done before, figuring out the exact dosage of radiation needed to do the job involves some highly involved and precise science. It will take time.

"We will rear pepper weevil in the laboratory, and then we will expose them to Cobalt-60 radiation in a contained facility, which will be Nordion in Ottawa," she explained. "What we're focusing on is finding the right dose that will sterilize the insect, but not affect any of their behavioural traits. They have to look and act like normal pepper weevil."

The pepper weevil is the subject of radiation pest control science at the University of Guelph. Facebook image.

If sterile weevils can be produced under highly controlled and contained laboratory conditions – and there is a strong likelihood they can be - the goal is to then incorporate them into greenhouse environments to control the populations. Sterile weevils mate with unsterilized ones, rendering the eggs unviable, thereby controlling the population.

At the same time, such an innovation is expected to reduce the dependency on insecticides to control the pest.

Cobalt-60 is a radioactive form of cobalt produced in Bruce Power's nuclear power reactors. It is used to help sterilize medical devices, and treat brain tumours.

The use of Cobalt-60 to control pests is considered environmentally-friendly. There is no danger of the pepper weevils spreading radiation, Scott-Dupree said.

Source: GuelphToday.com.

Montelíbano and Santa Rosa Mediterranean Fruit Fly Free Places and Sites of Production, Honduras, Central America

To be able to export melon (*Cucumis melo* L.) from Honduras to Taiwan the requisite was to export from an area free of the Mediterranean fruit fly (or medfly) and other fruit fly pests of quarantine significance. Nevertheless, the area where Montelíbano and Santa Rosa are located does not have such a phytosanitary status for these pests. The only area recognized having such a phytosanitary status for medfly only in Honduras is the Valle del Río Aguan, declared by the Servicio Nacional de Sanidad e Inocuidad Agroalimentaria y Agropecuaria (SENASA), in 2002.

Melon production and harvest in Honduras.

Through a careful review of the International Standards of Phytosanitary Measures (ISPM), SENASA determined that the pest risk mitigation scheme that could apply in this case was the "*Pest free places of production and pest free production sites*". This pest risk mitigation scheme is presented and described in detail in ISPM No. 10 "*Requirements for the establishment of pest free places of production and pest free production sites*". This concept is defined as follows: "Place or site of production in which a specific pest is absent as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period" (ISPM No. 5).

Following international fruit fly trapping guidelines (Appendix 1 of ISPM 26; IAEA 2013), SENASA established the fruit fly surveillance network in July 2011 for the Montelíbano production site of 400 hectares. 80 traps were placed in the commercial production areas (40 against medfly and 40 against *Anastrepha* species and other non-native fruity fly pests) and 60 traps in the buffer areas (30 against medfly and 30 against *Anastrepha* species and other non-native fruity fly pests). For the Santa Rosa production site of 800 hectares, 164 traps were placed at the production areas (82 against medfly and 82 against *Anastrepha* species and other non-native fruity fly pests) and 100 traps in the buffer areas (80 against medfly and 20 against *Anastrepha* species and other non-native fruity fly pests).

For the Montelíbano area results indicated zero captures of fruit fly pests of concern, including *C. capitata,* during 294 consecutive weeks (5.6 years) in the commercial area and 177 weeks (3.4 years) in the buffer area. The Santa Rosa area registered zero captures for 234 consecutive weeks (4.5 years) in the commercial area and 169 weeks (3.2 years) in the buffer area.

Trapping results clearly indicated the absence of fruit fly pests in the areas of interest. These results and the fact that melon is defined as a conditional host of the target fruit fly species were the critical technical factors used in the bilateral negotiations between the phytosanitary authorities of Honduras and Taiwan that resulted in an agreement to export melons using a pest risk mitigation scheme.

A work plan presenting clear technical guidelines was prepared and used as the basis for exports. It includes the following phytosanitary measures:

- All the melons for export to Taiwan must originate from registered and qualified orchards
- One month prior to the start of the export process to Taiwan, SENASA shall inspect the packing houses in pest free production sites to ensure and confirm that all packing houses comply with these quarantine requirements
- If the boxes used for packing have ventilation holes, these ventilation holes shall be sealed with a screen consisting of fine meshes with pores of 1.6 mm or less in diameter to prevent pest infestation
- Melon export inspection operations shall be conducted inside packing houses located in pest free production sites
- Melons which have been packed shall be inspected by SENASA staff members. The inspected samples must be at least 2% of the packages in each lot
- If any living Mediterranean fruit fly is found during inspection, that lot of melons shall be prohibited from being exported to Taiwan. In addition, the pest free production site status for export to Taiwan shall be suspended for the production site of the aforementioned melons
- Melons which have passed inspection for export to Taiwan shall be accompanied by phytosanitary certificates issued by SENASA.

