



Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Insect & Pest Control Newsletter



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To Our Readers



Ambassadors and Permanent Representatives to IAEA on September 29, 2014 at the symbolic ground-breaking ceremony in Seibersdorf, Austria for the construction of the new Insect Pest Control Laboratory of the FAO/IAEA Agriculture and Biotechnology Laboratories as part of the ReNuAL project (Renovation of the Nuclear Applications Laboratories). The second person from right to left is the FAO Deputy Director General, Maria Helena Semedo, the fourth the Chair of the IAEA Board of Governors, Martha Žiaková, and the fifth the IAEA Director General, Yukiya Amano. The ceremony was held in conjunction with a celebration to mark the 50th Anniversary of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture (see insert), which was attended by more than 200 participants with representation from 48 Member States.



Conceptual design of the new Insect Pest Control Laboratory to be built in 2015-2016 in Seibersdorf, Austria. The 2 145 m² (net) laboratory will consist of two floors and will house four sub-groups dealing with plant pests, livestock pests, human disease vectors and genetics/microbiology.

On 29 September 2014, a ceremony was held in Seibersdorf, Austria to commemorate the 50th Anniversary of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, as well as the ground-breaking for the renovation of the IAEA's Nuclear Sciences and Applications laboratories at Seibersdorf – including the FAO/IAEA Agriculture & Biotechnology Laboratories. This ceremony was honoured by the presence of the Chair and Members of the IAEA Board of Governors, senior management and over 200 participants, with 48 Member States represented.

All the former directors of the FAO/IAEA Joint Division since its inception in 1964, starting with its founder, Maurice Fried (1961-1983), Björn Sigurbjörnson (1983-1994), and James Dargie (1994-2005) were able to attend, together with our current Director Qu Liang (2005-present). Their dedication to establish the Joint Division and to develop strong and sustainable foundations is very much appreciated, as well as the efforts to travel to Vienna to join us for this new milestone in the history of the Joint Division.

IAEA Director General, Yukiya Amano, a representative of the FAO Director General, Ms Maria Helena Semedo, FAO Deputy Director General and Coordinator of Natural Resources, as well as Board of Governors Chair, Ms Martha Žiaková, each delivered remarks in support of Renovation of the Nuclear Applications Laboratories (ReNuAL) and the achievements of the Joint Division.

In his remarks, DG Amano said, “Our symbolic ground-breaking today marks the start of the implementation of the ReNuAL project. I am confident that with the active support

of Member States, by 2017, we will have a cluster of modern, well-equipped laboratories here in Seibersdorf that we can all be proud of.”

The enormous contributions of the Joint FAO/IAEA Division during the past 50 years were also honoured, serving stakeholders worldwide to meet the changing needs of Member States through the peaceful uses of nuclear technologies based on the shared goals of our two parent organizations and the five strategic objectives of FAO.

Established on 1 October 1964, this FAO/IAEA partnership still remains unique, with its key strengths based on inter-agency cooperation within the United Nations family. It is a tangible joint organizational entity with a fusion of complementary mandates, common targets, a joint programme, co-funding and coordinated management geared to demand-driven and results-based services to its Members and to the international community at large.

The mission of the Joint Division has proactively evolved to address new challenges in Member States and nuclear applications continue to provide added value to conventional approaches in addressing a range of agricultural problems and issues, including food safety, animal production and health, crop improvement, insect pest control and sustainable use of finite natural resources. Over the past 50 years, this partnership has brought countless successes with distinct socio-economic impact at country, regional and global levels in Member States.

The 50 year anniversary was taken as an opportunity to highlight examples of tangible, sustainable results derived

out of this unique partnership – beneficial to Member States of both parent organizations – and to share these with our many stakeholders around the world. These new communication materials outline successes using nuclear techniques related to field applications in food and agriculture:

<http://www-naweb.iaea.org/nafa/resources-nafa/IAEAsuccessStories-2014.pdf>

<http://www-naweb.iaea.org/nafa/resources-nafa/ProgBrochure-2014.pdf>

<http://www-naweb.iaea.org/nafa/resources-nafa/LabBrochure-2014.pdf>

The *ReNuAL* project is an initiative to modernize the eight laboratories in Seibersdorf that belong to the IAEA's Department of Nuclear Sciences and Applications. The project includes in its first phase for the construction of a new Insect Pest Control Laboratory (IPCL) to replace the existing IPCL, a patchwork of many additions over the last 50 years that urgently needs to be upgraded, not only to address a number of space and other biosecurity and staff safety limitations, but also to be able to respond to expanding current Member State demands. The first phase of *ReNuAL* will also include three additional laboratories related to other nuclear applications in the field of agriculture and the environment.

In July 2014, an architectural and engineering firm was contracted to develop with technical staff the conceptual designs for the new IPCL and the other laboratories, as well as to update the master plan for the Seibersdorf site. The conceptual design for the IPCL has been completed and construction is estimated to cost 10.8 million Euro. It will house laboratory sub-groups dealing with plant pests, livestock pests, human disease vectors and genetics/microbiology. The purpose of the conceptual designs is to provide the basic layout and structure of the new buildings, and in doing so to provide a greater degree of certainty regarding costs of construction.

Upon completion of the conceptual designs, the detailed architectural designs will be developed. These build further on the conceptual designs and add greater detail by making more concrete decisions on smaller elements of the buildings. With these designs and cost estimates, a tender for construction can then be issued, and it is estimated that construction can begin by mid-2015.

In the recent IAEA General Conference, Member States expressed strong support for the project and requested its further development and implementation. They also included a specific request to prepare thematic packages that separate the various elements of *ReNuAL*, into smaller components that will enable Member States to support specific programmatic areas according to their own interests and priorities.



FAO Director General, José Graziano da Silva, and IAEA Deputy Director General and Head of the Department of Nuclear Sciences, Aldo Malavasi, at their recent meeting in Rome to confirm the support of both organizations to the Joint FAO/IAEA Division, as well as support to fund-raising for and implementation of the ReNuAL project that includes upgrading the five laboratories of the FAO/IAEA Agriculture & Biotechnology Laboratories in Seibersdorf, Austria.

A number of Member States have also expressed support to the establishment of biosafety level 3 capabilities to be able to respond to emerging challenges related to transboundary animal diseases, some of which are transmitted by insect vectors. The IAEA and the Government of Austria are in consultations to establish such a laboratory, possibly at a recently established modern facility in Vienna belonging to the Austrian Agency for Health and Food Safety.

Finally I would like to inform you that we will be starting in 2015 a new Coordinated Research Project on “*Mosquito Handling, Transport, Release and Male Trapping Methods*”. The burden of mosquito transmitted diseases remains enormous; in fact, the incidence of dengue and other diseases has been growing dramatically around the world in recent years, while vector control effectiveness has been decreasing as mosquitoes develop insecticide resistance. During a Mosquito Thematic Plan Meeting held in Vienna in June 2014, experts identified the urgent need for innovative mosquito control methods, including exploring the potential of the SIT. The focus of this CRP is to develop transport and aerial release methods for deploying millions of sterile male mosquitoes, and to assess new methods in pilot sites to ensure the quality and the sexual capacity of the released males. The development and evaluation of affordable and efficient trapping methods for male mosquitoes are also of high importance for the assessment and success of mosquito suppression programmes.

As 2014 draws to a close, our best seasonal greetings on behalf of all of us at the Subprogramme. We look forward to another fruitful year and wish you a very successful 2015.

Jorge Hendrichs

Head, Insect Pest Control Section

Insect Pest Control Subprogramme

<http://www-naweb.iaea.org/nafa/ipc/index.html>

<http://www.fao.org/ag/portal/age-index.html>

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Forthcoming Events (2015-2016)

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

Second RCM on Exploring Genetic, Molecular, Mechanical and Behavioural Methods of Sex Separation in Mosquitoes. 9–13 March 2015, Juazeiro, Brazil.

Final RCM on Resolution of Cryptic Species Complexes of Tephritid Pests to Overcome Constraints to SIT Application and International Trade. 1–5 June 2015, Saint Pierre, France.

First RCM on Comparing Rearing Efficiency and Competitiveness of Sterile Male Strains Produced by Genetic, Transgenic or Symbiont-based Technologies. 6–10 July 2015, Vienna, Austria.

Third RCM on Use of Symbiotic Bacteria to Reduce Mass-rearing Costs and Increase Mating Success in Selected Fruit Pests in Support of SIT Application. 26–30 October 2015, Antigua, Guatemala.

First RCM on Mosquito Handling, Transport, Release and Male Trapping Methods. 23–27 November 2015, Vienna, Austria.

II. Consultants and Expert Meetings

Consultants Meeting on Mosquito Male Trapping Methods to Monitor the Efficacy of SIT Programme in the Field. 16–20 February 2015, Vienna, Austria.

Consultants Meeting on Improved Field Performance of Sterile Moths to Enhance SIT Application. 13–17 April 2015, Vienna, Austria.

Consultants Meeting on A Generic Approach for the Development of Genetic Sexing Strains for SIT Applications. 1–5 June 2015, Vienna, Austria.

III. Other Meetings/Events

FAO/IAEA Regional Training Course on Free Open Source Software for GIS and Data Management applied to tsetse and trypanosomiasis control programmes, French edition (under the Regional TC Project RAF5070). 19–30 January 2015, Vienna, Austria.

FAO/IAEA Coordination Meeting of the Africa Regional TC Project RAF5069 on Supporting a Feasibility Study to Eradicate Tsetse from Southern Mozambique, South Africa and Swaziland. 9–10 February 2014, Pretoria, South Africa.

FAO/IAEA Regional Training Course on Fruit Fly Biocontrol in West Africa (under Regional TC Project RAF5061). 2–6 March 2015, Nairobi, Kenya.

Tenth Session of the Commission on Phytosanitary Measures, International Plant Protection Convention, FAO. 16–20 March 2015, Rome, Italy.

FAO/IAEA Regional Training Course on Free Open Source Software for GIS and Data Management Applied to Fruit Flies in the Balkans and the Eastern Mediterranean (under Regional TC Project RER5020). 1–5 June 2015, Vienna, Austria.

FAO/IAEA Regional Training Course on Fruit Fly Monitoring and Suppression Including MAT and SIT for Indian Ocean (under Regional TC Project RAF5062). 22–26 June 2015, Reunion, Mauritius.

FAO/IAEA Regional Meeting on SIT Application, Including Rearing, Irradiation and Release of Fruit Flies (under TC Project RAF5062). 24–26 June 2015 Reunion, Mauritius.

FAO/IAEA Interregional Training Course on The Use of the Sterile Insect and Related Techniques for the Integrated Area-wide Management of Insect Pests (under Interregional TC Project INT5151). 3–28 August 2015, Metapa de Dominguez, Chiapas, Mexico and Antigua / El Pino, Guatemala.

Meeting of the Technical Panel on Pest Free Areas and Systems Approaches for Fruit Flies (TPPF), International Plant Protection Convention. 12–16 October 2015, Vienna, Austria.

Workshop on Microbial and Processing Criteria for Industrial Production of Probiotics or Bacteria as Source of Protein to Improve Fruit Fly Quality and SIT Efficiency. 23–25 October 2015, Guatemala City, Guatemala.

Meeting of the Technical Panel on Phytosanitary Treatments (TPPT), International Plant Protection Convention, FAO. 26–30 October 2015, Tohoku, Japan.

FAO/IAEA Regional Training Course on Taxonomy and Identification of Fruit Fly Pest Species for Southeast Asia (under Regional TC Project RAS5067). 16–20 November 2015, Brisbane, Australia.

3rd Meeting of the Tephritid Workers of Europe, Africa and the Middle East (TEAM), 11–14 April 2016, Stellenbosch, South Africa.

1st Meeting of the Tephritid Workers of Asia, Australia, and Oceania. (TAAO), 15–18 August 2016, Kuala Lumpur, Malaysia.

9th Meeting of the Tephritid Workers of the Western Hemisphere (TWWH), tentatively for October 2016, Buenos Aires, Argentina.

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

Past Events (2014)

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

Final RCM of CRP on Development and Evaluation of Improved Strains of Insect Pests for SIT. 7–11 April 2014, Capri, Italy.

Second RCM of CRP on Use of Symbiotic Bacteria to Reduce Mass-Rearing Costs and Increase Mating Success in Selected Fruit Pests in Support of SIT Application. 6–10 May 2014, Bangkok, Thailand.

Final RCM of CRP on Increasing the Efficiency of Lepidoptera SIT by Enhanced Quality Control. 2–6 June 2014, Kelowna, Canada.

Final RCM of CRP on Development of Generic Irradiation Doses for Quarantine Treatments. 2–6 June 2014, Vienna, Austria.

First RCM of CRP on Dormancy Management to Enable Mass-Rearing and Increase Efficacy of Sterile Insects and Natural Enemies. 21–25 July 2014, Vienna, Austria.

Second RCM of CRP on Enhancing Vector Refractoriness to Trypanosome Infection. 1–5 December 2014, Addis Ababa, Ethiopia.

II. Consultants and Expert Meetings

FAO/IAEA Consultants Meeting on New Methods for the Detection and Quantification of Irradiation in Intercepted Insects. 10–14 March 2014, Vienna, Austria.

FAO/IAEA Consultants Meeting on Process Control for Fruit Fly Rearing Facilities that Mass-Produce Insects for Sterilization. 13–15 May 2014, Bangkok, Thailand.

