Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Insect Pest Control Newsletter

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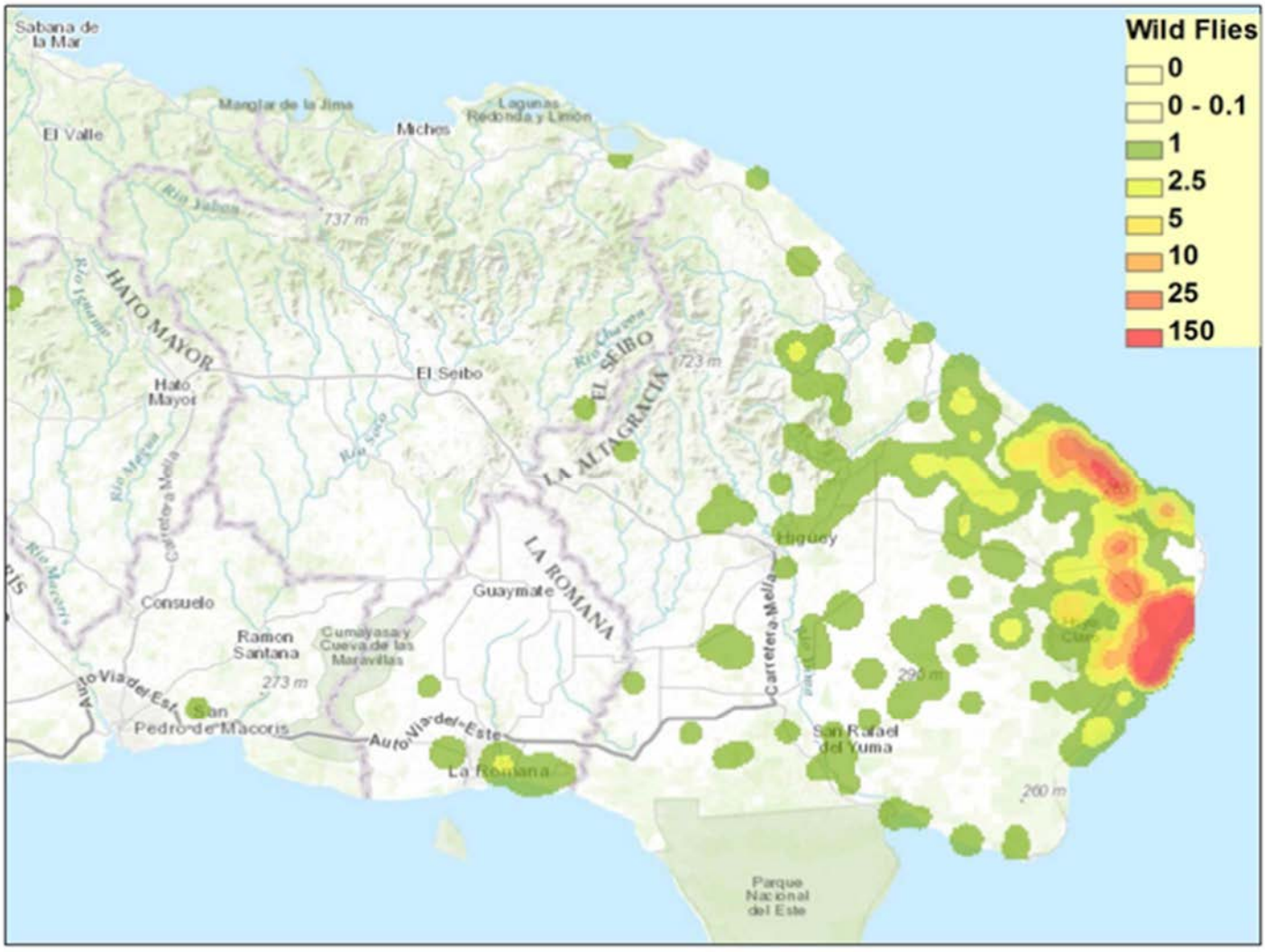
To Our Readers



The Caribbean was free of Mediterranean fruit fly until a large outbreak was detected in the Dominican Republic in 2015. The map shows the locations where flies were captured between 2015 and 2017 in the eastern Provinces of Alta Gracia, La Romana, El Seibo, Pedro de Macoris, and even Hato Mayor. The Mediterranean fruit fly was declared eradicated from the Dominican Republic on 7 July 2017, after a major eradication campaign that also included the area-wide application of the SIT. Colours represent the absolute numbers of wild fly detections per location.

An outbreak of the Mediterranean fruit fly, *Ceratitis capitata* (Wied.), in the Dominican Republic was first reported in March 2015 near the popular tourist city of Punta Cana, and rapidly spread to an area of 2000 km^2 in the east of the country. Investigations indicate that the Mediterranean fruit fly probably entered the country inside a tourist's luggage. Around five million tourists enter the country every year via the regional Punta Cana airport, accounting for more than 60% of the tourists visiting the country.

Although about 200 km away from the main horticultural production areas, an immediate import ban on several agricultural products, including avocado, citrus fruits, papaya and peppers was placed by major trading partners, such as the Haiti, Japan and the United States. The ban resulted in an estimated loss of about US $40 million in fruit and vegetable exports alone in the following nine months of 2015, putting thousands of jobs at risk. Consequently, immediate eradication efforts were implemented.

While most flies were initially detected in non-commercial almond trees along the coast, there was a fear that they might also invade commercial fruit and vegetable farms. As an emergency response, the Government of the Dominican Republic, through its Ministry of Agriculture, established the Moscamed Programme-DR, and made the required financial and operational support available to perform all required monitoring and control activities. Local personnel was immediately trained in establishing a surveillance systems throughout the country to trap and identify the fly, and in complementary pest control methods, such as tree pruning, the destruction of potential host fruits and the selective use of pesticides.

Plaque presented by FAO and IAEA to the Minister of Agriculture of the Dominican Republic in recognition to his commitment and leadership in the successful Mediterranean fruit fly eradication campaign.

The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, in close cooperation with the United States Department of Agriculture (USDA) and the Guatemala-Mexico-USA Moscamed Programme, provided technical assistance to the Dominican Republic to suppress this major invasive pest and to implement the sterile insect technique (SIT) as the main eradication tool. Other organizations that participated in this major effort to assist the Dominican Republic were the Food and Agriculture Organization of the United Nations (FAO), the International Regional Organisation for Plant and Animal Health (OIRSA), and the Inter-American Institute for Cooperation on Agriculture (IICA).

Through its Technical Cooperation Programme, the IAEA also provided assistance through emergency funds, conducting capacity building actions, and deploying a long-term expert on-site to train staff and implement the SIT to eradicate the pest. A facility in the town of Higuey was adapted as a fly emergence and release facility to manage the sterile male flies transported weekly as pupae from El Pino, Guatemala. From October 2015 until May 2017, over 4 billion sterile flies were released in the affected areas.

A Technical Advisory Committee of international experts chaired by the Joint FAO/IAEA Division was fundamental in providing technical guidance to the Ministry of Agriculture in the Dominican Republic.

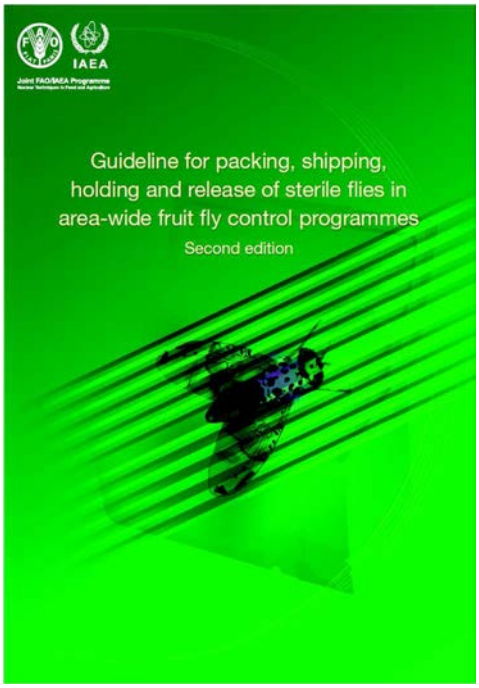
As a result of this major effort, the last Mediterranean fruit fly was detected in January 2017 and official eradication was declared six months later in July 2017. Export markets have since reopened and net revenues of the rapidly growing horticultural sector have been re-established.

Ceremony in Santo Domingo, in July 2017, during which the Minister of Agriculture officially declared Mediterranean fruit fly eradicated from the Dominican Republic, in the presence of the press and representatives of several countries and relevant international organisations.

The Dominican Republic is now on the list of countries that have successfully eradicated the Mediterranean fruit fly. It has successfully developed the capabilities for area-wide application of the SIT and has become a source of training and technology transfer for other countries in the region that are increasingly exposed to invasive pest incursions due to increased travel and trade. As a consequence of climate change, these pests increasingly survive in previously inhospitable areas. Had this devastating pest been allowed to establish itself, the whole Caribbean Region and all its

trading partners would have been at severe risk of devastating outbreaks and huge losses in export revenue.

Phytosanitary activities are now carried out by 117 inspectors, including the use of X-ray machines in the Dominican Republic's maritime ports, airports and border points to minimise the entry of the fly and other invasive pests. With very few exceptions, all fruits and vegetables arriving at these points are confiscated and incinerated.



A very important guideline used by the Dominican Republic project was the "*Guideline for packing, shipping, holding and release of sterile flies in area-wide fruit fly control programmes*". The second edition had just been produced and made freely available on the IPC website (http://www-naweb.iaea.org/nafa/ipc/public/Guideline-for-Packing-Sept2017.pdf). This guideline (see above) is an updated version of the one published in 2007. It is aimed at providing harmonized procedures for the handling and release of sterile fruit flies after production in mass-rearing facilities to FAO and IAEA Member States that want to embark on SIT implementation.

New FAO/IAEA Insect Pest Control Laboratory in Seiberdorf, Austria, inaugurated on 25 September 2017.

A very important event for the future of the Insect Pest Control Section was the inauguration on 25 of September 2017 of the new Insect Pest Control Laboratory (IPCL) in Seibersdorf, Austria. The new laboratory, with over 1,700 m^2 of laboratory space, will become operative during 2018, after gradually transferring the >250 insect species, strains and populations currently maintained at the old laboratory – a unique repository that Member States can draw upon. It will substantially increase the ability to assist Member States in applying nuclear techniques to combat major insect pests that spread diseases and damage crops. The new building has more and better-quality space and equipment to improve work-flow and efficiency and output.

Member State representatives, IAEA Director General Yukiya Amano, and FAO Assistant Director General Ren Wang, during the inauguration of the new Insect Pest Control Laboratory in Seibersdorf, Austria.

The inauguration marks a milestone in the IAEA's initiative to modernise its eight nuclear applications laboratories, built in Seibersdorf in 1962, under a project known as ReNuAL. Along with additional space to train experts to support the transfer of SIT to countries, the new IPCL will facilitate research on development and application of more environmentally friendly and therefore more sustainable pest control techniques. The new building will also feature a unique 230 m^2 'Ecosphere' – a climate controlled facility – to help scientists study the behaviour of sterilised insects.

Finally I would like to inform you that our colleague and former staff member of the Chinese Academy of Agricultural Sciences (CAAS), Daguang Lu, was appointed as new Insect Pest Control staff member, to provide support to Member States on the implementation of plant pest projects. Daguang has extensive experience with the management of projects in the area of entomology. During the last 2 years, he also served as First Secretary of the Permanent Representation of the People's Republic of China to the United Nations Agencies in Rome. His duty was to liaise and provide support to FAO, WFP and IFAD. We all welcome Daguang Lu to the Insect Pest Control Subprogramme and wish him much success in his new position.

Rui Cardoso Pereira

Head, Insect Pest Control Section

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

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Forthcoming Events (2018)

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

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

Second RCM on Improved Field Performance of Sterile Male Lepidoptera to Ensure Success in SIT Programmes. 12–16 March 2018, Hawke's Bay, 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. Consultants and Expert Meetings

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

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

Expert Meeting on Developing a Regulation for the Transport and Release of Sterile Male Mosquitoes in Europe (under Regional Europe RER5022). 15–19 October 2018, Vienna, Austria.

III. Other Meetings/Events

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

FAO/IAEA Second Coordination Meeting of the Latin America & Caribbean Regional Project Strengthening Regional Capacity in Latin America and the Caribbean for Integrated Vector Management Approaches with a Sterile Insect Technique Component, to Control *Aedes* Mosquitoes as Vectors of Human Pathogens, particularly Zika Virus (under Regional TC Project RLA5074). 5–9 March, 2018, Vienna, Austria.

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

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

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

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

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

FAO/IAEA Second Coordination Meeting of Latin America Regional Project Strengthening Fruit Fly Surveillance and Control Measures Using the Sterile Insect Technique in an Area-wide and Integrated Pest Management Approach for the Protection and Expansion of Horticultural Production (ARCAL CXLI) (under Regional Latin America RLA5070). 23–27 April 2018, Tapachula, Chiapas, Mexico.

FAO/IAEA Stakeholder Engagement Meeting for Sterile Male Mosquito Release Pilot Trials in Europe (under Regional Europe Project RER5022). Tentative month: April 2018, Vienna, Austria.

FAO/IAEA Workshop on Need-based Development, Application and Evaluation Guidelines of SIT for the Integrated Management of Human Disease Vectors (under Interregional TC Project INT5155). 16–18 May 2018, Bologna, Italy.

FAO/IAEA Regional Training Course on Training in Methods for the Various Components of the SIT Package for the Control of Mosquito Disease Vectors of Zika, Dengue and Chikungunya II (under Regional TC Project RLA5074). Tentative dates: 4–8 June, 2018.

