Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Insect Pest Control Newsletter

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To Our Readers

*The new fruit fly mass-rearing facility in Mauritius, finalized in May 2019, with the capacity to produce 15 million flies per week. The immediate plan is to simultaneously produce three fruit fly species (*Bactrocera dorsalis, Bactrocera zonata *and* Zeugodacus cucurbitae*).*

Fruit flies cause large losses to fruits and vegetables in Mauritius. The most economically important fruit fly species attacking fruits are, in order of importance, *Bactrocera dorsalis* (recently introduced), *B. zonata*, *Ceratitis rosa* and *C. capitata*. Preferred cultivated hosts include mango, guava, citrus, peach and loquat while the most heavily attacked wild fruit is the Indian almond. Fruit flies like *Zeugodacus cucurbitae*, *Dacus ciliatus* and *D. demmerezi* also attack vegetables such as cucurbits and are therefore also of economic importance. It is estimated that at least 30% of the fruit and vegetables production is damaged by fruit flies amounting to an annual loss of US $6 million. Island wide fruit fly surveillance, including fruit fly trapping and larval surveillance, has been carried out since 1994. Area-wide fruit fly control using the bait application technique and the male annihilation technique (MAT) has been carried out both in orchards and cucurbit plantations in selected production areas. As a result, fruit fly infestation has been reduced from >30% to <5%. In order to make fruit fly management more sustainable and environmental-friendly, and to cover a larger areas, a fruit fly mass-rearing facility has been constructed and equipped with the support of the Joint FAO/IAEA Division experts.

The facility is a two-store building with larval rearing on the ground floor and adult rearing on the first floor. The immediate plan is to mass-rear three fruit fly species (*B. dorsalis, B. zonata* and *Z. cucurbitae*). The target is to produce and sterilise about 15 million flies per week and release in fruit and vegetable production areas with the objective to suppress fruit and vegetable infestations in selected areas. The application of the sterile insect technique (SIT) will be integrated with other fruit fly suppression methods, such as MAT, bait sprays and sanitation.

The facility will also serve to host activities of capacity development for the benefit of technicians from neighbouring Indian Ocean and mainland Africa countries. It could also serve as infrastructure to supply sterile flies for small pilot projects in the region.

On the tsetse eradication campaign in Niayes region, Senegal, the USA has provided substantial financial support though the Peaceful Uses Initiative (PUI). The much appreciated USA contribution has been instrumental to the implementation of the operational phase of the project, particularly the aerial release of the sterile male flies. Without the USA contribution, the project would not have reached the successful stage it is in now, i.e. 99% suppression of the fly population and the elimination of disease transmission in most of the project area.

HE Dr Tulinabo Salama Mushingi, the USA ambassador to Senegal accompanied by Ms Shannon Petry, Second Secretary, and Justin Thomas, Public Affairs Officer from the USA Mission to International Organizations in Vienna, have visited, in May 2019, the tsetse eradication project in the Niayes, Senegal, to observe the progresses made so far.

We would like to announce that we have just published the 'Sterile Insect Release Density Calculations Spreadsheet'. The Spreadsheet is a valuable tool for the optimizing of fruit fly sterile insect release programmes. It was developed by colleagues from the Moscamed Regional Program and the USDA-APHIS office in Guatemala. The spreadsheet could be used for pests other than fruit flies, since the same principles apply. The Excel software allows all AW-IPM action programmes worldwide to have easy access to the spreadsheet calculations, since its use is global nowadays. This spreadsheet model has been validated and it is being used routinely by managers of the Moscamed Programme for optimization of sterile fly release.

The users can access the spreadsheet and its manual at the FAO/IAEA Insect Pest Control website (http://www-naweb.iaea.org/nafa/ipc/public/manuals-ipc.html).

In December 2018, the United Nations General Assembly declared 2020 the International Year of Plant Health (IYPH). The main objective of the IYPH is to raise global awareness on how protecting plant health can help end hunger, reduce poverty, protect the environment, and boost economic development. In our next newsletters we expect to announce and report some concrete activities in the framework of the IYPH.

INTERNATIONAL YEAR OF
PLANT HEALTH
2020

We would also like to inform you about the progress of transitioning from the old IPCL into the new IPCL. The postponement experienced last year of accepting the building and starting with the relocation were related to the delays with the completion of the energy centre which provides cooling and heating (and electricity at a second stage) and ensuring proper environmental conditions for the insect colonies. However, the first phase of the energy centre was completed in mid-May 2019, and extensive testing of all operational systems will be conducted in the ensuing months. Pending a positive outcome of this testing phase, the new IPCL will be officially handed over the Joint FAO/IAEA Division in mid-August 2019, which also will be the start of the actual relocation. It has been estimated that a total of 6 months will be needed to relocate all equipment, colonies and scientific activities to the new IPCL.

Regarding IPC personnel matters, Mr Andrew Parker is retiring at the end of July 2019. We would like to thank Andrew for his outstanding work and contribution to the Insect Pest Control Section for over 25 years and wish him all the best for the new chapter ahead.

Rui Cardoso Pereira
Head, Insect Pest Control Section

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Forthcoming Events (2019-2020)

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

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

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

Third RCM on Improved Field Performance of Sterile Male Lepidoptera to Ensure Success in SIT Programmes. 21–25 October 2019, Mendoza, Argentina.

Fourth RCM on Comparing Rearing Efficiency and Competitiveness of Sterile Male Strains Produced by Genetic, Transgenic or Symbiont-based Technologies. 2–6 December 2019, Adelaide, Australia.

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

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

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

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

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

II. Consultants and Expert Meetings

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

III. Other Meetings/Events

FAO/IAEA Interregional Training Course on The Use of the Sterile Insect and Related Techniques for the Integrated Area-wide Management of Insect Pests (under Interregional TC Project INT5155). 10 June–5 July 2019, Metapa de Dominguez, Chiapas, Mexico and Guatemala City/El Pino, Guatemala.

FAO/IAEA/WHO Workshop to Finalize Joint Guidance for the Application of SIT for Mosquito Borne Diseases (under Interregional TC Project INT5155). 2–4 July 2019, Vienna, Austria.

Technical Panel on Phytosanitary Treatments (TPPT), International Plant Protection Convention, FAO. 8–12 July 2019, Vienna, Austria.

FAO/IAEA Second Coordination Meeting of the Regional TC Project RLA5075 'Strengthening the Regional Capacities in the Prevention and Progressive Control of Screwworm'. 12–16 August 2019, Medellín, Colombia.

FAO/IAEA Regional Training Course on Modern Taxonomy and Identification Tools of Fruit Fly Species in Africa (under Regional TC Project RAF5074). 23–27 September 2019, Cotonou, Benin.

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

FAO/IAEA Regional Training Course on Communication within SIT Mosquito Projects (under Regional TC Project RER5022). 7–11 October 2019, Procida, Italy.

FAO/IAEA Regional Training Course on Area-wide Integrated Fruit Fly Management including Sterile Insect Technique (SIT) and Male Annihilation Technology (MAT) in Africa (under Regional TC Project RAF5074). 7–11 October 2019, Reduit, Mauritius.

FAO/IAEA Regional Training Course on Tsetse Dissections (under Regional TC Project RAF5080). 7–11 October 2019, Accra, Ghana.

FAO/IAEA Regional Training Course on New World Screwworm Epidemiology, Diagnostics, Population Genetics, Surveillance and Control (under Regional TC Project RLA5075). 7–11 October 2019, Porto Alegre, Rio Grande do Sul, Brazil.

FAO/IAEA Meeting on the review of Thematic Plan for the Development and Application of the Sterile Insect Technique (SIT) and Related Genetic and Biological Control Methods for Disease Transmitting Mosquitoes (under Interregional TC Project INT5155). 14–18 October 2019, Vienna, Austria.

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

FAO/IAEA Regional Training Course on Marking, Handling, Transport and Release of Sterile Mosquitoes (under Regional TC Project RLA5074). 21–25 October 2019, Buenos Aires, Argentina.

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

FAO/IAEA/WHO Regional Joint Meeting between Entomologists, Virologists and Epidemiologists to Boost the Collaboration for Vector Control in the European Region (under Regional TC Project RER5022). 4–8 November 2019, Tirana, Albania.

FAO/IAEA Workshop on Preparation of SIT Pilot Trials against Mosquitoes (under Interregional TC Project INT5155). 11–15 November 2019, Valencia, Spain.

FAO/IAEA Decision-makers Workshop on the Use of the SIT (under Interregional TC Project INT5155). 27–29 November 2019, Guangzhou, China.

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

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

FAO/IAEA Workshop on Genetic Diversity Analysis and Colony Management. 8–10 May 2020, Guatemala City, Guatemala.

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

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

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

Past Events (2019)

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

Second RCM on Integration of the SIT with Biocontrol for Greenhouse Insect Pest Management. 4–8 March 2019, Mendoza, Argentina.

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

II. Consultants and Expert Meetings

FAO/IAEA Consultants Meeting on Mosquito Radiation, Sterilization and Quality Control (under Regional TC Project RER5022). 27–31 May 2019, Vienna, Austria.

III. Other Meetings/Events

FAO/IAEA Training on Basic Use of R Software to infer Demographic Parameters of Wild and Sterile Mosquitoes from Entomological Monitoring Data (under Regional TC Project RER5022). 18–22 February 2019, Seibersdorf, Austria.

FAO/IAEA/WHO Workshop to Initiate the Development of Joint Guidance for the Application of SIT for Mosquito Borne Diseases (under Interregional TC Project INT5155). 27 February–1 March 2019, Tapachula, Mexico.

FAO/IAEA Workshop on Techniques for the Rearing, Quality Control and Radiation Sterilization of *Drosophila suzukii*. 10–12 March 2019, Mendoza, Argentina.

Fourteen Session of the Commission on Phytosanitary Measures, International Plant Protection Convention, FAO. 1–5 April 2019, Rome, Italy.

Technical Cooperation Projects

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

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

Country	Project Number	National Projects	Technical Officer
Bolivia	BOL5022	Reducing Fruit Fly Populations in Different Regions Introducing an Integrated Pest Management Approach Including the Use of the Sterile Insect Technique	Walther Enkerlin
Botswana	BOT5013	Using the Sterile Insect Technique Integrated with Other Suppression Methods for Managing *Bactrocera dorsalis*	Daguang Lu
Brazil	BRA5060	Using the Sterile Insect Technique to Evaluate a Local Strain in the Control of *Aedes aegypti*	Rafael Argiles
Burkina Faso	BKF5020	Strengthening the Insectarium to Create Agropastoral Areas Permanently Liberated from Tsetse Flies and Trypanosomiasis	Adly Abdalla
Chad	CHD5007	Contributing to the Eradication of *Glossina fuscipes fuscipes* to Improve Food and Nutritional Security	Rafael Argiles
Chile	CHI5051	Implementing Pilot Level of Sterile Insect Technique for Control of *Lobesia botrana* in Urban Areas	Walther Enkerlin
China	CPR5020	Integrating the Sterile Insect Technique (SIT) for Area-wide Integrated Pest Management of Tephritid Fruit Flies	Rui Cardoso Pereira
Cuba	CUB5021	Demonstrating the Feasibility of the Sterile Insect Technique in the Control of Vectors and Pests	Rafael Argiles
Ecuador	ECU5029	Improving Integrated Fruit Fly Management in Fruit and Vegetable Production Areas	Walther Enkerlin
Ethiopia	ETH5021	Enhancing Livestock and Crop Production Through Continued Consolidated and Sustainable Control of Tsetse and Trypanosomosis	Rafael Argiles
Fiji	FIJ5001	Examining Options for the Management of Fruit Flies	Daguang Lu
Guatemala	GUA5019	Strengthening National Capabilities for the Control of Agricultural Pests Using Nuclear Technologies	Walther Enkerlin
Israel	ISR5021	Assisting in the Development of a Strategy to Counteract *Bactrocera zonata*	Walther Enkerlin
Libya	LIB5011	Enhancing Area-wide Integrated Management of Fruit Flies	Walther Enkerlin

Mexico	MEX5031	Using the Sterile Insect Technique to Control Dengue Vectors	Danilo Carvalho
Morocco	MOR5035	Implementing the Sterile Insect Technique in the Souss Valley	Walther Enkerlin Carlos Cáceres
Oman	OMA5007	Strengthening Sterile Insect Technique Based Area-wide Integrated Management of Date Palm Pests	Marc Vreysen
Palau	PLW5002	Improving the Quantity and Quality of Fruits for Exportation and Domestic Consumption Through Area-wide Integrated Pest Management of *Bactrocera* Fruit Flies in Tropical Fruit and Vegetable Production Areas (Phase II)	Daguang Lu
Papua New Guinea	PAP5001	Supporting a Feasibility Study on Using the Sterile Insect Technique against the Cocoa Pod Borer	Marc Vreysen
Philippines	PHI5033	Building Capacity in Using the Sterile Insect Technique against Dengue and Chikungunya Vectors	Wadaka Mamai
Senegal	SEN5037	Supporting the National Programme to Control Tsetse and Trypanosomosis	Marc Vreysen Rafael Argiles
South Africa	SAF5014	Assessing the Sterile Insect Technique for Malaria Mosquitos in a South African Setting, Phase II	Hanano Yamada
South Africa	SAF5015	Supporting the Control of Nagana in South Africa Using an Area-Wide Integrated Pest Management Approach with a Sterile Insect Technique Component - Phase I	Marc Vreysen
Seychelles	SEY5009	Suppressing Melon Fruit Fly Species through Environment-Friendly Techniques to Enhance Food Security	Rui Cardoso Pereira
Sri Lanka	SRL5047	Establishing a National Centre for Research, Training and Services in Medical and Molecular Entomology for Vector-borne Disease Control	Kostas Bourtzis
Sudan	SUD5038	Implementing the Sterile Insect Technique for Integrated Control of *Anopheles arabiensis*, Phase II	Adly Abdalla
Thailand	THA5052	Developing Sustainable Management of Fruit Flies Integrating Sterile Insect Technique with other Suppression Methods	Daguang Lu
Uganda	UGA5036	Demonstrating the Feasibility of a Sterile Insect Technique Component as Part of an Area-wide Integrated Pest Management Approach to Increase Livestock Productivity	Rafael Argiles
Viet Nam	VIE5021	Integration of the Sterile Insect Technique with Other Suppression Methods for Control of *Bactrocera* fruit flies in Dragon Fruit Production	Rui Cardoso Pereira
Zimbabwe	ZIM5023	Improving Crop and Livestock Production through the Eradication of Bovine and Human Trypanosomiasis in Matusadona National Park	Rafael Argiles

