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The Sterile Insect Technique and Inherited Sterility in Lepidoptera

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ABSTRACT: The sterile insect technique (SIT) is an environment-friendly pest control technique with application in the area-wide integrated control of key pests, including the suppression or elimination of introduced populations and the exclusion of new introductions. It involves the colonization and mass rearing of the target pest species, sterilization of the insects through the use of gamma radiation, and their release into the field on a sustained basis and in sufficient numbers to achieve appropriate sterile to wild insect over flooding ratios. F1 inherited sterility Technique One approach to reduce the negative effects of radio-resistance in Lepidoptera has been the use of inherited.

Key words: SIT, Inherited Sterility, Lepidoptera, insect pest

INTRODUCTION

A. Lepidopteran insect pest

Lepidoptera species are among the most destructive pests of major annual and perennial crops, forests, and stored products throughout the world. More than 25% of the species that appear on a list of the 300 most important exotic insects that threaten the United States are in the order Lepidoptera (Carpenter, 2009). In a supplement to that list, where the 30 most serious threats to Agriculture are named, 50% of the species are lepidopterans (Brockerhoff *et al*., 2012). Unfortunately, control of lepidopteran pests worldwide is achieved almost entirely through the use of synthetic insecticides. This dependence on insecticides has contributed to the development of insecticide resistance in many of the most serious pests. Relevant examples include the codling moth, *Cydia pomonella* (Lepidopera: Tortricidae) (Varela *et al*. 1993; Carpenter *et al*., 2013), and the diamondback moth, *Plutella xylostella* (Lepidoptera: Plutellidae), where resistance has developed even against the microbial insecticide *Bacillus thuringiensis*. Development of alternative tactics to the unilateral use of insecticides is a major emphasis of most local, national and international research organizations concerned with pest control.

B. SIT on Lepidoptera

Moths treated with a lower sterilizing dose live longer, are stronger fliers, and mate more frequently than moths treated with higher radiation doses (Guohua *et al*., 2012). When inherited sterility systems are implemented into moth SIT programs, great improvements in programme efficiency can be obtained (Simmons *et al*., 2010). In 1992, an operational codling moth AW-IPM programme that included the release of sterile males was initiated in the Okanagan region of British Columbia, Canada to protect 8000 ha of apple and pear orchards (Dyck *et al*., 1993). The programme integrated the use of insecticidal sprays, mating disruption and tree banding with the release of sterile moths. Although initially designed to rear 5 million moths per week, by 2004, the production had increased to 16 million moths per week (Bloem *et al*., 2007). The results of this programme in the initial treatment area of 3200 ha were very encouraging, with a reduction in wild moth trap catches from 13 and 2.5 moths per trap per week for the first and second generation in 1995 to 0.08 moths per trap per week for the first and second generation in 2000. Orchards with no codling moth damage increased from 42% in 1995 to 95% in 2000 and sales of organophosphate pesticides declined to only 10% of 1995 levels (Bloem *et al*., 2005).

In 1998, the objective of the AW-IPM programme was changed from eradication to a permanent suppression There are many successful examples of SIT against Lepidoptera. These include operational containment, suppression and eradication programmes against the codling moth (Canada), pink bollworm (USA), cactus moth, *Cactoblastis cactorum* (USA), painted apple moth *Teia anartoides* (New Zealand), and false codling moth *Thaumatotibia leucotreta* (South Africa). In addition, there have been pilot projects to demonstrate feasibility in the field gypsy moth *Lymantra dispar* (L.), tobacco budworm *Heliothes virescens* (F.), corn earworm, oriental fruit moth, carob moth *Ectomyelois ceratoniae*, and Asian corn borer *Ostrinia furnacolis*.

One classical method used in pest GM is SIT; could anyone tell me what this is all about? This technique involves irradiating male insects, then releasing them to mate with wild fertile female insects. As fertilized eggs are not produced, the numbers of insects drop dramatically Why males? Firstly, for insects such as mosquitoes, the adult females are potentially dangerous even sterile females will bite and might transmit disease whereas males do not bite. Secondly, the presence of females in the release population may distract the sterile males from seeking out wild females.