A major advantage of this pest risk mitigation scheme is that no internal quarantine checkpoints are required and that places and sites of production need to be fruit fly free only during the entire fruit production and harvest period.
This pest risk mitigation scheme will allow Honduras to diversify its export markets by the opening of trade with Taiwan. Current melon exports from Honduras to Japan amount to US $3.6 million per year.

Source: Noe Pino Cesar Augusto, Servicio Nacional de Sanidad e Inocuidad Agroalimentaria y Agropecuaria (SENASA), Honduras.

Updated Electronic Multi-entry Keys for Identification of African Fruit-infesting Tephritidae

The morphological identification of African tephritids largely depends on the use of classical single-entry (dichotomous) keys, which are available for most African genera. The main disadvantage of such single-entry keys, however, is that species identification inevitably fails whenever the user is not able to select any of the dichotomous character states listed in the key (e.g., due to inadequate taxonomic expertise, lack of clarity, damaged specimen, etc.). Additionally, the specific terminology used in published keys represents a serious obstacle of the aforementioned issues.

To try and reduce the effects, a set multi-entry identification keys for African fruit flies was developed for the non-specialist by researchers of the Royal Museum for Central Africa (RMCA, Tervuren, Belgium), in collaboration with Dr Ian White (formerly Natural History Museum London, UK). This work was financially supported by the Belgian Directorate-General for Development Cooperation (framework agreement with RMCA) and the International Atomic Energy Agency (IAEA contract Nr 16859).

The keys provide a professional identification tool that is also accessible to non-specialists (i.e., people that might be interested in fruit fly identification such as students, technicians, agronomists, quarantine officers, ecologists, farmers, molecular biologists, etc.).

Matrixes containing scores for 340 characters from 400 frugivorous African species, including those of the main genera like *Bactrocera*, *Ceratitis* and *Dacus*, were compiled from data sets that were used within the framework of previous taxonomic revisions. These scores were transferred into separate data sets, imported into LUCID software (www.lucidcentral.org), and used as the main data sources for the multi-entry identification keys. Linked to the characters, an image library illustrating the different states and their variability was added. Further specifications and details on the keys can be found in Virgilio et al. (2014): http://zookeys.pensoft.net/articles .php?id=4091.

The keys are also freely downloadable on: https://fruitflykeys.africamuseum.be/.

Recently, factsheets for 29 of the economically important species were compiled. These factsheets comprise information on or suitable links to aspects pertaining taxonomy, DNA barcoding, biology, host plant range, impact, management, trapping and distribution where applicable.

The factsheets were compiled within the framework of two network projects by researchers from European and African institutions: The "ERAfrica_NI_027 Fruit Fly" project and the networking project "BL/37/FWI 08 FRUITFLY" funded by the Belgian Science Policy.

They can be consulted or downloaded on: https://fruitflykeys.africamuseum.be/en/pdf_keys.html. The main idea now is to convert the electronic key into a mobile application for the identification of African tephritids of economic importance and provide all necessary links in this app to the additional information.

Source: Marc De Meyer and Massimiliano Virgilio (4 May 2017).

Irradiation of Fresh Produce: New Database Will Help Determine the Right Disinfestation Dose

What is the correct radiation dosage for disinfesting fresh products to eliminate the risk of carrying new invasive pests into importing countries? A new database developed by the IAEA, in collaboration with the Food and Agriculture Organization of the United Nations (FAO), will help regulators and the industry better answer that question.

Fresh produce such as fruits, vegetables and cut flowers must be disinfested of regulated pests before being shipped out of infested areas. The most commonly used phytosanitary treatments are cold, heat, chemical fumigants and, increasingly, ionizing irradiation. With increasing restrictions placed on the use of chemical fumigants, the use of commercial phytosanitary irradiation is steadily rising.

The new International Database on Commodity Tolerance (IDCT) (https://nucleus.iaea.org/sites/naipc/IDCT/Pages/default.aspx) screens and interprets technical information in the scientific literature about the quality of fruits and vegetables after they have received ionizing radiation as phytosanitary treatment. The data can be used to determine the maximum doses of radiation that different types of fresh commodities including fruits, vegetables and cut flowers can tolerate.