		Regional Projects	
Regional Africa	RAF5074	Enhancing Capacity for Detection, Surveillance and Suppression of Exotic and Established Fruit Fly Species through Integration of Sterile Insect Technique with Other Suppression Methods	Daguang Lu
Regional Africa	RAF5080	Supporting Area-Wide Tsetse and Trypanosomosis Management to Improve Livestock Productivity - Phase IV	Rafael Argiles
Regional Asia (ARASIA)	RAS5076	Harmonizing and Strengthening Surveillance Systems to Prevent and Control Exotic and Native Fruit Flies Including the Use of the Sterile Insect Technique	Walther Enkerlin Adly Abdalla
Regional Asia	RAS5082	Managing and Controlling *Aedes* Vector Populations Using the Sterile Insect Technique	Marc Vreysen Hamidou Maiga
Regional Europe	RER5022	Establishing Genetic Control Programmes for *Aedes* Invasive Mosquitoes	Jeremy Bouyer
Regional Latin America (ARCAL)	RLA5070	Strengthening Fruit Fly Surveillance and Control Measures Using the Sterile Insect Technique in an Area-wide and Integrated Pest Management Approach for the Protection and Expansion of Horticultural Production (ARCAL CXLI)	Walther Enkerlin
Regional Latin America	RLA5074	Strengthening Regional Capacity in Latin America and the Caribbean for Integrated Vector Management Approaches with a Sterile Insect Technique Component, to Control *Aedes* Mosquitoes as Vectors of Human Pathogens, particularly Zika Virus	Hanano Yamada Rui Cardoso Pereira
Regional Latin America	RLA5075	Strengthening the Regional Capacities in the Prevention and Progressive Control of Screwworm	Walther Enkerlin
		Interregional Project	
Interregional	INT5155	Sharing Knowledge on the Sterile Insect and Related Techniques for the Integrated Area-wide Management of Insect Pests and Human Disease Vectors	Jeremy Bouyer Rui Cardoso Pereira

Highlights of Technical Cooperation Projects

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

Shielding Morocco from Invasive Fruit Fly Pests

In Morocco, the citrus industry plays an important socio-economic role. Citrus is cultivated on over 111 000 ha, with an average production of 1.3 million tons per year. Citrus is a major export commodity and therefore an important source of foreign currency. Around 500,000 tons of citrus fruit are exported every year mainly to Russia, the EU and also to the USA, valued at around US $400 million per year. On the social part, the citrus industry contributes significantly to improving the incomes of 13 000 farmers, generating nearly 21 million working days per year, 25% of these being for women. The citrus industry in Morocco is increasingly at risk, due to the presence of the Mediterranean fruit fly, *Ceratitis capitata*. Given this situation and the need to foster citrus production and exports, as well as the need to respond to the Moroccan consumer demands, the government of Morocco through the National Office for Food Safety (ONSSA) of the Ministry of Agriculture and the Ministry of Energy and Mines, requested the International Atomic Energy Agency (IAEA), for assistance to transfer the sterile insect technique (SIT) for the area-wide sustainable control of the Mediterranean fruit fly. The SIT is a proven cost-effective and environment friendly pest control nuclear technology.

Deployment of fruit fly traps at high risk points of entry in Morocco.

The use of the SIT, requires the mass-production, sterilization and release of insects. To achieve this milestone, the Moroccan Government and the citrus industry through Maroc-Citrus as the main contributing funders have engaged in the construction of such a facility. The facility is being built in Agadir, the heart of the citrus production in Morocco, and aims at a weekly production of 100 million sterile Mediterranean fruit flies per week, which will be sufficient to protect the commercial citrus production in the Souss–Massa Valley. It is envisioned that the Mediterranean fruit fly facility will start operations by the end of 2019.

National surveillance network against invasive fruit fly species in Morocco.

This major investment could be seriously disrupted if other non-native invasive fruit fly species are introduced into the country and manage to spread and establish. Among the greatest fruit fly risks are the peach fruit fly, *Bactrocera zonata* a native from India and Pakistan and already present in Egypt and in Libya, and the Oriental fruit fly, *B. dorsalis*, a native from Southeast Asia and present throughout sub-Saharan Africa including Mauritania. Other *Bactrocera* and *Anastrepha* fruit fly species are also of considerable risk to Morocco. To mitigate this risk, another major objective of this project has been to develop the national capacity for early detection and emergency response to the incursions of such invasive fruit fly species. This has been achieved by means of a number of workshops and expert missions which have transferred relevant technologies. This includes fruit fly trapping methodologies following international standards of the International Plant Protection Convention (IPPC) and emergency response protocols. It also includes Global Positioning Systems (GPS) for preparation of maps showing trapping grids and Geographical Information Systems (GIS) for data analysis, reporting and as a decision support tool. As part of the preparedness for an eventual incursion of any of these fruit fly species, the IAEA has also supplied the necessary materials to timely respond to a fruit fly incursion under the framework of the project. This includes materials for delimiting an infestation through intensive surveys as well as specific materials to effectively eliminate the infestation. Through these capacity building efforts, a group of young professionals from ONSSA is now available and already applying these technologies.

As a result, Morocco has deployed a national surveillance network for early detection and has built-in the capacity for an emergency response in the event of the incursion of any of these invasive pest species. The surveillance network is composed of 8 high risk points of entry spread-out throughout the country's borders, with a total of 94 traps (including at the Algeria and Mauritania borders). In addition, 19 risk sites in the interior of the country that include fruit markets, touristic sites and some orchards closely located to risk areas, in this case, with 150 traps. Therefore, a total of 27 risk sites are being surveyed in the country and a total of 244 traps baited with specific lures have been deployed that are being serviced every two weeks. With this network of specific traps placed along the Moroccan borders and in other risk sites in the interior of the country, the assets of the horticultural industry of Morocco and the SIT project against Mediterranean fruit fly are protected at the maximum from the introduction of non-native invasive fruit fly species.

Examining Options for the Management of Fruit Flies (FIJ5001)

The Rotuma Island is a small remote island of around 43.9 km^2 and located about 600 kilometres apart from Fiji main island (Viti Levu). There are two fruit fly species (*Bactrocera kirki* and *B. obscura*) present which are unique to this island within Fiji. Especially, *B. kirki*, which is a polyphagous fruit pest, poses a major quarantine threat to the fresh fruit and vegetable industry on the main islands of Fiji, which will impact the fruit trade to international markets. To mitigate the risk of *B. kirki* spreading to other islands of Fiji, the government of Fiji through the Biosecurity Authority of Fiji (BAF) requested assistance of managing *B. kirki* (a cuelure responder) on Rotuma Island using an area-wide integrated pest management (AW-IPM) approach.

Presently, two main strategies have been applied to the management of *B. kirki* on Rotuma Island. First, increasing the national capacity on fruit fly detection and interception. The entire island has been declared a biosecurity emergency area for the fruit fly species *B. kirki* and *B. obscura* since 2019. Any potential host materials including all fruits are prohibited being exported from the island. To enhance the fruit interception capability in Rotuma airport and sea port, TC project FIJ5001 supplied two X-ray luggage inspection systems. The national detection and surveillance trapping network in the main islands of Fiji has also been improved. Traps are placed in fruit fly host trees in high risk locations such as ports of entry, tourist areas, yacht clubs, wharves, green waste dump sites, residential and production areas. Each trap site includes three traps with different lures (cuelure, methyl eugenol and trimedlure). And Global Positioning System (GPS) coordinates have been recorded for all trap sites to ensure accurate trap positioning on maps with trapping data. The inspection intervals fluctuate from once every two weeks on the main island and once per month on remote islands which are difficult to access.

Fruit fly warning sign erected at Rotuma island sea port by Biosecurity Authority of Fiji (BAF).

The second strategy is the validation of possible suppression methods on Rotuma Island. A survey has indicated that most hosts are wild and present in the large forest areas on the island. A pilot suppression has been considered in the isolated western end of Rotuma to test methodologies, logistics and the possible extension of suppression activities to the whole island. Protein baits, male annihilation technique (MAT) with cuelure and sanitation will be applied in the pilot area with the participation of the local community.

Mr Eric Jang, IAEA expert shows the Biosecurity officers and Chief of the community how to make MAT blocks using coconut husks.

Integration of the Sterile Insect Technique with Other Sup-pression Methods for Control of *Bactrocera* fruit flies in Dragon Fruit Production (VIE5021)

Integrated Pest Management to Boost Dragon Fruit Production in Viet Nam

There is a reason why dragon fruit is considered a rich and famous fruit in Viet Nam: it is exported to 40 countries and return from dragon fruit production is several times higher than from rice production.

In Binh Thuan province, around 29 500 hectares are dedicated to growing the fruit, with a production of nearly 600 000 tonnes last year, and its Department of Agriculture and Rural Development plans to increase that by 2020. However, this plan may be hindered by formidable pests capable of decimating dragon fruit crops: fruit flies.

"Dragon fruit is a favourite crop in Viet Nam because farmers are aware of its potential to earn them a steady income," said Hien Thanh Thi Nguyen, Deputy Head of the Entomology Division at Viet Nam's Plant Protection Research Institute. "Unlike many other fruits that are seasonal, dragon fruit can be cultivated all year round and each crop season lasts only two and a half months, so it has great economic importance. The fruit is very important for the province's economy, but the fruit flies are a big problem for this area."

Therefore, the Plant Protection Research Institute, along with staff from the Agriculture and Rural Development Department of Binh Thuan province, teamed up with the IAEA and the Food and Agriculture Organization of the United Nations (FAO) in a pilot project to test the effectiveness of implementing an integrated pest management approach, including a form of insect pest control known as the Sterile Insect Technique (SIT). Using this technique, fruit flies are mass-produced and then sterilized using ionizing radiation before being released into the environment to mate with wild flies, producing no offspring.

Towards a Coordinated Area-wide Approach

Methods traditionally used to suppress fruit flies in the province have been uncoordinated, with individual orchards carrying out their own pest management using chemical pesticides on a field-by-field basis. This has limited effectiveness, given the speed at which the flies reproduce – laying up to 500 eggs at a time – and their ability to move easily to untreated crops on neighbouring farms. Integrated pest management using SIT offers the possibility of permanently reducing or eliminating fly populations across a wide area.

The integrated pest management pilot project began in January 2016, covering around 1500 hectares of dragon fruit crops. In the first three-year phase, bait sprays, sanitation and a male annihilation technique were used to reduce fruit fly infestation in the pilot area to half of the infestation levels on untreated farms.

The final stage of the programme is being implemented this year, involving the use of SIT for the first time in Viet Nam. Around one million fruit flies are being reared in special facilities every month, sterilized using irradiation, and then released into the pilot project's pest-infested areas to further reduce the fruit fly population. If successful, this has the potential to benefit around 30 000 households and 250 dragon fruit trading enterprises in Binh Thuan in the longer term.

"We'll release the sterile flies by driving through the dragon fruit fields by car and motorbike, throwing packets of irradiated flies out into the fields," said Hien. "We need to drive through the farms every week following the dragon fruit crop season timeframes."

Changing Farmers' Mindsets

Getting to the point of SIT implementation has not been easy, due to limited knowledge of the technique within the local offices and resistance from dragon fruit farmers, who did not at first understand how releasing more flies into the fields would ultimately reduce the population.

"They didn't understand that the fruit fly would be sterilized," said Hien. "They would say, 'We have so many flies already, how can we combat this by bringing in more flies?' So, we had to change the way we approached farmers about this with a series of trainings, leaflets and television advertisements, and it took about two years before they started thinking that maybe this could help. It's important because getting the programme to work depends on the farmers in the entire area actively participating in the pest management."

Continued FAO/IAEA Support

The IAEA and the FAO have supported the pilot project through the IAEA technical cooperation programme, focusing on integrating SIT with other suppression methods. This support has involved collecting baseline data, installing facilities to kick start the application of SIT in the country, supplying materials and equipment, and training experts in area-wide fruit fly management through scientific visits and fellowships.

As the pilot project prepares to enter its final phase, the IAEA and the FAO, through the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, continue to provide technical advice and knowledge on the use of integrated pest management techniques and SIT.

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

Although Seychelles still has managed to keep economically important exotic fruit fly species at bay, these efforts should continue to prevent the introduction of Oriental fruit fly, *Bactrocera dorsalis*, the major threat to Seychelles' agriculture. The country remains at high risk of its introduction through commercial consignments or by introduction of infested fruits by individuals when arriving in the country by air or by sea. However, Seychelles, until February 2019, is still the only sub-Saharan Country free of Oriental fruit fly. This status is mainly due the quarantine infrastructure and capacity building in quarantine enforcement achieved under this and previous projects.

The project also implemented of a melon fly (*Zeugodacus cucurbitae*) suppression study in a pilot area. With this objective, a melon fly pilot suppression study was conducted for three months (the cucumber crop cycle) on Mahe Island. The study area comprised about 8 km^2, and the following suppression methods were integrated: (1) sanitation; (2) male annihilation technique (MAT) blocks baited with cuelure (CUE); (3) bait spays with spinosad; and (4) mass-trapping with spinosad. To evaluate the impact of the suppression, a network of 41 Tephri traps with CUE as attractant was deployed and fruit sampling for larval infestation was conducted before and during the pilot trial. Adult populations caught in CUE traps decreased from about 6 flies per trap per day (FTD) to <1 FTD, and fruit infestation decreased from about 90% to 20%.

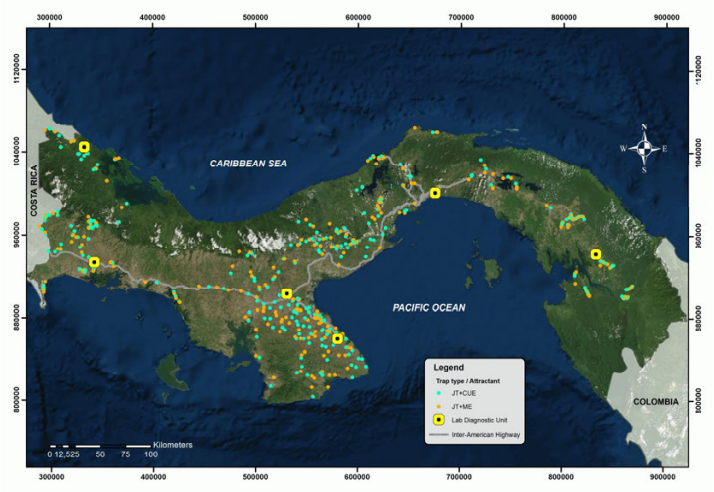
The wing of the new multipurpose laboratory where the Entomology Unit is located and that contains the infrastructure for future reception and handling of sterile flies.

Also, very important, the renovation of the donated former BBC Relay Station at Grand Anse, Mahe Island, was concluded in late 2018 and the new multipurpose laboratory is fully operational. This laboratory includes an entomology wing to support the reception and handling of the sterile melon flies potentially supplied by Mauritius.

Strengthening Fruit Fly Surveillance and Control Measures Using the Sterile Insect Technique in an Area-Wide and Integrated Pest Management Approach for the Protection and Expansion of Horticultural Production in Latin America (RLA5070)

Establishment of Surveillance Systems

One of the main objectives of this project was to establish in some Member States and to strengthen in others a surveillance network for early detection of invasive fruit fly species. This objective was achieved so far in 90% of the participating Member States. In total, 284 new risk sites were identified where 1669 traps were deployed. This prepares Member States for early detection of incursions of invasive fruit fly species and a rapid response in case of an outbreak. Protecting the horticultural industry in Member States will always result in the best return on investment. An example of such surveillance network for invasive fruit fly species established in Panama is shown in the Figure.