FAO/IAEA Consultants Meeting on Developing Sterile Mosquito Transport and Aerial Release Methods. 8–12 December 2014, Vienna, Austria.

III. Other Meetings/Events

FAO/IAEA Sub-regional Assessment Meeting of the Regional TC Project RAS5059 on Supporting Area-wide Integrated Pest Control of Native and Exotic Flies in the Middle East Subregion, Incorporating the Sterile Insect Technique. 25–26 February 2014, Vienna, Austria.

FAO/IAEA Regional Workshop to Present Respective Experiences with Fruit Flies and Synergise Future Activities in the Balkans and the Eastern Mediterranean (under Regional TC Project RER5020). 25–27 March 2014, Vienna, Austria.

Ninth Session of the Commission on Phytosanitary Measures, International Plant Protection Convention, FAO. 31 March–4 April 2014, Rome, Italy.

FAO/IAEA Regional Training Course on Taxonomy and Identification of Fruit Fly Pest Species Exotic to the Middle East (under Regional TC Project RAS5059). 31 March–4 April 2014, Seibersdorf, Austria.

Workshop on Characterization of Symbionts of Fruit Flies of Economic Importance via Bioinformatic Approaches. 4–5 May 2014, Bangkok, Thailand.

9th International Symposium on Fruit Flies of Economic Importance. 12–16 May 2014, Bangkok, Thailand.

FAO/IAEA Regional Training Course on Free Open Source Software for GIS and Data Management Applied to Tsetse and Trypanosomosis Control Programmes. 12–23 May 2014, Addis Ababa, Ethiopia.

FAO/IAEA First Coordination Meeting of the Regional TC Project RLA5067 on Supporting Capacity Building for Evaluation of Feasibility of a Progressive Control Programme for New World Screwworm. 2–6 June 2014, Panama City, Panama.

IAEA Meeting on “Thematic Plan for the Development and Application of the Sterile Insect Technique (SIT) and Related Genetic and Biological Control Methods for Disease Transmitting Mosquitoes”, 16–20 June 2014, Vienna, Austria.

FAO/IAEA Regional Training Course on Use of GIS for Area-Wide Fruit Fly Programmes in Indian Ocean (under Regional TC Project RAF5062). 18–22 August 2014, Zanzibar, United Republic of Tanzania.

FAO/IAEA Regional Training Course on Fruit Fly Monitoring and Suppression including MAT and SIT for Southeast Asia (under Regional TC Project RAS5067). 15–19 September 2014, Bandung, Indonesia.

FAO/IAEA Regional Training Course on Mass-Rearing and SIT-Related Activities for the Control of *Aedes* Mosquitoes (under Regional TC Project RAS5066). 22–26 September 2014, Juazeiro, Brazil.

FAO/IAEA Regional Training Course on Taxonomy and Identification of Fruit Fly Pest Species Exotic to the Balkans and Eastern Mediterranean (Regional TC Project RER5020). 13–17 October 2014, Tervuren, Belgium.

FAO/IAEA Regional Training Course on Diagnosis of the New World Screwworm (under Regional TC Project RLA5067). 27–31 October 2014, Pecora, Panama.

Expert Consultation on Phytosanitary Treatments for the *Bactocera dorsalis* Complex, International Plant Protection Convention, FAO. 1–5 December 2014, Yokoama, Japan.

FAO/IAEA Coordination Meeting of the West Africa Regional TC Project RAF5061 on Supporting Capacity Building and a Feasibility Study on Control of Fruit Flies of Economic Significance in West Africa. 10–12 December 2014, Vienna, Austria.

Technical Cooperation Field Projects

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

- Biocontrol using radiation
- Fruit flies
- Mosquitoes
- Moths
- Screwworm flies
- Tsetse flies

Country	Project Number	Title National Projects	Technical Officer
Angola	ANG5012	Supporting Feasibility Studies for using Sterile Insect Techniques as part of Area-Wide Integrated Pest Management for Control of Tsetse Flies (<i>G. morsitans centralis</i>)	Rafael Argiles
Burkina Faso	BKF5012	Collecting Baseline Data and Implementing Fruit Fly Suppression in Mango Fruit	Rui Cardoso Pereira
Chad	CHD5003	Finalising the Feasibility Study to Assess Whether the Sterile Insect Technique (SIT) Can Be Applied for the Creation of Sustainable Tsetse-Free Zones	Rafael Argiles
Costa Rica	COS5030	Supporting Biological Control of Stable Flies (<i>Stomoxys calcitrans</i>) through the Use of Parasitoids Reproduced on Fruit Flies	Jesús Reyes
China	CPR5020	Integrating the Sterile Insect Technique (SIT) for Area-Wide Integrated Pest Management of Tephritid Fruit Flies	Rui Cardoso Pereira
Ethiopia	ETH5018	Contributing to the Creation of Sustainable Tsetse Free Areas	Rafael Argiles Andrew Parker
Guatemala	GUA5017	Using the Sterile Insect Technique (SIT) to Establish Fruit Fly Low Prevalence Pilot Areas and to Assess it as an Alternative for the Control of the Sugarcane Borer in Pilot Areas	Jesús Reyes
Honduras	HON5006	Using Sterile Insect Technique (SIT) to Obtain Recognition as a Mediterranean Fruit Fly Free Area in the Aguan River Valley	Jesús Reyes
Israel	ISR5019	Supporting a Feasibility Study for the Implementation of Leafminer (<i>Liriomyza</i> spp) Sterile Insect Technique Combined with Biological Control under Greenhouse Conditions	Jesús Reyes
Libya	LIB5011	Enhancing Area-Wide Integrated Management of Fruit Flies	Jesús Reyes
Madagascar	MAG5021	Implementing the Sterile Insect Technique (SIT) in Integrated Fruity Fly Control for High Quality Fruit Production	Rui Cardoso Pereira
Mauritius	MAR5019	Supporting a Feasibility Study Using the Sterile Insect Technique (SIT) for the Integrated Control of Mosquitoes	Jeremie Gilles

Mauritius	MAR5022	Reducing Insecticide Use and Losses to Melon Fly (<i>Bactrocera cucurbitae</i>) through Environment-Friendly Techniques to Increase Production in Different Areas, Phase II	Jorge Hendrichs Rui Cardoso Pereira
Morocco	MOR5032	Supporting Control of the Medfly Using the Sterile Insect Technique for Citrus Fruits and Early Fruits and Vegetables to Establish Low Medfly Prevalence Zones	Jesús Reyes
Oman	OMA5002	Assessing the Suitability of Sterile Insect Technique (SIT) and Related Techniques for Combating Date Palm Insect Pests	Marc Vreysen
Panama	PAN5020	Strengthening Technical Capacity to Control Mediterranean Fruit Fly Using the Sterile Insect Technique (SIT)	Jesús Reyes
Palau	PLW5001	Improving the Quality of the Fruits and Vegetables Through an Area-Wide Integrated Pest Management of <i>Bactrocera</i> Fruit Flies in Production Areas of Palau	Rui Cardoso Pereira
South Africa	SAF5013	Assessing the Sterile Insect Technique for Malaria Mosquitoes in a South African Setting	Jeremie Gilles
Senegal	SEN5033	Supporting the Operational Phase of Eliminating <i>Glossina palpalis gambiensis</i> from the Niayes Area by Promoting the Development of Integrated Stockbreeding	Marc Vreysen Andrew Parker
Seychelles	SEY5005	Enhancing the Melon Fruit Fly Area-Wide Integrated Pest Management Programme Using the Sterile Insect Technique to Improve National Food Security	Rui Cardoso Pereira
Sri Lanka	SRL5044	Supporting a Feasibility Study Using the Sterile Insect Technique (SIT) for Integrated Control of Mosquitoes	Jeremie Gilles
Sudan	SUD5034	Supporting a Feasibility Study on the Suitability of the Sterile Insect Technique as a Strategy for the Integrated Control of <i>Anopheles arabiensis</i>	Jeremie Gilles
Thailand	THA5052	Developing Sustainable Management of Fruit Flies Integrating Sterile Insect Technique with other Suppression Methods	Rui Cardoso Pereira
Uganda	UGA5036	Demonstrating the Feasibility of a Sterile Insect Technique Component as Part of an Area-Wide Integrated Pest Management Approach to Increase Livestock Productivity	Rafael Argiles
Vietnam	VIE5017	Supporting Area-Wide Integrated Pest Management to Improve the Quality of Fruit for Export	Rui Cardoso Pereira
Zimbabwe	ZIM5019	Improving Crop and Livestock Production through the Eradication of Bovine and Human Trypanosomosis in Matusadona National Park	Rafael Argiles

Title			
Regional Projects			
Regional Africa	RAF5061	Supporting Capacity Building and a Feasibility Study on Control of Fruit Flies of Economic Significance in West Africa	Rui Cardoso Pereira
Regional Africa	RAF5062	Preventing the Introduction of Exotic Fruit Fly Species and Implementing the Control of Existing Species with the Sterile Insect Technique and Other Suppression Methods	Rui Cardoso Pereira
Regional Africa	RAF5064	Supporting Area-Wide Tsetse and Trypanosomosis Management to Improve Livestock Productivity and Enable Sustainable Agriculture and Rural Development	Rafael Argiles Andrew Parker
Regional Africa	RAF5065	Promoting the Sharing of Expertise and Physical Infrastructure for Mass-Rearing Mosquitoes and Integration of the Sterile Insect Technique (SIT) with Conventional Methods for Vector Control, among Countries of the Region.	Jeremie Gilles
Regional Africa	RAF5069	Supporting a Feasibility Study to Eradicate Tsetse from Southern Mozambique, South Africa and Swaziland	Marc Vreysen Rui Cardoso Pereira
Regional Africa	RAF5070	Supporting Area-Wide Tsetse and Trypanosomosis Management to Improve Livestock Productivity and Enable Sustainable Agriculture and Rural Development (Phase II)	Rafael Argiles
Regional Africa	RAF5072	Exploring the Use of Sterile Insect Technique as a Novel Technique for Control of Vector Mosquito for Chikungunya and Dengue (<i>Aedes albopictus</i>) in the Indian Ocean Region (PHASE I - 2014-2015)	Jeremie Gilles
Regional Asia	RAS5059	Supporting Area-Wide Integrated Pest Control of Native and Exotic Flies in the Middle East Subregion Incorporating the Sterile Insect Technique (SIT)	Jesús Reyes
Regional Asia	RAS5066	Promoting the Sharing of Expertise and Infrastructure for Dengue Vector Surveillance towards Integration of the Sterile Insect Technique with Conventional Control Methods among South and South East Asian Countries	Kostas Bourtzis Jeremie Gilles
Regional Asia	RAS5067	Integrating Sterile Insect Technique for Better Cost-Effectiveness of Area-Wide Fruit Fly Pest Management Programmes in South-east Asia	Rui Cardoso Pereira
Regional Europe	RER5020	Controlling Fruit Flies in the Balkans and the Eastern Mediterranean	Rui Cardoso Pereira
Regional Latin America	RLA5067	Supporting Capacity Building for Evaluation of Feasibility of a Progressive Control Programme for New World Screwworm	Jesús Reyes
Title			
Interregional Project			
Interregional	INT5151	Sharing Knowledge on the Use of the Sterile Insect and Related Techniques for Integrated Area-Wide Management of Insect Pests	Jorge Hendrichs

Highlights of Technical Cooperation Projects

Promoting the Sharing of Expertise and Physical Infrastructure for Mass-Rearing Mosquitoes and Integration of the Sterile Insect Technique (SIT) with Conventional Methods for Vector Control, among Countries of the Region.

Pilot release trial with sterile *Aedes albopictus* in Mauritius

Under project MAR/5/019 a field trial with sterile *Aedes albopictus* is being supported in Mauritius. The village of Panchvati was selected as an ideal site for the pilot trial and ovitraps were used to monitor the dynamics of the mosquito population in the village for more than a year. Five release points were selected covering three hectares of Panchvati and surroundings (see Figure). In each release point, 1000 sterile males were released twice a week giving a release rate of 10,000 sterile males per week.



Aerial photo of Panchvati village with the set-up of the release trial. Yellow circles indicate release points and red triangles indicate ovitrap sites.

To assess the impact of the weekly release of sterile males, a survey is ongoing in Panchvati with 14 ovitraps of which 8 are deployed inside the village and 6 around the village. Every week, the egg papers from each ovitrap were collected; the eggs counted and bleached to determine the presence/absence of an embryo. The sterility was calculated from the number of eggs without embryo divided by the total number of eggs. After 6 weeks of releases, an induced sterility of approximately 50% was observed indicating good performance of the sterile males.

Using the Sterile Insect Technique (SIT) to Assess it as an Alternative for the Control of the Sugarcane Borer in Pilot Areas (GUA5017)

The Southern Cornstalk Borer Moth *Diatraea crambidoides* (Grote) is a non-native / introduced pest in Guatemala. Females of this pest species oviposit their eggs in corn (*Zea mays*), sorghum (*Sorghum spp.* L) and the eastern gramagrass (*Tripsacum dactyloides* L.) in their native/reported distribution area in North America.



Large field cage trials in sugarcane production area testing the competitiveness of sub-sterilized moths to assess the effect of different sterile to wild moth ratios.