FAO/IAEA Regional Training Course on Training in Mass-rearing, Sex Separation, Irradiation and Dosimetry in the Context of the SIT Package for the Control of Mosquito Disease Vectors of Zika, Dengue and Chikungunya (under Regional TC Project RLA5074). Tentative dates: 19–23 June, 2018, Vienna, Austria.

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

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

FAO/IAEA Training Course on SIT for Mosquitoes Focused on Mass-rearing, Release and Monitoring (under Interregional TC Project INT5155). 27–31 August 2018, Juazeiro, Brazil.

FAO/IAEA Decision Makers Awareness Workshop on Sensitizing the SIT to Senior Public Health Officials (under Interregional TC Project INT5155). 1–5 October 2018, Vienna, Austria.

FAO/IAEA Training Course on Data Management, GIS and Modelling to Optimize SIT Control Efforts of Invading Mosquito Species in Europe (under Regional Europe RER 5022). 15–19 October 2018, Vienna, Austria.

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 2017, 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.

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.

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

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). 29–31 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 Identification of 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.

Joint 34th Conference of the International Scientific Council for Trypanosomosis Research and Control (ISCTRC) and 16th African Union's Pan African Tsetse and Trypanosomosis Eradication Campaign (AU-PATTEC) Coordinators' Meeting. 11–15 September 2017, Livingstone, Zambia.

FAO/IAEA Final Review Meeting on Promoting of Expertise and Infrastructure for Dengue Vector Control Surveillance towards Integration of the Sterile Insect Technique with Conventional Control Methods among South and South East Asian Countries (under Regional Asia Pacific Project RAS5066). 25–29 September 2017, Manado, Indonesia.

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 Workshop on Harmonization of Phytosanitary Measures for Fruit Fly Control Following Relevant International Standards on Phytosanitary Measures (under Regional Latin America Project RLA5070). 16–20 October 2017, Guatemala City, Guatemala.

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, Bagatelles, 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). 6–8 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). 27 November–1 December 2017, Kalangala, Uganda.

FAO/IAEA Regional Workshop on Database for Plant Pests of Quarantine Significance for the Middle East (under Regional Asia Project RAS5076). 27 November–1 December 2017, Vienna, Austria.

FAO/IAEA Regional Training Course on Quarantine and International Standards for Phytosanitary Measures for Fruit Flies in Southeast Asia (under Regional Asia Project RAS5067). 11–15 December 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). 11–15 December 2017, Hanoi, Viet Nam.

FAO/IAEA Europe Regional Coordination meeting on Progresses and Perspectives on the Control Programmes for *Aedes* Invasive. (under Regional Europe Project RER5022). 18–20 December 2017, Chania, Crete, Greece.

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	Continuing 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*	Daguang Lu
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	Daguang Lu
Guatemala	GUA5019	Strengthening National Capabilities for the Control of Agricultural Pests Using Nuclear Technologies	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)	Daguang Lu
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	Daguang Lu
Uganda	UGA5036	Demonstrating the Feasibility of a Sterile Insect Technique Component as Part of an Area-wide Integrated Pest Management Approach to Increase Livestock Productivity	Rafael Argiles
Viet Nam	VIE5021	Integration of the Sterile Insect Technique with Other Suppression Methods for Control of *Bactrocera* fruit flies in Dragon Fruit Production	Rui Cardoso Pereira
Zimbabwe	ZIM5023	Improving Crop and Livestock Production through the Eradication of Bovine and Human Trypanosomiasis in Matusadona National Park	Rafael Argiles

		Continuing Regional Projects	
Regional Africa	RAF5074	Enhancing Capacity for Detection, Surveillance and Suppression of Exotic and Established Fruit Fly Species through Integration of Sterile Insect Technique with Other Suppression Methods	Daguang Lu
Regional Africa	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
		Continuing 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
		New National Projects to Start in 2018	
Burkina Faso	BKF5020	Strengthening the Insectarium to Create Agropastoral Areas Permanently Liberated from Tsetse Flies and Trypanosomiasis	Adly Abdalla
Bolivia	BOL5022	Reducing Fruit Fly Populations in Different Regions Introducing an Integrated Pest Management Approach Including the Use of the Sterile Insect Technique	Walther Enkerlin
Brazil	BRA5060	Using the Sterile Insect Technique to Evaluate a Local Strain in the Control of *Aedes Aegypti*	Rafael Argiles

Chad	CHD5007	Contributing to the Eradication of Glossina Fuscipes Fuscipes to Improve Food and Nutritional Security	Rafael Argiles
Chile	CHI5051	Implementing Pilot Level of Sterile Insect Technique for Control of Lobesia Botrana in Urban Areas	Walther Enkerlin
Cuba	CUB5021	Demonstrating the Feasibility of the Sterile Insect Technique in the Control of Vectors and Pests	Rafael Argiles
Ethiopia	ETH5021	Enhancing Livestock and Crop Production Through Continued Consolidated and Sustainable Control of Tsetse and Trypanosomosis	Rafael Argiles
Israel	ISR5021	Assisting in the Development of a Strategy to Counteract *Bactrocera zonata*	Walther Enkerlin
Oman	OMA5007	Strengthening Sterile Insect Technique Based Area-Wide Integrated Management of Date Palm Pests	Marc Vreysen
South Africa	SAF5015	Supporting the Control of Nagana in South Africa Using an Area-Wide Integrated Pest Management Approach with a Sterile Insect Technique Component - Phase I	Marc Vreysen
		New Regional Projects to Start in 2018	
Regional Africa	RAF5080	Supporting Area-Wide Tsetse and Trypanosomosis Management to Improve Livestock Productivity - Phase IV	Rafael Argiles
Regional Asia	RAS5082	Managing and Controlling *Aedes* Vector Populations Using the Sterile Insect Technique	Kostas Bourtzis
Regional Latin America	RLA5075	Strengthening the Regional Capacities in the Prevention and Progressive Control of Screwworm	Walther Enkerlin

Highlights of Technical Cooperation Projects

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

FAO/IAEA Interregional Training Course on Use of the Sterile Insect and Related Techniques for the Area-wide Integrated Management of Insect Pests

From combating Zika-carrying mosquitos to protecting fruit from flies, long-term sustainability of insect pest control using nuclear techniques requires a solid technical foundation and strong management skills locally, agreed participants of a recent training course organized by the IAEA in cooperation with the Food and Agriculture Organization of the United Nations (FAO).

The four week long course targeted trainees from all regions of the world to train them in developing and managing projects using nuclear and other techniques to manage insect pests that affect plants, animals and humans. The course was successfully held in Mexico and Guatemala, from 6 November -1 December 2017, with 25 participants from 23 countries in Africa, Asia, Europe and Latin America, selected for the course among close to one hundred applicants. The excellent organization and hospitality both in Mexico and Guatemala is much appreciated.

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

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

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

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

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

The Africa Regional Workshop was held in Bagatelles, Mauritius from 23 to 27 October 2017. The goal was to review the progress in preparing for mosquito control, including a SIT component in some African Member States involved in the project. A WHO representative participated in the workshop and informed the participants on the WHO Global Strategy for the Control and Prevention of Vector Borne Diseases as well as the new procedures used by WHO to evaluate new vector control technologies like the SIT.

Participans of the 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.

Participants received information on the status of feasibility studies for the use of the SIT against mosquitoes on La Réunion Island and in Thailand, with a special focus on the collection of entomological baseline data, a prerequisite for any control programme. Participants were also informed on the latest developments of the mosquito SIT package at the FAO/IAEA's Insect Pest Control Laboratory, particularly on mass-rearing, irradiation, quality control, handling and release of sterile male mosquitoes.

Lectures were in addition given on the use of models to improve the integrated control of *Aedes* mosquitoes and on methods of mark-release-recapture to assess dispersal, survival and field competitiveness of sterile male mosquitoes and field monitoring protocols to assess the efficiency of SIT pilot projects. Finally, the participants visited the mosquito rearing facility of the Ministry of Health in Mauritius, and participated in the release of 50,000 sterile male *Aedes albopictus*, which is part of the routine weekly releases that are presently being implemented in a pilot site in Mauritius.

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

Final Review Meeting of Regional Project in Indonesia

The final review meeting of this regional Technical Cooperation project RAS5066 was held in the Sam Ratulangi University, Manado, Indonesia from 25-29 September 2017. Twenty two participants from eleven countries (China, Fiji, Indonesia, Lao PDR, Malaysia, Myanmar, Pakistan, Philippines, Singapore, Sri Lanka and Thailand), as well four experts (La Reunion-France, French Polynesia, Italy and Mexico), attended this meeting.

In South and South East Asian countries, *Aedes* mosquito-borne diseases continue to be a major public health problem with more than 2000 million people being at risk of contracting dengue, chikungunya, yellow fever, and Zika. The control of mosquito populations has largely relied on insecticide-based approaches. The FAO/IAEA Insect Pest Control Subprogramme has developed, and continues refining, sterile insect technique (SIT)-based approaches against *Aedes aegypti* and *Aedes albopictus* in order to suppress mosquito populations in the frame of area-wide integrated vector management strategies. The regional TC project RAS5066 aims to transfer this technology to Member States in the region.

In the frame of the final review meeting, the activities of the project performed during the period 2014-2017, including all the components of the SIT package, as well as small scale pilot trials performed or planned in different countries and future plans, were thoroughly reviewed. In addition, dissemination activities and local public engagement programmes were also discussed.

Participants of the Final Review Meeting (Sam Ratulangi University, Manado, Indonesia).

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

Regional Training Course on Fruit Fly Detection & Surveillance and Databases & Data Analysis for Fruit Fly Programmes in Africa

This regional training course was organized under the Africa regional TC project RAF5074 and was attended by 25 participants from 17 countries (Burundi, Burkina Faso, Botswana, Ghana, Cote d'Ivoire, Kenya, Madagascar, Mauritius, Mozambique, Namibia, Nigeria, Seychelles, Sudan, Swaziland, Uganda, United Republic of Tanzania, Zimbabwe). The course was held at the National Sericulture Research Centre, Kenya Agricultural & Livestock Research Organization (KALRO), Thika, Nairobi, Kenya from 2-6 October 2017.

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

- Surveillance and baseline data collection
- Adult surveys, as well as levels of infestation by fruit fly larvae
- Basic taxonomic information on the identification of the fruit fly specimens
- Protocols used for collection and shipments of alive and dead fruit fly specimens
- Databases and data analysis
- Training with a laboratory exercise on identification and data analysis.

Participants of the regional training course on Fruit Fly Detection & Surveillance and Databases & Data Analysis for Fruit Fly Programmes in Africa (Thika, Kenya).

The participants were exposed to theoretical lectures highlighting the main principles and issues with regard to the above topics. Focus was on the main indigenous and alien invasive fruit fly species that can be found throughout Africa and the Western Indian Ocean, such as *Bactrocera dorsalis*, *Zeugodacus cucurbitae*, *Ceratitis capitata*, *C. quilicii*, *C. rosa* and *C. cosyra*.

The theoretical lectures were complemented by practical sessions on fruit fly identification, trapping protocols, and GIS monitoring of surveying grids. This involved field visits to some of the KALRO research stations, private farmers in the Thika region, and the International Centre for Insect Physiology and Ecology (ICIPE) centre in Nairobi.

A lot of emphasis was put on the need for a regional approach in fruit fly surveillance and suppression, rather than isolated local or national initiatives. The regional training course was, therefore, an excellent opportunity for the participants to network among each other and exchange ideas and contacts.

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 (PAN5025)

Area-Wide Integrated Fruit Fly Management Paves the Way for Increasing Panama's Fruit and Vegetable Production and Exports

Few pests have a greater impact on world trade in agricultural products than tephritid fruit flies. They cause major losses in fruit and vegetables, and are often the target of intensive insecticide applications to protect commercial production. Their economic consequences are so great that countries free of the major tephritids prohibit the import of fresh produce from countries where these pests are endemic, and have active detection and emergency response programmes in place to maintain their fruit fly free status.

The sterile insect technique (SIT) is often used as part of area-wide integrated pest management (AW-IPM) programmes that aim to establish pest-free areas (PFA). Increasingly, SIT is also being applied as part of an integrated approach for area-wide suppression to achieve areas of low pest prevalence (ALPP). Horticultural products cultivated in PFA do not require quarantine measures for international trade. Products produced in ALPP can be commercialized in international markets, however, only when they are part of a set of pest mitigation measures known as a systems approach where ALPP status is one of the prerequisites. Postharvest treatments can be a pest mitigation measure in a systems approach.

FAO/IAEA and local experts exchanging information to guide future actions in this fruit and vegetable production and export area (Photo: MIDA, Panama).

Panama has embarked on an IAEA technical cooperation project PAN5025 to expand and strengthen a phytosanitary surveillance system for non-native fruit flies of economic and quarantine importance. The goal is to facilitate the establishment and maintenance of PFAs and ALPPs, and to determine potential technological alternatives for postharvest quarantine treatments for agricultural products to facilitate the trade of fruit and vegetables.

Within the framework of this project, an expert from the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture visited Panama to meet officials from Panama's National Plant Protection Directorate of the Ministry of Agricultural Development (MIDA), and to discuss options for post-harvest quarantine treatments against fruit flies with fruit and vegetable producers, with the goal of facilitating the international trade of fruit and vegetable products. The FAO/IAEA expert also provided training and exchanged information to guide future actions in this area.