Surveillance network for invasive fruit fly species in Panama (Blue dots=JT+CUE; Brown dots=JT+ME; Yellow dots=Laboratory Diagnostic Unit).

Opening of Export Markets Through the Establishment of Pest Risk Mitigation Schemes

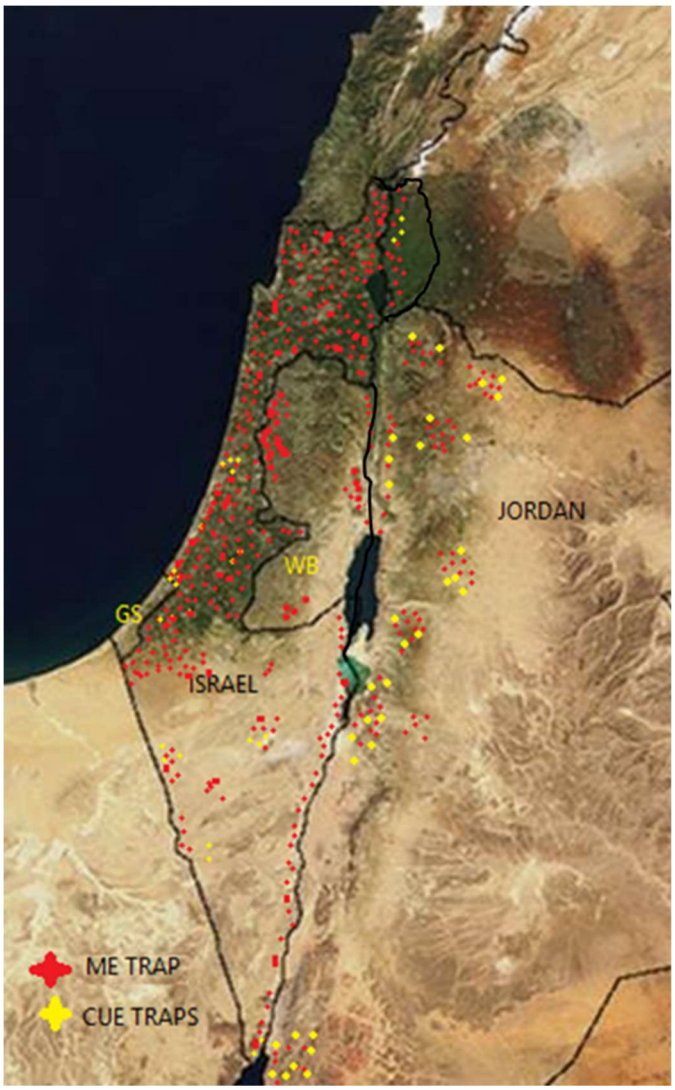
Through the strengthening of integrated fruit fly management, Member States were able to establish, declare and maintain fruit fly low prevalence areas as part of a systems approach to mitigate pest risk. As a result, a total of five areas were declared as a low-prevalence area and 14 official agreements for exports of commodities have been subscribed or will be subscribed shortly. This includes pitahaya or dragon fruit, blackberries and tree tomato from Ecuador to the USA, melons from Honduras to Taiwan and Mexico and melons from Brazil to China and mango from Brazil to South Africa and Korea.

Melons from fruit fly pest free places of production in Honduras exported and being marketed in Taiwan.

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

Shielding the Middle East Against Invasive Pests Through Good Will and Regional Cooperation

The IAEA and FAO have created capacities in the Middle East to prevent the incursion and establishment of non-native invasive fruit fly pests such as the peach fruit fly, *Bactrocera zonata* and the Oriental fruit fly, *B. dorsalis*. This has been possible through the establishment of a surveillance network against these insect pests through the deployment of over 1 000 specific traps placed at high risk points of entry and other risk sites such as fruit markets and touristic sites. In Israel, for example, the surveillance system against invasive pests has been enhanced in recent years, by risk management-driven distribution of traps with consideration to pests of the highest concern and high-risk areas. The monitoring system against pests of utmost concern has been augmented quantitatively by the addition of suitable traps. The recent expert workshops that took place in Jordan and in Israel in late 2018 provided the counterparts with further knowledge and advice on effective trap distribution, as well as the preparation of contingency plans to mitigate any case of invasion or outbreak of invasive fruit flies or other pests of concern. The continuous operation of the surveillance network allows for early detection of pest incursions and for rapid response using specific eradication techniques. The capacity for early response through the application of contingency plans against these invasive pests, has also been transferred to these Member States through IAEA technical cooperation. Such a surveillance network, shields the region from these invasive pests and in this manner protects the high valued plant resources including fruits and vegetables, contributing to food security and safety in the region. The figure shows a string of traps forming a solid ring around the region and protecting it from the invasive pests. This is an unprecedented achievement that has been possible through the good will and effective cooperation between Israel, Jordan and the Territories Under the Jurisdiction of the Palestinian Authority.



Surveillance network for invasive fruit flies in Israel, Jordan and the Territories Under the Jurisdiction of the Palestinian Authority.

The operation of this surveillance network is supported by specialized diagnostic laboratories and trained staff. This capacity has also been created through the technical cooperation projects. For example, in the Territories Under the Jurisdiction of the Palestinian Authority, such laboratory is now considered as the first entomological diagnostic laboratory. The Minister of Agriculture is working now for ac-

creditation of this central laboratory which will help Palestinians to boost access to international markets, especially those markets with strict quarantine regulations against insect pests. On 10th December 2018 this laboratory was officially inaugurated by his Excellency the Prime Minister of the Territories Under the Jurisdiction of the Palestinian Authority, who showed commitment to sustain this laboratory with all resources needed.

HE the Prime Minister of the Territories Under the Jurisdiction of the Palestinian Authority inaugurating the diagnostic laboratory in Palestinian Territories.

Supporting the National Programme to Control Tsetse and Trypanosomosis (SEN5037)

HE Dr Tulinabo Salama Mushingi, US Ambassador to Senegal Visits the Tsetse Eradication Project in the Niayes, Senegal

Since 2005, the Government of Senegal, through the Direction of Veterinary Services (Ministry of Livestock), and the Senegalese Institute of Agricultural Research (Ministry of Agriculture), has been implementing a project to create a sustainable tsetse-free zone in the Niayes, an area located north and east of the capital, Dakar. The project has received technical and financial support through the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, the IAEA Department of Technical Cooperation, but also substantial financial support though the Peaceful Uses Initiative (PUI) of the USA. Especially the contribution of the USA through the PUI has been instrumental to implement the operational phase of the project, particularly to fund the aerial release of the sterile male flies. Without the USA contribution, the project would not have reached the successful stage it is in now, i.e. 99% suppression of the fly population and elimination of disease transmission in most of the project area.

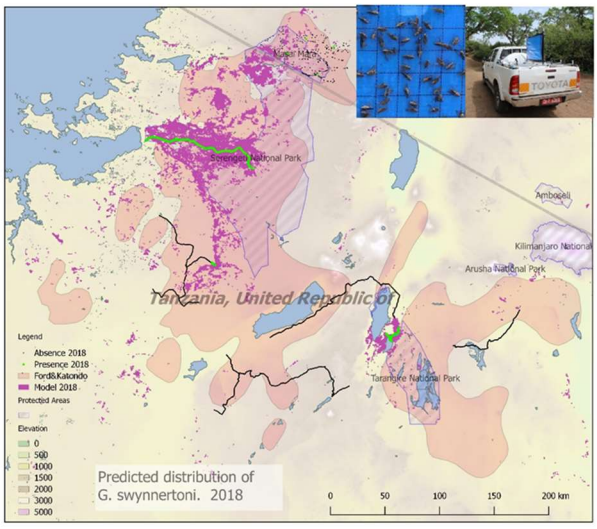
Ms Shannon Petry and Mr Justin Thomas, Second Secretary and Public Affairs Officer, respectively of the USA Mission to International Organizations in Vienna visited the project from 7–10 May 2019. Ms Petry received a complete overview of the project, and visited the insectary in Dakar, the parc de Hann, and the Domaine de Kalahari (company responsible for the aerial release operations). On 9 May 2019, the USA Ambassador to Senegal, HE Tulinabo Salama Mushingi, accompanied by staff of the USA Embassy in Dakar, visited the tsetse project as well. The Ambassador and his entourage visited a traditional farmer whose animals have been thriving since the removal of the tsetse (border of block 1 with Block 2), an industrial farm, a demonstration of the aerial releases with the gyrocopter, and a visit to the "Association Nationale pour l'Intensification de la Production Laitière" (ANIPL). The USA delegation through this visit could witness the very positive impact of their financial contribution to this project, i.e. the significant socio-economic impact of the suppression of the fly population on the development of more efficient and sustainable livestock production systems in the Niayes.

HE Dr Tulinabo Salama Mushingi, USA Ambassador in Senegal (seated right) being briefed by a traditional farmer (standing right) on the significant socio-economic benefits of the tsetse project, on how it has improved the productivity of his livestock and how it has enhanced his livelihood.

The visit of the US ambassador was covered by local and international media (e.g. Swiss radio, the Washington Post: https://www.washingtonpost.com/world/africa/a-us-funded-nuclear-project-to-zap-a-killer-fly-into-extinction-is-saving-west-africas-cows/2019/05/31/12f92626-7713-11e9-a7bf-c8a43b84ee31_story.html?utm_term=.6d1f80ee0b54), and a press conference was organised at the US Embassy in Dakar with the participation of several local news agencies.

Supporting Area-Wide Tsetse and Trypanosomosis Management to Improve Livestock Productivity and Enable Sustainable Agriculture and Rural Development (Phase IV) (RAF5080)

The distribution of the tsetse savannah species *Glossina swynnertoni* has been updated using the geo-referenced fly-round and predicted distribution software. The geo-referenced fly-round consists of a moving blue sticky target that is photographed at regular time intervals and a software that extracts the coordinates of the metadata of the pictures with new tsetse catches. It takes advantage of the behaviour of some tsetse savannah species that are attracted to large moving objects. A machine learning model (Maximum Entropy software – MaxEnt) is used to predict the species realized niche based on the entomological data collected and the use of remote sensing environmental data.



Predicted distribution map of G. swynnertoni *in 2018 compared to the distribution mapped by Ford & Katondo (United Republic of Tanzania and Kenya).*

More than 10 000 presence/absence data were collected by the technicians of the Vector and Vector Borne Disease Research Institute in the northern part of the United Republic of Tanzania. In only 9 days of field work, transects were followed along paths and dirt tracks selected in the areas of interest identified using the entomological data from the National Atlases on T&T provided by FAO. The new distribution, with a pixel resolution of 500m, indicates that there has been a dramatic reduction in the size of the *G. swynnertoni* belt since the last maps from Ford and Katondo (around 85% reduction) and that populations are usually restricted to natural protected areas. Fragmented populations can be identified and targeted for elimination in future control programmes. Similar entomological surveys are planned for this year to update the distribution of savannah species in other countries (Burkina Faso, Kenya, Senegal, United Republic of Tanzania, Uganda, Zambia and Zimbabwe).

Using the Sterile Insect Technique to Evaluate a Local Strain in the Control of *Aedes aegypti* (BRA5060)

In Brazil, Moscamed has initiated a pilot project to demonstrate the feasibility of using the SIT to suppress *Aedes aegypti* population in Recife, a city that was hard hit in 2016 by Zika infections and microcephaly cases in new born infants. The pilot site has a surface area of 65 ha and is located in the neighbourhood of Brasília Teimosa, an isolated area surrounded by the sea. A local strain of *Ae. aegypti* has been colonised and characterised, and sterilization procedures using gamma radiation have been developed for adult males. The Municipality of Recife through the Centro de Vigilância Ambiental of the Health Secretary is very committed to the project and has recently finalised the construction of a small insectary with a production capacity of one million sterile males per week.

The map of the area selected for the pilot project using SIT against Aedes aegypti *in Brasilia Teimosa, Recife, Bahia.*

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 (RLA5074)

Regional Training Course on Components of the Sterile Insect Technique package: Principles and Practice, Buenos Aires, Argentina, 6–10 May 2019

A regional training course on "Components of the SIT package: Principles and Practice" was hosted by the Comisión Nacional de Energía Atómica (CNEA) at the Centro Atómico Ezeiza, in Buenos Aires, Argentina from 6–10 May 2019, with participants from Argentina, Uruguay and Paraguay.

Participants of the Regional Training Course on Components of the Sterile Insect Technique package: Principles and Practice recapturing mosquitoes during a mock mark-release-recapture study, in semi-field cages.

The purpose of the training was to solidify the understanding of all the components of the SIT in both theory and practice, and to coordinate the activities between three neighbouring Member States in their joint efforts to initiate pilot trials in their respective field sites. The course provided hands-on training in rearing, pupae sexing, irradiation and dosimetry, handling and marking adult males, and release/recapture of marked males in the frame of a mock marc release recapture in large semi-field cages. The participants also visited the selected pilot field sites to learn about the surveillance of wild mosquito populations, and the importance of community engagement activities.

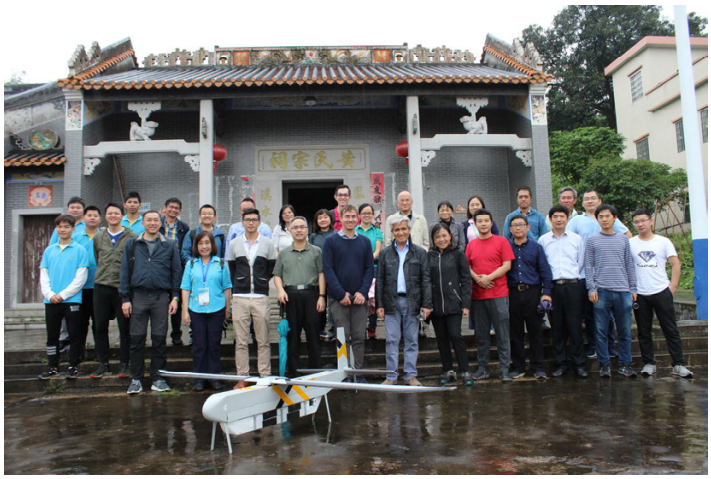
Managing and Controlling *Aedes* Vector Populations Using the Sterile Insect Technique (RAS5082)

Requirements to Develop a Sterile Insect Technique Pilot Project against Disease Transmitting Mosquitoes, Guangzhou, Guangdong, China, 6–10 May 2019

A high-level scientific visit of key stakeholders on "Requirements to Develop a Sterile Insect Technique Pilot Project against Disease Transmitting Mosquitoes" was hosted by the Department of Parasitology, Zhongshan School of Medicine, Sun Yat-sen University, Guangzhou, Guangdong, China from 6–10 May 2019. The purpose of the visit was (1) to sensitize decision makers on recent advances with the development of the SIT package for mosquitoes and its potential to mitigate mosquito-transmitted diseases, (2) to provide information on resources required for developing and implementing a pilot release trial (capital investment + operational cost), and (3) to create awareness on area-wide integrated pest management approaches and the phased conditional approach implementation strategy.