In Guatemala, *Diatraea crambidoides* has been found ovipositing in sugarcane (*Saccharum officinarum* L.), where the larva bores through the sugarcane stalk reducing productivity in large production areas, having an economic impact on this very important income-generating crop. Additionally, there is the risk that *D. crambidoides* could revert to corn, one of its native hosts, in which case the pest presence could become a food security issue for this country. There are no control treatments available for this pest, despite the various attempts to generate options.

A public/private sector alliance was created in Guatemala to deal with this problem and technical support requested through a technical cooperation project from the IAEA. Subsequently the sugarcane industry has established rearing activities for the production of pupae of *D. crambidoides*. After their production, moths were exposed to different doses of gamma radiation to determine the most effective sub-sterilizing dose using the F1 sterility concept. Irradiation has been administered in collaboration with the existing fruit fly rearing facilities of the cooperative trilateral Guatemala- Mexico-USA Moscamed Program.

Small and large field cage experiments have been used to determine a sterile to wild ratio for moth releases that could reduce the density of the resident moth populations. Based on the results, the field release of small amounts of moths

is currently being conducted to study their longevity, field dispersal, performance and potential impact on the resident moth population in the pilot area. Larger production of sterile moths is programmed for the coming months to increase the size of the field tests.

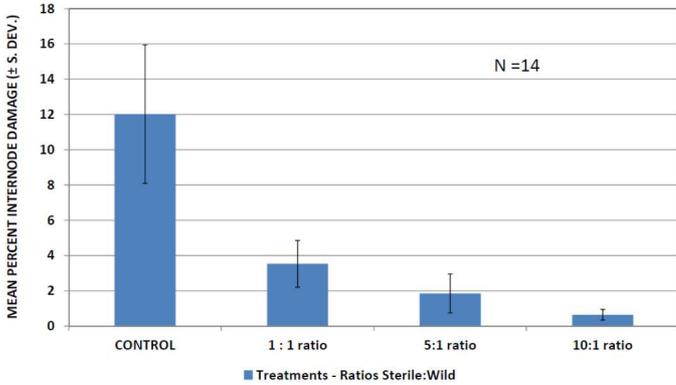


Chart showing the sterile: fertile ratio tested and the degree of control achieved.

Contributing to the Creation of Sustainable Tsetse Free Areas (ETH5018)

The Southern Tsetse Eradication Project (STEP) is an ongoing national intervention by the Government of Ethiopia to suppress and eventually to eradicate populations of two species of tsetse flies in the Southern Rift Valley, making the area suitable for cattle rearing and enhancing agriculture.

Since 1997, the IAEA has offered both funding and expertise to support the objectives of STEP. Most notably, a small gamma cell was procured on behalf of the Government of Ethiopia, allowing national counterparts to irradiate the blood that is fed to the tsetse colonies. However, the activities associated with STEP have now outgrown this small system.

On 19 July, representatives from IAEA, Africa Development Bank and other organizations attended a ceremony in Kality, Addis Ababa, to inaugurate an industrial irradiator with a wet stored cobalt source of 60.000 curies - a key piece of machinery for the sterilization of mass-reared tsetse males and the decontamination of blood for their diet. The new irradiator was partly-funded by the IAEA, and its introduction marks an important milestone on the road to a tsetse-free valley and rural development.

Tsetse flies are relatively large, blood-sucking insects that are the primary biological vector for trypanosomes, which cause 'nagana' in cattle and sleeping sickness in their human caretakers. Sometimes called the 'poverty insect', the tsetse flies have presented a notable barrier to the development of the Southern Rift Valley affecting the health and productivity of local livestock. Due to the importance of cattle for their draught power and for their meat, milk and dung tsetse flies not only pose a health risk, but an econom-

ic risk as well.



View of the turntables of the wet storage panoramic irradiator at the Kality mass-rearing facility.

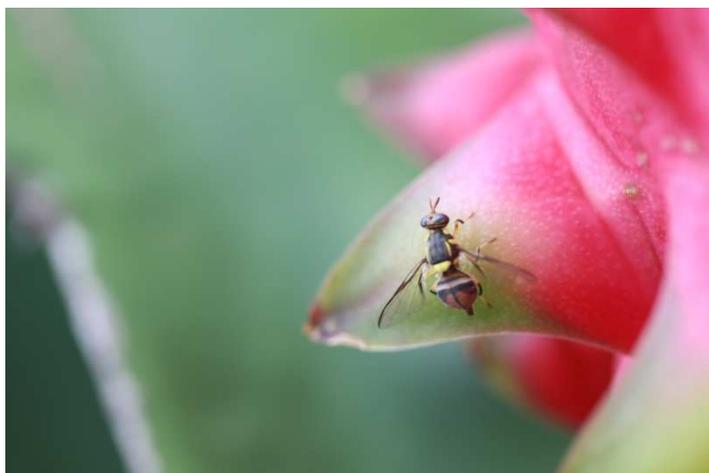
In support of the Government of Ethiopia, and under the auspices of STEP, the IAEA has supported the adoption of a safe, environmentally-friendly intervention known as the sterile insect technique (SIT). Expert missions, scientific visits, and fellowships have been organized in order to support the development of the expertise necessary to conduct SIT operations.

However, the SIT is only applied once an insect population has been adequately suppressed using conventional activities. These activities have been deployed in the region since 1997, suppressing the pest in large swathes of land for use by farmers and herders. While effective, these conventional measures are not sufficient or sustainable in the long-term – the SIT is necessary to eradicate the population completely.

Livestock bred in the region are now surviving in greater numbers, allowing local farmers to increase the area ploughed, increase their yields, plan for future harvests, and produce nutritious food for nearby markets and communities. Furthermore, spending on trypanosomosis medication has been reduced, freeing income to invest in better livestock breeds and improved agricultural practices. With the industrial irradiator now in place, the production capacity of sterile males in the mass-rearing facility in Kality can be substantially enhanced in order to meet the future needs of STEP.

Supporting Area-Wide Integrated Pest Management to Improve the Quality of Fruit for Export (VIE5017)

Dragon fruit is the most important agricultural product of Binh Thuan Province and the most important fruit commodity of Vietnam. The total dragon fruit production area in the province amounts to approximately 20 000 ha, producing ca. 560 000 tons a year, from which 90% are for export. This year the production was especially high and the exports in the first 6 months of 2014 have already surpassed the total amount of exports in 2013 (500 000 tons, from which 470 000 tons were destined for the Chinese market). Other markets include Asian countries in the region, the USA and Europe. From these production areas, 5 700 ha are under VIETGAP management (from which 1 570 ha are certified to export to USA) and 157 ha are under GLOBALGAP management (fulfilling requirements to export to Europe).



Bactrocera dorsalis female exploring oviposition site in a dragon fruit.

Different post-harvest treatments are in place due to the different requirements of the importing countries (hot vapour treatment to export to South Korea and Japan and irradiation to export to the USA). Other countries do not require any post-harvest treatment, but in the case of exports to Europe, production under GLOBALGAP management requires low pesticide residues. Due to the short shelf life of the dragon fruit after harvest (maximum 1 month), exports to the USA and Europe are via airfreight.

As a result of the high price of the product in export markets, the production is growing with new areas of plantation being added. Due to current closure of most borders between China and Vietnam, and the consequent decrease of market prices, exporters are seeking alternative markets in the region. Nevertheless, fruit fly infestation is a major phytosanitary problem, necessitating effective pre-harvest controls and post-harvest treatments required by the importing countries. Fruit flies damage the fruit and lower the quality of the product for marketing and result in trade barriers due to additional quarantine regulations of importing countries.

In late 2013, a pilot project in a 400 ha area was implemented with IAEA support to demonstrate the area-wide fruit fly suppression in dragon fruit production. The area is 2 km by 2 km with a core area in the centre of 1 km by 1 km (100 ha).

Three different suppression methods were applied in the core area: (1) sanitation, including alternative host removal and fruit stripping, (2) male annihilation (MAT) blocks in all 400 ha, and (3) a weekly bait spray using beer waste protein and insecticide applied to the plant leaves. Monitoring of the adult and larval population was conducted in core, buffer and no-suppression areas.

The results showed a continuous decrease of the wild population from values of about 5 flies per trap per day (FTD) to an FTD of 0.82 in the core area and 1.74 in the buffer area. In the no-suppression area no reduction occurred and the population was above 5 FTD during the whole period.

As result of the successful pest suppression in the pilot area, the area has been extended to 1 000 ha (with 400 ha core area) in October 2014. The possibility of using sterile flies as an additional suppression method for low populations is now also under consideration, which will be implemented in the second quarter of 2015, depending on the availability of sterile flies produced in Thailand.

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

Regional Training Course on Diagnosis of Screwworms

A Regional Training Course for South America on “Diagnosis of screwworms” under the IAEA Technical Cooperation Project RLA5067 (“Supporting Capacity Building for Evaluation of Feasibility of a Progressive Control Programme for New World Screwworm”) was conducted in Panama, at the screwworm mass-rearing facility of the Panama-United States Commission for the Eradication and Prevention of Screwworm (COPEG), from 27 to 31 October, 2014 with the participation of 10 representatives from five countries.

The Regional Training Course was conducted with the objective to transmit the knowledge on morphology of eggs, different larval stages, and identification of adults of *C. hominivorax* and *C. macellaria*, as well as comparing the myiasis-related larvae of other fly species belonging to the families Calliphoridae, Muscidae, Oestridae and Sarcophagidae.

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

Regional Training Course on Mass-Rearing and SIT-related Activities for the Control of *Aedes* Mosquitoes, the Major Vectors of Dengue and Chikungunya

In the frame of IAEA TC regional project RAS5066 “Promoting the Sharing of Expertise and Infrastructure for Dengue Vector Surveillance towards Integration of the Sterile Insect Technique with Conventional Control Methods among South and South East Asian Countries”, a training course on “Mass-rearing and SIT-related activities for the control of *Aedes* mosquitoes, the major vectors of dengue and chikungunya” was organized in Juazeiro and Jacobina (Brazil) from 22–26 September 2014. Fifteen participants from eight countries (China, Indonesia, Malaysia, Pakistan, Philippines, Singapore, Sri Lanka and Thailand) attended this training course.



Participants of the regional training course on Mass-Rearing and SIT-related Activities for the Control of *Aedes* Mosquitoes, the Major Vectors of Dengue and Chikungunya (Juazeiro, Bahia, Brazil).

The training course took place in the Moscamed Brazil facilities where an active pilot SIT program against *Aedes aegypti*, a major mosquito vector species, is on-going. Lectures and practical training were provided by Moscamed Brazil staff members, cost-free experts from Israel and the USA, and an FAO/IAEA technical officer.

During the course, the participants had the opportunity to visit the *Aedes aegypti* mass-rearing facility in Juazeiro as well as the release centre in Jacobina where they observed an actual release of sterile male mosquitoes, participated in monitoring the mosquito ovitraps in houses and got informed about the local public information and engagement programme.

Supporting Fruit Flies in the Balkans and the Eastern Mediterranean (RER5020)

Regional Training Course on Taxonomy and Identification of Fruit Fly Pest Species Exotic to the Balkans and the Eastern Mediterranean

This Regional Training Course was attended by 12 participants from 11 Member States (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Georgia, Greece, Montenegro, Romania, Slovenia and the Former Yugoslav Republic of Macedonia). The course was held at the Royal Museum for Central Africa, Tervuren, Belgium from 13–17 October 2014.



Participants of the regional training course on Taxonomy and Identification of Fruit Fly Pest Species Exotic to the Balkans and the Eastern Mediterranean (Royal Museum for Central Africa, Tervuren, Belgium).

The programme of the training course consisted of theoretical lectures, demonstration and practical exercises and covered the following main topics:

- Introductory lectures on taxonomy of Tephritidae; on recognition of the major fruit fly pest genera; and presentation of the major pest species of economic significance.
- Lectures on the use of different identification tools, including DNA barcodes and electronic multi-entry keys, with particular reference to fruit flies.
- Hands-on training in developing identification skills for fruit fly genera *Bactrocera*, *Dacus* and *Ceratitis*.
- Lectures and demonstrations on fruit fly collection management, DNA barcoding protocols and database development.

The participants also visited the entomological collections and the molecular laboratories of the Royal Museum for Central Africa to become acquainted with the techniques and methods used for preservation and molecular manipulations of DNA extraction and PCR.

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

Regional Training Course on Fruit Fly Monitoring and Suppression Including MAT and SIT for Southeast Asia

The FAO/IAEA Regional Training Course on “Fruit fly monitoring and suppression including MAT and SIT for Southeast Asia”, was organized under the Regional Technical Cooperation Project RAS5067, and held in Bandung, Indonesia, 15-19 September 2014. This course was attended by a total of 20 participants, from 8 Member States (China, Fiji, Indonesia, Lao P.D.R., Malaysia, Palau, Thailand and Vietnam).

The Regional Training Course addressed the following aspects:

- Experiences on fruit fly activities in the respective Member States.
- Fruit fly biology and ecology.
- Adult and larval surveillance.
- Monitoring systems (traps, density, attractants).
- Concept of Area-Wide Integrated Pest Management (AW-IPM), phased conditional approach, Sterile Insect Technique (SIT), and Male Annihilation Technique (MAT).
- Other suppression techniques.
- Integration of suppression techniques into an AW-IPM approach.
- Practical exercise in relation to the SIT (Curaçao model).



Participants of the regional training course on Fruit Fly Monitoring and Suppression including MAT and SIT for Southeast Asia (Bandung, Indonesia).