The database already contains information on 89 fresh commodities and more are being added. "This information will help users optimize phytosanitary irradiation doses without having to go through hundreds of research papers on the topic," said Guy Hallman, research entomologist at the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, and one of the information architects of the database.

Compared to other commercial treatments, irradiation has several major advantages, according to Hallman. "Each of the traditional treatments works only for certain types of commodities. For example, methyl bromide fumigations are good for citrus fruits, grapes and cut flowers, but are not tolerated by most tropical fruits," he said. By contrast, more fresh fruits and vegetables tolerate radiation than any other commercial phytosanitary treatment. "Phytosanitary irradiation is an effective and safe method."

Despite the recent growth in phytosanitary irradiation, which is now accepted by more than 60 importing countries, the total amount of fresh produce disinfested through irradiation remains rather small. In 2016, around 30 000 metric tons of fresh produce was irradiated worldwide, while 350 000 tons of mangoes were disinfested with a hot water treatment in Mexico alone.

Barriers to the expansion of irradiation treatment include steep initial investment costs, strict government regulation and general perceptions of radiation technology, Hallman said. "Several countries do not accept fresh produce treated with irradiation at all," said Hallman – even though the method leaves no residues in the produce undergoing treatment.

As irradiation makes up only a small, although growing share of phytosanitary measures used worldwide, getting precise and accurate information on the proper doses of radiation for different types of commodities is challenging. "More and more countries are starting to see its benefits and are considering adopting this method, and that is why this new database can be very useful," said Hallman.

The database is an extension of the International Database on Insect Disinfestation and Sterilization (IDIDAS) (https://nucleus.iaea.org/Pages/ididas.aspx), a database initially developed in 2004 that is a global compendium of information on the doses of radiation required by many different types of pest insects to guarantee reproductive sterility of adult insects when applying the sterile insect technique or of immature insect stages – eggs, larvae and pupae – when disinfecting commodities as part of phytosanitary irradiation.

In addition to creating and maintaining databases on pest control through irradiation, the IAEA and the FAO co-organize the Annual Chapman Phytosanitary Irradiation Forum at Chapman University in California. The objective of this forum is to increase the understanding and use of irradiation treatment to enhance global trade and prevent the international spread invasive pests. Experts from the Joint FAO/IAEA Division delivered a session on the two databases at the Seventh Annual Forum on 21-22 March 2017.

Source: Office of Public Information and Communication, IAEA.

The Proceedings of the 9th International Symposium on Fruit Flies of Economic Importance Have Been Published

The *Proceedings of the 9th International Symposium on Fruit Flies of Economic Importance*, that took place in Thailand in 2014, have now been published online. The publication can be viewed https://nucleus.iaea.org/sites/naipc/twd/Documents/Proceedings_9thISFFEI.pdf. The document contains thirty-four papers on a broad range of topics concerning fruit flies, including area-wide programmes, control methods and supporting technology, chemical ecology and attractants, biology, ecology, physiology and behaviour, the Sterile Insect Technique, natural enemies and biological control, and risk analysis.

The symposium is a quadrennial event that first took place in Greece in 1982, and has since been held on five continents, reflecting the widespread nature of the economic threat posed by fruit flies. The 10th International Symposium will take place in Tapachula, Mexico, 23-27 April 2018.

IAEA Deputy Director General Aldo Malavasi, who chaired the International Fruit Fly Steering Committee responsible for organizing the 9th Symposium, commented on the rising global demand for fresh fruit and vegetables and recognized their importance in addressing non-communicable diseases, such as diabetes and obesity. "The global market for fresh produce is a lucrative economic opportunity for many countries, but the threat of the many fruit fly species can be a serious deterrent to investment and trade. These symposia are an ideal opportunity to share global know-how on the issue and the papers published today in the Proceedings reflect the essential advances that can be, and are being, made".

Mr Malavasi recognised the work of the organisers of the 9th Symposium, as well as the editors of these Proceedings (Beatriz Sabater-Muñoz, Teresa Vera, Rui Pereira and Watchreeporn Orankanok), and the role of the Joint FAO/IAEA Division that has supported and participated in all nine Symposia over the past 35 years.

Source: Office of Public Information and Communication, IAEA.