The successful pilot trials in China, Singapore and Thailand using the combined SIT-IIT strategy were presented to the participants, as well as the plans to up-scale these trials in the near future. Participating countries were China, Indonesia, Malaysia, Philippines, Singapore, and Thailand. These countries presented their strategy for pilot trials and received inputs from all experts present, following the phased conditional approach.

The meeting included a one-day visit to the mosquito mass-rearing facility of Wolbaki and a one-day visit to the pilot release sites. The participants could observe the entire production chain of the sterile males from larval rearing to irradiation of pupae and adult releases by drone. Wolbaki has developed a new larval rack system, modified from the reference IAEA system, that contains 100 larval trays (70 by 60 by 3 cm) with a total loading capacity of 1.2 million larvae per rack. The system allows a recovery of 70-80% of male pupae following a single tilting event, and currently, the facility produces 8 million sterile male *Aedes albopictus* per week. In addition, an automatic pupae sorter has been developed for quick sorting of the male from female pupae with less than 0.3% female contamination.



Participants of the high-level scientific visit of key stakeholders on "Requirements to Develop a Sterile Insect Technique Pilot Project against Disease Transmitting Mosquitoes" (Guangzhou, Guangdong, China).

The scientific visit was considered successful as the participating countries were provided with essential information to make an informed decision for setting up a SIT trial project (including colony establishment and maintenance, handling, irradiation and release protocols and field monitoring) against disease transmitting mosquitoes.

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

Regional Coordination Meeting on Progresses and Perspectives on the Control Programmes for *Aedes* Invasive Mosquitoes Including Pilot SIT Trials, Vienna, Austria, 17–19 December 2018

The meeting was organized from 17 to 19 December 2018 at IAEA headquarters, Vienna, Austria and included all European countries actively participating in the regional TC project RER5022 (Albania, Bulgaria, Bosnia and Her-

zegovina, Croatia, Cyprus, Georgia, Greece, Montenegro, Romania, Serbia, North Macedonia, and Turkey) actively participating in the regional TC project RER5022. In these countries, invasive *Aedes* mosquitoes have been detected, have become established, or pose an imminent risk of becoming established. Experts from other European countries (Germany and Italy) that are presently implementing SIT activities against *Aedes albopictus*, were also invited.

The participants discussed the issues and challenges faced during the SIT pilot trials, shared the knowledge on mosquito control and SIT related activities and harmonized protocols for mosquito rearing, irradiation, transport and monitoring. The pilot operations under implementation in Germany, Greece, Italy and Montenegro were presented, as well as recent research developments at the IPCL.

The participants also shared the status of several feasibility studies on using SIT for *Aedes* control and discussed future SIT pilot trials to be conducted in Europe.

The meeting contributed improving regional capabilities to apply SIT as part of an area-wide integrated management approach and enhanced the regional network of specialists and stakeholders involved in invasive mosquitoes control activities.

Training Course on Basic Use of R Software to Infer Demographic Parameters of Wild and Sterile Mosquitoes from Entomological Monitoring Data, Seibersdorf, Austria, 18–22 February 2019

The training course was organized from 18–22 February 2019 at the FAO/IAEA Laboratories in Seibersdorf, Austria. Eighteen participants from Albania, Bosnia and Herzegovina, Bulgaria, Cyprus, Georgia, Greece, Montenegro, North Macedonia, Portugal, Romania and Serbia attended the training course.

Participants of the Regional Training Course on Basic Use of R Software to Infer Demographic Parameters of Wild and Sterile Mosquitoes from Entomological Monitoring Data (Seibersdorf, Austria).

The implementation of integrated pest management programmes including a sterile insect technique (SIT) component against *Aedes* mosquito vectors of human disease requires the collection of baseline data in the feasibility phase and continuous monitoring of mosquito populations in the pilot and operational phases.

The appropriate storage of these large datasets in relational databases is essential to warrant their accessibility and implement adaptive project management. Geographic Information Systems (GIS) are also essential tools to visualize field data and take informed decisions. Finally, modelling is very useful not only to understand the spatio-temporal dynamics of the populations and optimize the integration of SIT with other control tools, but also to focus control operations according to the risk of disease outbreaks.

The purpose of the event was to provide the participants with the basic knowledge on the use of the R Statistical Software to analyze data and infer simple statistics on population of mosquitoes that can be used to inform control operations including a SIT component against *Aedes albopictus*. The training course included the creation and handling of data tables under R, the implementation of graphical representations of the datasets and the inference of mortality, dispersal and competitiveness parameters from datasets obtained through mark-release-recapture trials.

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/WHO Working Group Meeting on ‘‘Sterile Insect Technique for Mosquito-borne Diseases’’, Tapachula, Mexico 27 February–1 March 2019

The SIT applied to *Aedes* mosquitoes is designed to manage the vector and associated diseases including dengue, chikungunya and Zika. To improve public health, several Member States expressed the need for guidance on how to develop, assess and plan for SIT-*Aedes* experimental and operational programmes. The goal was to provide guidance to Member States on the use of the SIT as a component of integrated vector control programmes for disease prevention and control.

The specific objectives of the Working Group were:

- To critically review the provided protocols, procedures and guidance documents for each topic listed above for SIT against *Aedes*;
- To discuss each topic and make recommendations on key points of guidance;
- To identify critical gaps in documentation, knowledge or other aspects and to develop a detailed plan to help address these gaps;

- To help draft the guidance framework and assist in its review and finalization.

An expert Working Group appointed by the WHO and the FAO/IAEA will develop a framework to guide the planning and implementation of experimental and operational use of the SIT technology for *Aedes* control. The first meeting was conducted 27 February–1 March in Tapachula, Mexico to draft the FAO/IAEA/WHO guidance on the use of Sterile Insect Technique to control mosquito-borne diseases. The second will be conducted in Vienna in July 2019 to finalize the draft joint guidance.

Visit of the Working Group on "Sterile Insect Technique for mosquito-borne diseases" participants to the Aedes aegypti *mass-rearing facility in Río Florido, Tapachula, Mexico.*

The Working Group will develop an experimental and operational guide to support the following areas for SIT based control of *Aedes*-borne diseases:

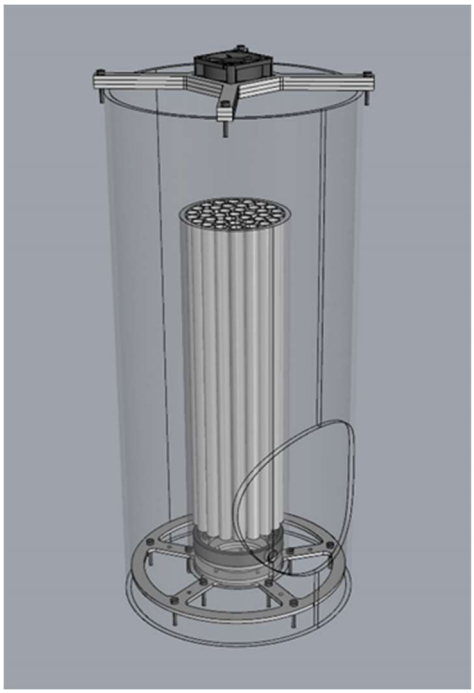
- Framework for SIT testing and application;
- Risk assessment;
- Permits and authorization pathways;
- Production and release of sterile male mosquitoes;
- Evaluation of entomological efficacy;
- Epidemiological efficacy / effectiveness;
- Community and stakeholders' engagement and ethics;
- Disease surveillance and program monitoring and evaluation;
- Cost effectiveness.

The workshop was very successful with all specific objectives met. Moreover, the SIT project in Mexico (pilot study MEX5031), coordinated by Mr Carlos Felix Marina Fernandez, Instituto Nacional de Salud Pública, organized a field visit to the mass-rearing facility located in Río Florido, Tapachula followed by a drone release of sterile male *Aedes aegypti* with the technical assistance of the Mubarqui group.

Second Meeting on Harmonization of Irradiation and Dosimetry Protocols for *Aedes* Invasive Mosquitoes. Vienna, Austria, 27–31 May 2019.

After the first meeting on harmonizing irradiation and dosimetry protocols for *Aedes* invasive mosquitoes for the Europe region conducted 12–14 February 2018, focused on the irradiation of mosquito pupae in small numbers, this second meeting expanded the scope to the irradiation of pupae in large numbers as well as chilled adults. Experts from Brazil, China, France, Italy, Mexico and the USA presented a series of irradiation protocols and, together with participants from Albania and Greece, discussed results on induced sterility and quality control in their programmes and research activities. Participants also visited the FAO/IAEA Insect Pest Control Laboratory (IPCL) in Seibersdorf, Austria, where technical staff demonstrated irradiation protocols and dosimetry procedures used to assess irradiation doses.

During the meeting, the experts discussed the draft Guidelines for Small Scale Irradiation of Mosquito Pupae in SIT Programmes, that will be soon available on the Insect Pest Control website and discussed priority research to develop guidelines for large scale irradiation. The importance of measuring quality along the production chain of sterile males, pre and post irradiation, was also discussed. The new test developed by the IPCL to measure flight ability within two hours will play an important role in quality control of irradiated mosquitoes.



Flight test device allowing to measure flight ability of Aedes mosquitoes, as a proxy of their quality.

The ultimate goal of the meeting was to achieve harmonization and standardization of irradiation protocols across all regions and to prepare for mosquito SIT field operations.

Coordinated Research Projects (CRPs)

Project Number	Ongoing CRPs	Project Officer
D4.10.25	Dormancy Management to Enable Mass-rearing and Increase Efficacy of Sterile Insects and Natural Enemies (2014-2019)	Rui Cardoso Pereira
D4.20.16	Comparing Rearing Efficiency and Competitiveness of Sterile Male Strains Produced by Genetic, Transgenic or Symbiont-based Technologies (2015-2020)	Kostas Bourtzis
D4.40.02	Mosquito Handling, Transport, Release and Male Trapping Methods (2015-2020)	Rafael Argiles
D4.10.26	Improved Field Performance of Sterile Male Lepidoptera to Ensure Success in SIT Programmes (2016-2021)	Marc Vreysen
D4.30.03	Integration of the SIT with Biocontrol for Greenhouse Insect Pest Management (2017-2022)	Andrew Parker Carlos Cáceres
D4.20.17	Improvement of Colony Management in Insect Mass-rearing for SIT Applications (2018-2023)	Adly Abd Alla Carlos Cáceres
	New CRPs	
D4.10.27	Assessment of Simultaneous Application of SIT and MAT to Enhance *Bactrocera* Fruit Fly Management (2019-2024)	Carlos Cáceres Rui Cardoso Pereira
D4.40.03	Generic Approach for the Development of Genetic Sexing Strains for SIT Applications (2019-2024)	Kostas Bourtzis

Second RCM of the CRP on Integration of the SIT with Biocontrol for Greenhouse Insect Pest Management. 4–8 March 2019, Mendoza, Argentina

Fifteen participants and several observers from 12 countries attended the meeting. During the first one and a half days of the meeting, RCM participants presented progress of their research related to the CRP, as well as their research plans for the next 18 months of the CRP. During the last three days of the meeting, general discussions were held to define and review the thematic areas of the CRP and to review the general and specific R&D objectives to be addressed during the 5 years of the CRP. The CRP Logical Framework was reviewed, in order to agree on minimum outputs to be achieved at the end of the CRP. Furthermore, participants were divided into two working groups (*Drosophila suzukii* and Lepidoptera) to develop more detailed R&D plans to be conducted during the next 18 months of the CRP.

For *D. suzukii*, advances have been made in the genetics, behaviour and populations characterized from Argentina, Brazil, Canada and Mexico. Comparison of the radiation response showed that, despite earlier concerns, the work in different locations agreed and a combined dose response curve could be generated and the effect of hypoxia on the radiation response has been investigated. For the Lepidoptera group, improvements in rearing have been made for *Tuta absoluta*, *Spodoptera littoralis* and *Helicoverpa armigera*. It has been demonstrated that the populations of *T. absoluta* outside South America have very limit genetic variability and probably derive from only one or a few introductions. Whilst parthenogenetic strains have been identified in France and Tunisia, no evidence was found for parthenogenetic development in Argentinian populations.

The RCM was followed by three days of practical sessions on *Drosophila suzukii* SIT and biocontrol. Irradiated *D. suzukii* were prepared and the first ever releases of sterile *D. suzukii* in greenhouses were made to test the utility of SIT in this environment. Eggs were collected from pots of artificial diet and from strawberry fruits growing in the greenhouses to record the reduction in hatch following sterile insect release. The production of various biocontrol agents was demonstrated, including lacewings, ladybirds

and mirid bugs and these were deployed in *D. suzukii* infested greenhouses.

Participants of the Second RCM of the CRP on Integration of the SIT with Biocontrol for Greenhouse Insect Pest Management verifying fruit infestation by Drosophila suzukii *(Mendoza, Argentina).*

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

The Research Coordination Meeting (RCM) was successfully held with the participation of 27 research agreement and contract holders, as well as observers. Main achievements of the CRP include the understanding dormancy responses and temperature biology of a number of insect species. Also, very encouraging results are being obtained in manipulating the seasonal biology of some pests to facilitate their mass-rearing as a result of understanding the three phases of diapause (induction, maintenance and termination) plus any related quiescence responses, all of which can be influenced by temperature and photoperiod.

Participants of the fourth RCM on "Dormancy Management to Enable Mass-rearing and Increase Efficacy of Sterile Insects and Natural Enemies" (Thessaloniki, Greece).

