# Production, Shipment and Use of Natural Enemies Facilitated by Irradiation

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## *FAO/IAEA Coordinated Research Project D4.30.02:*

## *"Evaluation of Nuclear Techniques to Improve the Production and Use of Natural Enemies"*

**18 research teams from 15 countries:**
Argentina, Austria, Bangladesh, Bulgaria, China, India, Indonesia, Israel, Mexico, Pakistan, Poland, Slovakia, Syria, Turkey, USA

that participated in
this 6-year Coordinated Research Project




**Special Issue consisting of 25 publications on the "Use of Radiation in Biological Control" (2009).**

## *1. Improving Rearing*

a) Understanding host-parasitoid physiological interactions to be able to modulate defensive reactions of hosts.

- **Pseudo-parasitization** by irradiated *Glyptapanteles liparidis* in *Lymantria dispar* larvae: injecting sterile eggs with polydnavirus and venom, caused delayed *L. dispar* larval development and high mortality during pupal stage.

- Only the complete recombination of larvae with teratocytes and polydnavirus and venom allowed successful emergence of parasitoids (Hoch et al. 2009).

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## 1. Improving Rearing

b) Suppressing host immune responses can increase rearing efficiency and allow the use of factitious hosts that are easier / more economical to mass-rear.

• Irradiation of *P. interpunctella* and *E. kuehniella* larvae increased emergence of *Venturia canescens* compared to non-irradiated controls.

• *V. canescens* could develop in irradiated *G. mellonella* larvae, a factitious host, while development is extremely limited in non-irradiated larvae (Genchev 2007).



## 1. Improving Rearing

c) Expanding the time window suitable for host parasitization and delaying host/prey development to the benefit of the biological control agent.

• Irradiating *Chilo infuscatellus* larvae allowed the normally unsuitable 4th and 5th instar larvae to be parasitised by *Cotesia flavipes* (Fatima et al. 2009).

• Irradiating 3rd instar *Anastrepha* spp. larvae extended the parasitization period and increased the quantity and quality of the parasitoid *Diachasmimorpha longicaudata* developing in these hosts (Cancino et al. 2009).



## 1. Improving Rearing

d) Radiation can be used to arrest development and thus allow for storage and stockpiling of hosts, prey and/or natural enemies.

• Irradiated eggs of *E. kuehniella* could be stored at 4°C for up to 30 days without any quantitative or qualitative loss in the production of *T. evanescens* and for up to 60 days with only a minor decrease (Tunçbilek et al. 2009).

• Parasitoids in diapause could be stored inside irradiated host eggs for a period of 50 days without adverse effect on emergence (Tunçbilek et al. 2009).



## 1. Improving Rearing

e) Utilising by-products of SIT mass-rearing facilities for simultaneous production of biological control agents.

• Irradiated excess eggs of *C. capitata* and *A. ludens* used to produce egg parasitoids and discarded larvae and pupae to produce larval and pupal parasitoids (Cancino et al. 2009).

• Irradiated *C. capitata* eggs for the production of the minute pirate bug *Orius laevigatus*, a predator of *Frankliniella occidentalis* (Steinberg and Cayol 2009.

• Mass-rearing of *C. capitata* genetic sexing strains allows the use of excess females for the production of larval and pupal parasitoids (Viscarret et al. 2006).

## 2. Facilitating Handling, Shipment, Trade & Release

a) Eliminating the cost of separating of parasitoids and non-parasitized pest adults (or unused prey individuals), as well as the delays related to waiting for the emergence from pupae of fertile unused pest individuals.

• Irradiation of *A. ludens* eggs and the pupae of *M. domestica* and *A. ludens* avoids having to wait for adult emergence as well as unnecessary handling during the mass-rearing of egg and pupal parasitoids for these pests (Cancino et al. 2009; Zapater et al. 2009).



## 2. Facilitating Handling, Shipment, Trade & Release

b) Avoiding the shipment of fertile host/prey and ameliorating concerns relating to the introduction of non-native, pesticide resistant or new strains of pest insects into new areas or the incidental presence of other hitchhiking pests.

• Shipment of entomopathogenic nematodes within sterilized hosts to establish a safe mode of transport and dispersion without concern for the inadvertent release of uninfected fertile hosts (Seth & Barik 2009).

• Irradiated eggs of the spider mite *Tetranychus urticae* Koch to provision shipments of predatory mites (Baptiste et al. 2003).



## 2. Facilitating Handling, Shipment, Trade & Release

c) Shipment of sterilised pests/factitious hosts or prey (in the absence of natural enemies) for redistribution across borders for use as host/prey at smaller rearing facilities.