Teamwork Award from FAO-AG Department to IPPC-IAEA Joint Team on the Fruit Fly Standards

On 26 January 2017 an award for exceptional teamwork was conferred to the cross-UN agency team consisting of staff from the Joint FAO/International Atomic Energy Agency (IAEA) Division of Nuclear Techniques in Food and Agriculture, and staff from the Standard-setting Unit of the IPPC Secretariat in Rome. The award is an honour bestowed upon staff of the Agriculture and Consumer Protection Department of FAO "who carry out activities through exceptional teamwork that have a major impact on meeting the UN Sustainable Development Goals and the FAO strategic objectives".

Over the past 12 years, the IPPC-FAO/IAEA joint team has worked first to facilitate the development of a suite of fruit fly international standards (the last of which was adopted in 2016) and second to reorganize and harmonize those fruit fly standards to enhance countries' understanding and ability to implement them at a national level. Enhanced implementation of the standards will help limit the spread of invasive fruit fly pests, which in turn will help reduce poverty as farmers will have a higher yield, less loss and increased opportunity to trade. Ultimately, this reorganization of the fruit fly standards will help improve the living conditions of farmers, including smallholder farmers from some of the poorest parts of the world.

In addition, the joint team has worked collaboratively on raising awareness about ensuring safer trade and the importance of preventing and limiting the spread of fruit fly pests through the international movement of commodities. Examples are the news article on "Host status", the side event "Stop those pests!" held during the 43rd session of the Committee on Food Security, and the many training courses and workshops that have been conducted in Member States.

Brent Larson from IPPC receiving the Teamwork Award.

As Eva Moller, IPPC Secretariat, said: "Sometimes, we may think that doing our job is nothing exceptional. We all try to give our best every day, knowing that we work for a noble cause and wishing to do our bit to meet our overall goals. We know that, but we did not know that all this is in fact not to be taken for granted - that it is in fact exceptional."

Rui Cardoso Pereira, Joint FAO/IAEA Division, agreed: "We won the award because of the dedication of our team to the work and because we have managed to find ways of smooth and inclusive collaboration between our organizations. Communication has been continuing and support from management strong, leading to effective results that will have a decisive impact at the national and international levels."

While the joint team officially includes only those who have supported the work on a daily basis, many more staff from the two organizations and numerous external experts have been involved over time, and the results attained would not have been possible without them, in particular the experts of the IPPC Technical Panel on Pest Free Areas and Systems Approaches for Fruit Flies (TPFF), as well as the Standards Committee.

The joint team includes the following FAO/IAEA/IPPC staff members:

1) the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture Rui Cardoso Pereira, Entomologist and member of the TPFF, Walther Enkerlin, Entomologist and former member of the TPFF, and Nima Mashayekhi, Support to the TPFF meetings; and

2) the IPPC Secretariat members Brent Larson, Standards Officer, Eva Moller, Support to the TPFF, and Céline Germain, Support to the TPFF.

Source: Office of Public Information and Communication, IAEA.

Relevant Published Articles

Non-host status of papaya cultivars to the oriental fruit fly, *Bactrocera dorsalis* (Diptera: Tephritidae), in relation to the degree of fruit ripeness

Domingos Cugala[1], João Jone Jordane[2] and Sunday Ekesi[3]

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[3]*International Centre of Insect Physiology and Ecology (icipe), PO Box 30772-00100 Nairobi, Kenya.*