The major achievements by the end of the CRP include:

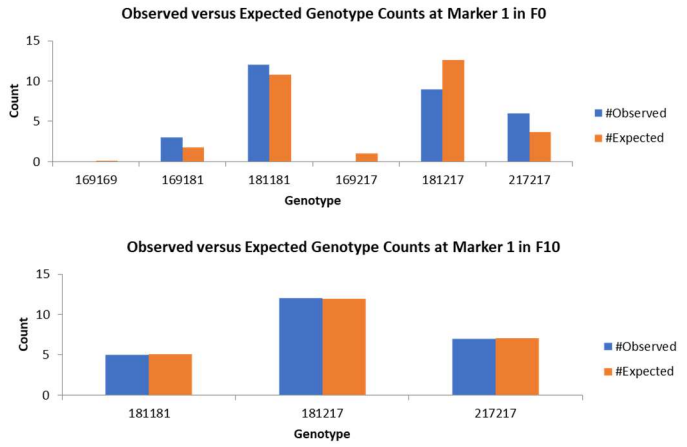
- Identified treatments including thermal regimes that use brief warm pulses interspersed with longer periods of dormancy-inducing cold, fluctuating thermal regimes, that enhance the shelf life of beneficial pollinators (e.g., the bee *Megachile rotundata*) and also pest insects targeted for sterile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

Developments at the Insect Pest Control Laboratory (IPCL)

Insect Genetics and Molecular Biology

Genetic and Symbiotic Communities' Changes of the Mediterranean Fruit Fly *Ceratitis capitata* during Laboratory Adaptation

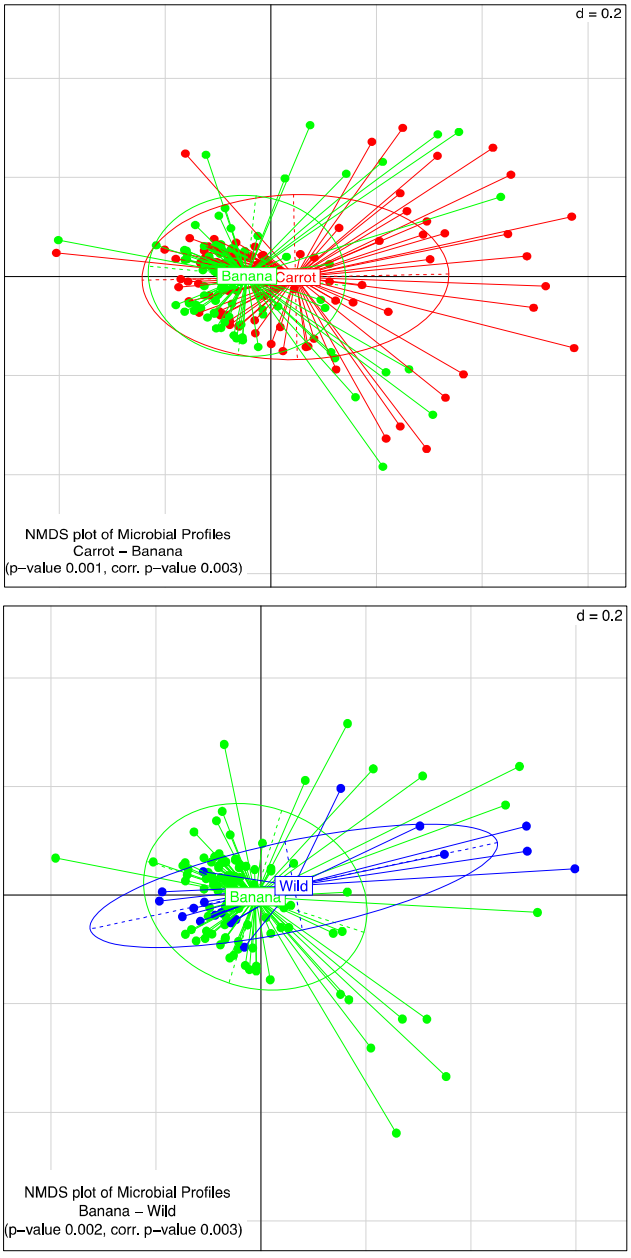
Insects can rapidly adapt to new environments including artificial laboratory conditions. Any natural wild population that is introduced and reared in an artificial environment is required to respond to selective forces that will eventually shape the genetic and symbiotic variability of the population. The adaptation process can be rapid and may affect insect quality and performance, a phenomenon that might prove to be detrimental in the case of rearing insects for sterile insect technique (SIT)-based research and applications.



Allele frequencies of Mediterranean fruit fly Marker 1 used in the present study.

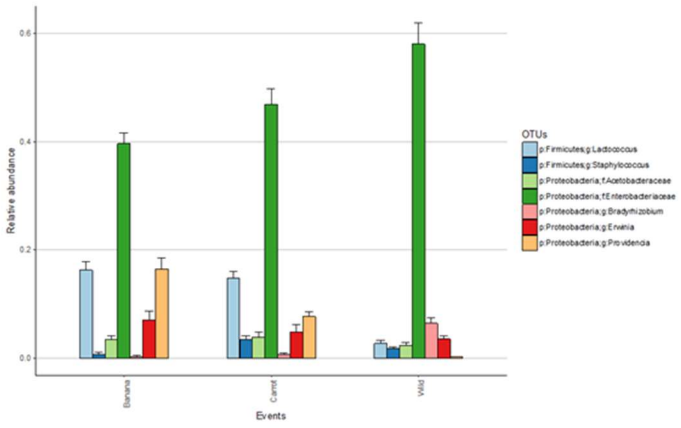
The Mediterranean fruit fly *Ceratitis capitata* is one of the main target insect species for SIT applications because of its huge economic impact in the affected areas. In addition, it is a model species for SIT-related research in order to enhance the current SIT technology including the production of high-quality insects as well as to expand it to other insect pests and disease vectors. A wild population of *C. capitata* was introduced in the IPCL and reared for more than ten generations on two different diets, i.e. carrot and banana. Genetic and symbiotic communities' changes occurring during the laboratory adaptation process were assessed by microsatellites and 16S rRNA gene amplicon sequencing, respectively.

Analysis of the genetic structure was carried out using eight previously developed highly polymorphic microsatellite markers. Laboratory adaptation seemed to affect the allele frequencies in most microsatellite markers. The above figure shows the different frequencies observed for a specific marker in generations F0 and F10. Further analysis of all markers will shed light on the relative contributions of selection and drift. As long as we identify the microsatellite loci that are under selection during a laboratory domestication process, we could attempt to search for the nearby genetic loci that are influenced by selection.



(top) Non-metric multidimensional scaling (NMDS) plot of the community composition of bacterial genera for adult Mediterranean fruit fly kept on a diet based on banana (green) and carrot (red). Samples belonging to adult flies kept on the banana-based diet group together and form different bacterial profiles than those kept on the carrot diet. (bottom) NMDS plot of the community composition of bacterial genera for adult Mediterranean fruit fly kept on a diet based on banana (green) and wild populations (blue). Samples belonging to adult flies kept on the banana-based diet group together and form different bacterial profiles than the wild population.

The changes in the symbiotic communities were monitored using tissue samples from the guts and the gonads from a wild population and from laboratory colonies during different generations of adaptation. Three developmental stages (teneral, 5-10-day old adults, and 15- day old adults), two diets (carrot and banana), as well as larval samples were used. The bacterial community composition and diversity was investigated by 16S rRNA gene amplicon sequencing and 8 354 584 reads were produced after quality filtering. Multivariate statistics were used to analyse the bacterial composition within the groups. The non-metric multidimensional scaling (NMDS) plot is based on a generalized Unifrac, and creates a two-dimensional visualization of a multidimensional data set, and was generated to display the bacterial communities in the different developmental stages (larvae and adults). The distance between the points is based on the degree of similarity of the bacterial communities, where adjacent points have more similar bacterial profiles than non-adjacent points. By analysing the NMDS plots, the wild population and the two laboratory populations kept on different artificial diets form separate clusters (see figure above). The formation of distinct clusters between the wild individuals and those kept on artificial diets indicated that the bacterial diversity and composition were affected by the diet status. Regarding the diet effect on the bacterial composition, our results indicate that adults maintained on artificial diets tend to have a higher relative abundance of *Providencia* sp. and *Lactococcus* sp. while members of the Enterobacteriaceae family decrease (see figure below).



Relative abundance of bacterial OTUs in a wild and two laboratory populations of the Mediterranean fruit fly kept on carrot and banana-based diet.

Harnessing Insect Gut Associated Symbiotic Bacterial Species for the Enhancement of the Sterile Insect Technique

The continuous supply of large numbers of high-quality insects produced under industrial conditions and the sexual competitiveness of the released sterile flies in the field are fundamental for large scale operational SIT applications. Several studies have shown that symbiotic bacterial species play a major role in the biology, physiology and ecology of insect species affecting, among other functions, nutrition, immunity, reproduction and mating behaviour. Based on this knowledge and using as a model insect species the Mediterranean fruit fly, a series of experiments have been initiated at the IPCL to isolate gut associated bacterial species from the VIENNA 8 genetic sexing strain (GSS) and to harness them as probiotics for the potential improvement of the rearing efficiency and biological quality of the strain under small-scale rearing conditions.

Cultivation-dependent and -independent approaches, mainly based on 16S rRNA gene amplicon sequencing, showed that Enterobacteriaceae bacterial species dominate the gut symbiotic community of the VIENNA 8 GSS. In a previous issue, it was reported that one of the isolates was *Enterobacter* sp., which, when added to the diet, showed improvement of both pupal and adult productivity, as well as reduced rearing duration, particularly for males, without affecting pupal weight, sex ratio, male mating competitiveness, flight ability and longevity under starvation.

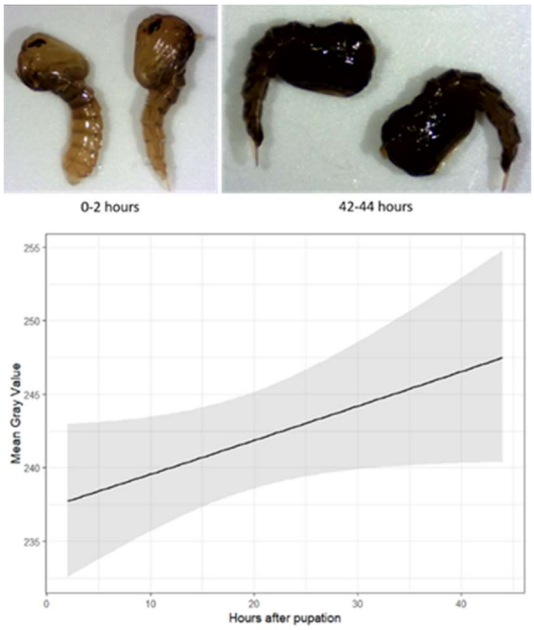
We recently tested a second Enterobacteriaceae species, which was also isolated from the gut, for its potential as a dietary supplement. The dry bacterial biomass was added either as a total or as a partial replacement of yeast. All experiments were conducted using the VIENNA 8 GSS strain reared at the IPCL under small-scale rearing conditions. Several quality control parameters were checked including developmental times of all stages, fecundity, pupal weight, longevity under stress and flight ability. All the above-mentioned parameters are part of the standard quality control procedures applied for the evaluation of insect strains used in SIT applications. Interestingly, the results showed not only improvement of some quality control parameters but also decrease in some of them, indicating that not all dietary supplements can serve the same purpose.

Determining the Right Developmental Stage for Irradiation by Monitoring the Melanisation Process in *Aedes* Mosquitoes

In most applications of the sterile insect technique, male sterility is induced by irradiating pupae at a given developmental stage. The pupae should neither be very old nor very young, otherwise the residual fertility will be too high, or the biological quality of the sterile insects will be compromised, respectively. During the pupal stage, holometabolous insects like mosquitoes undergo metamorphosis to become adults. As soon as an insect larva turns into pupa, its cuticle hardens as well as darkens through the release of polyphenols.

The initial steps, which last around 120 minutes at 28°C, are responsible for converting the white colour of the cuticle to dark yellow/brown. However, the colour keeps darkening over time during the pupal stage becoming sooty black after 44 to 48 hours, just before adult emergence. We initiated a study to determine the age of pupae by monitoring the melanisation process of wild type populations of

Aedes aegypti and *Aedes albopictus* under laboratory-controlled conditions. This would ultimately allow us to optimize and facilitate the selection of "pupae of right age" for irradiation. Photos were taken of *Ae. aegypti* and *Ae. albopictus* pupae at 2 hrs intervals from the initiation of pupation until adult emergence. All pictures were taken using the same background and light conditions and images were analysed using the ImageJ software to calculate the mean gray value and the integrated density. The results showed that there is a statistically significant correlation between pupa colour and age-interval, which can be used to select pupae of the "right age" for irradiation thus maximizing the induced sterility without compromising the biological quality of the sterile insects.



(top) Aedes aegypti *pupae at two different developmental stages: early pupae (just after the initiation of pupation) and late pupae (just before adult emergence) (bottom) Intensity of melanisation of* Aedes aegypti *pupae.*

Plant Pests

Spotted Wing Droshophila, *Drosophila suzukii*

The rapid dispersal of *Drosophila suzukii* and the subsequent economic losses of the affected crops, encouraged the development of different approaches for the efficient management of this pest. The SIT can potentially be integrated in area-wide integrated pest management (AW-IPM) approaches to manage this pest under confined environment systems such as greenhouses. Staff of the IPCL have been working on the development of the SIT package for *D. suzukii* including determination of the optimum sterilization dose, development of effective mass-rearing procedures and quality control protocols as well as the assessment of their mating behaviour.

Experiments were carried out in small laboratory cages to determine the ability of sterile males to compete with fertile males for mating with fertile females from the same laboratory population. The tests were carried out under controlled laboratory conditions to observe mating behaviour and interactions during the time of sexual activity. Sterile and fertile insects were released in the laboratory cages and the number of successful matings assessed.

The pupae were irradiated with 220 Gy in a ^{60}Co source under normal atmosphere conditions (normoxia) or under hypoxia conditions. The aim of the tests was to assess whether hypoxia conditions could mitigate some of the negative effects of the irradiation and potentially improve their mating performance as compared with the males treated under normoxia conditions. Preliminary results indicate that irradiated males were less successful in mating with the females as compared with fertile males, but males irradiated under hypoxia conditions achieved more matings than sterile males irradiated under normoxia conditions.

South American Fruit Fly *Anastrepha fraterculus*

As reported previously, the Plant Pest group has been working on the development of a genetic sexing strain (GSS) of *Anastrepha fraterculus* that is based on a pupal colour dimorphism (brown-black) that is resulting from a reciprocal translocation between the Y chromosome and the autosome carrying the wild type locus of the black pupae (*bp*) gene.

Experiments for the screening of new GSS lines of Anastrepha fraterculus *being prepared.*

Mr Mario Alvarez, an intern from Guatemala collaborated with IPCL staff to carry out further screening of the colony. As a result, four new GSS lines (translocations) were isolated, increasing the number of available GSS lines of *A. fraterculus* to eight for further evaluation.

Bactrocera correcta

Ms Le Thi Xuyen, a fellow from Viet Nam has been assessing the effect of age, dietary protein and methoprene applications on the mating success and the mating behaviour of male *Bactrocera correcta* under laboratory conditions. Emerged adult males were separated and fed or topically treated (tt) with the following four treatments:

- Feeding sugar
- Feeding protein and sugar mix

- Feeding sugar and methoprene (tt)
- Feeding a protein and sugar mix plus methoprene (tt)

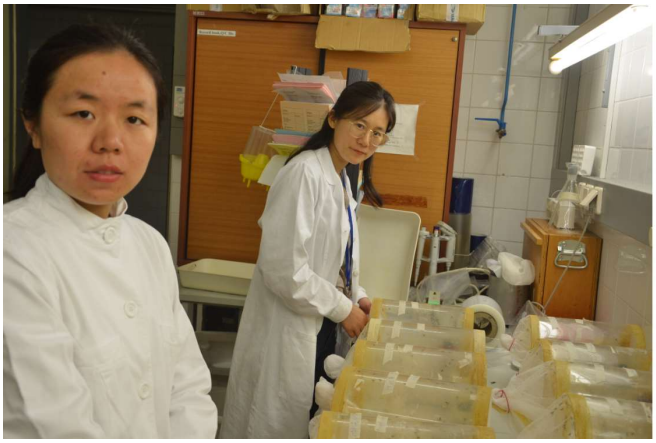
Preparation of Bactrocera correcta males to assess the effect of methoprene (a juvenile hormone analogue), and dietary protein on their sexual maturation and mating behaviour.

