1. Introduction

1.1 SCOPE

This guidance represents the recommendations, reached by consensus of an international group of experts, on the standard procedures for the packing, shipping, holding and release of mass reared and sterilized tephritid flies that are to be used in area-wide programmes that include the Sterile Insect Technique (SIT). The majority of the procedures were initially designed specifically for the Mediterranean fruit fly *Ceratitis capitata* (Wiedemann) (or Medfly), but they are applicable, with minor modifications, for other tephritid species such as those in the genera *Anastrepha*, *Bactrocera* and *Dacus*. The guidance is designed to be a working document that can be subject to periodic updates due to technological developments and research contributions. Future editions will endeavour to include more specific recommendations for other species of fruit flies as the relevant data become available.

The procedures described in this guidance will help ensure that released sterile fruit flies will be of optimal quality and that the resulting field density of these flies will be as closely aligned to the individual programme needs. It is hoped that this guidance will help to quickly identify and correct problems in programme effectiveness, resulting from less than optimal emergence and release conditions.

The procedures in this guidance are presented following a logical flow of activities in operational programmes from packing after pupal irradiation to field release of sterile flies (*FLOW CHART*, see **Appendix 2**).

1.2 BACKGROUND

The SIT relies on the release of thousands of insects per unit area to reduce the reproductive potential of a specific target pest. The release of insects is the process by which sterile insects are delivered into a target area to allow them to compete with their wild counterparts. Prior to their release, sterile insects are shipped and handled, emerged from their puparia, matured and are loaded into delivery vehicles for aerial or ground releases. The conditions under which these activities are conducted are as relevant to the overall success of SIT activities as is the production of a high quality sterile insect.

The SIT for fruit flies has developed in parallel for several pest species in different countries and action programmes (**Table 1.1**). Programmes integrating the SIT have been conducted with great success and have developed information during their activities that, although it may not be peer reviewed and published, offers a successful guide for specific pest problems. With this information of practical implementation, action programmes have developed operational guidance that summarize their approach to solve their local needs, however, this information is generally only available to the respective programme.

Interactions among some programmes have allowed new procedures and technology to be developed. Researchers have also contributed by experimentally determining the most appropriate approach to specific problems.

A quality control manual has also been developed as a contribution to understanding what makes a successful sterile insect. This manual describes the standard evaluations required to determine the quality of mass reared sterile insects (FAO/IAEA/USDA 2003). Most of these tests can also be applied to measure the integrity of the processes that are used to release sterile insects. These parallel developments have produced a wealth of information and technology that now need to be summarized into manuals to provide guidance. New area-wide programmes utilizing SIT technology will benefit from this compilation in order to implement their activities using state of the art technology.

An SIT programme can be clearly divided into two areas of activity. The mass rearing of insects is a specialised activity and minor variations in rearing procedures can have a significant impact on the quality of reared flies. Rearing and irradiation are carried out in strictly controlled environments prior to insect release.

The post-production process, involving the packing, shipping, handling, emergence, holding and release of sterile flies, is also a specialised procedure and requires similar but different skills. Generally insects are handled in smaller batches and the focus is on the adult stage. Adults have entirely different demands for space and movement compared with factory based stages and are generally held for shorter periods (several days) compared with weeks at the production facility.

New World Screwworm flies *Cochliomyia hominivorax* (Coquerel) have now been eradicated from the continental USA. as well as from Mexico and Central America using aerial release. This technology was initially also used for fruit fly aerial release but has been superseded by new technology developed over the last 25 years in the different fruit fly programmes (**Table 1.1**). The need for increased numbers of insects in large scale programmes has led to the development of standardized conditions for all the processes from emergence through to insect release. This document is a compilation of the standardized processes currently used in most of the fruit fly SIT applications world wide.

1.3 STERILE INSECT TECHNIQUE (SIT) APPLICATIONS

The Food and Agriculture Organization of the United Nations (FAO), through its International Plant Protection Convention (IPPC) whose standards are accepted by the signatory countries of the SPS Agreement of the World Trade Organization (WTO) defines “control” of a given plant pest (FAO 2006) as encompassing: suppression, containment or eradication of a pest population.

These three strategies would apply to most area-wide integrated pest management (AW-IPM) programmes with a sterile insect technique (SIT) component, including those against insect pests of medical and veterinary importance. However, the most efficient and cost-effective “control” programme is the one that aims at preventing the entry of a pest (movement of a pest into an area where it is not yet present (FAO 2006, Enkerlin 2005). This is preferable to dedicating resources to suppress, eradicate or contain an introduction (the entry of a pest resulting in its establishment (FAO 2006)) once it has occurred (Knipling 1979). On this basis, the fourth control strategy is “prevention”. **Table 1.1**, summarizes all the current fruit fly programmes releasing sterile insects and their current strategic objective(s).