Abstract

Phytosanitary measures are a major barrier to trade in papaya. We assessed the infestation of tephritid fruit flies on different stages of maturity of papaya, to determine its non-host stage of maturity, for market access. Papaya fruits were collected from Kilifi and Embu counties, Kenya from March 2013 to December 2014, to assess the level of infestation by fruit flies according to the degree of fruit ripening. In all locations, no fruit fly infestation was recorded on papaya when fruits were at the 0, 25 and 50% yellow fruit ripening stage. *Bactrocera dorsalis* (Hendel) was, however, observed attacking fruits when papaya fruits were at 75 and 100% all yellow (fully ripe fruit ripening stage), with infestations of 0.19−0.51 *B. dorsalis*/kg fruit and 0.24−1.24 *B. dorsalis*/kg fruit, respectively, in all locations. Field cage exposure of *B. dorsalis* to fruits of five papaya cultivars—'Papino', 'Neo Essence', 'Sunrise Solo', 'Tainung No. 1' and 'Tainung No. 2' in Manica Province, Mozambique—showed that *B. dorsalis* did not infest fruits at 0, 25 and 50% yellow ripening stages at the densities of 50 and 100 flies per cage. However, at 75% yellow ripening stage, up to 13.1 pupae/kg of fruits was recorded at a density of 150 flies per cage in Tainung No. 1, and infestation ranged from 4.5 to 136 pupae/kg fruits at 100% yellow ripening stage across all the cultivars and infestation densities. Laboratory evaluation of volatiles emanating from freshly crushed papaya pulp of four cultivars: 'Sunrise Solo', 'Red Lady', 'Papayi' and 'Apoyo' on egg viability of *B. dorsalis* showed that at 0, 25 and 50% yellow, egg hatchability was inhibited, suggesting that semiochemical compounds present in green tissues of papaya prevent egg development, although this effect was variable across the four cultivars and ripening stages. Export papaya is harvested at less than 40% yellow ripening stage. Our results, therefore, suggest that quarantine treatment for fruits at this ripening stage is inconsequential, as *B. dorsalis* does not infest papaya fruits at this stage; thus, authorities should permit entry of these papaya cultivars of less than 40% yellow ripening stage to quarantine-sensitive markets.

The full paper was published in: International Journal of Tropical Insect Science (2017) 37: 19-29.

Development of a mechanical sexing system to improve the efficacy of an area-wide sterile insect release programme to control American serpentine leafminer (Diptera: Agromyzidae) in Canadian ornamental greenhouses

Maryam Sultan, Rose Buitenhuis, Graeme Murphy and Cynthia D Scott-Dupree

School of Environmental Sciences, University of Guelph, Guelph, ON, Canada.

Abstract

Background: The American serpentine leafminer (ASL), *Liriomyza trifolii* (Burgess), is a significant pest of greenhouse ornamental crops, and females damage leaf tissue with their ovipositor during feeding and oviposition. The sterile insect technique has been advocated as a non-chemical alternative to currently available control methods. In area-wide sterile insect release programmes, males act as true vectors of sterility. Females should be eliminated from a cohort of pupae prior to irradiation to maximise production economics and sterility spread. The aim of this research was to develop a mechanical sexing system based on pupal size to reduce the proportion of ASL females.

Results: Cumulative frequency distributions were used to examine significant differences in male and female pupal length and dorsal and lateral width distributions. Optimum size cut-off points based on the largest differences in distribution curves were used to determine the dimensions of three different sieve designs. Sieve pores measuring 1.543 mm by 0.765 mm excluded 76% of female pupae and doubled the proportion of males in the throughput sample.

Conclusion: Pupal sexual dimorphisms identified in this research can be used to design a sieve to aid in reducing the proportion of females prior to irradiation, thus improving the efficacy of an area-wide sterile insect release programme.

The full paper was published in: Pest Management Science 73: 830–837.

Can Polyphagous Invasive Tephritid Pest Populations Escape Detection for Years under Favorable Climatic and Host Conditions?

D.O. McInnis[1], J. Hendrichs[2], T. Shelly[3], N. Barr[4], K. Hoffman[5], R. Rodriguez[6], D.R. Lance[7], K. Bloem[8], D.M. Suckling[9], W. Enkerlin[2], P. Gomes[7], K.H. Tan[10]