• Gaining efficiencies in the production of biocontrol agents or to standardize the use of strains of host/prey material to ensure product quality (Steinberg and Cayol 2009).

• Production and shipment of sterile *Musca domestica* host pupae to mass rear parasitoids in other locations (Zapater et al. 2009).



## 3. Supplementing Hosts in the Field for Survival or Early Build-up of Biological Control Agents

a) Provisioning of sub-sterile or sterile hosts or prey in the field as supplemental food to increase the initial survival of inoculatively released biological control agents.

• Irradiated cotton bollworm *Helicoverpa armigera* and diamondback moth *Plutella xylostella* adults released in field crops during critical periods where their sterile eggs served as hosts for feral egg parasitoids resulting in parasitoid population increases (Wang et al. 2009).

• In sugarcane fields, the provisioning early in the season of supplemental sterile host eggs to *T. chilonis* allowed populations of parasitoids to build-up (Fatima et al. 2009).

## 3. Supplementing Hosts in the Field for Survival or Early Build-up of Biological Control Agents

b) Provisioning of sub-sterile or sterile hosts or prey in the field as supplemental food to increase the early build-up of native biological control agents in advance of pest population build-up.

• Irradiated eggs, as well as sterile F1 eggs and larvae resulting from irradiated parents of the gypsy moth, *L. dispar*, were distributed in a natural forest and found to be suitable as hosts for a number of parasitoid species prior to the imminent cyclical pest outbreak (Zubrik and Novotny 2009).



## 4. Integrating Biocontrol and SIT or F1 Sterility

Integrating natural enemies with the SIT or inherited sterility results in synergistic action: biocontrol agents reproducing/feeding on sterile or substerile offspring; and sterile insects impacting on the adult stage.

• False codling moth *T. leucotreta* sterile eggs are suitable for development of *T. cryptophlebiae*, and releases of irradiated moths combined with releases of *T. cryptophlebiae* provide synergistic suppression of false codling moth populations (Carpenter et al. 2004).

• The release of *Diglyphus isaea*, the parasitoid of celery miner fly *Liriomyza bryoniae*, with sterile males of *L. bryoniae* for application in greenhouses (Kaspi and Parella 2008; Steinberg and Cayol 2009).



## 5. Applying the SIT against biocontrol agents that have become pest insects.

Developing the SIT against biocontrol agents that have become pest insects themselves.

• *Cactoblastis cactorum* was eradicated in 2009 from outbreaks in Mexico and contained in the SE USA by the integrated application of SIT to protect native *Opuntia*-based ecosystems in the south-western USA and Mexico.

• The Uzi-fly *Exorista sorbillans,* an endoparasitoid of the silkworm *Bombyx mori* is a pest due to its impact on silk production. Radiation studies have been carried out to assess if the SIT can contribute to an integrated control of this pest.



## 6. Using Reproductively Inactivated Hosts as Sentinels in the Field

a) The exploration for, and collection of, new biological control agents;

b) The monitoring in the field of populations of parasitoids, predators and microorganisms.

• Reproductively inactivated larvae of *E. kuehniella* and *P. interpunctella* to monitor the density of *V. canescens* and *Habrobracon hebetor* in warehouses/mills (Celmer 2006),

• Sterilized *M. domestica* pupae in traps to monitor populations of pteromalid parasitoids under conditions of livestock production (Zapater, pers. communication).

## 7. Field Confirmation of Host Specificity of Potential Classical Biocontrol Agents

In cases where host specificity doubts remain, facilitating the use of exotic species for classical biological control, through assessment in the field of sterilised individuals without the risk of establishing breeding populations.

• *Sterile C. cactorum* females exhibited normal oviposition preferences and were used safely under field conditions to predict the host range and interactions with natural enemies (Tate et al. 2009).

• Another potential system being considered is a Pyralid in quarantine in Florida for the control of Brazilian pepper tree (Moeri et al. 2009).



## Conclusions

- **The results confirm that radiation can contribute to facilitating the use and increasing the safety and cost-effectiveness of biological control agents.**
- **Nevertheless, a major constraint faced by producers of biological control agents, who would like to adopt some of these technologies, is access to radiation sources.**
- **Radiation sources represent a significant financial investment and bring with them logistic and regulatory constraints. Mehta (2009) provides a review of smaller radiation sources available.**
- **In view of the increasing difficulty of transporting radioactive materials, non-isotopic sources such as those emitting X rays, will gain in importance.**

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