The purpose of this research is to elucidate the effect of the juvenile hormone treatment and protein supplement or the combination of both, on the acceleration of sexual maturity and enhancement of mating competitiveness of males of *B. correcta*. Acceleration of sexual maturity is a prerequisite to pre-treat males with the semiochemical Methyl Eugenol (ME) before release.

Early application of ME will allow the release of precocious pre-treated young male flies in a strategy of simultaneous application of the sterile insect technique and the male annihilation technique against this pest species

Bactrocera dorsalis and *Zeugodacus cucurbitae*

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



Insects being prepared for irradiation dose response curves for Bactrocera dorsalis *and* Zeugodacus cucurbitae.

The FAO/IAEA/USDA Project on Phytosanitary Treatment

The phytosanitary research under the USDA/IAEA collaborative agreement, "Harmonization of phytosanitary treatments for exotic fruit flies", is evaluating the extent to which irradiation of fruit fly larvae under modified atmosphere can influence larval development. Preliminary results have shown that irradiation of *Anastrepha fraterculus* larvae with ~25 Gy (sub-lethal dose) under hypoxic and severe-hypoxic conditions can increase the proportions of phanerocephalic pupae, pharate adults, and fully developed adults as compared with insects irradiated under normoxia. In contrast, all *A. fraterculus* larvae irradiated with 70 Gy under hypoxic and severe-hypoxic conditions did not further develop and died as coarctate larvae. The same study is currently being conducted with *Anastrepha ludens*, *Bactrocera dorsalis*, and *Ceratitis capitata*.

Dissection of irradiated mangoes for phytosanitary treatments research.

The research comparing relative cold tolerance of domesticated (F23 to F36) and wild (F1 to F6) populations of *C. capitata* from Spain has been completed. A single larva of *C. capitata* from the wild population was found alive after a treatment of 15 days at 1.37 to 1.50°C but failed to pupariate and did not survive to the adult stage. This result suggests that 3rd instar larvae of *C. capitata* from wild populations could be more tolerant to cold treatments than domesticated populations.

Populations of *Zeugodacus tau* from Bangladesh, China, and India are being compared to determine if they differ in cold tolerance. Cold treatments are currently not available for use on hosts of this species. Thus, results from this research have the potential to support the application of cold treatment against *Z. tau* by Member States of FAO and IAEA.

Livestock Pests

The BSI Automated Chilled Adult Tsetse Release Machine and Mating Competitiveness of *Glossina palpalis gambiensis*.

The sterile insect technique was successfully used to eradicate a population of the tsetse fly *Glossina austeni* from Unguja Island, Zanzibar, United Republic of Tanzania in 1994-1997.

(top) BSI chilled adult tsetse release machine, (bottom) tsetse mating competitiveness studies in walk-in field cages.

Thereafter, there were several attempts to implement the SIT in several African countries in mainland Africa i.e. Ethiopia and Senegal. However, due to the special biology of the tsetse flies, i.e. their low reproductive capacity and being hematophagous, the rearing of tsetse flies in large numbers represents a significant challenge. The establishment of large tsetse mass-rearing facilities to produce sufficient sterile males for the implementation of the SIT requires a capital investment. Therefore, smaller projects like the eradication of a tsetse fly population (*Glossina palpalis gambiensis*) from the Niayes around Dakar, Senegal, adopted the strategy of procuring the sterile male pupae from abroad (the CIRDES in Burkina Faso, the Slovak Academy of Sciences, Bratislava, Slovakia and the Insect Pest Control Laboratory, Seibersdorf, Austria). So far, the aerial release of sterile males has been mainly conducted using biodegradable cartons that are being dropped from a fixed wing aircraft or a gyrocopter. The use of carton boxes is however very expensive, and therefore efforts have been made to develop devices that release the chilled adults without being boxed. A new digitalised and automated chilled adult release machine (BSI) has been developed by a company in Senegal and is being tested at the IPCL. During the release process with this device, there will be mechanical friction and chilling of the flies before they are released. The aim of this study was therefore to assess the impact of this release machine on fly performance with special attention to their mating competitiveness.

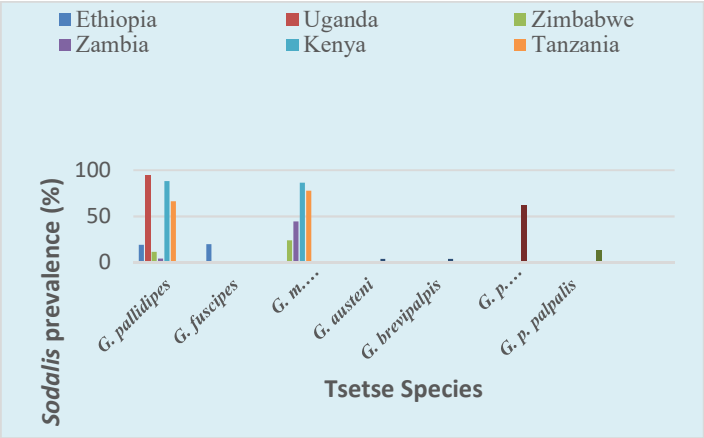
Dissection of female tsetse flies to assess their insemination status.

After calibration of the machine and evaluation of its flowability of releasing flies, the impact of the release process was assessed on *G. p. gambiensis* male's survival, flight ability, and mating competitiveness in walk-in field cages. This work is undertaken in collaboration with Mr Gratian Mutika and Ms Caroline Mirieri (two consultants hosted at the IPCL). The experimental design included both an assessment of the impact of the irradiation treatment (120 Gy) but not passed through the BSI machine, and the irradiation treatment combined with different chilling (at 5 °C) times in the release machine, i.e. at the start of the release

process, after one hour and after 2 hours, which is a realistic estimate for the duration of the entire release process. The males that were able to fly out of the fly cylinder in the flight propensity test (conducted 5 days post emergence) were used for the mating competitiveness tests in the field cages that were kept in an insect greenhouse with temperature and humidity controls under natural light. The preliminary results indicate that male flies that were irradiated and released through the machine mated with colony female flies in similar proportions as the non-treated colony male flies. Dissections of the female flies that mated also confirmed transfer of seminal fluids.

The Prevalence of the Tsetse Symbiont *Sodalis glossinidius in* Natural Tsetse Populations

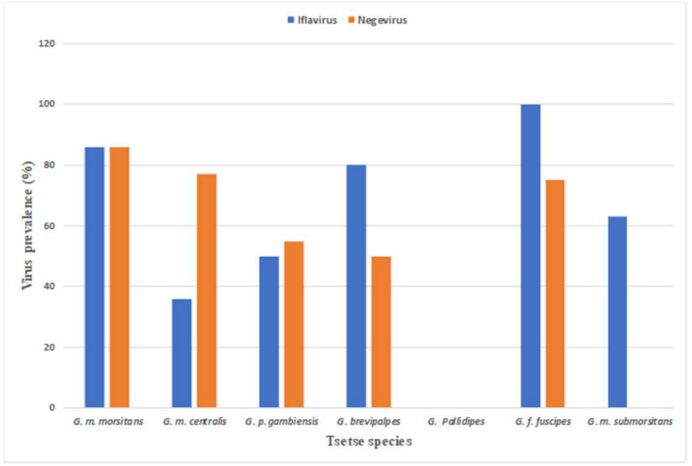
Tsetse flies are harbouring four symbiont bacteria that play an important role in tsetse biology including productivity, performance and their susceptibility to trypanosome infections. The symbionts bacteria are *Sodalis*, *Wigglesworthia*, *Spiroplasma* and *Wolbachia*. *Sodalis* infection seems to be correlated with enhanced trypanosome infection and therefore it is important to assess *Sodalis* prevalence in natural tsetse population as it might provide information about the potential of trypanosome infection. Therefore, Mr Mouhamadou Dieng from Senegal was employed as a consultant at the IPCL to assess *Sodalis* and trypanosome prevalence in natural tsetse populations. So far, 2047 individual tsetse flies from seven tsetse species collected from nine countries were analysed for the presence of *Sodalis* infection. The preliminary results indicate that the *Sodalis* prevalence varied from 5-95%. In *Glossina pallidipes*, *Sodalis* prevalence varied with sample site with the lowest prevalence of 5% in Zambia and the highest prevalence of 95% in Uganda. Similar results were observed in *G. m. morsitans* from different countries.



Prevalence of Sodalis *in natural tsetse populations.*

The Impact of Iflavirus and Negevirus Infection on Tsetse Fly Performance.

Insect mass-rearing often suffers from various types of stress factors such as crowding, which hampers the insect immune system and promotes the emergence of pathogenic bacteria, fungi and viruses that in many cases negatively affect the sustainability of the insect mass-rearing. Recently, two single stranded RNA viruses were detected in the tsetse fly *Glossina morsitans morsitans* of which a colony is maintained at the IPCL. The genome sequence, gene organisation and the phylogenetic analysis revealed that the two viruses belong to the Iflavirus and Negevirus taxon. The names proposed for the two viruses are: *Glossina morsitans morsitans iflavirus* (GmmIV) and *Glossina morsitans morsitans negevirus* (GmmNV). To assess the host range of these viruses and its impact on tsetse rearing, a PCR and quantitative PCR specific detection tools were developed in collaboration with Mr Mohammadreza Rezapanah, a cost-free consultant from Iran. The preliminary results indicate that the two viruses are also present in other tsetse species and that the prevalence is highly variable. Only *G. pallidipes* proved to be free of the Iflavirus and Negevirus. Preliminary results of the quantitative PCR analysis indicated that the midgut showed a high level of virus infection compared to other tissues such as salivary glands, fat bodies, and ovaries. The role of these two new viruses in the fly is enigmatic. Work is continuing to assess the impact of Iflavirus and Negavirus infections on tsetse colony performance and colonies with high and low virus prevalence are being established.



(top) assessment of virus infection prevalence in tsetse colonies, and (bottom) prevalence of Iflavirus and Negevirus in tsetse colonies at the IPCL.

Human Disease Vectors

A New Aerial Release Device for Sterile Mosquitoes

Operational use of the sterile insect technique against human disease vectors continues to reveal areas where new technologies could further improve efficiency. The mosquito SIT package that is under development at the IPCL includes advances made in mass-rearing, irradiation, handling, transport and release protocols.

There is increasing interest expressed in several Member States to use drones for releasing mosquitoes, but in some countries, its use is hampered by stiff security regulations with respect to weight of the drones. Therefore, the use of lighter drones and especially, light-weight mosquito release containers is becoming imperative. We therefore developed and tested a light-weight release device (< 2 kg including the drone) with respect to the quality of released males and homogeneity of the releases at different rotation speeds. Mosquitoes were marked and irradiated as chilled adults before release through the new device.

These treatments had no negative impact on the quality of the released males as assessed with the flight ability test. Only few mosquitoes were damaged, and survival was good. The new device is now ready for testing in the open field.

Mass-transport of Sterile Male Mosquitoes

In most SIT projects, the production centre of the sterile insects is located at a certain distance from the release area, and even sometimes in a different region or country. This requires the long-distance transport of the sterile males that are destined for the release. We are presently developing a method for packing and shipping chilled sterile mosquito males using iso-thermic vacuum insulated transport boxes that contain phase-change material packs to control the temperature.

(left) Sterile male mosquitoes packed in storage cartons (middle) storage cartons covered with netting (right) iso-thermic insulated transport box.

Adult sterile male mosquitoes were chilled and immobilized at 10°C and placed in storage cartons at a density of 125 mosquitoes / cm^3 giving a compaction layer not larger than 2 cm corresponding to 25 000 mosquitoes per box. The box is closed and covered with a net. Two storage cartons can be placed in each transport box corresponding to 50 000 sterile males. Preliminary results are encouraging, with an absence of additional mortality in comparison to control groups and a 20% reduction of the flight ability measured by the flight ability test. Further improvements are in process to reduce this loss of quality as much as possible.

The IAEA Reference Larval Rearing Unit and Sex Separation of *Aedes aegypti* with the Fay-Morlan Glass Plate Sorter

The production of large numbers of mosquitoes of adequate biological quality and sex separation before release are key challenges when applying the sterile insect technique as part of an area-wide integrated pest management for mosquitoes. The IPCL of the Joint FAO/IAEA Division has developed dedicated technologies, trays and rack for rearing large number of larvae. In addition, a Fay-Morlan glass plate sorter is the most common method used to separate male from female mosquitoes and it is based on the sexual size dimorphism at the pupal stage. Field pilot studies prior to SIT application against *Aedes aegypti* are currently being implemented in some countries. Therefore, there is a need to fully evaluate the production and efficacy of such equipment in order to plan and reach a daily operational level allowing to sustain continuous large-scale operation activities. We evaluated pupae production using the FAO/IAEA rack unit and procedures and the female contamination rate after males sorting which the Fay-Morlan glass plate sorter.

Each tray was filled with 5 litters of osmosis water the day before the addition of larvae. Six trays per rack at different levels (from bottom to top positions in the rack that may hold up to 50 trays) were used to rear larvae at a density of 18 000 first instar larvae / tray to which 4% IAEA reference diet was added. From day 6 to 10 of development (after egg hatching), trays from each rack were tilted and their contents sorted either for each individual tray or after mixing the content of all trays from the rack. The pupae production and the female contamination rate were estimated with respect to day of collection, position of the tray, type of tilting and sorting operator.

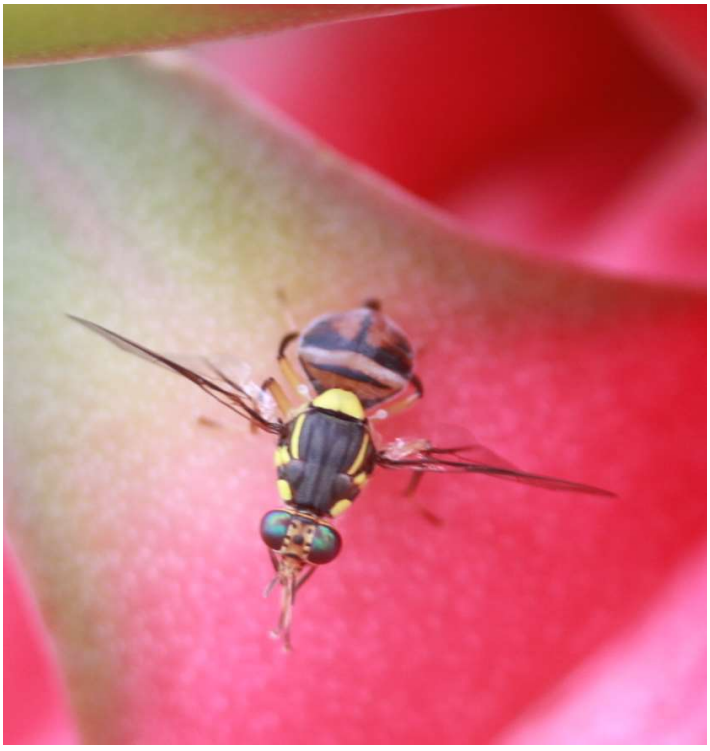
Results showed a high pupae production level (>2500 male pupae/tray until the second day of collection) and an estimated female contamination rate around 1%. Neither tray position nor type of tilting affected the pupae production and female contamination rate. However, the operator had a significant effect on female contamination rate. These results highlight the need to optimize pupae production during the early days of collection and to develop a more effective method of sex separation.