The IAEA and FAO have been working with Panama in this area for over ten years, and this support has been instrumental in strengthening the capacity of Panama's National Fruit Fly Programme. This Programme is designed to

ensure that the country meets the standards required by trading partners, and thus facilitates the export of fruits and vegetables grown in Panama. This has had positive consequences on the horticultural industry and in general on the socioeconomic development of the country.

Improving Agro-Forestry and Agro-Pastoral Production through the Use of Nuclear Technologies (BKF5018)

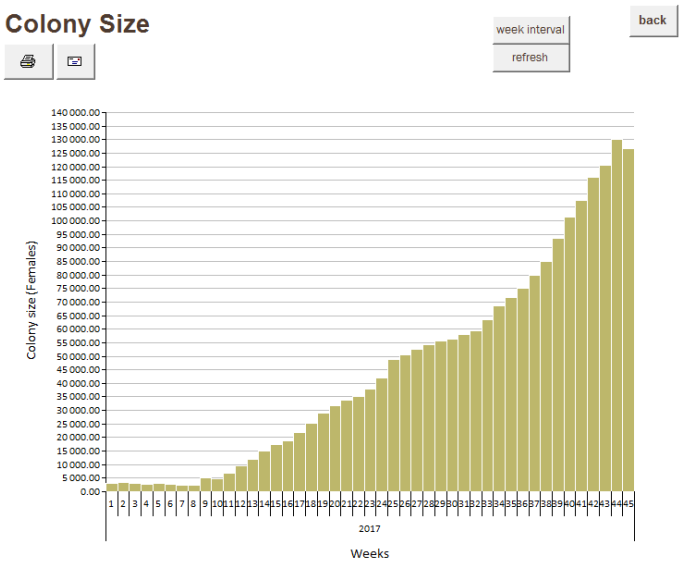
Training course on Blood Collection and Preparation for Tsetse Flies Following the FAO/IAEA Standard Operation Procedure

The national training course was held in Bobo Dioulasso, Burkina Faso, 9-13 October, 2017, and was attended by eight participants (two from the Centre International de Recherche-Développement sur l'Elevage en zone Subhumide (CIRDES) and 6 from the Insectary Bobo-Dioulasso (IBD). The course aimed to train participants in (i) the collection and defibrination of blood at the slaughter house, (ii) blood handling procedures, irradiation, and bacteriological tests, (iii) the conducting of bioassay test to assess the collected blood and (iv) the implementation of quality control procedures for tsetse mass-rearing.

The first day was devoted to oral presentations to explain the steps of the SOP for the blood collection and preparation for tsetse mass-rearing and the relation between tsetse flies and bacterial microbes. In addition, a quality control protocol for tsetse mass-rearing was presented. This was followed by a group visit to the slaughter house in Bobo Dioulasso.

Participants of the training course "Blood collection and preparation for tsetse flies following the FAO/IAEA standard operation procedure (SOP)", 9-13 October 2017, Bobo Dioulasso, Burkina Faso.

The second two days were devoted to laboratory work to conduct hands-on training on blood handling procedures, irradiation, and bacteriological and bioassay tests (Figure on the left). The last two days were devoted to conduct quality control procedures for tsetse mass-rearing and assess the colony status (Figure below).



The size of the Glossina palpalis gambiensis *colony in the Insectary of Bobo Dioulasso, Burkina Faso.*

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

Regional Europe Training Course on Field Procedures for Mosquito Population Surveillance, Detection and Quantification

The Regional Europe Training Course was held from 04 to 15 September 2017 in Tirana, Albania. Eighteen participants from 8 countries (Albania, Bulgaria, Greece, Macedonia, Montenegro, Romania, Serbia, and Turkey) received training in field monitoring techniques, and participated in a mark-release-recapture (MRR) experiment, which included the use of three trapping methods at 40 sites. The aim was to estimate the mortality, dispersal and competitiveness of 40 Gy irradiated sterile male *Aedes albopictus* in the field.

The sterile males were produced in the Centro Agricoltura Ambiente "G. Nicoli", Italy (CAA) and shipped as irradiated adults to Albania before the course. A local strain originating from the release site in Tirana was amplified in CAA to enable the release of 60,000 sterile males in total, released in two batches at one week interval.

The MRR trial was overall very successful and will provide good estimates of the desired entomological parameters. The success of this challenging training course was mainly due to the excellent organization of the Institute of Public Health, Albania. Participants were very pleased with the theoretical and practical knowledge gained.

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

Project MEX5031 aims to develop and transfer sterile insect-based technologies as part of an integrated approach to suppress *Aedes* spp. mosquito populations, that transmit dengue, chikungunya and Zika viruses, in a pilot study near Tapachula, southern Mexico.

Continuing the process of community engagement, the Mexican project counterparts held a community-wide mosquito release ceremony in the presence of representatives of the public health system, the press, and the community leaders from the two pilot areas selected for mosquito release (see photo). This event in Rio Florido was the first of its kind releasing sterile male mosquitoes, a milestone in this community.

Community leaders of the two pilot project areas near Tapachula, Chiapas, Mexico, during the event in November 2017, marking the first releases of sterile male mosquitoes.

The progress and results of this project were presented during the ongoing Interregional Training Course on "Use of the Sterile Insect and Related Techniques for the Area-wide Integrated Pest Management of Native and Exotic Insect Pests", which was an excellent opportunity to view the preparatory activities carried out so far. During this training course, the participants had also the chance to see a demonstration of a new aerial release device using drones. This system is currently in use for aerial releases of some fruit flies species and parasitoids in different countries, and now is being adapted for mosquito releases too.

The Mexican counterparts, Centro Regional de Investigación en Salud Pública (CRISP) and El Colegio de la Frontera Sur (ECOSUR), continue to collect baseline data (using ovitraps and adult traps) to estimate the mosquito population density in the selected areas. These data will help to adjust the numbers of mosquitoes required for the following phase, which comprises the mosquito releases. The rearing center is close to Rio Florido mosquitoes release site, which will facilitate the mosquito releases.

Demonstrating the Feasibility of a Sterile Insect Technique Component as Part of an Area-wide Integrated Pest Management Approach to Increase Livestock Productivity (UGA5036)

Project UGA5036 has recently obtained the mandatory permits from the Civil Aviation Authority to use a Remotely Piloted Aircraft System (RPAS, drone) for pilot releases of sterile tsetse males over the Kalangala islands in the Lake Victoria. A light release machine weighing less than 200 g has been designed and installed in a hexacopter drone, capable of performing fully automated release flight missions over the island.

Sterile pupae of *Glossina f. fuscipes* are being shipped weekly from the laboratory of the Insect Pest Control Section in Seibersdorf to the field insectary in Kalangala. The emerging flies will be released by air in the open field using the RPAS, in order to conduct compatibility and competitiveness tests.

The lush vegetation on the island of Serinya, Uganda where a mating competitiveness test of G. f. fuscipes *sterile males is being planned.*

In connection with these tests, a regional training course was held in Kalangala. The course was attended by ten participants from six tsetse affected Member States planning tsetse control operations in the near future, in addition to several participants from Uganda, including observers from several ministries and departments with interest in this work. Trainers from the company developing the RPAS gave presentations on the hexacoper platform and the control system, before practical demonstrations of the system. These were somewhat disrupted by bad weather and strong winds, but a local football pitch was selected as a safe open area for the demonstrations. Test releases of fresh killed tsetse were also performed to assist with calibration of the release system.

The meeting was opened by HE Vincent Bamulangaki Sempija, the Minister for Agriculture and Livestock, who accompanied the training course to Serinye Island for demonstrations of the system.

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

Project Number	Ongoing CRPs	Scientific Secretary
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
	New CRP	
D4.20.17	Improvement of Colony Management in Insect Mass-rearing for SIT Applications	Adly Abd Alla Carlos Caceres

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

The first RCM of this new CRP, was held in Vienna and was attended by ten participants from nine countries and three observers.

This CRP was initiated to explore the possible combination of SIT with other biological control methods to address specific issues with certain pests that disrupt biological control and pollination in greenhouses through periodic outbreaks of other insect pests that require the application of chemical insecticides to bring them under control.

Following presentations and general discussions, the participants were divided into two working groups, one on *Drosophila suzukii* and one on Lepidoptera (*Spodoptera exigua, Helicoverpa armigera* and *Tuta absoluta*). Each group discussed their current work, prepared research plans for the next year, and outlined their proposal for the full-term of the five-year CRP.

D. suzukii is a recent invasive pest in Europe, North America and other regions, where it causes considerable damage in soft fruit production, principally berries such as raspberry, strawberry and blueberry. In many areas these soft fruits are produced in greenhouses and infestation with *D. suzukii* can lead to almost 100% crop loss as there is currently no effective biological control agent available. Several groups are investigating the development and potential application of the SIT for *D. suzukii* suppression and it is hoped that this CRP will provide a means to improve communication and coordination between the groups.

Tuta absoluta has invaded North America, Europe and Africa from its native range in South America and is spreading eastwards through Asia. It attacks Solanaceous crops, principally tomato, leading to almost complete loss of production in both field and greenhouse crops. In Europe biological control through two native mirid bugs has proved effective, but these bugs cannot be imported to countries outside their native range. As a result losses due to the pest are likely to be high as it moves further eastwards.

Current control relies almost exclusively on frequent chemical control with negative impact on worker health and the envi-

ronment and raised pesticide residues in the crops. To manage the pest new approaches are required and the SIT offers the possibility of environmentally-friendly control.

The two Noctuid pests, *Spodoptera exigua* and *Helicoverpa armigera* are widely spread and generally do not cause significant losses, but periodic outbreaks occur. The principal biological control is through the egg parasitoid *Trichogramma* spp., but control during outbreaks is poor as the parasitoid is not efficient at finding the scattered eggs of these pests and additional control is sometimes required, often consisting of pesticides. Both species have been investigated in the past for potential SIT application and rearing methods and diets are available, but SIT has not been adopted for them in any country. One of the main objectives of this CRP is to understand the barriers to adoption of the SIT in greenhouse situations.

The 2nd RCM is scheduled for early 2019 in a location in Argentina.

Final RCM of the CRP on *Enhancing Vector Refractoriness to Trypanosome Infection.* 27 November–1 December 2017, Tanga, Tanzania.

The fourth and final RCM was held at the Mkonge Hotel, Tanga, Tanzania. The meeting was hosted by the Tanzania Veterinary Laboratory Agency (TVLA), with the arrangement made by Ms Imna Malele the Manager of the Vector & Vector Borne Disease Institute (VVBD).

The meeting was officially opened by the Regional Administrative Secretary Engineer Zena Said. Twenty-two participants from sixteen countries (Austria, Belgium, Burkina Faso, Cameroon, Ethiopia, France, Germany, Greece, Italy, Kenya, Netherlands, Slovakia, Turkey, United Kingdom, United Republic of Tanzania and United States of America) attended the meeting, together with one consultant from Kenya, and three observers (from Germany, Slovakia, and Kenya).

The first two days of the meeting were devoted to presentations, whereas during the remainder of the meeting the participants discussed the major achievements and recommendations in two working groups: one on tsetse parasites and pathogens, and the other on tsetse symbionts.

It was concluded that the CRP had been very productive, with a much better understanding of the many aspects of the physiology of the tsetse fly, including its fecundity, that are influenced by the fitness of its symbiotic fauna. The methodology to produce tsetse refractory to trypanosome infection needs to be further refined.

The CRP has resulted in some important achievements which will help in improving tsetse mass-production for SIT programmes. These achievements include the following:

- The complete genome sequence of 6 tsetse species
- Optimisation and validation of the methodology to produce tsetse flies refractory to trypanosome infection
- Optimisation of the methodology to combine paratransgenesis with SIT to release tsetse males refractory to trypanosome infection
- Revealing the interactions among tsetse symbionts, pathogens and parasites
- Determining the impact of irradiation treatment on tsetse symbionts
- Discovery of *Spiroplasma* infection in natural populations and laboratory colonies of *Glossina fuscipes* and *G. tachinoides*
- Development of a reliable molecular tool for tsetse flies identification.
- Demonstration of the role of *Wolbachia* in tsetse speciation and development of a tsetse hybrid between *G. m. morsitans* females and *G. m. centralis* males
- Analysis of the prevalence and genetic diversity of salivary gland hypertrophy in natural tsetse populations and its impact on the tsetse immune system
- Dissemination of these discoveries to endemic countries and interested parties in Member States through the RCMs and two workshops
- Research being published in a Special Issue of BMC Microbiology Journal.

Participants of the fourth RCM on Enhancing Vector Refractoriness to Trypanosome Infection. 27th November-1st December 2017, Tanga, Tanzania.

Developments at the Insect Pest Control Laboratory (IPCL)

INSECT GENETICS AND MOLECULAR BIOLOGY

Cytogenetics in support of SIT and global trade

For more than 30 years now, cytogenetics has been an important component of IPCL's work, either with activities carried out 'in house' or through collaboration with external cytogenetic groups. Cytogenetics has supported the SIT in different ways. The development, evaluation and improvement of Mediterranean fruit fly *Ceratitis capitata* genetic sexing strains (GSS) has been facilitated by classical genetic linkage studies that helped a) to identify linked markers of importance, b) the cytogenetic characterization of Y:A translocations, and c) isolation and characterization of inversions that increase the GSS stability.