The participants visited the National Nuclear Energy Agency (BATAN) in Jakarta, where fruit fly monitoring, laboratory rearing and sterilization studies are ongoing; also the food irradiation facilities and the Pest Forecasting Institute where phytosanitary treatments (mainly vapour heat and hot water treatment) are under development to allow the exports of mango to external markets.

Preventing the Introduction of Exotic Fruit Fly Species and Implementing the Control of Existing Species with the Sterile Insect Technique and Other Suppression Methods (RAF5062)

Regional Training Course on Use of GIS for Area-Wide Fruit Fly Programmes in Indian Ocean

A workshop on “Applying GIS for Data Management of Fruit Fly Pest Management Programmes in the Indian Ocean” was convened in Zanzibar, United Republic of Tanzania between 18 and 22 August, 2014. Participants arrived from Madagascar, Mauritius, Mozambique, Seychelles, South Africa, and the United Republic of Tanzania.

Training sessions included both theoretical presentations, and hands-on practice sessions. The theoretical material covered GIS data formats, loading and stylizing data layers, coordinate reference systems, cartographic elements, spatial databases, and an introduction to raster data sets. After each theoretical session, participants were directed to perform specific exercises to better absorb and learn to use the techniques.



Participants of the regional training course on Applying GIS for Data Management of Fruit Fly Pest Management Programmes in the Indian Ocean (Zanzibar, United Republic of Tanzania).

The formal training made extensive use of the FAO/IAEA Live DVD tutorial disk, which is based on open source GIS software. This live system includes a variety of GIS applications, all pre-installed in a full, independent computer environment. The DVD contains the practice data layers, and a series of video lessons explaining GIS concepts and demonstrating the techniques. All participants had the DVD running on their laptops, so that they could review the recorded lessons and work on the exercises in parallel. Furthermore, each participant returned home with a copy of the same tutorial DVD for future reference.

In order to enhance future cooperation and sharing of experiences and information, an email forum was opened to deal with issues concerning GIS in the context of area-wide pest control programs. The forum accepts questions, and user's posts offering any information relevant to these topics. Anyone interested can join the distribution list here: <https://groups.google.com/forum/#!forum/gis-awipm>.

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

Project Number	Ongoing CRPs	Scientific Secretary
D4.10.23	Resolution of Cryptic Species Complexes of Tephritid Pests to Overcome Constraints to SIT Application and International Trade (2010-2015)	Jorge Hendrichs
D4.10.24	Use of Symbiotic Bacteria to Reduce Mass-Rearing Costs and Increase Mating Success in Selected Fruit Pests in Support of SIT Application (2012-2017)	Carlos Cáceres
D4.20.15	Enhancing Vector Refractoriness to Trypanosome Infection (2013-2018)	Adly Abd Alla Andrew Parker
D4.40.01	Exploring Genetic, Molecular, Mechanical and Behavioural Methods of Sex Separation in Mosquitoes (2013-2018)	Jeremie Gilles
D4.10.25	Dormancy Management to Enable Mass-rearing and Increase Efficacy of Sterile Insects and Natural Enemies (2014-2019)	Rui Cardoso Pereira
Project Number	New CRPs	Scientific Secretary
D4.20.16	Comparing Rearing Efficiency and Competitiveness of Sterile Male Strains Produced by Genetic, Transgenic or Symbiont-based Technologies (2015-2020)	Kostas Bourtzis
D4.40.02	Mosquito Handling, Transport, Release and Male Trapping Methods (2015-2020)	Rafael Argiles Jeremie Gilles

CRP on Resolution of Cryptic Species Complexes of Tephritid Pests to Overcome Constraints to SIT Application and International Trade

One of the important outcomes of this CRP is the recent synonymization of *Bactrocera invadens*, *B. papayae*, *B. philippinensis* with *B. dorsalis*. This is the culmination of a global research effort coordinated over the last five years under this CRP, and involving the collaboration between 33 research organisations in 20 countries.

The multi-author paper, coordinated by Mark Schutze and Tony Clarke, from the Queensland University of Technology in Brisbane, Australia was published in the journal *Systematic Entomology*: <http://onlinelibrary.wiley.com/doi/10.1111/syen.12113/abstract> (see also page 33 of this newsletter).

It has finally resolved a major biosecurity issue, confirming that the four of the world's most destructive agricultural pests are actually one and the same. For 20 years it has been impossible to distinguish some of the world's most damaging fruit pests from each other. The ability to identi-

fy pests is central to quarantine, trade, pest management and basic research.

In 2009 the coordinated research effort got underway following an integrated multidisciplinary approach that examined evidence across a whole range of disciplines, using morphological, molecular, cytogenetic, behavioural and chemoecological data to definitively resolve the differences, if any, between five of these major fruit fly pests: the Oriental fruit fly, the Philippine fruit fly, the Invasive fruit fly, the Carambola fruit fly, and the Asian Papaya fruit fly. These species cause incalculable damage to horticultural industries and food security across Asia, Africa, the Pacific and parts of South America.

Based on the compelling and consistent data generated under the coordinated project, little doubt was left that the species are identical, leading to the taxonomic change after which the four species have now been combined under the single name: *Bactrocera dorsalis*, the Oriental fruit fly. However, the closely-related Carambola fruit fly, *B. carambolae*, remains distinct.

This outcome has major implications for global plant biosecurity, especially facilitating trade among developing

countries in Africa, Asia and the Pacific. The findings will also simplify the use of sterilized males to suppress pest populations in view that the four fruit flies freely interbreed, which means that instead of using males from the four supposedly different species, mass-produced sterile Oriental fruit fly males can now be used against all the different populations of this major pest.



A female oriental fruit fly (Bactrocera dorsalis) (credit Ana Rodriguez).

FAO, IPPC, various regional plant protection organizations and a number of countries have already endorsed the synonymization; most relevant are press releases by:

FAO:
(<http://www.fao.org/news/story/en/item/262972/icode/>)

and

IPPC:
(<https://www.ippc.int/news/ippc-secretariat/four-devastating-fruit-flies-pests-are-one-and-same-species>).

First RCM of CRP on Dormancy Management to Enable Mass-rearing and Increase Efficacy of Sterile Insects and Natural Enemies. 21–25 July 2014, Vienna, Austria.

The overall objective of this new CRP, approved for the period 2014–2019, is to understand and harness dormancy management, physiological conditioning, and cold-storage approaches to enable mass-rearing of insect species previously difficult to rear and to enhance current mass-rearing efforts for biological control, specifically using sterile insects and natural enemies as part of an environmentally friendly, area-wide integrated pest management approach.

Twenty-eight scientists from 17 countries attended this first RCM, held in Vienna, Austria from 21–25 July 2014.



Participants of the first RCM on Dormancy Management to Enable Mass-rearing and Increase Efficacy of Sterile Insects and Natural Enemies (Vienna, Austria).

The specific R&D objectives to be addressed during the 5 years of the CRP include two main subjects, divided into two main areas of work:

1. Manipulation of dormancy responses

- Genetics of dormancy responses.
- Environmental treatments that may affect dormancy responses.
- Pharmacological manipulations that may affect dormancy responses.
- Performance outcomes of dormancy management.

2. Low temperature biology

- Treatment conditions and manipulations that improve insect cold tolerance.
- Facilitation and enhancement of survival and performance under long-term cold storage.
- Enhancement of the thermal performance of insects destined for release.
- Manipulation of thermal biology to cause ‘ecological suicide’ in a pest control context.

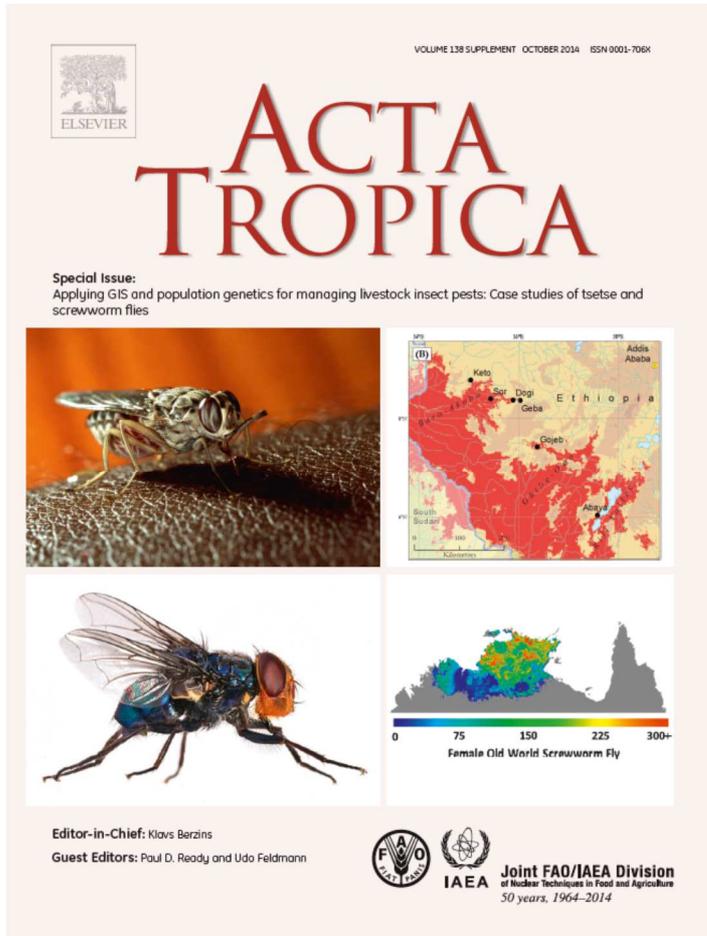
Additionally, a glossary of technical terms frequently used in this field was revised and updated with the objective of harmonizing the exchange of information among participants and developing protocols to be used in publications during the CRP.

Special Issue on Applying Population Genetics and GIS for Managing Livestock Insect Pests

The Food and Agriculture Organization of the United Nations (FAO) and the International Atomic Energy Agency (IAEA) have supported from 2008 to 2013 a Coordinated Research Project (CRP) on ‘Applying GIS and population genetics for managing livestock insect pests’.

This six-year CRP focused on research aimed at underpinning the Area-Wide Integrated Pest Management (AW-IPM) of populations of tsetse and screwworm flies, and an

introductory paper to the special issue in *Acta Tropica* integrates the findings of the CRP participants and discusses them in a broader context.



The tools and techniques for mapping and modelling the distributions of genetically-characterised populations of tsetse and screwworm flies are increasingly used by researchers and managers for more effective decision-making in AW-IPM programmes, as illustrated by the reports in this special issue.

Currently, the insect pests are often characterized only by neutral genetic markers suitable for recognizing spatially isolated populations that are sometimes associated with specific environments.

Two challenges for those involved in AW-IPM are the standardization of best practice to permit the efficient application of GIS and genetic tools by regional teams, and the need to develop further the mapping and modelling of parasite and pest phenotypes that are epidemiologically important.

A hard copy of the special issue can be requested or visited at: <http://www.sciencedirect.com/science/journal/0001706X/138/supp/S>.

Special Issue on Development of Mass-Rearing for African, Asian and New World Fruit Fly Pests in Support of the Sterile Insect Technique

The papers presented in this special issue of the *International Journal of Tropical Insect Science* are focused on developing and validating procedures for artificial rearing of selected fruit fly species of economic importance for use in area-wide integrated pest programmes with an SIT component. They are the result of a 5-year FAO/IAEA CRP on 'Development and Improvement of Rearing Techniques for *Anastrepha* and *Bactrocera* Fruit Flies'. Twenty-two CRP participants from 18 countries worked on both basic and advanced rearing procedures of different fruit fly species to overcome technical bottlenecks and to develop appropriate and relevant procedures for use in mass-rearing facilities.



A variety of studies were undertaken for three groups of tephritid species: (1) those for which mass-rearing for SIT application was available, but further refinement would be useful; (2) those for which mass-rearing for SIT application was under development in the laboratory, but that had not reached mass-rearing status; and (3) those for which research to develop colonization and rearing methods was needed. Many of the protocols developed or improved during the CRP have been transferred to the different fruit fly mass-rearing facilities worldwide.

The special issue can be visited at: <http://journals.cambridge.org/action/displayIssue?decade=2010&jid=JTI&volumeId=34&issueId=S1&iid=9377479>.

Special Issue on *Development and Evaluation of Improved Strains of Insect Pests for SIT*

The SIT has the ability to suppress insect pest populations, or to prevent, contain or even eradicate the establishment of new outbreaks of invasive pests. However, managers have indicated that programme efficiency can still be considerably enhanced when certain components of the technology are improved such as, for example, the availability of genetic sexing strains (GSS) against new target species or the development of strains carrying genetic markers which would allow the differentiation of released sterile insects from wild populations.

To address these gaps, the FAO/IAEA Insect Pest Control Subprogramme conducted the CRP "Development and Evaluation of Improved Strains of Insect Pest for SIT applications". The activities of this CRP were focused on four main areas: (1) insect genetics and transformation, (2) sex determination, (3) development of novel sexing systems and (4) improvement and evaluation of existing strains for SIT applications. This special issue published in *BioMed Central Genetics* presents part of the progress accomplished in the frame of this CRP.



Cover of the special issue in *BMC Genetics* (Vol 15, Supplement 2) with CRP results.