Reports

Fourteenth Session of the Commission on Phytosanitary Measures (CPM), International Plant Protection Convention, 1–5 April 2019, Rome, Italy

The FAO Assistant Director General of the Agriculture and Consumer Protection Department, Mr Bukar Tijani, opened the meeting welcoming the participants on behalf of the FAO Director General, Mr Jose Graziano da Silva. He further congratulated the IPPC for achieving the milestone of having 2020 proclaimed as the International Year of Plant Health (IYPH) by the United Nations General Assembly, which would provide a significant platform to increase awareness of the importance of plant health for healthy living.

The Secretary of the International Plant Protection Convention (IPPC) Jingyuan Xia, presented the major achievements of the IPPC in 67 years. He stressed that the entire IPPC community should be very proud of these achievements and should be also well prepared for moving towards 2020 to celebrate the IYPH, and towards 2030 to contribute to achieving UN Sustainable Development Goals (SDGs).



*Oriental fruit fly (*Bactrocera dorsalis*).*

The CPM adopted six Diagnostic Protocols (DP), including the DP29 '*Bactrocera dorsalis*' as Annex of ISPM 27 (Diagnostic protocols for regulated pests).

Final Meeting of the SUZUKILL Project, 24 May 2019, Lyon, France

The SUZUKILL (Managing cold tolerance and quality of mass-produced *Drosophila suzukii* flies to facilitate the application of biocontrol through incompatible and sterile insect techniques) is a bilateral (Austria – France) research project which aims to develop new approaches for the population suppression of *Drosophila suzukii,* a major agricultural pest. The final meeting of SUZUKILL took place at the University Claude Bernard Lyon 1, Lyon, France on 24 May 2019 with the participation of researchers from Ecosystèmes, Biodiversité, Evolution (ECOBIO) Laboratory, University of Rennes 1 /Rennes, Laboratoire de Biométrie et Biologie Evolutive (LBBE), University Claude Bernard Lyon 1/Lyon, Institute of Forest Entomology, Forest Pathology and Forest Protection (IFFF), University of Natural Resources and Life Sciences, Vienna (BOKU) and the Joint FAO/IAEA Insect Pest Control Subprogramme.

Participants of the final meeting of SUZUKILL (Lyon, France).

Oral presentations and discussion focused on the overall progress achieved in the frame of this project in four major research areas: (a) the development of sterile insect technique (SIT) including the mass-rearing of this pest, irradiation and quality control protocols; (b) the development and evaluation of strains suitable for incompatible insect technique (IIT) or combined SIT/IIT approaches; (c) the study of cold tolerance and its potential exploitation in support of SIT and / or IIT approaches and (d) the monitoring of genetic changes which may be occurring during the laboratory domestication in support of mass-production of sterile males for population suppression strategies. In addition, there was discussion about potential follow-up projects which would allow to continue the research efforts to optimize the tools and strategies developed which could ultimately result in their testing and validation in pilot trials.

Announcements

Sterile Insect Release Density Calculations Spreadsheet

Sterile insects have been defined as beneficial organisms by the International Plant Protection Convention. The sterile insect technique (SIT) has been applied in more than 30 countries worldwide for pest suppression, eradication, containment and prevention. Current more than 3 billion sterile insects are produced every week in support of pest control programmes. The investment that programmes make in SIT applications (including production and release of sterile insects) is estimated in millions of Euro per year; therefore, an efficient use of the sterile insects is fundamental to ensure economic feasibility to SIT programmes.

The Sterile Insect Release Density Calculations Spreadsheet is a valuable tool for optimization of fruit fly sterile insect release programmes. It was developed by colleagues of the Moscamed Regional Program and the USDA-APHIS office in Guatemala. The spreadsheet could be used for pests other than fruit flies, because the same principles apply. However, the introduction of pest specific parameters will be required to adapt its use to other insect pests subjected to area-wide SIT. The Excel software allows all action programmes worldwide to have easy access to the spreadsheet calculations since its use is global nowadays. This spreadsheet model has been validated and it is being used routinely by managers of the Moscamed Program for optimization of sterile fly release.


BACK TO MENU

GO TO POP. INCREASE GRAPH

RELEASE BLOCK # ONE

WEEKS	RELEASE RATE STERILE INSECTS/HECTARE	TOTAL INSECTS RELEASED/Km²	♂FTD sterile	♂FTD wild/fertile	RATIO STERILE	RATIO WILD	REQUIRED S:W RATIO	NEW RELEASE RATE/Km²	NEW RELEASE RATE STERILE INSECTS/HECTARE
1	400	40,000	0.183	0.0006	320.0	1.0	100	12,500	125
2	500	50,000	0.020	0.0003	70.0	1.0	100	71,429	714
3	500	50,000	0.023	0.0003	82.0	1.0	100	60,976	610
4	500	50,000	0.013	0.0001	180.0	1.0	100	27,778	278
5	500	50,000	0.015	0.0003	52.0	1.0	100	96,154	962
6	500	50,000	0.013	0.0003	47.0	1.0	100	106,383	1,064
7	500	50,000	0.009	0.0003	32.0	1.0	100	156,250	1,563
8	500	50,000	0.016	0.0001	220.0	1.0	100	22,727	227
9	500	50,000	0.017	0.0001	240.0	1.0	100	20,833	208
10	500	50,000	0.014	0.0001	192.0	1.0	100	26,042	260
11	500	50,000	0.014	0.0004	38.4	1.0	100	130,208	1,302
12	500	50,000	0.014	0.0006	21.3	1.0	100	234,375	2,344
13	500	50,000	0.014	0.0009	14.8	1.0	100	338,542	3,385
14	500	50,000	0.014	0.0012	11.3	1.0	100	442,708	4,427
15	500	50,000	0.014	0.0015	9.1	1.0	100	546,875	5,469
16	500	50,000	0.014	0.0018	7.7	1.0	100	651,042	6,510
17	500	50,000	0.014	0.0021	6.6	1.0	100	755,208	7,552

POP. INCREASE FORMULA | POP. INCREASE GRAPH | RATIOS S/W AND DEGREE OF CONTROL | SINGLE BLOCK FTD CALC BLOCK ONE | RELEASE DENSITY CALC BLOCK ONE | SINGLE BLOCK F

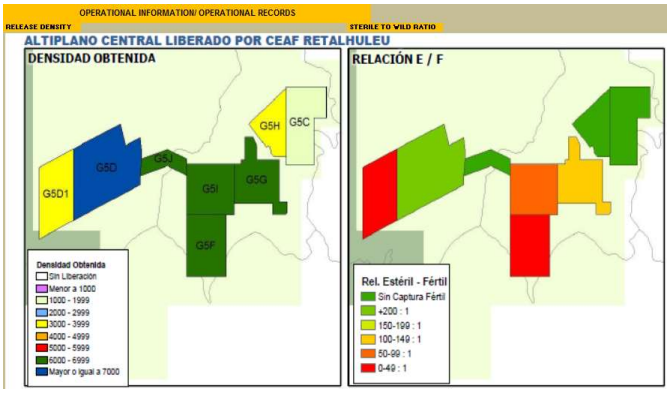
Example of the release density automated calculations page (real operational data need to be entered in cells with red numbers).

The main objective of the Sterile Insect Release Density Calculations Spreadsheet is the dynamic determination of sterile insect release density required to induce sterility in a wild insect population in a given area and at a given time. To be able to properly use the spreadsheet model, the following parameters need to be assessed:

- Measure pest population growth rate through a detection system deployed in the field and the determination of flies per trap per day (FTD) of the wild population and by measuring population growth rate inside field cages
- Determine the percent of induced sterility by sterile insects and the sterile:fertile (wild) ratio at which the greatest effectiveness is achieved

With this information available, the model can compute and present the following results:

- Calculations that allow sterile insect releases at desired densities and to obtain predictable sterile:fertile ratios
- Present the computations in the form of an electronic spreadsheet which facilitates analysis and record keeping, as well as
- The graphical representation of the results and evolution of the sterile insects' releases carried out in the field. Such representation facilitates decision making for technicians and action programs managers.



Left: Recommended release densities by block and Right: Monitoring of sterile: wild ratios in each release block.

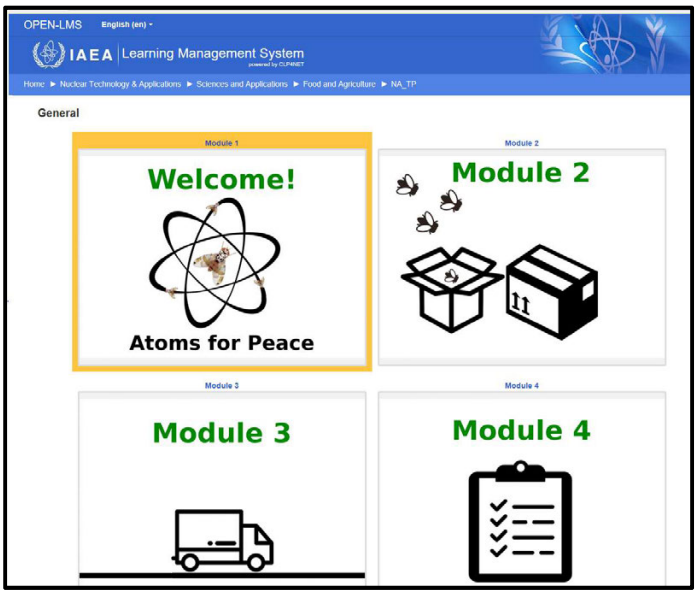
The users can access the spreadsheet and its manual at the FAO/IAEA Insect Pest Control website (http://www-naweb.iaea.org/nafa/ipc/public/manuals-ipc.html).

E-Learning Course for Packing, Shipping, Holding and Release of Sterile Flies in Area-Wide Fruit Fly Control Programmes!

This e-learning course is based on the ''Guideline for packing, shipping, holding and release of sterile flies in area-wide fruit fly control programmes''. The guideline was published by the FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture in 2017, Vienna, Austria (http://www-naweb.iaea.org/nafa/ipc/public/Guideline-for-Packing-Sept2017.pdf).

This e-learning is divided into 7 modules, each containing one or more chapters. At the end of each chapter there is a 10-question quiz, which must be passed with a rate of 90% of correct answers. Only then, can one move to the next chapter. The information in the modules is complemented through hyperlinks with other relevant technical information available in shorts videos and infographics as well

as in one instance with an Excel spreadsheet. Each module has a list of references for one's perusal should one wish to search further into the topic. Furthermore, an extensive list of appendixes containing additional information as well as all references and glossaries is available throughout the whole course.



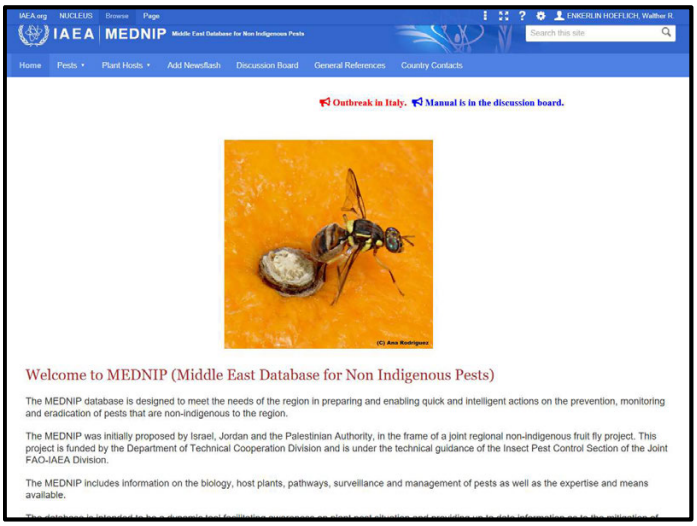
E-learning course front page.

This e-learning course does not have a time limit. Therefore, the course can be started at any time, breaks can be taken, and the course can be continued at convenience.

The aim of the e-learning is to understand the principles behind packing, shipping, holding and release of sterile flies in area-wide fruit fly control programmes. By successfully completing this e-learning course one will be able to apply the lessons learned including in real life operational programmes.

Launching of the Middle East Database for Non-Indigenous Pests (MEDNIP)

As part of the prevention strategies and as a decision-making support tool, a Plant Pest Database named Middle East Database for Non-Indigenous Pests (MEDNIP) was developed under the IAEA Technical Cooperation Project RLA5076 and launched in December 2018. The MEDNIP is currently in full use by Member States. It provides a platform, which is first and unique in the region, for information exchange through a discussion board on plant pests of quarantine significance to the Member States. The database contains detailed information on the plant pests of concern including their taxonomy, affected crops, geographical distribution and available methods for prevention and control.



Middle East Database for Non-Indigenous Pests launched December 2018.

The MEDNIP also functions as a pest alert system through a "Newsflash" feature which provide the users of the database with the newest update on pest and plant situations, as well as anything concerning the group members and the database. The database is planned to serve the plant protection authorities in the project region for the continuous exchange of information and sustained collaboration (database access only open to the counterparts of this regional project).

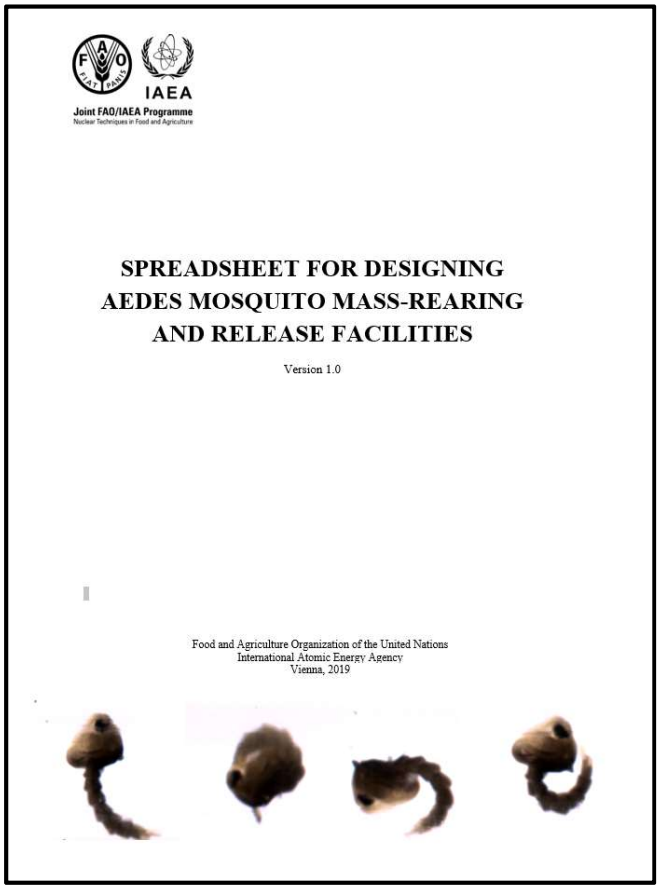
Action Plan in the Case of a Detection of Non-Native Fruit Flies of the Genus *Bactrocera* in Latin America and the Caribbean

This action plan (available in Spanish only at http://www-naweb.iaea.org/nafa/ipc/public/Plan-de-Accion-Bactrocera-spp_agosto2018-Final.pdf) provides guidance for the delimitation of incursions and outbreak eradication of fruit flies belonging to the *Bactrocera* genus, that respond to Methyl Eugenol such as the Oriental fruit fly, *B. dorsalis*, the peach fruit fly, *B. zonata* and the carambola fruit fly, *B. carambolae*. It also provides guidance for fruit fly species responding to Cuelure, mainly the melon fly, *Bactrocera (Zeugodacus) cucurbitae*.