[1]USDA/ARS (retired),
[2]FAO/IAEA, Vienna, Austria,
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[5]CDFA, Sacramento, CA, USA,
[6]SAG, Santiago, Chile,
[7]USDA/APHIS/CPHST (retired);
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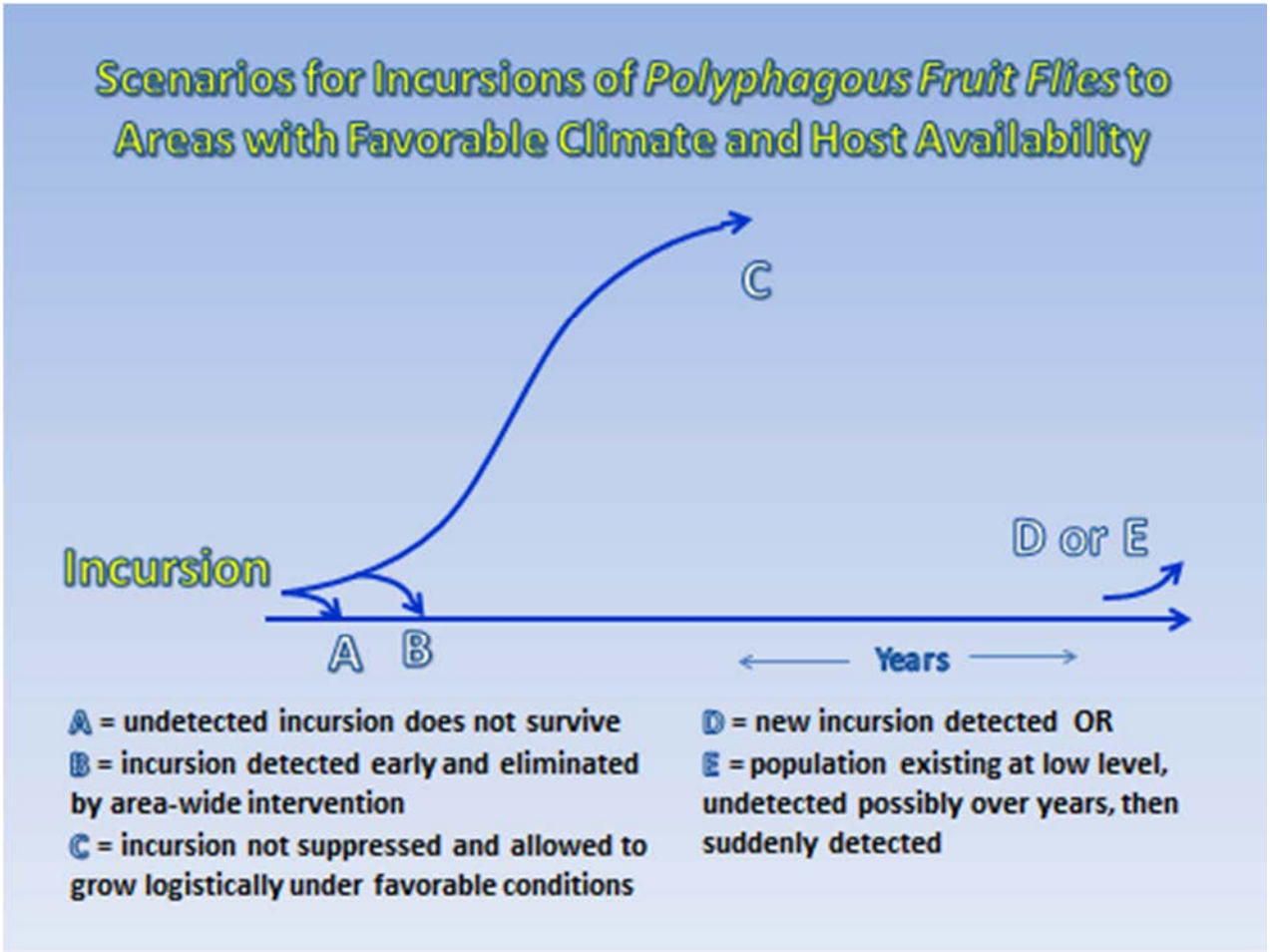
[9]The New Zealand Institute for Plant & Food Research Limited and University of Auckland, Christchurch, New Zealand,
[10]Mobula Research, Penang, Malaysia

Summary

- Theory predicts that most fruit fly incursions do not survive to become self-sustaining populations (Fig. 1, **scenario A**) or are eliminated quickly after detection and area-wide intervention (Fig. 1, **scenario B**).
- Under favorable growing conditions, if not detected and eliminated by area-wide intervention, r-selected fruit fly populations will increase rapidly (Fig. 1, **scenario C**).
- Genetic evidence and incursion outbreak patterns in Australia, California, Chile, and Mexico strongly support the notion of multiple incursions of fruit flies rather than established populations (Fig. 1, **scenario D, not E**).
- Mark-release-recapture studies show that medfly and *Bactrocera* populations will be detected by trapping at standard densities within the first few generations after an incursion.
- Because a negative cannot be proven scientifically, the burden of proof lies with those postulating established fruit fly populations.
- A methodology should be formulated by advocates of fruit fly established populations to prove the existence of alleged sub-detectable populations by making them detectable.
- Claiming fruit fly establishment without positive proof can be very damaging to fruit fly-free production areas with large horticultural exports and to their economic well-being, by endangering many jobs linked to agricultural industries and leading to widespread use of insecticides.

The full paper was published in: American Entomologist 63 (2): 89-99.



Papers in Peer Reviewed Journals

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