Using classical genetic approaches, CRP participants succeeded in developing and characterizing new GSS against major agricultural pests such as the Mexican fruit fly (mexfly) *Anastrepha ludens* and the carambola fly, *Bactrocera carambolae*. Another major achievement was the development and evaluation of male-only strains of the Australian

sheep blowfly, *Lucilia cuprina*, using modern biotechnology approaches.

Using similar molecular genetic approaches, male-specific Y-linked markers were developed which could enhance biologically-based control of the mexfly. In addition, Y-linked, male-biased genes and male-specific phosphorylated proteins were characterized in the Mediterranean fruit fly, *Ceratitis capitata*, which opens the way for new markers as well as the elucidation of sex determination pathways. Transcriptomic approaches were also employed to elucidate these pathways in two other important species, *Bactrocera jarvisi* and the olive fruit fly *Bactrocera oleae*.

This supplement also includes a very thorough review about the currently available genetic, molecular and microbial tools for improved SIT applications against Australian endemic pest tephritids as well as two additional contributions on the *C. capitata*: the first focuses on polyandry phenomena, critical to the implementation of the SIT, while the second reviews recent advances on functional genomics and how they might contribute to pest control.

There is an urgent need to develop and apply the SIT against new target agricultural pest species such as the South American fruit fly *Anastrepha fraterculus*. This requires a very good knowledge of the biology and the genetics of the species. Progress in this area is herein summarized in a review article. In addition, two original research articles describe the development of microsatellite markers and their use to monitor changes which might be happening upon the laboratory colonization of an *A. fraterculus* population for mass-rearing and SIT applications.

Cytogenetics analyses can play a significant role in many aspects of basic and applied research including mapping a single gene in chromosomes to resolving species boundaries within species complexes and this special issue presents such examples in two manuscripts: the first presents a TSA-FISH approach which was developed to map single-copy genes in the codling moth *Cydia pomonella* while the second describes how comparative cytogenetic analysis can support SIT applications by contributing to species delimitation in the *Bactrocera dorsalis* species complex.

During the last years, new strains based on biotechnological engineering have been developed for SIT or related applications. These transgenic strains carry a single killing system and major concerns have been raised with regards to resistance development. The last manuscript of this special issue presents a perspective about how "redundant killing", through an additional independent conditional expression system, could be developed and used to biotechnologically enhance SIT strategies.

In conclusion, significant progress was achieved in the frame of the CRP as shown in the manuscripts included in the special issue. The publication is freely available at: (<http://www.biomedcentral.com/bmcgenet/supplements/15/S2>).

Developments at the Insect Pest Control Laboratory (IPCL), Seibersdorf

INSECT GENETICS AND MOLECULAR BIOLOGY

Laboratory colonization of insect populations: the importance of the genetic and the symbiotic community diversity

During the transfer of a natural insect population to a laboratory, significant changes occur to allow adaptation of the insect to the new environment and (usually) diet. Different studies have already shown that changes can be drastic and can happen in the few first generations. These changes can alter both the genetic structure of the insect population and the composition of its symbiotic community. The expected 'direction' of these alterations are reduction in the degree of genetic polymorphism of the population and loss of the variability of the symbiotic community; both phenomena can be regarded as 'bottlenecks' and they can lead to the loss of specific characters that are important for the fitness and competitiveness of a laboratory strain and can compromise its effectiveness in mass-rearing and sterile insect technique (SIT) applications.

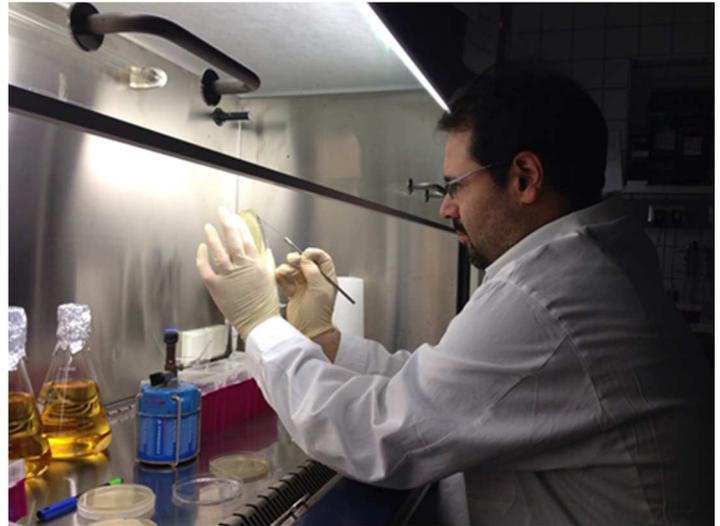
Efforts are ongoing to determine and quantify the changes observed during laboratory adaptation, both at the population and symbiotic community level. Focus is on different Tephritidae pests of the genera *Ceratitis*, *Bactrocera* and *Anastrepha*. As a priority species, *Ceratitis capitata*, the Tephritidae model for SIT application was selected. For this purpose, populations collected from known host plants in nature have been transferred to the IPCL under different artificial conditions and are being monitored in consecutive generations.

Monitoring includes:

a) Population analysis, using available microsatellite markers. This kind of analysis is expected to show how rapid the genetic structure of the colonized population is altered. This knowledge can be useful in establishing protocols regarding the reduction of the rate of these changes or the enrichment of laboratory colonies with material from the wild. Especially for *C. capitata*, taking into account the availability of cytogenetic maps, low resolution linkage maps and a draft of the genome sequence, this analysis could point to specific genomic regions that harbour important traits regarding adaptation.

b) Analysis of the gut symbiotic community, using mainly 16S rRNA gene-based Next Generation Sequencing (NGS) approaches. The aim of this project is to follow the changes in the diversity and relative abundance of the different gut and reproductive symbionts. Gut and reproductive tissues are being collected from different generations,

including different life stages (larvae, teneral adult and older adults) and sexes (males and females). The expected outcome is to recognize specific symbionts that are lost or severely reduced during laboratory colonization and others that appeared *de novo* or increase their titre.



The consultant Antonios Augustinos from Greece isolating and identifying gut-associated bacterial species of the Mediterranean fruit fly *Ceratitis capitata* VIENNA 8 genetic sexing strain.

This approach can be coupled with feeding of specific bacterial strains, trying to restore the negative impact of the collapse of the symbiotic community. Indeed, research currently carried out at the IPCL, in line with previous studies in this field, point to the benefits that the supplement of bacteria in the diet can have in different aspects of the insect's physiology and behaviour, although the specific 'mechanism' providing these positive effects is still unresolved.

PLANT PESTS

Gel larval diet testing for *Bactrocera* species

The ability to mass-rear the target insect is a crucial element for a functional area-wide integrated pest management (AW-IPM) programme that includes an SIT component. Insect rearing can represent 50% or more of the cost of the SIT package. Any improvement that could significantly reduce rearing costs would make the SIT more attractive. A Mediterranean fruit fly *Ceratitis capitata* gel larval diet was developed and tested earlier in the Mos-camed programme in Guatemala. Researchers at the IPCL are seeking to validate the same technology for some *Bactrocera* fruit flies of economic importance with the aim of developing a generic gel diet for these pests with emphasis on *B. dorsalis* and *B. tryoni*. Both species are candidates for future potential AW-IPM projects in Asia and Australia

respectively. Benefits from a gel diet technology include reduced waste diet, no need of a bulking agent, reduced storage space for diet ingredient and associated labour, and reduced use of diet preservatives. The gel diet would also allow the inoculation of desirable microorganisms (probiotics) to provide better nutrition for the larvae that might result in more competitive sterile insects for field releases. The validation of the gel diet technology is important as its adoption will significantly impact operations in the rearing facility and the design of mass-rearing equipment.



Thilakasiri Dammalage holding mature larva of *Bactrocera tryoni* reared on gel diet.

Phytosanitary cold treatment research

The USDA/IAEA collaborative agreement on “Development of phytosanitary treatments for exotic tephritid fruit flies” is currently focussed on cold treatments. It reflects concerns by the International Plant Protection Convention (IPPC) and national plant protection organizations about the long-standing treatment technique that uses temperatures in the range of 0-3°C for 10-22 days to prevent viable invasive tephritids from accompanying horticultural trade. In September 2014 Guy Hallman formerly of USDA-ARS arrived as a consultant at the IPCL to continue leading this research. Objectives are to determine the most cold-tolerant development stage, to assess whether hosts affect efficacy, to assess whether populations of the same species differ in cold-tolerance, and to assess the feasibility of developing generic cold treatments across tephritid species and fruit commodities. The diverse species and strains of tephritids maintained at the IPCL in Seibersdorf are critical to this research.

LIVESTOCK PESTS

Tsetse symbionts and virus

Tsetse flies harbour three symbiont bacteria and a pathogenic virus (salivary gland hypertrophy virus (SGHV)). In some colonies of the tsetse fly species such as *Glossina pallidipes*, the SGHV hampers their mass-rearing by reducing productivity. The effect of the interaction of tsetse symbionts and the virus on the performance of tsetse colonies remains unclear. Research is in progress to identify symbiotic bacteria that may interfere with the establishment and transmission of trypanosomes and/or SGHV, with the aim to develop refractory tsetse fly lines that could be used for release in SIT programmes. The impact of SGHV infection on tsetse symbiont titre is being analysed by a visiting scientist from Turkey, Güler Demirbas, and primary results indicate that the increase of SGHV titre after virus injection in *G. pallidipes* teneral flies is associated with an increase in both *Sodalis* and *Wigglesworthia*, but not in *Wolbachia* titres.

In addition, to further investigate the SGHV’s host range, the ability of injected SGHV to replicate in *G. fuscipes fuscipes* teneral flies was assessed. Preliminary results suggest that the virus titre does increase, but this is not associated with SGH symptoms in the injected parent or its progeny. This result indicates that SGHV isolated from *G. pallidipes* can infect other tsetse species via intracellular injection. However, *per os* infection was not observed most probably due to a significant barrier in the midgut.

Identification of tsetse species using molecular tools

During the last decades, the IPCL has established laboratory colonies of several tsetse species originating from field populations. In addition, thousands of tsetse specimens of many different *Glossina* species/populations have been collected from different locations in many African countries. These specimens have been extremely useful in support of different applied R&D projects, including population genetics as well as studies on symbionts, pathogens and parasites.



Irene Meki from Kenya preparing DNA samples of tsetse for further molecular analysis.

In the frame of these studies, IPCL staff and collaborators came across some results which questioned the “species status” of some of these samples. This is an important issue which might be due to mislabelling, misidentification or in some cases might be due to other factors like expansion of the distribution of some of these pest species. Given the great significance of species identification as well as the long and tedious process required to properly identify thousands of specimens through classical taxonomic approaches, IPCL staff and collaborators have initiated an ambitious project that aims at the use of molecular markers to address this problem.

We currently use the mitochondrial gene markers cytochrome oxidase I (COI), cytochrome oxidase II (COII), 16S rRNA, as well as the nuclear internal transcribed spacer (ITS1) and microsatellite markers, for PCR and/or sequencing-based approaches for species identification. Preliminary results are encouraging and suggest that the nuclear marker ITS1, and to a lesser degree some of the mitochondrial markers, can be exploited for the development of a robust and easy to use molecular platform for the species identification of *Glossina* specimen.

VECTORS OF HUMAN HEALTH DISEASES

Estimating egg numbers of *Anopheles arabiensis*

Managing the production of mosquitoes will require accurate methods to estimate produced egg numbers. In a previous newsletter, we reported on the development of a method to estimate egg numbers that involved the drying of eggs on egg sheets, and then brushing and weighing the eggs. The work was continued and the effect of the method was assessed on larval and adults' life history traits such as egg hatch, pupation rate and emergence rate, body size, male mating success, and fecundity. No significant differences between dried and fresh eggs were observed for all life history traits studied.

Egg collection in the newly developed adult mass-rearing cage differs from collecting eggs in small laboratory cages. In the mass-rearing cage, eggs are directly oviposited on the bottom of the cage and collected by an outlet (together with dead adults and debris). To separate the eggs from these other particles, 3 layers of sieves, each with a different mesh size are placed below the flow of water containing egg and debris. The first sieve has the biggest mesh size and retains the dead bodies of the adult mosquitoes, the second sieve collects a mixture of separated body parts (legs and wings) while the last sieve that has the smallest mesh size collects the eggs and other finer particles (see Figure).

The egg collection process (flushing and sieving) from the mass-rearing cage did not impair egg hatch. However, fewer eggs were collected than expected because fine particles like scales, cuticle fragments, parts of legs, thorax, abdo-

men or wings were also collected in the last sieve. This resulted in an overestimation of egg numbers which has to be taken into consideration when using this method of egg estimation.



Collection of *An. arabiensis* eggs from the mass-rearing cages: (a) the three sieves to separate dead bodies, body parts and eggs; (b) water flushed from the mass-rearing cage into the sieves; (c) collection of all the eggs and dead bodies, then the body part are rinsed; and finally (d) the eggs are collected in the last sieve.

Thawed-frozen or fresh blood for mosquito rearing?

A crucial aspect in mosquito mass-rearing is the regular delivery of a clean, warm blood meal to the females. Currently, two types of blood are used for mosquito feeding at the IPCL: (1) a weekly collection of fresh pig blood collected at the slaughter house, and (2) frozen cow blood that is thawed before it is used for feeding (thawed-frozen blood). The preference of *Anopheles arabiensis*, *Aedes albopictus* and *Aedes aegypti* for these two types of blood was assessed.