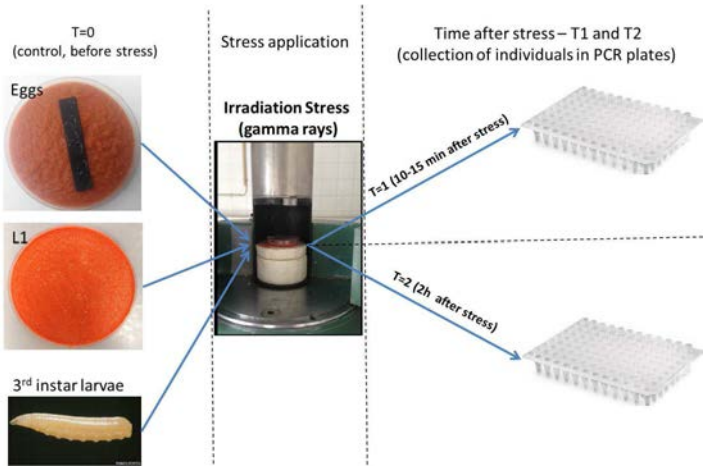
Up to now, polytene chromosome analysis is the quickest and most effective way to verify the identity of the Mediterranean fruit fly VIENNA 7 and VIENNA 8 GSS, as well as the presence of the D53 inversion. At the same time and taking into account that a) chromosomal rearrangements are a common 'highway' to speciation in Diptera, and, b) that for resolving relations among closely related species, multidisciplinary approaches are needed, cytogenetics has supported species delimitation in different Tephritidae species complexes.

The advances in sequencing technologies that enabled genome sequencing of species of interest are greatly benefited from cytogenetic work already performed. Under the lead of emeritus professor Antigone Zacharopoulou (Department of Biology, University of Patras, Greece) and with the combined effort of other research groups (including the GMB group of IPCL), a review manuscript showing the importance of cytogenetics and its contribution in the last four decades in different aspects of SIT and global trade has been published earlier this year. (http://onlinelibrary.wiley.com/doi/10.1111/eea.12616/full)

Assessing response to irradiation stress: tolerance profile and transcriptomic analysis of *Ceratitis capitata* and *Bactrocera tryoni*

In collaboration with the Australian research teams of Wei Xu of Murdoch University and Alexie Papanicolaou of the University of Western Sydney, the response to irradiation of two highly invasive fruit flies of primary concern for Australia is being assessed. The main objective is to define the response of the Mediterranean fruit fly and the Queensland fruit fly, *Bactrocera tryoni*, to irradiation using lethal and sub-lethal doses, aiming to 'dissect' the pathway activated at the transcriptomic level mainly for flies that are surviving the stress. This can provide valuable knowledge regarding genes that are engaged in stress response and recovery plus potentially useful biomarkers that are expressed after irradiation stress.

To do so, different irradiation doses have been applied in different developmental stages (24 h old eggs, L1 and L3) for two populations of these two species deriving from Australia and colonized at the IPCL. Lethality has been defined based on the percentage of individuals that do not manage to reach subsequent developmental stages. Samples for RNA-seq analysis were collected before the irradiation stress was applied, and ~15 min and ~2 h after the application of the stress (see figure).



Experimental set up for assessing the response to irradiation and samples' collection for transcriptomic (RNA-seq) analysis.

Our data show that the tolerance of the two species can be variable, depending on the developmental stage. As an example, 24 h old B. *tryoni* eggs seem to tolerate higher irradiation doses as compared with 24 h old eggs of the Mediterranean fruit fly. Ongoing transcriptomic analysis is expected to shed light on the genes and gene networks that are differentially expressed in response to irradiation stress. Comparing such networks among different species and developmental stages can show whether response to irradiation and stress response in general is modulated by 'universal' or species/developmental stage specific genes.

'Repatriation' and evaluation of Mediterranean fruit fly VIENNA genetic sexing strains (GSS) from mass-rearing facilities worldwide

In previous newsletters, we pointed out the importance of regularly evaluating strains used in mass-rearing facilities using standardised approaches. The outcome of the repatriation to the IPCL and subsequent evaluation of VIENNA 7 and VIENNA 8 GSS under the same conditions has provided some important findings, presented

in a recent publication of our group (http://onlinelibrary.wiley.com/doi/10.1111/eea.12612/full) Differences were observed among the strains that could not be attributed to either the type of the translocation involved (VIENNA 7 versus VIENNA 8 translocation), or the presence of the D53 inversion that is introduced in some VIENNA 8 strains (VIENNA 8^{D53+} versus VIENNA 8^{D53-}). Differences were observed both in adult recovery under standard rearing conditions and in male recovery under elevated temperatures used for the temperature sensitive lethal test. Among the important findings of this study, the VIENNA $8D^{53+}$ strain derived from Israel showed extraordinary properties, including increased egg hatch, pupation and adult recovery rates, plus increased male recovery at the temperatures routinely used for the *tsl* test.

Our results point to the possible involvement of different factors that could be responsible for the observed differences. To gain more insight in this, we are currently investigating both the genetic and gut symbiotic structure of this strain and we are revisiting its properties, including genetic stability of the sexing system and recovery under both standard and elevated temperatures. This analysis is expected to help understand whether the differences observed among strains that have the same origin can be attributed to genetic differences accumulated through time and/or differences in the symbiotic profile, and how colony management and mass-rearing practices have contributed to the accumulation of these differences.

Towards the development of a SIT-based package against *Drosophila suzukii*

Drosophila suzukii has spread and established recently in several niches globally. By the end of 2010, *D. suzukii* had dispersed to the Western and Eastern USA, Canada, and most of the Mediterranean region. The species demonstrates a high dispersal potential, which is mainly attributed to increasing global travel and trade and the pest's migratory behavior. Its great colonizing ability is also enhanced by the ability of the insect to adapt easily to environments with high humidity and moderate temperatures. Absence of natural predators and/or effective parasitoids for this invasive species, as well as competitors of fresh fruits, facilitates its establishment in the invaded habitats.

Because of the serious threat posed by *D. suzukii* to soft fruit production and lack of appropriate control methods, the IPCL, in the frame of the SUZUKILL project, is currently developing the SIT package for potential greenhouse application against this major pest species. In parallel, and given that natural populations of *D. suzukii* are infected with *Wolbachia*, we are exploring *Wolbachia* symbiosis in case we need to integrate *Wolbachia*-induced cytoplasmic incompatibility (CI) with irradiation. This would result in the development of a combined SIT/IIT approach, i.e. a similar strategy as proposed for the suppression of the mosquito disease vectors *Aedes albopictus* and *Aedes aegypti* populations. This project is carried out in collaboration with colleagues at the BOKU University in Vienna (Christian Stauffer) and at the Centre National de la Recherche Scientifique/ Laboratoirse de Biométrie et Biologie Evolutive (CNRS/LBBE) in Lyon (Laurence Mouton, Patricia Gilbert and Fabrice Vavre).

Two *Wolbachia*-infected *D. suzukii* lines, provided by the LBBE/Lyon colleagues, have been established in the laboratory using an artificial diet that is a mix of the carrot diet used in the IPCL and the standard *Drosophila* diet. The *Wolbachia*-infected lines were introgressed with the *D. suzukii* line (originating from Italy) maintained by the Plant Pest group of the IPCL to align their genetic backgrounds. After eight generations of introgression, we are currently testing several biological traits including fertility, fecundity, CI expression, potential effect of males' age on CI levels of these lines. These experiments are carried out using either the standard carrot diet, fresh raspberries or grape juice agar plates (see figures below). The completion of these experiments will provide insight on the impact of *Wolbachia* on the biological quality of the lines, which is a critical factor if these lines will be used for a combined SIT/IIT strategy.

Wolbachia-*infected* D. suzukii *lines assessed on standard carrot diet, fresh raspberries or grape juice agar plates.*

The implementation of SIT (and/or IIT) also requires the development of mass-rearing of competitive insects on an industrial scale. Under laboratory domestication and continuous mass-rearing, laboratory strains can lose their ability to survive and compete under natural conditions. The competitiveness of the sterile insects can be drastically reduced which might compromise the success of SIT programmes. Some of these changes have a genetic basis as they result from inadvertent selection, genetic drift or bottlenecking in laboratory populations.

To assess these changes, we have collected a wild population that will be adapted under laboratory conditions for several generations. The genetic changes will be checked with next generation sequencing (NGS) that will allow us to judge which alleles are selected during the laboratory domestication process.

PLANT PESTS

Overexpression of antioxidant enzymes and the effect of low-oxygen atmosphere treatments and irradiation on the quality of Caribbean fruit fly males

Vanessa Simões Dias (Brazil) is a PhD student at the University of Florida and currently a fellow at the IPCL (TC project RLA5070). She has been conducting research to assess the biological effects of irradiation in wild-type and transgenic strains of the Caribbean fruit fly, *Anastrepha suspensa,* as reported in NL 89.

Behavioural studies of the effects of irradiation on the quality of Caribbean fruit fly, Anastrepha suspensa.

In operational fruit fly SIT programmes, late pupae are always sterilized under a low-oxygen atmosphere to minimize the adverse effects of ionizing radiation. This reduces oxidative damage and improves sterile insect performance.

The hypothesis under evaluation is that the overexpression of a key antioxidant enzyme, the mitochondrial superoxide dismutase (MnSOD), combined with low-oxygen atmosphere treatments, can interact synergistically to reduce oxidative stress and increase mating success of *A. suspensa* males.

We compared the total antioxidant capacity, the sexual performance, and sterility of wild-type (WT) and transgenic males overexpressing mitochondrial superoxide dismutase (SOD2 5.2), irradiated under normoxia (oxygen tensions between 10–21%), and two low-oxygen atmosphere regimes (hypoxia and quasi-anoxia). Despite the apparent sexual advantage of SOD2 5.2 flies over WT flies irradiated under normoxia, overexpression of mitochondrial superoxide dismutase did not synergistically improve the mating success of irradiated males.

Hypoxia and quasi-anoxia, per se, increased antioxidant capacity and improved the sexual competitiveness of WT males. Lek formation of normoxia irradiated insects was affected in comparison to non-irradiated insects, but did not differ for both hypoxia and quasi-anoxia irradiated males. In addition, males irradiated under low-oxygen remained sterile, similarly to males irradiated in normoxia.

The results from this project will allow a better understanding of the biological effects of radiation in sterile insects and reinforce the use of pre-irradiation treatments that protect flies against the side-effects of ionizing radiation.

Bactrocera tryoni white pupae hybrid strain

Mitzy Porras (Colombia) is a PHD student at Pennsylvania State University and an intern at the IPCL. She has worked on assessments of some quality control parameters of the white pupae hybrid strain of *Bactrocera tryoni*. *B. tryoni* is a major pest in orchards in Australia, and key insecticides traditionally used to manage the pest have recently been restricted, which has resulted in increased demands to develop environment-friendly control methods such as the SIT. Recently the SIT managers in Australia have shown strong interests in the development of a genetic sexing strain (GSS) for this fruit fly to enable male-only releases to enhance SIT efficiency.

Currently, no morphological markers are available for *B. tryoni* that allow the development of a practical GSS. As a first option, it was therefore suggested to induce a white pupae line of *B. tryoni* by means of introgression, having as a target marker the *white pupae (wp)* gene of *Bactrocera dorsalis*. The scheme of introgression of the *wp* gene into the genome of *B. tryoni* has involved several crosses and backcrosses between males of *B. tryoni* and white pupae females of *B. dorsalis* line.

First results of laboratory mating compatibility tests in small cages have shown sexual compatibility between the hybrid *B. tryoni* males and *B. tryoni* wild type females. The promising results of the present study encourage further investigation using walk-in field cages and assessments of the chemical signals that might drive the compatibility between the hybrid strain and wild *B. tryoni* females.

Bactrocera tryoni *wild type pupa (left), and* B. tryoni *white pupae of hybrid strain (right).*

FAO/IAEA/USDA post-harvest treatment project - influence of low-oxygen atmosphere on phytosanitary irradiation efficacy

Ionizing radiation has been successfully used as a post-harvest phytosanitary treatment to disinfest commercial fruit and facilitate trade by reducing quarantine barriers. To ensure the consistency and effectiveness of phytosanitary irradiation, multiple aspects that might affect its ability to prevent insect emergence must be considered, from the determination of target doses to commodity and organismal radiation tolerance. Prior studies focusing on the definition of target doses against fruit flies have significantly contributed to advance the use of phytosanitary irradiation worldwide.

Camilo Rivera Arrivillaga, an intern from Guatemala, measuring oxygen concentration for phytosanitary irradiation efficacy experiments.

Conversely, more research needs to be done to determine whether low-oxygen atmosphere conditioning, a treatment widely applied to preserve commodity quality, increases the insect's radiation tolerance and reduces the efficacy of irradiation treatments. Aiming to examine the risks of reduction in phytosanitary irradiation efficacy under low-oxygen conditioning, IPCL staff has been conducting several experiments to determine if the adult emergence of irradiated 3rd instar tephritids increases when naturally infested hosts are irradiated under hypoxic and anoxic conditions.

The results of this research can contribute to significant advances in our understanding of tephritid larval radiosensitivity and, ultimately, they might contribute to the revision of restrictions applied by regulatory agencies to phytosanitary irradiation under modified atmosphere.