C. The Sterile Insect Technique and Inherited Lepidoptera

Since the 1950s, it is known that insect pests can be controlled through a 'birth control' method based on genetic manipulation and known as autocidal pest control or the SIT (Knipling, 1955). It involves the colonization and mass-rearing of the target pest species, sterilization through the use of gamma radiation and the sustained release in the target area in sufficient numbers to achieve appropriate sterile to wild insect over flooding ratios (Cagnotti *et al*., 2012). After release, the sterile males will locate and mate with wild females and transfer the sperm with the dominant lethal mutations. The sperm can fertilize the eggs, but because of the dominant lethal mutations, embryogenesis is arrested and there is no offspring. This will cause a reduction in the natural pest population (Carpenter, *et al*., 2009; Carpenter *et al*., 2010). In Special situations of isolated populations, systematic application can ultimately drive a wild population to extinction the validity of this method has been demonstrated for many insect pests, including moths, screwworms, tsetse flies and fruit flies (Dyck *et al*., 2005).

D. F1 Inherited sterility Technique

F1 inherited sterility Technique One approach to reduce the negative effects of radio-resistance in Lepidoptera has been the use of inherited or F1 sterility, Like SIT, programme, mainly because quarantine measures were not implemented (Bloem *et al*., 2007).

F1 sterility involves the mass rearing and release of genetically altered insects to insure that when matings occur in the field, a significant proportion of matings involve a treated, released insect (Potgieter *et al*., 2012). The lower dose of radiation used in F1 sterility increases the quality and competitiveness of the released insects (North 1975).

E. Origin of F1 Inherited sterility Technique

Following the successful area-wide integrated pest management (AW-IPM) programme, integrating the sterile insect technique (SIT), against the screwworm fly *Cochliomyia hominivorax* (Coquerel) (Knipling, 1955). studies were conducted on the possibility of suppressing lepidopteran pest populations through the release of radiation sterilized moths (Chen, 2013). However, because Lepidoptera are relatively more radioresistant compared with most other insects (LaChance *et al*., 1967; Bakri *et al*., 2005), a fully sterilizing dose of radiation reduced the ability of sterile moths to compete with wild moths. To increase the competitiveness of irradiated Lepidoptera, Proverbs (1962) investigated the effects of substerilizing doses of radiation on the codling moth *Cydia pomonella* (L). Male moths treated with substerilizing doses and then mated to fertile females produced reduced numbers of F1 progeny, the majority of which were males with very low fertility thus it was called as 'inherited' or 'F1 sterility'. Inherited Sterility (IS) is also referred to as inherited partial sterility, partial sterility, delayed sterility, semi-sterility and F1 sterility. Radiation-induced deleterious effects can be inherited for several generations; however, the majority of the inherited deleterious effects are expressed in the F1 generation (LaChance, 1985).

Inherited sterility is predicted to be more effective than complete sterility whenever matings between irradiated-lineage partners are unsuccessful this is rarely examined experimentally. Successful eradication also requires sufficient depression of fertility from matings between irradiated-lineage and wild partners and those sufficient irradiated males are released to overcome the natural rate of increase of the wild population (Soopaya *et al*., 2011).

F. Historical overview

Knipling realized in the 1930s that, if male insects could be sterilized genetically without affecting their ability to mate, then they could be used to introduce a genetic load into a wild population in the field that would lead to its suppression or even eradication.

Inherited sterility was first reported in the Soviet Union in the mid 1930s by Astaurov and Frolova while studying radiation induced genetic anomalies in the silkworm *Bombyx mori* (L.). A few years later *Ostriakova Varshaver* reported IS in the greater wax moth *Galleria melonella* (L.). In North America, Proverbs (1962) was the first to describe IS in the codling moth.

CONCLUSIONS

The sterile insect technique (SIT) is a very efficient control tactic for creating pest-free areas or areas of low pest prevalence within such AW-IPM programmes. A previous CRP on Lepidoptera SIT focused on improvements of codling moth SIT to facilitate its' expansion in the field. Further development of the SIT to target other key lepidopteran pests requires improvements that increase the quality control of mass-rearing, irradiation, shipping, release and field assessment activities. Relevant knowledge and know-how on the behaviour and ecology of codling moth was gained thereby, which were instrumental in increasing the efficiency of the integrated application of the SIT against this major insect pest. Moreover, the CRP has considerably advanced the basic genetic knowledge of the codling moth in relation to the development of genetic sexing strains in Lepidoptera and stimulating R and D by several laboratories in this field. Finally, collaboration among and between researchers in genetics, codling moth behaviour and ecology, SIT and biological control and has significantly increased awareness of the private sector and policy makers of the benefits of the SIT as part of AW-IPM programmes.

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