Fecundity of female *An. arabiensis* was similar when offered either fresh or thawed-frozen blood. However, only very few *Ae. albopictus* and *Ae. aegypti* females that were offered thawed-frozen blood oviposited any eggs (0.33% and 0.65% respectively). On the other hand, the proportion of *Ae. albopictus* and *Ae. aegypti* females that oviposited eggs after taking a fresh blood meal was 64% and 61%, respectively.

The mass-rearing of large numbers of mosquitoes will entail the management and storage of larger volumes of blood. Managing larger amounts of freshly collected blood for *Aedes* feeding could be problematic. There is therefore the search for other solutions, such as the addition of phagostimulants (ATP) to the thawed-frozen blood. Preliminary data indicate that a high proportion of females oviposited eggs after taking a meal of thawed-frozen blood and ATP. This proportion was not significantly different from the proportion of females that laid eggs after taking a

fresh blood meal, but was significantly higher compared to females that had fed on thawed-frozen blood without ATP. However, the fecundity of females fed on thawed-frozen blood + ATP was 20% lower than the fecundity of females fed on fresh blood.

Effects of irradiation on mating performance of *Wolbachia* infected strains of *Aedes albopictus* under laboratory and semi-field conditions

The incompatible insect technique (IIT) relies on the release of *Wolbachia* infected male mosquitoes into the target area. Mating of a *Wolbachia*-infected male with a wild female that has no *Wolbachia* or a different *Wolbachia* strain will result in no offspring. The IIT requires the “fail proof” elimination of *Wolbachia*-infected females from the release material. Combination of the SIT (sterile insect technique) with IIT would be an elegant way to prevent population replacement as a result of accidental releases of females due to imperfect sex separation systems. Irradiating *Ae. albopictus* females with a dose of 28 Gy induces complete sterility in these females. Male *Ae. albopictus* of a triple *Wolbachia*-infected strain (HC) would also receive this dose before being released in the field and the effect of this treatment on the mating competitiveness of these males was studied. The results so far indicate that non-irradiated males of the HC strain showed equal mating competitiveness as compared to non-irradiated males of a wild-type double *Wolbachia*-infected strain (GUA) in both laboratory (30x30x30 cm) and semi-field cages (170x170x170 cm). When irradiated with 28 Gy, the mating competitiveness of males of the HC strain was reduced by half as compared to non-irradiated males of the GUA strain when released in a 1:1 and 5:1 HC:GUA ratio in laboratory cages. However, the irradiated HC males were found to be equally competitive to untreated GUA strain males with a 10:1 HC:GUA release ratio in semi-field cages. More replicates in field cages are required to conclusively assess the impact of an irradiation dose of 28 Gy on the mating performance of HC strain males under semi-field conditions. These studies in addition, need to be expanded to open field conditions.

Induction of mutations in *Anopheles arabiensis* with ethyl methanesulfonate (EMS)

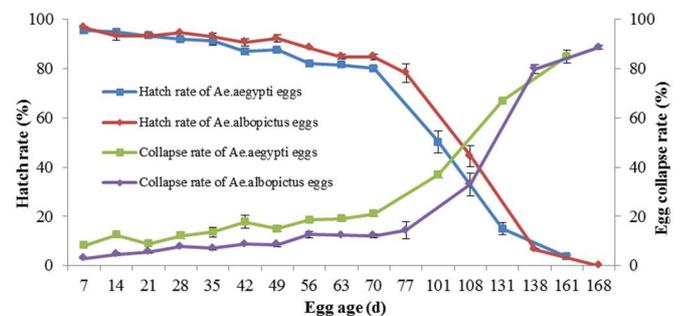
EMS (ethyl methanesulfonate) is a chemical agent known to generate a wide variety of mutations in organisms. The successful application of the SIT for mosquitoes requires the availability of a genetic sexing strain (GSS) which would allow the complete elimination of females prior to the release of irradiated male mosquitoes. For the development of such a GSS, morphological markers and / or conditional lethal mutations (like temperature sensitive lethal) would be extremely helpful. An EMS-based mutagenesis screen has therefore been initiated to isolate such mutations in *Anopheles arabiensis* (Dongola strain). Our initial efforts focussed on determining the appropriate experimental conditions as well as the optimal EMS concentration that would give sufficient viability and fertility but

would also induce useful mutations. Candidate mutations were detected in all developmental stages (with the exception of eggs); however, most of these were not viable. Further screening is ongoing and should viable and fertile potential mutations be detected, appropriate genetic crosses will be set up in order to determine the pattern of genetic inheritance of the observed trait.

Storage of *Aedes* eggs

Mass-rearing of mosquitoes in future production facilities will require the management, handling and storage of millions of eggs. *Aedes* mosquito eggs are quite resistant to desiccation and can be stored for a certain period of time. Studies were undertaken to assess the effect of two storage methods on egg hatch.

In the first method egg paper strips were transferred to zip lock plastic bags that were kept in a black plastic box with cover at room temperature ($27\pm 1^\circ\text{C}$) and 70% RH. Every week, for the 10 first weeks (and thereafter every month), three egg paper strips were randomly removed from the box and transferred to 100 ml plastic cups filled with a hatch solution (0.7 litre of deionized water, 0.25 g of CM0001 Nutrient Broth and 0.05 g of yeast). After 48h, the hatch rate of each egg paper strip was calculated. The quality of the eggs appeared to be good with an overall hatch rate $> 80\%$ during the first 10 weeks. Thereafter, the hatch rate decreased rapidly to reach zero after 4 months (see Figure).



Effect of storage period on egg hatch and on the percentage of collapsed eggs of *Ae. aegypti* and *Ae. albopictus*.

In the second method, each egg paper strip was put in a small covered plastic cup filled with 100 ml deionized water. Cups were stored at room temperature ($27\pm 1^\circ\text{C}$) and 70% RH. Every month during a period of 5 months, three plastic cups were randomly selected and the egg paper removed from the water and hatch rate during the storage time was assessed (“storage hatch rate”). The egg paper was transferred to a new cup filled with 100 ml hatch solution (0.7 litre of deionized water, 0.25 g of CM0001 Nutrient Broth and 0.05 g of yeast) and the hatch rate was estimated after 48h (“final hatch rate”).

This method likewise gave good results with egg hatch of 85% for both species after 5 months of storage. Egg hatch was very limited during storage for both species, i.e. 10% and 3% for *Ae. aegypti* and *Ae. albopictus*, respectively.

Reports

8th International *Wolbachia* Conference, 6–11 June 2014, Innsbruck, Austria

The 8th International *Wolbachia* Conference was held in Innsbruck, Austria, from 6 to 11 June 2014. The Conference, which is a bi-annual event, was attended by 108 scientists coming from 19 countries from almost all continents. The scientific program consisted of 44 posters presented in two sessions and 55 oral presentations organized in six symposia: “Ecology, Diversity, Dynamics”, “Evolution”, “Phenotypes”, “Cell Biology”, “Genetics and Genomics” and “Disease and Pest Control”.



Participants of the 8th International *Wolbachia* Conference (Innsbruck, Austria).

The symposium on “Disease and Pest Control” included 11 oral presentations which covered several aspects of the application potential of *Wolbachia* as a tool to control insect species of agricultural, veterinary and human health importance. Oral and poster presentations also focused on the effects, positive and negative, this group of symbionts might have on insect hosts as well as on the possible combination of the sterile insect technique with the *Wolbachia*-based incompatible insect technique (IIT) for the control of insect pests and disease vectors. The 9th International *Wolbachia* Conference will be held in Australia in 2016.

Meeting on “Thematic Plan for the Development and Application of the Sterile Insect Technique (SIT) and Related Genetic and Biological Control Methods for Disease Transmitting Mosquitoes”, 16–20 June 2014, Vienna, Austria

Under IAEA TC project INT0089 -Developing Human Resources and Supporting Nuclear Technology, an expert meeting was convened to develop a “Thematic Plan for the Development and Application of the Sterile Insect Technique (SIT) and Related Genetic and Biological Control Methods for Disease Transmitting Mosquitoes”. This meeting was held at the Vienna International Center at IAEA Headquarters from 16 to 20 June 2014 with the participation of the World Health Organization (WHO) and other experts.

The objective was to review the state of mosquito management (with an emphasis on malaria, dengue, chikungunya and yellow fever) and to provide guidance on the opportunities and research gaps in the fields related to the SIT and other potential tactics and strategies to control vector-borne diseases – including policy issues.



Participants of the Thematic Plan for the Development and Application of the Sterile Insect Technique (SIT) and Related Genetic and Biological Control Methods for Disease Transmitting Mosquitoes (Vienna, Austria).

The burden of mosquito transmitted diseases remains enormous with the incidence of dengue and other diseases growing dramatically around the world in recent decades, while chemical vector control effectiveness is decreasing as mosquitoes develop insecticide resistance. Therefore, the experts agreed that there is an urgent need for innovative mosquito control methods. The experts identified several technologies, including the SIT, which could be complementary to the commonly used control tactics for malaria, dengue, chikungunya and yellow fever.

During the meeting current control methods and recent developments on SIT for vector-borne diseases control strategies were reviewed for application under the Area-Wide Integrated Vector Management (AW-IVM) approach. Special consideration was given to the advantages, disadvantages, constraints, gaps and challenges of implementing AW-IVM approaches.

Research and development needs were identified, including requirements for developing and fine-tuning components of the SIT and other genetic methods. Subsequently, scientific evidence on the feasibility of AW-IVM can then be used for policy, planning and implementation. AW-IVM approaches, which can include the SIT or other genetic methods, were encouraged as these are not only environmentally friendly and more sustainable, but are aligned with the IAEA and WHO policies and goals.

This effort resulted in a comprehensive document stating:

- 1) the magnitude of the problem of mosquito-borne diseases;
- 2) general trends of control tactics addressing specific methods for *Anopheles* and *Aedes* species;
- 3) R&D needs to further develop the SIT and other strategies for vector control under an AW-IVM approach;
- 4) developments within the IAEA and ongoing projects and collaborations;
- 5) identification of knowledge gaps and potential future role of the IAEA and the Joint FAO/IAEA Division; and
- 6) recommendations for policy makers with respect to planning and implementation.



Male of Aedes albopictus visiting flower for feeding.

Based on the review, the following recommendations were proposed:

General Recommendations to IAEA

- To invest in supporting the control of the mosquito species which transmit malaria, dengue, chikungunya and yellow fever through continued funding of the development of the SIT and other related genetic and environment-friendly methods. Control pilot projects should

be developed and applied following an Area-Wide Integrated Vector Management approach.

- To continue the assistance in developing and implementing effective interventions using SIT and other related species-specific technologies.
- To continue R&D and technology transfer activities related to the SIT package.
- To continue the support of R&D on transgenic and symbiont-based approaches; this can be useful in the control of mosquito-borne diseases as well as to exploit their complementary potential with classical SIT.
- To continue developing the SIT package for mosquito management at the FAO/IAEA Agriculture and Biotechnology Laboratories, e.g. mass-rearing technology, sex-separation and sterilization methods that should be further refined and disseminated to Member States. However, to accomplish the aforementioned in an effective and timely manner, and to provide adequate technical support to technology transfer under technical cooperation projects, funding support for facilities and personnel must be enhanced significantly. Current personnel are clearly insufficient to address the increasing demand and future needs related to mosquito control.
- To develop efficient, environment-friendly and economically affordable irradiation-induced sterility methods for SIT.
- To continue providing technology transfer and capacity building support to Member States for the management of mosquitoes using an AW-IVM approach with an SIT component.
- To support dissemination and outreach activities, including novel IT platforms, as a way to expand AW-IVM projects with a SIT component against mosquito species, and facilitate their transfer to Member States.
- To continue to seek strategic partnerships and funds mobilization to support AW-IVM approaches with a SIT component in cooperation with Member States.

Pilot Projects

- To gradually scale up the AW-IVM approach and further develop the SIT components, pilot projects should be supported in Member States.
- To develop an inter-regional project on dengue and chikungunya and regional projects on malaria and dengue especially in Africa.
- To support specific national projects that aim at integrating the SIT and other related approaches, including technical advice to establish mass-rearing facilities, sterilization methods and related technologies.

Translation into Policy

- To incorporate the AW-IVM approach into public health policies within a holistic approach. The existing policy setting mechanism within WHO should be used to review the evidence and to make initial recommendations for their use by Member States.

- To establish a Memorandum of Understanding (MoU) or Practical Arrangement between WHO and IAEA to facilitate harmonization and alignment of joint activities.
- To continue providing technical and policy advice on existing or any new technology towards the control of mosquito populations.

International Congress on Invertebrate Pathology and Microbial Control and the 47th Annual Meeting of the Society for Invertebrate Pathology, 3–7 August 2014, Mainz, Germany

The International Congress on Invertebrate Pathology and Microbial Control and the 47th Annual Meeting of the Society for Invertebrate Pathology (SIP) was attended by 450 researchers in insect pathology including microbial, fungal, microsporida, nematode and viral diseases. During the meeting many research papers were presented and several discussions focussed on the potential role of the SIP in developing strategies to control insect diseases, a major bottleneck in insect colonies that are increasingly being mass-reared for food, feed and other purposes.