LIVESTOCK PESTS

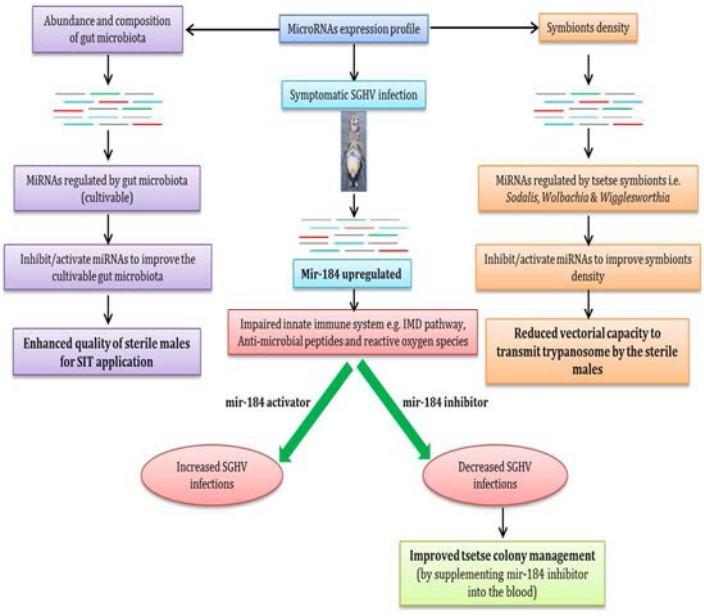
Tsetse microRNA expression profile and the management of bacterial microbiota and pathogens

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

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

The SIT has proven to be an effective method for integration in area-wide integrated pest management (AW-IPM) programmes that aim to eradicate tsetse fly populations. The SIT requires a large number of sterile males that are produced in mass-production facilities. Tsetse fly colonies infected with the SGHV are difficult to sustain and are even known to collapse, which is a serious problem for such programmes. Although a virus management strategy was developed based on the combination of a clean feeding system that minimises the re-use of blood, and the use of an antiviral drug, the potential risk of the development of virus resistance to the antiviral drugs prompted more research on alternative virus management strategies.

This study was designed to understand the role of microRNAs (miRNAs) during SGHV asymptomatic and symptomatic infections in *G. pallidipes*. Identification of the miRNAs that regulate SGHV infections may be useful to control/manage virus infections in tsetse colonies.



Schematic flow chart of experimental design: Identification of tsetse microRNAs (miRNAs) that regulate SGHV infections, symbionts density and gut microbiota community, and assessment of their potential application for tsetse colony management and production of quality sterile males for SIT application.

MiRNAs are also known to regulate the symbionts density and/or the gut microbiota community in insects, which may affect insect performance and thus is especially crucial for SIT application. This study aims to determine the miRNAs that regulate tsetse gut microbiota and the symbionts, and their potential application to improve the quality of the sterile males for SIT implementation (see figure). This work is being conducted by Irene Meki (Kenya), a PhD student at Wageningen University, The Netherlands, and currently a consultant at the IPCL.

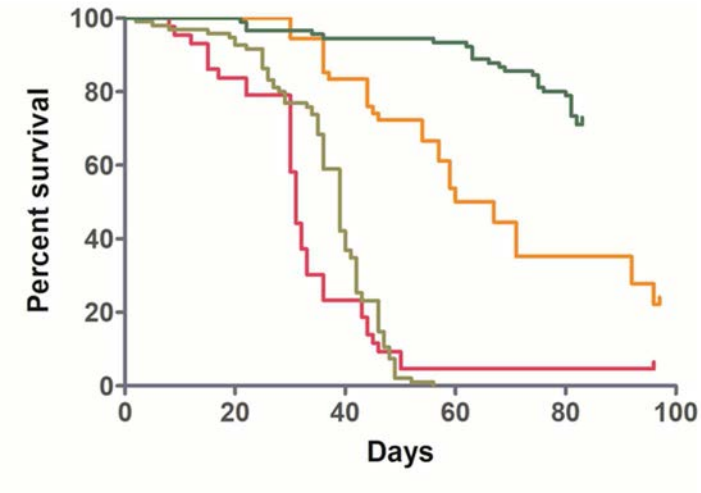
Impact of transportation and irradiation on longevity of *Glossina morsitans morsitans* males

The implementation of the SIT requires the production of sterile males of adequate biological quality to be able to survive in the field and compete with wild males for mating with wild females. In certain SIT programmes, the mass-rearing facilities are located at a significant distance from the release area, which requires the aerial transport of irradiated males. 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 sexes at the pupal stage using a near infra-red sorter device indicate the possibility of separating male from female pupae on day 22 post larvipostion. Therefore an assessment was made of the impact of irradiating 22-day old pupae, combined with transport, on male survival.

The results of male *G. m. morsitans* survival, emerged from pupae exposed to 110 Gy and transported as pupae from the IPCL in Seibersdorf to the Institute of Tropical Medicine in Antwerp, Belgium show a significant effect of irradiation at the pupal age of 22 days (see figure on the right).

This work was conducted by Guler Demirbas (Tukey), a PhD student at the Technical University, Vienna, Austria, and currently a consultant at the IPCL.



Impact of irradiation (110 Gy) and transportation of G. m. morsitans *male pupae on adult survival. Red line: transported and irradiated male pupae. Light green: non-transported irradiated. Orange line: transported non-irradiated. Dark green: non-transported non-irradiated.*

HUMAN DISEASE VECTORS

Testing new mosquito containers for *Aedes* species rearing

A United States Department of State grant of nearly USD 4 million and entitled "Surge Expansion of Sterile Insect Technique (SIT) to Control Mosquito Populations that Transmit the Zika Virus" was awarded to the IPCL in 2016. As part of the grant, an office container park was refurbished and modified into mosquito rearing areas and laboratories.

The new insectaries became operational in August 2017, and the initial weeks were devoted to ensure that the environment in the different rearing rooms was appropriate for mosquito rearing prior to moving any live material.

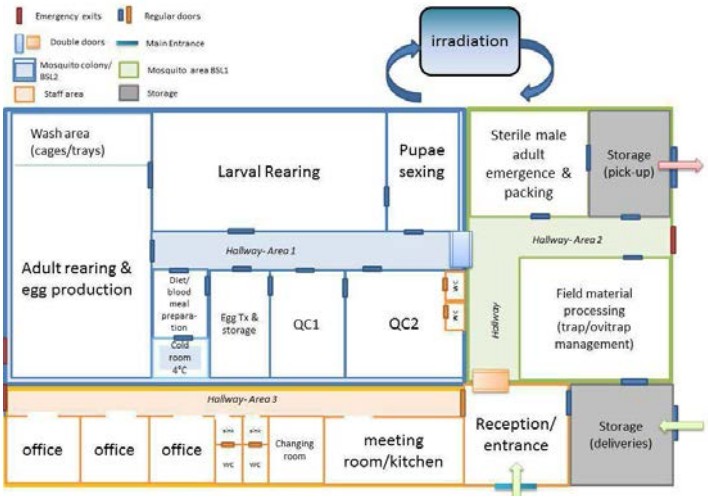
Two sets of experiments were carried out to assess the life history traits of the mosquitoes both in the old IPCL and the new container laboratories. The data of the trial confirmed that the environment was adequate for the rearing of *Aedes* mosquitoes and one strain of *Ae. albopictus* and *Ae. aegypti* have already been transferred to the new container laboratories and have been maintained so far without any major problems.

Left: main corridor of the container refurbished into an insectarium, giving access to 13 rooms corresponding to a 264 m^2 confined working space. Right: blood feeding of Aedes *spp. mosquitoes in the reference FAO/IAEA mass-rearing cage.*

Development of an inexpensive, modular, mobile rearing facility

With the assistance of our building management and construction experts, we have been working on an interim solution for our Member States planning pilot sterile male release trials, but currently lack the facility to produce the mosquitoes and handle field material for monitoring activities.

The idea is to develop a modular, mobile and relatively inexpensive rearing facility that consists of shipping containers and can be expanded as the project grows, or moved to consecutive release sites. A general floor plan with basic requirements is suggested in the figure below.



Suggested layout of a basic facility for mosquito production, packaging and shipment, and surveillance activities for SIT pilot trials.

Optimization of mass-rearing methods for *Anopheles arabiensis* larval stages: effects of rearing water temperature and larval density on mosquito life-history traits

The long-term operational success of the SIT when applied as a component of AW-IPM depends on the ability to continuously produce and release sterile males in large numbers and good quality to achieve appropriate sterile to wild insect ratios. Temperature, larval density and nutrition are important factors that affect growth and development of immature mosquitoes. Therefore, continuous attempts are made at the IPCL to improve the rearing conditions during the early stages of *An. arabiensis* mosquito development to maximize pupal production to achieve target male production levels for release and for colony maintenance.

Three sets of experiments were carried out to determine the optimal number of eggs that could be aliquoted into each larval rearing tray and the appropriate water temperature which ensured the best pupae production.

Results indicated that water temperature and egg quantity, and hence larval density, affect the production parameters of *An. arabiensis* mosquitoes required for mass-release programmes. The data point out the negative impact of high larval densities (7,000 eggs/tray) and low water temperature (22°C) on *An. arabiensis* pupae production and adult size.

With the current mass-rearing tools available at the IPCL, and within the tested range, rearing conditions of 4,000 or 6,000 eggs per larval rearing tray, hatched at a water temperature of 27°C, are the optimal conditions for mass-rearing this mosquito species, providing the largest number of pupae (105,000 pupae / larval rearing unit (rack)) with subsequent emergence of large males for release and females for eggs production.

The results are valuable for the development of standard operation procedures for the efficient large scale rearing of *An. arabiensis* mosquitoes.

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

Several studies have been completed to develop standardised methods for the sexual sterilisation of male mosquitoes for SIT releases. Dose-response curves for males of the 3 species in the presence and absence of oxygen have been mapped and clear differences in the induced sterility have been observed when irradiated in hypoxic versus normoxic states. Furthermore, effects of irradiation at semi-sterilising doses on F_1 progeny resulting from the first and second gonotrophic cycles are also being investigated. The comparison of sterilization methods using Cobalt-60 rays versus X rays has also suggested differing biological effects when the same dose is applied, but decreased voltage is used.

Impending results will contribute to an increased understanding of the radiobiology of mosquitoes and the development of guidelines for the SIT package for mosquitoes.

Standardising marking techniques for sterile male *Aedes* mosquitoes

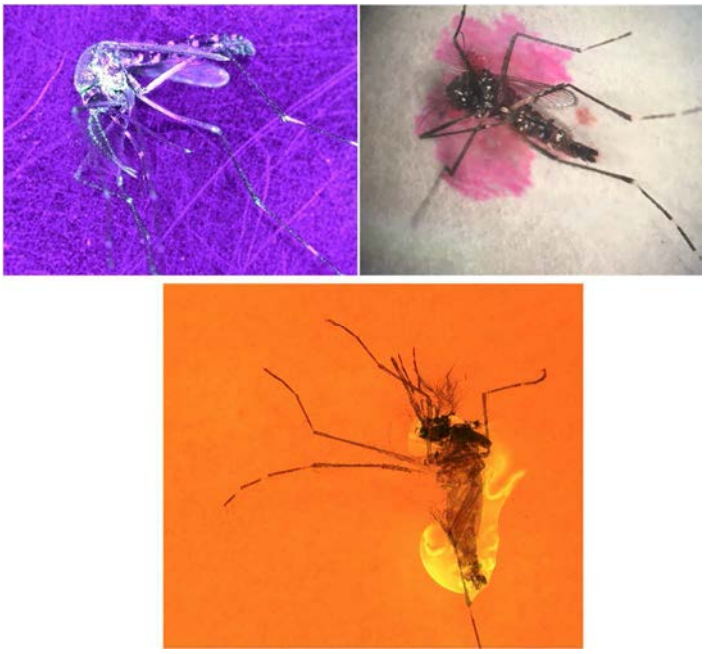
As reported in NL 87, an optimised method for marking sterile *An. arabiensis* was developed at the IPCL. As a follow-up of this research, several methods of marking sterile male *Ae. aegypti* and *Ae. albopictus* have been investigated with promising results. First, a technique using fluorescent dust to mark chilled adults was tested. It was noted that the optimal dust amount used for *An. arabiensis* was too high for both *Ae. aegypti* and *Ae. albopictus*, thus several lower quantities were tested. These lower amounts did not impact survival and were still visible on the adults for at least 14 days after application. Further experiments are presently ongoing at the IPCL to design the same optimised marking method for *Aedes* species than for *Anopheles* species.

The use of rhodamine B as a marking tool has been investigated recently (*Johnson et al. 2017: Use of rhodamine B to mark the body and seminal fluid of male Ae. aegypti for mark-release-recapture experiments and estimating efficacy of sterile male releases. PLOS Neglected Tropical Diseases 11(9): e0005902*). Following the technique described, adult male *Ae. aegypti* were fed on a sucrose solution spiked with 4 concentrations of rhodamine B for 4 days before being refed on normal sucrose solution for a period of 7 days.

We confirmed that rhodamine B did not appear to impact mortality with any of the concentrations when compared to the controls. Additionally, by using a DinoLite handheld digital microscope, we were able to detect and verify that rhodamine B was visible at all concentrations even after 7 days of normal sugar feeding (see pictures next page).

Ae. albopictus proved to be more sensitive to the higher rhodamine B concentrations used for *Ae. aegypti* and four lower concentrations were thus tested. The same results were observed with *Ae. albopictus*, with no impact upon mortality and rhodamine remaining within the body following 7 days of normal sugar feeding.

Further tests are planned to assess if the seminal fluid can be marked with rhodamine B and detected upon female dissection. Trials with *An. arabiensis* are also planned for early next year.



Upper left: Male Aedes albopictus *marked using fluorescent dye under UV light. Upper right: Rhodamine B-fed male* Ae. aegypti *after squashing under normal light. Bottom: Rhodamine B-fed male* Ae. aegypti *after squashing under a DinoLite microscope.*

Aerial release of sterile male mosquitoes using drones is almost in sight

As previously reported, the IPCL, together with the NGO *WeRobotics*, successfully secured an award of USD 400,000 from the United States Agency for International Development (USAID) in 2016 to design an aerial release system for sterile male mosquitoes.