TABLE 1.1
Countries where SIT is being integrated into are-wide fruit fly control

Country	Fruit fly species	Objective
Argentina	Mediterranean fruit fly (or Medfly) (*Ceratitis capitata*, Wiedemann),	Eradication
Australia	Queensland fruit fly (or Qfly) (*Bactrocera tryoni*, Froggatt)	Prevention, eradication
	Medfly	Prevention
Brasil	Medfly	Suppression
Chile	Medfly	Prevention
Guatemala	Medfly	Containment, eradication
Israel	Medfly	Suppression, eradication
Japan, Okinawa	Melon fly (*B. cucurbitae*, Coquillett)	Prevention
Jordan	Medfly	Suppression, eradication
Mexico	Medfly	Eradication
	Mexican fruit fly (or Mexfly) (*Anastrepha ludens*, Loew)	Prevention, suppression
	West Indian fruit fly (*A. obliqua*, Macquart)	Prevention, suppression
Peru	Medfly	Suppression, eradication
	South American fruit fly (*A. fraterculus*, Wiedemann)	Suppression
Portugal, Madeira	Medfly	Suppression
Philippines	Philippine fruit fly (*B. philippinensis*, Drew & Hancock)	Suppression
South Africa	Medfly	Suppression
Spain	Medfly	Suppression
Tunisia	Medfly	Suppression
Thailand	Oriental fruit fly (*B. dorsalis*, Hendel)	Suppression
	Guava fruit fly (*B. correcta*, Bezzi)	
USA, California	Medfly	Prevention
USA, Florida	Medfly	Prevention
USA, Hawaii	Melon fly	Suppression
USA, Texas	Mexfly	Suppression, eradication

1.3.1 Eradication

In the past, most AW-IPM programmes integrating the SIT aimed at eventual eradication of the target population, and high densities of sterile insects were often released only during the last phase of the programme. The eradication strategy is applied mainly in the following two situations (Hendrichs *et al.* 2005):

- Eliminating an established pest population, e.g. the tsetse fly Glossina austeni in Unguja Island (Zanzibar) (Vreysen *et al.* 2000)
- Eliminating outbreaks of an exotic invasive species before full establishment can occur, e.g. the painted apple moth in New Zealand (Suckling 2003)

The second situation is likely to increase, with more pest introductions due to globalization, and the growing awareness by governments of the need for monitoring networks for early detection to facilitate eradication. Once the target pest has been eliminated from a given area, it is imperative to maintain this area pest free. This will require efficient, permanent, and stringent quarantine procedures to preclude reinvasion.

For eradication, two very important concerns (which have significant economic implications) have to be addressed: (1) the period of time in which releases of sterile insects should continue after the last wild insect has been detected (Vreysen 2005), and (2) the duration of continued monitoring after releases have stopped, to be able to declare with sufficient confidence the status of eradication (Barclay 2005).

The eradication of the Medfly in Chile (SAG 1996) opened trade opportunities annually worth several hundred million USD, and the eradication of the Mexican fruit fly (or Mexfly) and the West Indian fruit fly in north-western Mexico allows fruit trade with the USA without the need for costly postharvest treatments (Reyes *et al.* 2000; Enkerlin 2005).

1.3.2 Suppression

A suppression strategy requires continuing low to medium density releases of sterile insects to maintain the low population level. Permanent application of a suppression strategy, including continuing releases of sterile insects, could be considered disadvantageous when compared with the sustainable elimination of a pest from an area. However, this permanent need for sterile insects could stimulate and promote investment in, and the commercialization of, the mass production of sterile insects (Hendrichs *et al.* 1995, Enkerlin and Quinlan 2004). For some key fruit fly and moth pests of major agricultural crops, using sterile insects as part of a suppression strategy has become cost-competitive with conventional or other population reduction methods, e.g. Mediterranean fruit fly in Israel and Jordan (Cayol *et al.* 2004) and in South Africa (Barnes *et al.* 2004), Oriental fruit fly in Thailand (Enkerlin *et al.* 2003), and codling moth in British Columbia, Canada (Bloem and Bloem 2000).

1.3.3 Containment

Containment programmes are adopted to avoid the spread of invading exotic pests that have become established, or to consolidate progress made in an ongoing eradication programme (Hendrichs *et al.* 2005). In areas where pest levels are too high for sufficient numbers of sterile insects to be released, they have to be integrated with other population reduction tools where, as in low pest prevalence areas with remaining pest remnants or incursions, high density releases of sterile insects are particularly effective. In adjacent areas that already are largely pest free, but that are subject to regular pest entries (FAO 2005), low density releases of sterile insects are effective as insurance in a buffer zone, over parts of the contiguous pest free areas to which the pest may occasionally be moved by the transport of infested host material. An example is the Queensland fruit fly Tri-State Fruit Fly programme, which has operated since 1988 in eastern Australia to protect a quarantine area called the Fruit Fly Exclusion Zone (FFEZ). This region contains much of the horticultural production areas of southern New South Wales, northern Victoria, and eastern South Australia (Jessup *et al.* 2004) and its fruit fly free status results in enhanced access to domestic and export trade. Other examples are the Moscamed Programme which has operated since 1983 at the Guatemala–Mexico border to protect northern Guatemala, Mexico and the USA, and the Mediterranean fruit fly programme which has operated since 1996 at the Peru–Chile border to protect Chile's multibillion export horticultural industry. Some of these programmes are stationary and thus become permanent containment efforts, whereas others successfully advance or gradually retreat and eventually collapse (Hendrichs *et al.* 2005).

1.3.4 Prevention

Preventive release has been applied where the invasion pressure is very high, and quarantine activities are not sufficient to maintain the area pest free. Permanent low density releases of sterile flies are required. An example is the permanent release of sterile melon flies over the Japanese islands closest to Taiwan (Kuba *et al.* 1996) and the preventive release of sterile Medflies in California and Florida, USA (CDFA 2002). *Sequential* or *serial* eradication approaches are probably more viable economically in situations where the invasion risk is not very high (Hendrichs *et al.* 2005).

It should be noted that all preventive and containment programmes use eradicative releases, as needed, to augment their regular releases in case of an outbreak.

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