The methods and technologies presented and described in the plan, have been validated and extensively used by National Plant Protection Organizations (NPPO) in various Member States of the Food and Agriculture Organization of the United Nations (FAO) and the International Atomic Energy Agency (IAEA). This publication was prepared under the framework of Practical Arrangement between the Joint FAO/IAEA Division and the Organismo Internacional Regional de Sanidad Agropecuaria (OIRSA).

Spreadsheet for Designing Aedes Mosquito Mass-Rearing and Release Facilities

The number and production capacity of mass-rearing insectaries for mosquitos is expected to increase in the coming years and this FAO/IAEA interactive Spreadsheet for Designing *Aedes* Mosquito Mass-Rearing and Release Facilities has been developed to assists in technical and economic decision making associated with design, cost, construction, equipment, and facility operation.



The spreadsheet is user friendly and thus largely self-explanatory. Nevertheless, it includes a basic instruction manual that has been prepared to guide the user, and thus should be used together with the software. Both the spreadsheet and the users' manual are available for free download at the website of the Insect Pest Control Section (http://www-naweb.iaea.org/nafa/ipc/public/manuals-ipc.html).

Americas Congress on Fruit Flies and the 10th Meeting of the Tephritids Workers of the Western Hemisphere (TWWH)

The event will be hosted by the Colombian Agricultural Institute (ICA) and held in Bogotá, Colombia, from 16–20 March 2020. It is aimed at promoting the exchange of experiences between scientists and personnel in charge of directing programs for the surveillance and control of fruit flies in the Western Hemisphere. Among the disciplines that will be addressed during the event the following are included: biology, population ecology and ethology, genetics, taxonomy, morphology, monitoring systems, control methods and area-wide management.

Other News

Mediterranean Fruit Fly Suppression by National Action Plan in Neretva River Valley of Croatia in 2017 and 2018

The Mediterranean fruit fly *Ceratitis capitata* (Wiedemann) (Diptera, Tephritidae) was first recorded in Neretva valley (Opuzen, 1958.). It is a pest of huge economic impact. Its presence expanded to the broad coastline of Croatia as a result of the spread and great adaptation to various climate conditions. Citrus cultivation is very important in Croatian fruit growing. 75% of their total mandarine production is being exported. Due to huge economic damage caused by the Mediterranean fruit fly, the Minister of Agriculture adopted the Action Plan for the Prevention of spreading and Suppression of the Mediterranean Fruit Fly in the Neretva Valley in 2017, and the revised Action Plan for the period from 2018. to 2021.

Citrus growing area in Neretva river valley, Croatia.

The Action Plan defines methods of systematic implementation of phytosanitary measures for suppression, designed to implement an effective control management strategy of this pest, to determine all the activities that need to be undertaken, as well as jurisdictions and responsibilities of the participants in the implementation process. Institutions and services carrying out activities of this plan are: Phytosanitary Policy Department, Croatian Agency for Agriculture and Food, Phytosanitary Inspection, Agricultural Inspection, Croatian Agricultural and Forestry Advisory Service, in cooperation with local municipalities.

Activities carried out on 6 000 ha of the valley area include: monitoring of adult and larval populations, early detection of hotspots and response in case of fruit fly presence, supervision of implementation of sanitary measures defined by the law, implementation of suppression measures and mass-trapping in peach or nectarines orchards, natural environment and the public areas, the removal of individual uncultivated host trees on public areas and uncultivated orchards, as well as education of farmers.

Release of sterile Mediterranean fruit fly males through the tube of a ground release machine.

Apart from the above-mentioned activities, a total of 4 000 ha (of the 6 000 ha) in the area from the Neretva Estuary to Opuzen, is also being treated with sterile male Mediterranean fruit flies. The maximum acceptable fly per trap per day (FTD) in this Action Plan for 2017 and 2018 was a FTD = 0.5 for the whole valley area. In the year 2017, a maximum FTD of 0.008 was recorded for the Neretva estuary/Opuzen area, an area where all available control tactics have been implemented. In the Opuzen-Metković area where the SIT has so far not been applied, the highest FTD recorded was 0.5. In 2018, the highest FTDs were 0.049 and 0.341 for the Neretva estuary/Opuzen and the Opuzen-Metković area, respectively.

According to the Phytosanitary Inspection Report, none of the exported shipments of mandarins originating from Neretva has been returned due to the presence of larvae. The implementation of the action plan, the allocation of adequate responsibilities and obligations with the cooperation and support of the local municipalities has resulted in a successful suppression of the Mediterranean fruit fly in the Neretva Valley.

Source: Luka Popović and Ivan Poje (Croatian Agency for Agriculture and Food).

The Sterile Pink Fly: A Wise Solution

On 12 October 2018, the Consortium Productions in Integrated Management of South Montreal, (PRISME) inaugurated its brand-new onion fly, *Delia antiqua* production facility. This 2 800 square foot building, located in Sherrington, Canada and built at a cost of approximately Canadian $650 000, will allow a mass-production of tens of millions of flies annually.

The Phytodata research company which is part of the PRISME Consortium, has been working on the sterile onion fly for about fifteen years. In the 1990's, the control of the onion fly relied solely on the use of chlorpyrifos insecticide applied to the seedlings. In addition, several foliar treatments were applied when damage to onions exceeded 1%. Even at that time, a chlorpyfiros insecticide treatment three times the allowed dose still failed to control the pest. By 2002, the losses caused by the onion flies and the mass application of insecticides prompted PRISME and Phytodata to develop alternative tools, including the use of sterile flies. The technique consists of irradiating mass-reared males with ionizing radiation at the pupal stage to render them sterile. If mating occurs, the females will lay unfertilized eggs following releases, since the males are infertile.

In the summer of 2019, 21 farmers from Montérégie and four from Lanaudière, in Quebec will release sterile flies pink-dyed in their onion fields. More pilot trials will also be conducted in Ontario, and testing is expected to start by 2020 in New York State in collaboration with two researchers from Cornell University.

*The production of sterile onion flies (*Delia antiqua*) starts from the end of October to the beginning of February the following year. The field releases were performed on a weekly basis, from May until fall.*

Cost estimate of the technique is now comparable to that of chemical insecticides. In addition, this approach is not subjected to strict regulations and decreases the risks associated with insecticides on health and the environment.

Source: https://www.laterre.ca/actualites/lutte-integree/la-mouche-rose-sterile-une-solution-judicieuse.

New Sterile Insect Release Facility in Sarasota, Florida. The Facility Supports the USDA, APHIS Mediterranean Fruit Fly (Medfly) Preventive Release Program

Animal and Plant Health Inspection Service (APHIS)' Plant Protection and Quarantine (PPQ) program marked the opening of its newest Sterile Insect Release Facility in Sarasota, Florida. The facility supports the APHIS's Mediterranean fruit fly (Medfly) Preventive Release Program, which plays a critical role in preventing the establishment of Medflies in Florida. Medfly is considered one of the world's most damaging agricultural pests because it attacks more than 200 different types of fruits and vegetables, rendering them unfit for consumption.

APHIS Deputy Administrator Osama El-Lissy (center, holding scissors) marks the official opening of our newest sterile insect release facility in Sarasota. The facility supports the agency's Mediterranean fruit fly (Medfly) Preventive Release Program, which plays a critical role in preventing Medfly outbreaks in Florida.

Every week, PPQ rears and releases about 100 million sterile flies over high-risk areas in Florida. These sterile flies mate with wild Medflies and produce no offspring, helping to breed out of existence any possible Medfly populations before they can become a threat. As a result, no Medfly outbreaks have occurred in areas under Florida's preventive release program. The new facility doubles the capacity of the one it replaces.

Source: *www.usda.gov, 18 April 2019.*

Fruit Fly Outbreaks in South Australia have been Eradicated Successfully

Fruit Flies Eradicated as Loxton Quarantine Lifted

Quarantine restrictions for a Queensland fruit fly outbreak in Loxton have been lifted thanks to a successful eradication programme delivered collaboratively by the State Government, industry and the community.

Queensland fruit fly (Bactrocera tryoni).

Minister for Primary Industries and Regional Development Tim Whetstone praised the efforts of industry and community in successfully eradicating fruit fly from the Loxton area. "It is important to acknowledge the efforts of all involved in the eradication process as battling a fruit fly outbreak requires considerable resources and effort from across the Riverland and beyond," said Minister Whetstone. "With the lifting of quarantine restrictions for Loxton, access to domestic markets will resume from the area without requiring expensive additional treatment.". "The international market access process takes longer, and we are working with the Commonwealth Government to have export arrangements back in place as soon as possible."

"That's why when fruit fly infiltrates our borders, the State Government quickly implements an effective programme to rid of the horticulture pest." Minister Whetstone said the use of sterile insect technique (SIT) and zero tolerance at roadside inspections played a key role in eliminating wild flies from the Loxton outbreak area.

"South Australia is leading the way in SIT and this has proven to be a valuable tool when fighting fruit flies, with 16 million sterile flies produced at the Port Augusta based facility released at the Loxton outbreak area," said Minister Whetstone.

As an emergency response to this fruit fly outbreak, the State Government also implemented a zero-tolerance approach at the Yamba Quarantine Station and random roadblocks and these measures will now continue to protect the Riverland from the further threat of fruit fly.

Ceduna Fruit Fly Quarantine Restrictions Lifted

Quarantine restrictions in the Ceduna Mediterranean fruit fly (Medfly) outbreak area have been lifted following a successful eradication programme. A fruit fly outbreak was declared in Ceduna after the detection of larvae in the area on 14 June 2018.

Minister for Primary Industries and Regional Development Tim Whetstone said it was a whole of community effort to eradicate Medfly from Ceduna. "I thank residents and businesses for their efforts during the quarantine period and recognise their assistance in eliminating the threat of fruit fly in the area," said Minister Whetstone.

Mediterranean fruit fly (Ceratitis capitata).

"They were informed about what to do and their cooperation during the eradication programme was essential to its success." "Medfly has been eradicated from the area through a combination of baiting and hygiene operations, as well as the release of sterile fruit flies."

Meanwhile, the local community is reminded the Medfly eradication program in nearby Thevenard continues and quarantine restrictions in the area remain in place. "These include maintaining good backyard hygiene and picking up any fruit or fruiting vegetables from the ground."

The Thevenard quarantine is expected to be lifted on 24 October 2019.

Source: https://www.pir.sa.gov.au/biosecurity/fruit_fly (30 April and 14 May 2019, respectively).

Relevant Published Articles

Reconstructing the European Grapevine Moth (Lepidoptera: Tortricidae), Invasion in California: Insights From a Successful Eradication

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[2]*Department of Health Sciences, Dominican University of California, San Rafael*

[3]*Division of Agriculture and Natural Resources, University of California, Cooperative Extension, Napa County CA*

[4]*USDA-APHIS, Salinas, CA*

[5]*Department of Chemistry and Biology, Ryerson University, Toronto*

[6]*University of California, Cooperative Extension, Sonoma County CA*

[7]*Department of Entomology, University of California, Riverside*

Abstract

Successfully eradicated invasions are ideal opportunities for understanding the factors governing biological invasions and developing robust management strategies should the same, or similar, organisms again invade. We used geospatial analyses and habitat suitability modeling to reconstruct the spatiotemporal dynamics of an invasive vineyard pest, the European grapevine moth (*Lobesia botrana* [Denis & Schiffermüller]), in northern California. *L. botrana* detections were most strongly autocorrelated at local spatial scales (≤250 m) and remained clustered up to ~10 km. Generalized linear model, boosted regression tree, and random forest modeling methods performed well in predicting habitat suitability for *L. botrana*; annual mean temperature, elevation, and distance to the nearest road were identified as important predictors. Hotspots in *L. botrana* occurrence were spatiotemporally dynamic, yet habitat suitability was less important than purely spatial effects in explaining hotspot persistence. Our results indicate that local regulatory response to novel *L. botrana* detections was appropriate; 500 m treatment zones around detections are sufficient given the apparent propensity for very local movement by *L. botrana*. Our results also confirm the role of anthropogenic effects in *L. botrana* spread and support the establishment of quarantine procedures to limit human-mediated dispersal. Lastly, ensemble predictions provide a fine-scale measure of relative risk for a portion of northern California in the event of future *L. botrana* introductions.

The full paper was published in: Annals of the Entomological Society of America, 112 (2): 107–117.

Artificial Selection of Snsects to Bioconvert Pre-consumer Organic Wastes. A Review

Trevor M. Fowles, Christian Nansen,

Agronomy for Sustainable Development, Department of Entomology and Nematology, University of California, Davis, USA

Abstract

As the human population continues to grow, so too do the concerns regarding the sustainability of waste management from our food production systems. Faced with limited environmental resources for food production, issues related to food loss and waste are critical in mitigating challenges stemming from projected population growth and long-term food security and sustainability. The potential for using insects to consume organic waste materials and convert them into feed for animal, biofuels, and other valuable secondary products is gaining momentum as both a research discipline and as a business opportunity. Here, this ecosystem service is referred to as "insects as bioconverters of organic waste." Scientific reviews of this topic have mainly focused on the challenges associated with development of commercial scale systems. To compliment existing reviews, we address this exciting topic from an artificial selection perspective, as we review and discuss aspects associated with targeted breeding and adaptation of both gut microbial communities and host insects themselves. We describe the "ideal insect bioconverter," insects uniquely equipped to convert wastes into biomass and other valuable secondary products, and we present the current knowledge and existing research gaps towards the development of such organisms. We conclude that (1) targeted breeding of insects and their gut microbes can produce tailored insect lineages for bioconversion of specific waste streams; (2) research is needed to take full advantage of the existing insect diversity to identify new candidate species for bioconversion; and (3) further research into insect-gut microbial complexes will likely provide important insight into ways insects can be used as sustainable bioconverters of highly specialized waste streams.

The full paper was published in: Agronomy for Sustainable Development (2019) 39(3): 3.

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