During the last six months, two prototype release systems have been tested at the IPCL. After investigating flowability (homogeneity of the release rate), the most suitable prototype was selected and there was no impact on the quality of sterile male *Ae. aegypti*, after measuring their fly ability using the unmanned aerial vehicle and release system referred to in the previous newsletter (see figure). Final laboratory and semi-field tests were being carried out in late 2017. Three different release rates were tested and the corresponding damage to the sterile males assessed.

The impact of various wind speeds will also be investigated in order to determine the maximum flying speed of the drone. A wind tunnel has been built especially for this test to simulate similar conditions that mosquitoes will encounter upon being ejected from the release system. Batches of male mosquitoes will be compacted and held immobile for various durations to determine via flight ability tests how the quality of mosquitoes decreases over time in order to determine the maximum ferry duration that can be tolerated before release.

Field test of a drone equipped with a mosquito release machine.

Additionally, the recovery time for mosquitoes after chilling will be recorded to determine the minimal release height. The results of the above detailed tests will be crucial for establishing the parameters for an actual aerial release in pilot tests in the field planned in 2018.

Reports

WHO Vector Control Advisory Group and the Combined Sterile Insect Technique / Incompatible Insect Technique, 2-4 November 2016, Geneva, Switzerland

Aedes aegypti and *Ae. albopictus* are considered vectors of major human pathogenic viruses, including dengue, chikungunya, yellow fever and Zika. The FAO/IAEA Insect Pest Control Subprogramme has developed, and keeps refining, the SIT package to be used as a component of an area-wide integrated vector management strategy to suppress populations of *Aedes* vector species. A critical step for mosquito SIT is the separation of males from females (for male-only releases), since elimination of female mosquitoes prior to male releases is essential because the females transmit the diseases. In the absence of 100% efficient sex separation methods (or genetic sexing strains), we have integrated SIT with the Incompatible Insect Technique (IIT) which is based on the symbiont *Wolbachia* that is known to (a) induce cytoplasmic incompatibility (CI; it is expressed as embryonic mortality in crosses between infected males with females that lack the *Wolbachia* strain present in males) and (b) to provide protection against some major human viruses, including DENV, CHIKV, ZIKV and yellow fever. As a result of IIT, any female accidentally released will not be able to transmit disease, and because of the sterilization, it will not be able to reproduce.

The combined SIT / IIT approach against *Ae. aegypti* and *Ae. albopictus* was presented at a WHO Vector Control Advisory Group (VCAG) meeting and received the following conclusions and recommendations (http://apps.who.int/iris/bitstream/10665/255824/1/WHO-HTM-NTD-VEM-2017.02-eng.pdf): (a) The combined SIT/IIT technology has potential for long-term control of *Ae. aegypti* and *Ae. albopictus* mosquitoes, and (b) VCAG strongly recommends that further entomological and epidemiological field trials be conducted to validate the use of this intervention and its claims of efficacy against disease.

Scientific Workshop on Field Testing of Gene Drive Mosquitoes. Foundation for the National Institutes of Health (FNIH), 11-13 July 2017, Geneva, Switzerland

FAO/IAEA staff participated in a workshop on field testing of gene drive mosquitoes, organized by the Foundation for the National Institutes of Health (FNIH) in Geneva, Switzerland. The discussions focussed on current opportunities and challenges to test gene drives against malaria vectors. The project "Target Malaria", funded by Bill and Melinda Gates & Open Philantropy plans to release a gene drive construct of *Anopheles gambiae* in Burkina Faso, Mali and Uganda within the next 5 years. This technology will be free of intellectual property and made freely available for participant countries. A fast diffusion of the genetic construct(s) is anticipated, with a corresponding replacement or reduction of the target insect population, depending on the selected strategy.

No reversal strategy is presently available, whereas it is anticipated that resistance against the gene drive constructs will occur quickly (quicker than for insecticides), leading to rebounds of the target populations. Thus a complementary "elimination" strategy will be needed, where the SIT could play a role. The SIT might also represent a remediation to the gene drive approach, particularly in areas where it will be applied against insecticide resistant target populations. The two technologies (gene drive and SIT) both rely on mass-rearing and release of insects and could thus be highly compatible.

The FNIH expert group was very much in favour of releasing gene drive mosquitoes to control malaria in the near future. A report entitled "Guidance for Field-testing of Mosquitoes Carrying Low Threshold Gene Drive: Recommendations of a Scientific Working Group" will be published soon to make the conclusions of the expert groups publically available.

International Congress on Invertebrate Pathology and Microbial Control and the 50th Annual Meeting of the Society for Invertebrate Pathology. 13-17 July 2017, San Diego, La Jolla, California, USA

The International Congress and the Golden Jubilee of the Society for Invertebrate Pathology was held with the participation of 350 researchers in insect pathology, covering microbial, fungal, microsporidia, nematode and viral diseases. During the annual meeting, many research papers were presented reviewing the major achievements of the society over the last 50 years.

During the conference, IPC staff participated in a meeting of the INSECTPATH network that was chaired by Prof Monique van Oers, Wageningen University, The Netherlands. INSECTPATH is a proposal for a European collaborative network about research on diagnosis and control of insect diseases in insect mass-production. It was submitted to the European funding call in 2016 but was not granted. The meeting reviewed the comments of the reviewers on the submitted proposal of INSECTPATH in 2016, and it was agreed to submit a revised proposal in 2017.

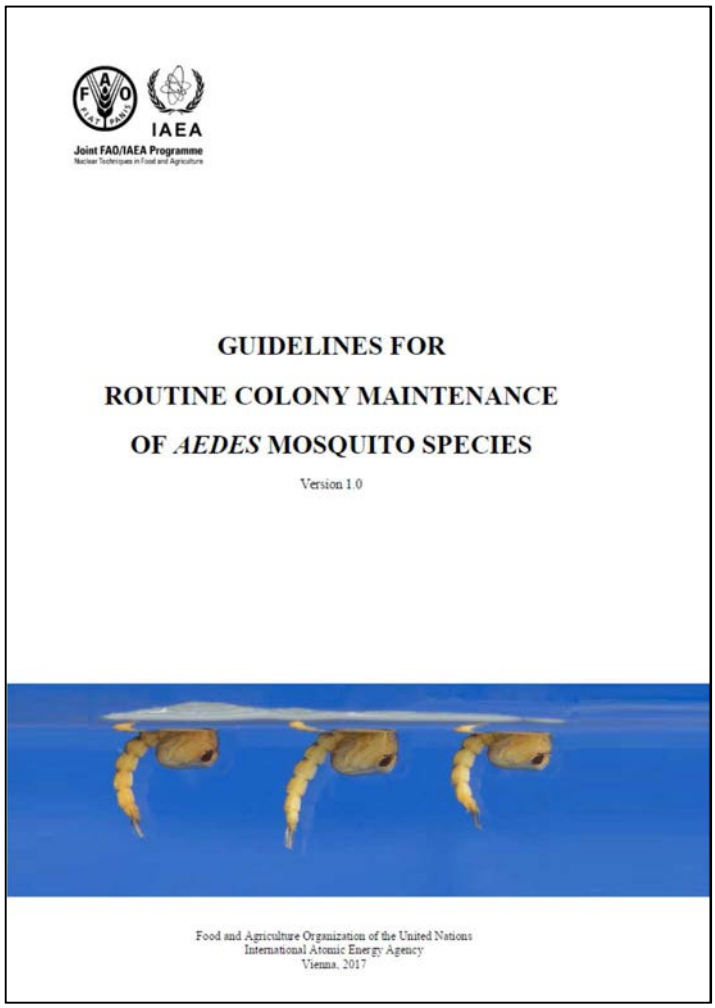
It is worth noting that insect mass-rearing for the sterile insect technique is included in the revised proposal. In addition, a new participant from Valencia, Spain joined the network with the objective to analyse the impact of virus infections on the Mediterranean fruit fly. The next meeting of the society will be held on 12-16 August 2018, Gold Coast Australia.

Announcements

GUIDELINES FOR ROUTINE COLONY MAINTENANCE OF *AEDES* MOSQUITO SPECIES

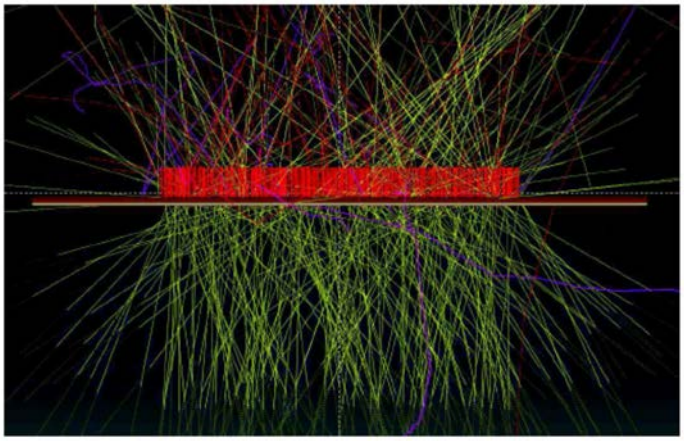
Guidelines for routine colony maintenance of *Aedes* mosquito species were recently developed by the Joint FAO/IAEA Programme. This document aims to provide a description of procedures required for *Ae. aegypti* and *Ae. albopictus* routine colony rearing. It summarises necessary steps such as optimizing climatic conditions in the insectary, egg hatching, larval rearing, pupal and larval sorting, sugar and blood feeding, egg collection, handling and storage, used at the FAO/IAEA Insect Pest Control Laboratory (IPCL) to build and maintain a laboratory colony.

This is a temporary guide that will be regularly updated. It is available on the Insect Pest Control website (http://www-naweb.iaea.org/nafa/ipc/public/guidelines-for-routine-colony-maintenance-of-Aedes-mosquito-species-v1.0.pdf).



IAEA
Joint FAO/IAEA Division

TECHNICAL SPECIFICATION FOR AN X-RAY SYSTEM FOR THE IRRADIATION OF INSECTS FOR THE STERILE INSECT TECHNIQUE AND OTHER RELATED TECHNOLOGIES



Monte Carlo simulation of X ray production. The gold target is shown in brown, backed by the cooling water in blue. The incident electrons are red and the X ray photons yellow. High energy scattered electrons are in magenta. ©Dr Josef Mittendorfer

This report, made freely available at the IPC website (http://www-naweb.iaea.org/nafa/ipc/public/X-Ray-system-sit.pdf), describes the requirements, including detailed technical specifications and physical requirements, for a self-contained X ray irradiator that may be used for SIT applications and other related uses. It includes safety requirements, performance specifications, including tests to be conducted following the commissioning phase.

These tests establish baseline data for evaluating facility effectiveness, predictability, and reproducibility for the range of conditions of operation for the key operating parameters that affect absorbed dose in the product. These tests provide the evidence that an irradiator meets the set specifications.

This Technical Specification was developed at the request of the USA Department of Energy to support the gradual transfer from gamma and other radioactive sources to X ray sterilization.

In Memoriam

Michelle Lynn Walters (1950-2017)

Dr. Michelle Lynn Walters (Mickey), 67, died July 28 at home with hospice care, friends and family in attendance, from cancer and complications from treatment.

Born to C.P. Mike and Dorothy Walters, November 25, 1950 in Mesa, Arizona, she resided in Scottsdale most of her life, with short stints in Buckeye and Mayer, Arizona, and in College Station, Texas. She earned a bachelor's degree in Agribusiness from Arizona State University in 1973, a Master's in Entomology from Texas A&M in 1987, and a PhD in Information Systems Management in 1993.

She took a job at the USDA in Phoenix before finishing her degree, and worked there for the rest of her life, telecommuting from home in recent months as her illness progressed.

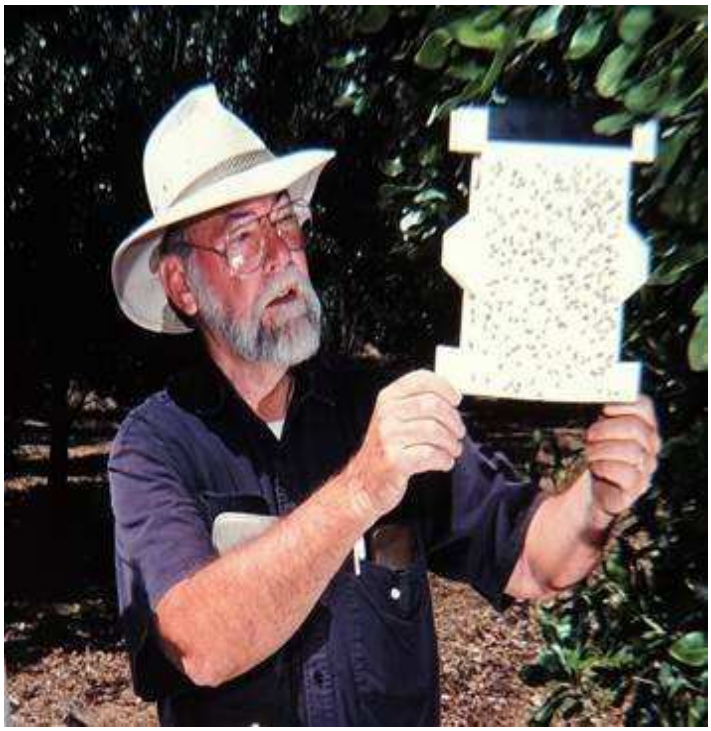
She loved science and solving problems, and was proud of her contribution to the regional project that eradicated the pink bollworm in the U.S., especially since the project moved cotton-growing away from its heavy use of insecticides into smarter non-toxic insect controls.