In view of the increasing public and commercial interest in this rapidly expanding area it was decided to plan a divisional symposium on this topic during the next meeting (9–13 August 2015) in Vancouver, Canada.

Standards Committee Meeting, International Plant Protection Convention. 10–14 November, Rome, Italy

The meeting took place at FAO Headquarters in Rome with the participation of five of the seven officially nominated Standards Committee (SC) Members representing FAO's seven regions. During the SC meeting the formal objection was discussed that was presented by the Comité Regional de Sanidad Vegetal del Cono Sur (COSAVE) to CPM 2014 on the draft ISPM "Determination of host status of fruit to fruit fly (Tephritidae)", against the use of the term "conditional host" for one of the categories of host presented in the draft.

In consultation with the Technical Panel on Pest Free Areas and Systems Approaches for Fruit Flies (TPFF) prior to the meeting, it was decided that this was a terminology issue to be addressed by SC and any reasonable name without the change of the concept in the draft would be accepted.

The SC suggested the use of the term "semi-natural" and the draft was approved with 3 categories of hosts ("natural host"; "semi-natural host" and "non-host") for adoption at the CPM 2015, through a voting process, without the option of formal objection.



The determination of host status of fruit to fruit fly includes methodologies for surveillance under natural conditions and field trials under semi-natural conditions. Those trials include: field cages (a), greenhouses (not pictured above) or bagged fruit-bearing branches (b). Laboratory trials will no longer be accepted. Figure adapted from Aluja & Mangan, Annu. Rev. Entomol. 2008. 53:473–502.

The other draft standard, the annex of the ISPM 26 "Phytosanitary procedures for fruit fly (Tephritidae) management" was also discussed and approved after minor changes for adoption at CPM 2015, through the normal process (possibility of a formal objection 14 days prior to the CPM).

The three phytosanitary treatments on "Cold treatment for *Bactrocera tryoni* on *Citrus sinensis*"; "Cold treatment for *Bactrocera tryoni* on *Citrus reticulata* x *Citrus sinensis*"; and "Cold treatment for *Bactrocera tryoni* on *Citrus limon*", were discussed in relation to the technical justification to answer the formal objections presented to the CPMs of 2013 and 2014. All three were recommended for adoption at the CPM 2015 through the voting process, without the option of formal objection 14 days prior to the CPM.

Announcements

Interregional Training Course on *The Use of the Sterile Insect and Related Techniques for the Integrated Area-wide Management of Insect Pests* 3–28 August 2015, Metapa de Dominguez, Chiapas, Mexico and Antigua / El Pino, Guatemala

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

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

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

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

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

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

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

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

Application Procedure: Nominations should be submitted on the standard IAEA application form for training courses/workshops (downloadable from: <http://www-tc.iaea.org/tcweb/participion/astraine/default.asp>). Completed forms should be endorsed by and submitted through the official channels established (either the Ministry of Foreign Affairs, the National Atomic Energy Authority, the Office of the United Nations Development Programme, the Office of the FAO Resident Representative or the Ministry of Agriculture). (**Deadline for nominations: 30 April 2015**).

Participants' Qualifications: The course is open to about 22 participants from IAEA and FAO Member States in all geographical regions. Preference will be given to qualified candidates from developing countries. Applicants must have at least a Bachelor of Science degree or equivalent in entomology or a related biological field. As the course will be conducted in **English**, participants must have an adequate working knowledge of that language.

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

Call for Submission of Research Proposals for a new FAO/IAEA Coordinated Research Project on *Mosquito Handling, Transport, Release and Male Trapping Methods*

The burden of mosquito transmitted diseases remains enormous; in fact, the incidence of dengue and other diseases has been growing dramatically around the world in recent decades while vector control effectiveness has significantly decreased as mosquitoes develop insecticide resistance. During a Thematic Plan Meeting held in Vienna in June 2014, experts have identified the urgent need for innovative mosquito control methods, including the SIT.

The development and evaluation of transport/release methods and new trapping tools and methods for male mosquitoes through this CRP will have the following tangible benefits for mosquito control programmes that have an SIT component:

- 1) Sterile male handling and transport systems developed allowing considerably increased size of suppression programmes using sterile males.
- 2) Ground and aerial release system permitting the release of sterile males in geographic locations which are currently difficult to access.
- 3) Surveillance systems enabling the monitoring of suppression programmes (via male-specific traps) to measure male quality and programme progress and to allow adjustment to operational activities.

The CRP objective is to explore transport and aerial release methods and evaluate their performance as sustainable methods to release high-quality mosquito males in large scale programmes that have a SIT component. In parallel, new devices will be developed and assessed for their efficacy of trapping male mosquitoes.

The expected duration of the CRP is 5 years (2015-2020) and the first Research Coordination Meeting is planned for 23-27 November 2015 in Vienna, Austria. Scientists and researchers who are interested in collaborating in this new CRP should contact Rafael Argiles (R.Argiles-Herrero@iaea.org). Information on the IAEA Coordinated Research Programme and how to apply for research contracts and research agreements can be found at <http://www-crp.iaea.org/>. Applications should be submitted by **31 May 2015** to Official.Mail@iaea.org.

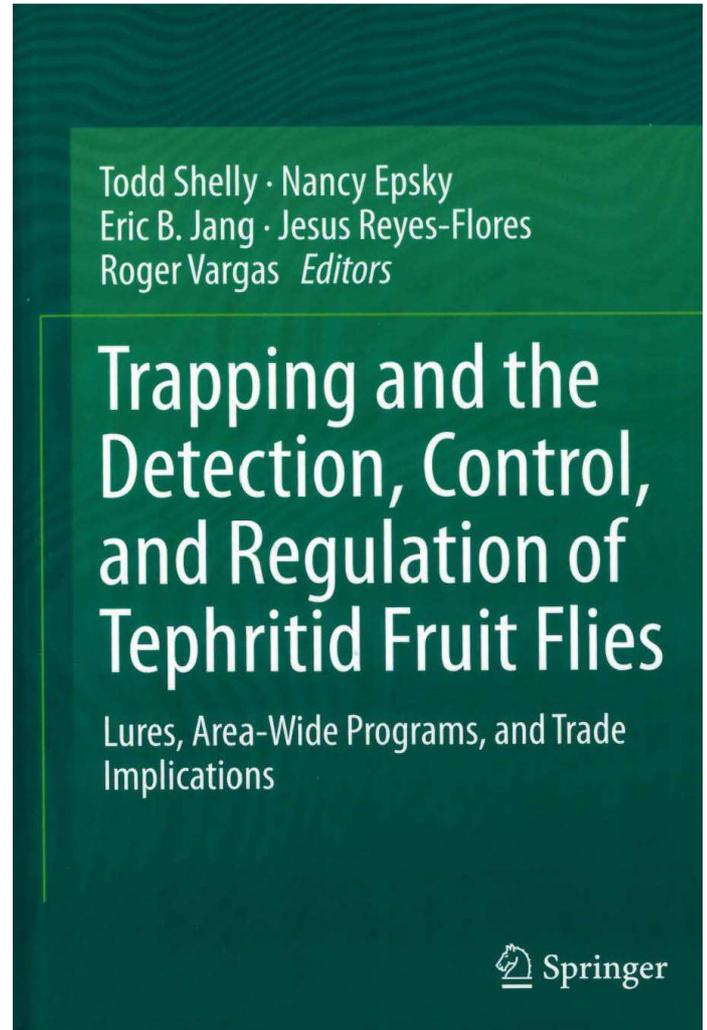
New Book on Fruit Fly Trapping

The idea of producing a book on fruit fly trapping emerged from three simple facts:

- Certain species of tephritid fruit flies are among the world's most notorious pests of commercially important fruits and vegetables;
- Trapping these flies is vital to identifying infestations, controlling detected populations, and establishing guide-

lines for international transport of agricultural commodities; and

- Despite the central role of trapping issues, there is no comprehensive repository of factual or theoretical material relating specifically to this field for economically important Tephritidae.



This volume is a comprehensive synthesis of tephritid-centric trapping issues, and accordingly the topics included are far-ranging and address lures and traps, population ecology and detection, suppression and eradication strategies. It also includes a novel topic on fruit fly trapping and phytosanitary issues related to trade of fresh fruit and vegetables between countries.

The book was dedicated to the memory of Bob Heath (1945-2011) and Don Lindquist (1930-2011), in view of Bob's major contribution on the development and application of insect semiochemicals and Don's vision, support and coordination of multinational programmes to test novel approaches.

We believe this volume will prove useful for many years to come.

Announcement of FAO/IAEA Interregional and Regional Training Courses

- Regional Training Course on *Fruit Fly Biocontrol in West Africa* (under Regional TC Project RAF5061). 2–6 March 2015, Nairobi, Kenya. (**Deadline for nominations: 9 January 2015**).
- Regional Training Course on *Free Open Source Software for GIS and Data Management Applied to Fruit Flies in the Balkans and the Eastern Mediterranean*, (under Regional TC Project RER5020). 1–5 June 2015, Vienna, Austria. (**Deadline for nominations: 31 March 2015**).
- Regional Training Course on *Fruit Fly Monitoring and Suppression Including MAT and SIT for Indian Ocean* (under Regional TC Project RAF5062). 22–26 June 2015, Mauritius. (**Deadline for nominations: 15 April 2015**).
- 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 INT5151). 3–28 August 2015, Metapa de Dominguez, Chiapas, Mexico and Antigua / El Pino,

Guatemala. (**Deadline for nominations: 30 April 2015**).

- Regional Training Course on *Taxonomy and Identification of Fruit Fly Pest Species for Southeast Asia* (under Regional TC Project RAS5067). 16–20 November 2015, Brisbane, Australia. (**Deadline for nominations: 31 August 2015**).

Application procedure: Nominations should be submitted on the standard IAEA application form for training courses/workshops (downloadable from: <http://www-tc.iaea.org/tcweb/participion/astraineer/default.asp>).

Completed forms should be endorsed by and submitted through the official channels established (either the Ministry of Foreign Affairs, the National Atomic Energy Authority, the Office of the United Nations Development Programme, the Office of the FAO Resident Representative or the Ministry of Agriculture).

The completed forms must be submitted to the International Atomic Energy Agency, Vienna International Centre, P.O. Box 100, 1400 Vienna, Austria. Advance nominations by facsimile (+43-1-26007) or email (official.mail@iaea.org) are welcome.

Other News

Mexico Declares Free of Pink Bollworm the State of Chihuahua and some Municipalities of the States of Coahuila and Sonora

The declaration of pink bollworm (*Pectinophora gossypiella*) pest free area, a quarantine pest that can cause damage up to 40% of the cotton production, represents an important improvement for this agricultural sector with significant importance in supplying the Mexican textile industry.

This outcome benefits growers that planted in 2013 a surface area of 125 432 ha, with a production of 587 337 tons, representing an estimated value of approximately 5 725 millions of Mexican Pesos (about 410 million US dollars).

The declaration of this free status is the result of a combined effort of the Federal Mexican and State Governments and the producers, in conjunction with the simultaneous area-wide eradication campaign that has been ongoing on the other side of the border in the southwestern States of the USA using SIT integrated with the planting of transgenic cotton and other measures.

The confirmation of the pink bollworm free area was based on extensive surveys made by the Mexican National Plant Protection Organization (Dirección General de Sanidad Vegetal) using cotton sampling, trapping and diagnostic techniques in the determined geographic areas.

Source: SAGARPA (www.sagarpa.gob.mx).

Fruit Fly Control and Eradication Programme in San Juan, Argentina

The ProCEM (Programme for the Control and Eradication of Fruit Fly in the Province of San Juan, Argentina) has had mixed results, since its inception in the seventies, and had until recently not been able to achieve in any of its valleys a status either of free area or low prevalence of the pest, the Mediterranean fruit fly.

The recent change in the strategy implemented in the last three years has allowed the achievement of free and low prevalence areas for some valleys, as well as a sustained decrease in the fruit fly populations through the use of an Integrated Pest Management (IPM) approach integrating several control methods with the Sterile Insect Technique.

The change of strategy, that has involved among others the targeting of actions in isolated or semi-isolated valleys, has been the basis of the promising results. The effect of the control actions has been enlarged with the participation of producers, the general public and municipalities. The reformed detection system implemented in accordance with international standards, conducted systematically and georeferenced, has made the progress possible.

In urban areas, where fruit fly hotspots are frequent, the use of a mass-trapping system has been expanded. The reformulation of the ground insecticide application in a more efficient way, by concentrating the resource on hot spots according to the detections of the pest, contributed to a cost-effective suppression of the fruit fly population.

Also, the application of spinosad by air in Ullum and Zonda valleys contributed to the suppression obtained in these valleys due to the area-wide coverage, contributing to an 88% reduction of the pest in both valleys (from 0.72 to 0.09 fly per trap per day (FTD) in Zonda and from 2.34 to 0.27 FTD in Ullum).

As a consequence there was some reduction in the need for sterile insects, and efforts were concentrated on improving the quality of insects produced according to standards established internationally, and on using this limited resource only against suppressed pest populations. The overall results show a significant decrease (79%) of the pest in the last two seasons throughout the province.

Source: Gustavo Taret, San Juan, Argentina (13 October, 2014).