She loved horses and dogs, owning one of each most of the years of her life. She took classes at the Scottsdale Artist School for many years, producing a houseful of high quality oils of scenery, portraits, and animals (her favourite subject), selling some but mostly painting for the joy of it and the honing of her skills. Sadly, she was waiting for retirement to use it as a creative and profitable occupation. She is survived by her 97-year-old mother Dorothy (Scottsdale), brother Tim (and Terri, Mesa), sister Sharon (Davis, CA), nieces Melisa Smith (Victorville, CA), and Charlotte (Albuquerque, NM), and nephew Benjamin (Davis, CA). Mickey was a generous, caring, funny, loving, intelligent, tolerant, and involved family and community member. She belonged to St. Stephen's Episcopal Church, where the memorial service was held August 6th.

Source: Eoin B. Davis, APHIS-USDA.

Roy T. Cunningham (1932-2017)

Roy T Cunningham, a retired USDA-ARS Research Entomologist, died at age 85 on 11 May 2017 in Hilo, Hawaii. He passed on peacefully surrounded by his wife, Dee, and his children and grandchildren. Roy had an accomplished, illustrious career at USDA-ARS. During his over 30 years of dedicated service to the U.S. government, leading many fruit fly quarantine action programmes in the US and abroad, he demanded (he was a U.S. Marine) accuracy in collecting data because he believed that "data do not lie."



The following are few highlights of Roy's contributions to the suppression and eradication of pestiferous fruit flies, leading to a much safer horticultural commerce globally.

The '60s: Establishing Fruit Fly Management Methods of Today:

Fresh from Cornell University with a PhD and MENSA-qualified IQ (top 2%), Roy joined the USDA-ARS Hawaii Fruit Fly Laboratory. During early 1960s, under the leadership of Loren Steiner, the Hawaii Fruit Fly Laboratory embarked on monumental efforts to prove that sterile insect technique (SIT), male annihilation technique (MAT), and insecticidal protein bait application can eradicate established fruit fly populations.

To accomplish this mission, the Hawaii Fruit Fly Laboratory worked cooperatively with the U. S. Navy and the U. S. territorial governments of Guam and the Northern Marianas to eradicate the melon and oriental fruit flies (OFF) by using a combination of MAT and SIT, along with spot protein bait applications.

The SIT proved to be extraordinarily successful in the Northern Marianas, where eradicating the melon fly on the island of Rota in 1963, and MAT for the eradication of OFF on the islands of Guam, Rota, Agiguan, Tinian, and Saipan in 1965. This was the beginning of fruit fly eradication technologies that remain relevant and useful today.

From the '70s through the mid-'90s: Developing/Improving Fruit Fly Lures and Toxicants:

The fruit fly incursions in the continental U.S., particularly in California, influenced the course of Roy's research programme and assigned responsibilities at USDA-ARS.

The outcome of Roy's research on lures, baits and toxicants became indispensable, was used by APHIS-PPQ in implementing more effective eradication programmes based on SIT and MAT.

Roy and his co-workers also delivered significant innovations to APHIS-PPQ: ultra-low volume malathion bait sprays and spot treatment application of Dibrom + methyl eugenol using Min-u-Gel (a thickener). Roy and his co-workers also developed and patented a number of new technologies for detecting, monitoring, and controlling fruit flies.

Roy received various national and international awards for recognition of his excellence in research and technology transfer. He served as the USDA science adviser for the fruit fly eradication programmes in mainland United States and the MOSCAMED projects that established Mexico as Mediterranean fruit fly free country, preventing the northward movement of this fly to the U.S.

Roy was the Laboratory Director of the USDA-ARS facility in Hawaii, presently known as the Daniel K Inouye Pacific Basin Agricultural Research Center, during early to mid-'90s. Roy also served in various capacities as consultant for FAO and the US-AID projects.

Roy in our Thoughts: We remember Roy T. Cunningham, together with Loren Steiner, as major pioneers in the area of suppression and eradication of fruit flies. He demanded the best from himself and expected the same from his colleagues. His eloquence in his written and verbal communication reminded us of his extraordinary command of the English language, and, of course, his Ivy League pedigree.

Forever etched in memory of those who had worked with Roy in Hawaii were his boots, his bike, and his elixir Dr. Pepper. He was hardy; he biked the slopes of Mauna Kea from Steinback Highway to Upper Kaumana almost every day. We always thought that he would be forever young. We will always remember him as a friend, a colleague, and a mentor.

Source: Nic Liquido, ARS-USDA.

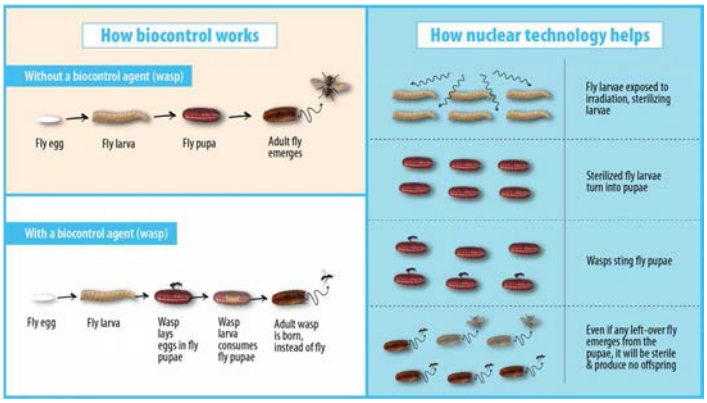
Other News

Costa Rica Aims to Control Harmful Flies with the Help of Wasps and Nuclear Technology

A group of Costa Rican experts has demonstrated that using a tiny wasp and nuclear technology can help control the stable fly, *Stomoxys calcitrans*, a pest that is causing major losses to cattle breeders in Costa Rica and beyond, as well indirectly to the pineapple and other export crop producers. The pilot project was supported by the IAEA and the Food and Agriculture Organization of the United Nations (FAO).

Just about the same size as the common housefly, the stable fly, bites and causes stress in the cattle it attacks in large numbers, provoking anaemia, weight loss and reduced milk production. It breeds among others in pineapple residue, which is abundant in Costa Rica, the world's number one pineapple producer.

"The pest is having an economic impact, because it's affecting the health of cattle; a social impact, because the public blames the pineapple producers; and an environmental impact, because the pineapple producers are required to apply more and more pesticide and plastic traps to control it," said Arturo Solórzano, the leading entomologist at Costa Rica's National Institute of Agricultural Technology Innovation and Transfer (INTA).



The solution that FAO/IAEA advised INTA to control the fly is simple: a parasitoid wasp. It is based on the use of radiation to sterilize insects, but in this case the nuclear application is applied in conjunction with biological control rather than sterile flies, which would also bite livestock. "It is extremely hard to get rid of the fly," Solórzano said. "Its populations are indestructible. So it's important to attack the fly before populations explode, which is what the wasp does by stinging the pupae."

The *Spalangia endius* wasp is a parasitoid, an insect that attacks other insects. A natural enemy of the stable fly, it lays its eggs in the fly's pupae and feeds on it. Upon hatching, the wasp larvae consume the pupae and, when the adult wasp is born, no fly emerges. It all happens naturally, which is why the wasp is called a biocontrol agent. And as for the wasp itself, it neither stings nor bites livestock.

With support from the FAO/IAEA's technical cooperation programme, experts at INTA established a pilot facility in 2012 to rear *Spalangia* wasps. When the wasps mature into adults, they are mass-released in cattle farms in eastern Costa Rica. The wasps seek out stable fly pupae to lay their eggs in, reducing the fly population. See this photo essay (https://www.iaea.org/newscenter/multimedia/photoessays/the-fly-killing-wasps-of-costa-rica) to learn more about their work in Costa Rica. The wasp, it has turned out, can kill up to 70 per cent of the stable flies, Solórzano said, over twice as many as initially expected.

Rearing wasps requires bringing a colony of stable flies, or even Mediterranean fruit flies, into the facility and using their pupae as hosts for the wasps. However, if a pupa does not have wasp eggs in it, it can develop into an adult stable fly — and be released, causing more damage to cattle.

Here is where the need for nuclear technology comes in. In order to make sure that any adult flies emerging from these pupae do not get released, the host flies are sterilized with X-rays at the larval stage. "This way, even if a few adult flies emerge that were not parasitized by wasps, they are sterile and produce no offspring," said Walther Enkerlin, an entomologist at the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture.

This has provided a safe and cost-effective solution to an escalating problem for Costa Rica. It is also a good alternative to importing and using costly chemical insecticides, which harm the environment and are becoming less and less effective.

Olivier Vargas (left), manager at pineapple producing company Dole, examines pineapple plant leftovers with Arturo Solórzano (right), entomologist at Costa Rica's National Institute of Agricultural Technology Innovation and Transfer (INTA).

With a production of over 2.5 million tonnes per year, Costa Rica is the top producer of fresh pineapple in the world. It supplies 60 per cent of global exports. Dole alone produces about 25 million pineapples a year, which it exports to the USA and Europe. Indirectly, according to Mr Vargas, the company generates employment for around 15 000 people.

Cattle breeders are most affected by the stable fly. "The flies are growing in very large numbers in the areas with more pineapple," said Marco Antonio Fallas, Project Head at the Stockbreeding Promotion Corporation CORFOGA. "Farmers are seeing their animals lose appetite and die, in front of their eyes. Cows, bulls, even horses."

"The fly is a serious national problem," said Óscar Arias, President of Agribiotecnología (AgriBio), a Costa Rican agricultural citrus and pineapple company that is working with INTA to control the pest. "And it is getting worse." According to 2015 and 2016 findings by INTA, the fly has started to breed in coffee, oil palm and citrus fruit residues as well as in rice straw.

Experts at Costa Rica's Ministry of Agriculture and Livestock are analysing the results of the pilot study to prepare a national action plan. Both farmers and producers hope science will solve their problem. "We trust that scientists will make sure this does not stay at the research level," Mr Arias added. "We want to apply it at a wider scale, across the country. I am positive that this work in progress will help reduce the fly population."

Source: Laura Gil, IAEA Office of Public Information and Communication, 5 October 2017.

South Africa's Systems Approach to EU's New False Codling Moth Regulations

The South African citrus industry has been preparing a systems approach to manage false codling moth (FCM), *Thaumatotibia leucotreta*, for the past four years, in expectation of what has indeed come to pass: from 1 January 2018 FCM will be a regulated pest in the European Union (EU).

Sean Moore, of Citrus Research International (CRI), presented information on the systems approach to delegates at a workshop on FCM and other citrus pests, as part of a nationwide CRI roadshow on FCM.

"We can scientifically prove that the system we have developed will mitigate the phytosanitary risk and this approach is in line with the International Standards for Phytosanitary Measures of the FAO's International Plant Protection Convention. It has been developed in conjunction with all stakeholders within the citrus industry. Apart from lemons, which are exempt from the regulation as a non-host for FCM, there will be no other way of exporting to the EU".

South African citrus being processed in packing house for exports to Europe.

Three exporting options have been developed for citrus to the EU. The default option, option C, includes four requirements: i) registration of each orchard, ii) orchard sanitation, iii) pheromone trap monitoring, and iv) pallet inspection by South Africa's Official Perishable Produce Export Certification Board (PPECB).

The other two options (A & B) have additional requirements in terms of fruit infestation monitoring on the farm and in the packhouse. Orchard sanitation is an effective control measure and should be conducted weekly from early in the production season and continued until after the harvest. Mr Moore emphasises the importance of training everyone in spotting the signs of FCM in fruit, from those picking the fruit to do an initial pre-sorting check, to the sorters and graders in the packhouse. He also discussed two other valuable treatments that can be included in an FCM programme to effectively suppress this pest, the sterile insect technique and mating.

Source: Carolize Jansen, Fresh Plaza, 9 July 2017.

APHIS Proposes to Allow Tree Tomatoes from Ecuador to be Imported into the Continental United States

The United States Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) is proposing to allow fresh tree tomatoes (*Solanum betaceum*) from Ecuador into the continental United States. APHIS has determined that tree tomatoes produced under a systems approach can be safely imported. The proposed rule will be published on June 21, 2017 and available for comment for 60 days.

The systems approach includes the following measures:

•Commercial consignments of tree tomatoes must be grown in pest-free production areas registered and approved by the NPPO of Ecuador.

•Tree tomatoes must meet requirements for orchard pest control, post-harvest safeguards, and fruit culling.

•APHIS must be able to trace shipments back to the orchard where they were grown.

•Tree tomatoes must be packed in covered insect-proof containers within 24 hours of harvest.

•Tree tomatoes must be inspected at the port of entry and found to be free of quarantine pests in accordance with the proposed requirements.

Additionally, the National Plant Protection Organization (NPPO) of Ecuador will have to provide APHIS with an operational work plan (subject to APHIS approval) that details activities the NPPO of Ecuador and production and packinghouses would implement to meet the requirements of the proposed systems approach. Tree tomatoes must be accompanied by a phytosanitary certificate with an additional declaration stating that they were produced under, and meet all the components of the systems approach.

APHIS will carefully consider all comments received by the deadline August 21, 2017 and then make its decision regarding any change to the Agency's import regulations for fresh tree tomatoes from Ecuador into the continental United States.

Source: USDA-APHIS, 21 June 2017.

National Sterile Insect Facility in Port Augusta, South Australia is set to produce 50 million sterile male Queensland fruit flies a week by 2019

The ambitious three-year project is all in a bid to safeguard the multi-billion dollar horticulture industry across South Australia and Victoria. Queensland fruit fly destroys an estimated A$300 million of fruit and vegetable crops every year. The $45 million SITPlus initiative, led by Horticulture Innovation Australia, complements the state-of-the-art mass-rearing facility in Port Augusta, approximately 350 kilometres from Adelaide.

Courtney Fowler had an exclusive tour through the $3.8 million facility, with SIT program director Dan Ryan and Biosecurity SA's Will Zacharin. Mr Ryan said the SIT programme was a 'game-changer' for management of the Queensland fruit fly across south-eastern Australia. He said the facility would not only ensure South Australia's remains fruit fly-free, but would also help reduce populations across the country.

"South Australia markets horticulture overseas based on freedom from Queensland fruit fly, that's worth a lot of money to the industry," he said. "If they lost that market access, it would really impact the value of their businesses, so this is all about protecting those businesses." Another use is for areas where you have large isolated farms, a good example of that might be Hillston, New South Wales (NSW), where you've got a collection of large citrus and cherry farms. "It's a great place to put that pressure down and perhaps establish longer term another pest-free area. The third use is helping farmers in endemic areas manage the flies; one of the problems growers have is they can manage the fly on their farm, but they're always getting reinvasion from off the farm."

Biosecurity SA executive director Will Zacharin said the facility in Port Augusta was putting South Australia on the world map in sterile insect technology. "It's the first purpose-built fruit-fly facility in Australia, to make sure that we could significantly ramp up the number of flies that we could get out of the factory," he said. "This will enable us to provide flies right across south-eastern Australia for those areas that need it. This is moving from a solution in a can and just trying to use chemicals to control a problem, to using new innovative technology in terms of sterile insects. It's going to be more long-term, it's going to be good for the producer, it's going to be good for the environment and it's going to be good for consumers."

Mr Zacharin said he was confident the program could help other major horticultural regions across southern NSW and Victoria strive towards becoming fruit fly-free. "We've looked at facilities overseas that produce up to a billion flies a week, so on world terms this is a small facility," he said. "But it's about demonstrating to industries and communities that releasing sterile flies is a better way to go in the long-term. If we can prove this works very well in the Australian environment, there's no reason why we can't push fruit fly freedom from where we are in South Australia, right across the Murray corridor, into southern NSW and Victoria. That will increase productivity for growers and will also give them better access to international markets."

The SITPlus program is led by Horticulture Innovation Australia, in partnership with Primary Industries and Re-

gions SA, South Australian Research and Development Institute, Victorian Department of Economic Development, Jobs, Transport and Resources, CSIRO, Plant and Food Research Australia, NSW Department of Primary Industries and Macquarie University.

Source: ABC Rural, Courtney Fowler, 1 August 2017.

Tweaking pepper weevil reproduction: Tiny bug a massive problem for Ontario, Canada 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 (*Anthonomus eugenii*), 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 Crop Science Chair in Sustainable Pest Management, said she has entered into a multi-year study in conjunction with Bruce Power in Tiverton, Ontario, 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, in British Columbia, Canada.

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

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.

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

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 environment friendly. There is no danger of the sterile pepper weevils spreading radiation, Scott-Dupree said.

Source: Rob O'Flanagan, 26 February 2017.

Ecuador Starts Pitahaya (Dragon Fruit) Exports to the United States

On 21 September 2017, the Animal and Plant Health Inspection Service (APHIS) of the United States Department of Agriculture (USDA) authorized the imports of pitahaya (*Hylocereus* spp.) from Ecuador. According to the work plan signed by APHIS and the Agencia Ecuatoriana de Aseguramiento de la Calidad del Agro (AGROCALIDAD), pitahaya fruit can now be exported to the USA from fruit fly free production sites and from authorized fruit collection centres. The possibility of exporting fruits and vegetables from pest free production sites and pest free places of production is a pest risk mitigation measure adopted by signatory countries to the International Plant Protection Convention (IPPC). This brings to a happy ending a long process of negotiations carried out by the two countries.

Commercial pitahaya production in Ecuador.

At present, 1898 hectares of pitahaya are cultivated in the country by some 389 registered growers and exporters.

The first shipment of fresh pitahaya fruit left Ecuador's Mariscal Sucre International Airport in Quito on 29 September 2017 reaching the Miami Airport shortly after. AGROCALIDAD certified the shipment of 315 kg of de pitahaya, complying in this way with the bilateral work plan.

*Yellow pitahaya fruits (*H. megalanthus*).*

Pitahaya exports to the USA will generate significant benefits to the growers at national level, mainly from the provinces of Morona Santiago, Guayas, Pichincha, Imbabura, Bolívar, Manabí, Sucumbíos, Esmeraldas, Los Ríos, Santa Elena y El Oro. These provinces maintain fruit fly monitoring systems using specific traps, complying in this manner with phytosanitary requirements established by the importing country.

In 2016, 830 tonnes were exported to other destinations; however, with the opening of the US market and according to recent estimates, the exports could increase to an estimated 8,000 tonnes per annum.

Source: Jose Vilatuña, AGROCALIDAD, Ecuador.

Argentina: Expanding the SIT against the Fruit Fly in Blueberries

Argentina has been implementing the sterile insect technique (SIT) against *Ceratitis capitata*, better known as the Mediterranean fruit fly, in parts of Patagonia, Mendoza and San Juan.

Now the National Service for Agricultural Food Health and Quality (SENASA), through the National Program for the Control and Eradication of Fruit Fly of Northeastern Argentina (PROCEM NEA), and the Association of Blueberry Producers of the Mesopotamia region of Argentina (APAMA), made the first pilot releases of sterile male flies for the control of Mediterranean fruit fly in the province of Entre Rios.

Commercial blueberry production in north-eastern Argentina.

The goal of these demonstration releases is to encourage and train the technical staff of the Program and of APAMA, as well as the productive sector and the citizens of the area, in the handling of this biological material, how to release it in the fields, and the advantages of the SIT.

These actions, which will be accompanied by a public information plan at the regional and national level, are carried out so that the region's productive establishments incorporate this control tool to their integrated pest management.

The sterile pupae and part of the necessary inputs to achieve fly emergence and transformation into adult insects were provided by the Santa Rosa Sterile Insect Production Biofactory, under the Institute of Agricultural Health and Quality of Mendoza (ISCAMEN).

The staff of the program's laboratory, which is located in the town of Chajari, has been receiving training on biological material, preparation protocols and quality tests before proceeding to its release in the blueberry production farms of Berries del Sol and Arandeira, in the Department of Concordia. The agency will continue to make releases and analyse the information generated in these pilot tests in the remainder of the production season.

The SIT is a method of biological control that is friendly to the environment. It consists of the release of thousands of sterile males that do not generate offspring, which interrupts the life cycle of the target pest population.

Source: Fresh Plaza, 16 November, 2017.

Relevant Published Articles

Evaluation of predicted Medfly (*Ceratitis capitata*) quarantine length in the United States utilizing degree-day and agent-based models

Travis Collier, Nicholas Manoukis

Daniel K. Inouye US Pacific Basin Agricultural Research Center (PBARC), United States Department of Agriculture, Agricultural Research Service, Hilo, Hawaii, USA.

Abstract

Invasions by pest insects pose a significant threat to agriculture worldwide. In the case of *Ceratitis capitata* incursions on the US mainland, where it is not officially established, repeated detections are followed by quarantines and treatments to eliminate the invading population. However, it is difficult to accurately set quarantine duration because non-detection may not mean the pest is eliminated. Most programs extend quarantine lengths past the last fly detection by calculating the amount of time required for 3 generations to elapse under a thermal unit accumulation development model ("degree day"). A newer approach is to use an Agent-Based Simulation (ABS) to explicitly simulate population demographics and elimination. Here, predicted quarantine lengths for 11 sites in the continental United States are evaluated using both approaches. Results indicate a strong seasonality in quarantine length, with longer predictions in the second half of the year compared with the first; this pattern is more extreme in degree day predictions compared with ABS. Geographically, quarantine lengths increased with latitude, though this was less pronounced under the ABS. Variation in quarantine lengths for particular times and places was dramatically larger for degree day than ABS, generally spiking in the middle of the year for degree day and peaking in second half of the year for ABS. Analysis of 34 *C. capitata* quarantines from 1975 to 2017 in California shows that, for all but two, quarantines were started in the second half of the year, when degree day quarantine lengths are longest and have the highest uncertainty. For a set of hypothetical outbreaks based on these historical quarantines, the ABS produced significantly shorter quarantines than degree day calculations. Overall, ABS quarantine lengths were more consistent than degree day predictions, avoided unrealistically long values, and captured effects of rare events such as cold snaps.

The full paper was published in: F1000Research 2017, 6:1863 (*https://f1000research.com/articles/6-1863/v1).*

Implementing the sterile insect technique with RNA interference – a review

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Abstract

We review RNA interference (RNAi) of insect pests and its potential for implementing sterile insect technique (SIT)-related control. The molecular mechanisms that support RNAi in pest species are reviewed in detail, drawing on literature from a range of species including *Drosophila melanogaster* Meigen and *Homo sapiens* L. The underlying genes that enable RNAi are generally conserved across taxa, although variance exists in both their form and function. RNAi represents a plausible, non-GM system for targeting populations of insects for control purposes, if RNAi effector molecules can be delivered environmentally (eRNAi). We consider studies of eRNAi from across several insect orders and review to what extent taxonomy, genetics, and differing methods of double-stranded (ds) RNA synthesis and delivery can influence the efficiency of gene knockdown. Several factors, including the secondary structure of the target mRNA and the specific nucleotide sequence of dsRNA effector molecules, can affect the potency of eRNAi. However, taxonomic relationships between insects cannot be used to reliably forecast the efficiency of an eRNAi response. The mechanisms by which insects acquire dsRNA from their environment require further research, but the evidence to date suggests that endocytosis and transport channels both play key roles. Delivery of RNA molecules packaged in intermediary carriers such as bacteria or nanoparticles may facilitate their entry into and through the gut, and enable the evasion of host defence systems, such as toxic pH, that would otherwise attenuate the potential for RNAi.

The full paper was published in: Entomologia Experimentalis et Applicata 164: 155-175.

The Moscamed Regional Programme: review of a success story of area-wide sterile insect technique application

W.R. Enkerlin, J.M. Gutierrez Ruelas, R. Pantaleon, C. Soto Litera, A. Villaseñor Cortes, J.L. et al.

Abstract

The Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae), is considered one of the most important pests worldwide because of its direct damage to fruit and vegetable production, and restrictions imposed to commercialization of horticultural commodities by countries free of the pest. It was introduced to Brazil in 1901 and to Costa Rica in 1955, from where it spread across the Central American region, reaching Guatemala and Mexico in 1976 and 1977, respectively. In response, the governments of Guatemala, Mexico, and the USA joined efforts to (1) contain further northward spread of the pest, (2) eradicate it from the areas it had invaded in southern Mexico, and (3) in the longer term eradicate it from Guatemala and eventually from the rest of Central America. To this effect, cooperative agreements were subscribed between the three countries and also between the USA and Belize. This allowed regional cooperation against the Mediterranean fruit fly and the creation of the Moscamed Programme. The programme was the first area-wide large-scale application of the sterile insect technique (SIT) against this pest. By 1982, the Programme had achieved its first two objectives with the containment of the northward advance of the pest, and its eradication from the areas it had invaded in the states of Chiapas and Oaxaca in southern Mexico. Furthermore, by 1985 the Mediterranean fruit fly had been eradicated from areas in Guatemala located at the border with Mexico. Since then, the programme has had years with significant territorial advances in the eradication of the pest from areas within Guatemala, combined with years when it had setbacks resulting in losses of the territorial gains. Nevertheless, during 4 decades, the programme has effectively served as an effective containment barrier maintaining the Mediterranean fruit fly-free status of Belize, Mexico, and the USA. It has also protected and increased the Mediterranean fruit fly-free areas in Guatemala. As a result, it has protected the assets of horticultural producers and contributed during this period to the development of multibillion dollar export industries in these countries. This paper provides an historical review of the programme and describes briefly how technological innovations and decision-making tools have contributed to programme efficiency. It also discusses how non-technical and external factors have limited the eradication process and further programme advance within the Central American region.

The full paper was published in: Entomologia Experimentalis et Applicata 164: 188-203.

Review of research advances in the screwworm eradication program over the past 25 years

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Abstract

New World screwworms, *Cochliomyia hominivorax* (Coquerel) (Diptera: Calliphoridae: Chrysomyinae), are devastating pests of warm-blooded animals that cause significant economic damage to livestock. The successful campaign to eradicate screwworms from continental North America, led by the US Department of Agriculture and using the sterile insect technique, continues to receive research support that has resulted in improved technologies for all aspects of the program. The process and ingredients for mass-rearing screwworms is more efficient and sustainable, and there is now a standardized protocol for developing new strains used in mass-rearing. Cryopreservation of screwworm embryos allows strains to be preserved and recovered if necessary and also reduces rearing requirements for backup and research strains. Sterile fly release procedures and equipment have been updated leading to optimized sterile fly release rates. Surveillance for screwworm infestations and outbreaks have incorporated new trap designs, habitat analysis, and molecular genetic techniques that enhance monitoring the progress of the program as well as early detection and response to outbreaks. Genetic analyses of screwworm populations across their current range have increased the understanding of genetic differentiation, which may aide in developing new strains and determining the geographic origin of screwworms causing outbreaks when they occur. The ability to release only sterile males, which has been a goal of the program for over 60 years, has recently been accomplished through the development of transgenic sexing strains. The strains carry a conditional female lethal gene and are comparable to the wild-type strain for several biological parameters that are important for mass production and performance in the field. The strains should improve efficiency of population suppression of the current and future eradication and prevention programs against screwworms. These research advances as well as future considerations are presented.

The full paper was published in: Entomologia Experementalis et Applicata (2017) 164:226-236.

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