ProCEM

USDA and Peace Corps Team Up in Screwworm Eradication Efforts in Panama

Over the past few months, USDA's Animal and Plant Health Inspection Service (APHIS), as part of the U.S. Panama Commission for Eradication of Screwworm, has started to partner with Peace Corps Volunteers in Panama to enhance APHIS' surveillance activities. Volunteers will be working in rural Panama and meeting with local communities to raise awareness and report suspected cases of New World screwworm, one of the most costly and economically significant pests of livestock in South America.

The New World screwworm is a parasite of warm-blooded animals, including humans. Female screwworms are attracted to and lay their eggs in exposed flesh wounds. Larvae burrow and feed on flesh, causing severe tissue damage and may even be lethal to the host. The screwworm was eradicated from the United States, Mexico, Puerto Rico, the Virgin Islands, Curacao and, finally, all of Central America by 2006 using the SIT. To prevent the screwworm from spreading north of South America, The Commission is maintaining a barrier at the Darien Gap between Panama and Colombia, by utilizing both preventive release of sterile flies and field surveillance.

Effective surveillance is crucial to maintaining the screwworm barrier. Beyond Peace Corps Volunteers, the U.S. Panama Commission for Eradication of Screwworm relies on field staff and an estimated 552 honorary volunteer inspectors, composed of farmers and private veterinarians to stay on the lookout for suspected cases of screwworm. There is a constant threat of screwworm reintroduction beyond the Darien Gap from Colombia, where the pest is still present and the migration of people, domesticated animals, and cattle pose a risk. Because most of the Darien Gap and rural areas in Eastern Panama are not easily accessible, APHIS enlisted Peace Corps volunteers, who are already trained and skilled at working with rural communities, to assist with the screwworm surveillance program and reach out to local communities and their officials to explain the risk this pest poses to both people and livestock.

See more at: <http://blogs.usda.gov/2014/11/13/usda-and-peace-corps-team-up-in-screwworm-eradication-efforts-in-panama/#sthash.UY2zxwU2.dpuf>.

Source: USDA blog (<http://blogs.usda.gov>, 13 November, 2014).

USDA-APHIS/PPQ News

CPHST sets guidelines for tephritid fruit flies phytosanitary treatment research.

At the request of trading partners, the Center for Plant Health Science Technology (CPHST) Raleigh, North Carolina, USA has developed guidelines for research to control tephritid fruit flies using vapor heat / forced hot air treatment. The guidelines are based on a consensus of protocols from the scientific literature and treatment schedules now

successfully used by APHIS and trading partners. The guidelines include requirements for insect colonies, host commodity and infestation, experimental design, facilities, equipment, monitoring, statistics and data submission.

CPHST requests that trading partners submit final detailed research work plans or protocols to CPHST prior to initiation of research. CPHST review of research results will consider all uncertainties introduced by deviation from the agreed research protocol, scalability, accuracy, variability and inconsistencies in the data, and the level of detail provided about the experimental design.

Source: USDA-APHIS.

Management of Queensland Fruit Fly in Australia and *SITplus*

Kostas Bourtzis, the leader of the Genetics Group at the Joint FAO/IAEA Insect Pest Control Laboratory, was invited to a Horticulture Innovation Australia Limited (HIA) workshop held in Sydney on 19th of November 2014 to advice on the management of the nation's major horticulture pest, the Queensland fruit fly (Qfly) *Bactrocera tryoni*.

He presented to the technical committee and stakeholders of *SITplus*, a research partnership committed to a strategic, coordinated and national approach to Qfly management, the technical, managerial and logistical prerequisites that need to be met to ensure the success of this project, including availability of relevant entomological baseline data; genetic sexing strain(s), assessment of mating competitiveness of sterile insects and availability of back up strains; timely and thorough data analysis; feedback mechanisms; public awareness and education; dedicated management and regular reviews by independent experts. He also mentioned to the participants of this workshop that all components of the *SITplus* project are important, and that if one fails, the whole project will fail.

During his two-week visit in Australia, Kostas was also invited to the University of Western Sydney (UWS) in Richmond, Elizabeth MacArthur Agricultural Institute (EMAI) in Camden, Queensland University of Technology in Brisbane, South Australian Research and Development Institute (SARDI) in Adelaide and Department of Agriculture and Food Western Australia (DAFWA) in Perth. At all these locations he had several meetings with university professors and researchers in respect to the management of Qfly and Mediterranean fruit fly (*Ceratitidis capitata*) populations through area-wide-integrated pest management approaches with an SIT component. He also gave seminars at the UWS, SARDI and DAFWA on the role of irradiation, genetics and symbionts for the control of insect pests and disease vectors. During these meeting, he also informed the Qfly and Mediterranean fruit fly researchers about the new CRP on "Comparing Rearing Efficiency and Competitiveness of Sterile Male Strains Produced by Genetic, Transgenic or Symbiont-based Technologies" that will be initiated in 2015.

Relevant Published Articles

Eradication of tephritid fruit fly pest populations: outcomes and prospects

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Abstract

BACKGROUND: The number of insect eradication programmes is rising in response to globalisation. A database of arthropod and plant pathogen eradications covers 1050 incursion responses, with 928 eradication programmes on 299 pest and disease taxa in 104 countries (global eradication database b3.net.nz/gerda).

METHODS: A subset of the database was assembled with 211 eradication or response programmes against 17 species of fruit flies (Tephritidae) in 31 countries, in order to investigate factors affecting the outcome.

RESULTS: The failure rate for fruit fly eradication programmes was about 7%, with 0% for *Ceratitis capitata* (n=85 programmes) and 0% for two *Anastrepha* species (n=12 programmes), but 12% for 13 *Bactrocera* species (n=108 programmes). A number of intended eradication programmes against long-established populations were not initiated because of cost and other considerations, or evolved during the planning phase into suppression programmes. Cost was dependent on area, ranged from \$US 0.1 million to \$US 240 million and averaged about \$US 12 million (normalised to \$US in 2012). In addition to the routine use of surveillance networks, quarantine and fruit destruction, the key tactics used in eradication programmes were male annihilation, protein bait sprays (which can attract both sexes), fruit destruction and the sterile insect technique.

CONCLUSIONS: Eradication success generally required the combination of several tactics applied on an area-wide basis. Because the likelihood of eradication declines with an increase in the area infested, it pays to invest in effective surveillance networks that allow early detection and delimitation while invading populations are small, thereby greatly favouring eradication success.

The full paper was published in: *Pest Management Science* (2014) DOI 10.1002/ps.3905.

Synonymization of key pest species within the *Bactrocera dorsalis* species complex (Diptera: Tephritidae): taxonomic changes based on a review of 20 years of integrative morphological, molecular, cytogenetic, behavioural and chemocological data

Mark K. Schutze¹ et al. (48 other authors from 34 different institutes)

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Abstract

Bactrocera papayae Drew & Hancock, *Bactrocera philippinensis* Drew & Hancock, *Bactrocera carambolae* Drew & Hancock, and *Bactrocera invadens* Drew, Tsuruta & White are four horticultural pest tephritid fruit fly species that are highly similar, morphologically and genetically, to the destructive pest, the Oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae). This similarity has rendered the discovery of reliable diagnostic characters problematic, which, in view of the economic importance of these taxa and the international trade implications, has resulted in ongoing difficulties for many areas of plant protection and food security. Consequently, a major international collaborative and integrated multidisciplinary research effort was initiated in 2009 to build upon existing literature with the specific aim of resolving biological species limits among *B. papayae*, *B. philippinensis*, *B. carambolae*, *B. invadens* and *B. dorsalis* to overcome constraints to pest management and international trade. *Bactrocera philippinensis* has recently been synonymized with *B. papayae* as a result of this initiative and this review corroborates that finding; however, the other names remain in use. While consistent characters have been found to reliably distinguish *B. carambolae* from *B. dorsalis*, *B. invadens* and *B. papayae*, no such characters have been found to differentiate the latter three putative species. We conclude that *B. carambolae* is a valid species and that the remaining taxa, *B. dorsalis*, *B. invadens* and *B. papayae*, represent the same species. Thus, we consider *B. dorsalis* (Hendel) as the senior synonym of *B. papayae* Drew and Hancock syn.n. and *B. invadens* Drew, Tsuruta & White syn.n. A re-description of *B. dorsalis* is provided. Given the agricultural importance of *B. dorsalis*, this taxonomic decision will have significant global plant biosecurity implications, affecting pest management, quarantine, international trade, postharvest treatment and basic research. Throughout the paper, we emphasize the value of independent and multidisciplinary tools in delimiting species, particularly in complicated cases involving morphologically cryptic taxa.

The full paper was published in: *Systematic Entomology* (2014), DOI: 10.1111/syen.12113.

Global assessment of seasonal potential distribution of Mediterranean fruit fly, *Ceratitis capitata* (Diptera: Tephritidae)

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Abstract

The Mediterranean fruit fly (Medfly) is one of the world's most economically damaging pests. It displays highly seasonal population dynamics, and the environmental conditions suitable for its abundance are not constant throughout the year in most places. An extensive literature search was performed to obtain the most comprehensive data on the historical and contemporary spatio-temporal occurrence of the pest globally. The database constructed contained 2328 unique geo-located entries on Medfly detection sites from 43 countries and nearly 500 unique localities, as well as information on hosts, life stages and capture method. Of these, 125 localities had information on the month when Medfly was recorded and these data were complemented by additional material found in comprehensive databases available online. Records from 1980 until present were used for medfly environmental niche modeling. Maximum Entropy Algorithm (MaxEnt) and a set of seasonally varying environmental covariates were used to predict the fundamental niche of the Medfly on a global scale. Three seasonal maps were also produced: January-April, May-August and September-December. Models performed significantly better than random achieving high accuracy scores, indicating a good discrimination of suitable versus unsuitable areas for the presence of the species.

The full paper was published in: *PLoS ONE* (2014) 9(11): e111582.

Estimation of populations and sterility induction in *Anastrepha ludens* (Diptera: Tephritidae) fruit flies

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Abstract

The relationship between different release densities of sterile flies and fly trap captures, expressed as flies per trap per day, in the monitoring of *Anastrepha ludens* (Loew) populations was evaluated in mango orchards. The induction of sterility in fertile females was evaluated using different ratios of sterile: fertile males under field cage conditions. A direct relationship between recaptured flies and densities of release sterile flies was found. However, trap efficiency, expressed as percentage of recaptured flies, decreased as the density of released flies increased. Sterility induction was positively correlated to the ratio of sterile: fertile flies. A significant difference in egg fertility among treatments was observed. The trajectory of sterility induction slowed down after a sterile: wild ratio of 30:1, which suggests that this ratio could be appropriate in an sterile insect technique program with *A. ludens*. Sterility induction was greater when only sterile males were released than when releasing both sterile males and females, but the differences were not significant. Our findings contribute to a better interpretation of fly captures obtained from the field trapping networks, and to an improvement in the efficiency of sterile insect technique against *A. ludens* fruit flies, through the implementation of more rational sterile fly release densities.

The full paper was published in: *Journal of Economic Entomology* (2014) 107(4): 1502-1507.

Genetic diversity of *Bactrocera dorsalis* (Diptera: Tephritidae) on the Hawaiian islands: Implications for an introduction pathway into California

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Abstract

Population genetic diversity of the oriental fruit fly, *Bactrocera dorsalis* (Hendel), on the Hawaiian islands of Oahu, Maui, Kauai, and Hawaii (the Big Island) was estimated using DNA sequences of the mitochondrial cytochrome c oxidase subunit I gene. In total, 932 flies representing 36 sampled sites across the four islands were sequenced for a 1,500-bp fragment of the gene named the C1500 marker. Genetic variation was low on the Hawaiian Islands with >96% of flies having just two haplotypes: C1500-Haplotype 1 (63.2%) or C1500-Haplotype 2 (33.3%). The other 33 flies (3.5%) had haplotypes similar to the two dominant haplotypes. No population structure was detected among the islands or within islands. The two haplotypes were present at similar frequencies at each sample site, suggesting that flies on the various islands can be considered one population. Comparison of the Hawaiian data set to DNA sequences of 165 flies from outbreaks in California between 2006 and 2012 indicates that a single-source introduction pathway of Hawaiian origin cannot explain many of the flies in California. Hawaii, however, could not be excluded as a maternal source for 69 flies. There was no clear geographic association for Hawaiian or non-Hawaiian haplotypes in the Bay Area or Los Angeles Basin over time. This suggests that California experienced multiple, independent introductions from different sources.

The full paper was published in: *Journal of Economic Entomology* (2014) 107(5): 1946-1958.

Detection of the acetylcholinesterase insecticide resistance mutation (G328A) in natural populations of *Ceratitis capitata*

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Abstract

Wild Mediterranean fruit fly specimens collected from various regions worldwide were screened for the glycine to alanine (Gly->Ala) point mutation (G328A) in the acetylcholinesterase enzyme, presumably causing resistance to organophosphates. We found that the single nucleotide polymorphism (SNP) responsible for this amino acid change is located at the beginning of exon 6 of the Ccace2 gene. The identification of the exact location of the SNP permitted PCR primer design around this site and direct sequencing of the corresponding genomic region. We detected the resistance allele in natural Mediterranean fruit fly populations from Brazil and Spain, but not from other sites in four continents. The known treatment history of sites suggests that the resistance build up is linked to organophosphate application in the field. The PCR-based detection provides a screening method useful for monitoring Mediterranean fruit fly insecticide resistance in local populations and improving pest management strategies accordingly.

The full paper was published in: *Journal of Economic Entomology* (2014) 107(5): 1965-1968.

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