9. Sterile fly release densities

STEP V OF PROCESS IN FLOW CHART IN APPENDIX 2

9.1 FACTORS TO CONSIDER FOR ESTABLISHMENT OF STERILE FLY DENSITY (FROM HENDRICHS ET AL. 2005)

9.1.1 Pest aggregation

Aside from the absolute population density, the degree of population aggregation or dispersion is important. Sterile insects are often released by aircraft, and are thus distributed fairly homogeneously over the target area, irrespective of whether the target pest is distributed evenly or clumped. Pest insects with a clumped distribution require higher release rates (Barclay 2005) as compared with a homogeneous pest distribution, to obtain the required sterile to wild male ratios (Vreysen 2005), and thus pest aggregation also affects strategy selection and its cost. Only if the released insects can find the same aggregation sites and aggregate in a similar manner as wild insects, so that adequate sterile to wild male over-flooding ratios are obtained in those sites, is there no need to increase release rates to compensate for such clumping.

9.1.2 Sterile male longevity

The density of the sterile male population in the field, which fluctuates in relation to the release frequency and the sterile male mortality rate, should not decrease below that needed to maintain the critical overflooding ratio (**Figure 9.1**, upper graph) (Barclay 2005; Kean *et al.* 2005). Therefore, the frequency of release and number of sterile males released has to be carefully assessed in relation to the average longevity or survival of the sterile males, to effectively avoid periods when insufficient sterile males are present in the field (**Figure 9.1**, lower graph).

As generations normally overlap in multivoltine species, releases for such pest species have to be continuous, with survival determining whether releases have to occur once a week (New World screwworm), twice a week (Mediterranean fruit fly, tsetse), or even daily basis (pink bollworm). The importance of assessing the survival of sterile male insects in the natural habitat must be emphasized here, as their actual survival in open field conditions is often drastically lower than in protected field-cage situations, where sterile males have easy access to food and are protected from predation (Hendrichs *et al.* 1993). In addition, mass-rearing conditions often inadvertently select for short-lived individuals (Cayol 2000). A shorter sterile male lifespan, although not directly representative of competitiveness, often requires higher release frequencies, and thus can significantly increase programme costs compared with longer-lived sterile insects (Hendrichs *et al.* 2005).

Different species have different average life expectancies in the field, varying from days to weeks. In Queensland fruit fly, the majority (about 80%) of recaptures are made within 3 to 4 weeks of releases (Dominiak and Webster 1998, Dominiak *et al.* 2003a, Meats 1998). In Medfly, Cunningham and Couey (1986) determined that Steiner traps baited with trimedlure caught almost 94% of the total sterile fly recapture 24 hours after release.

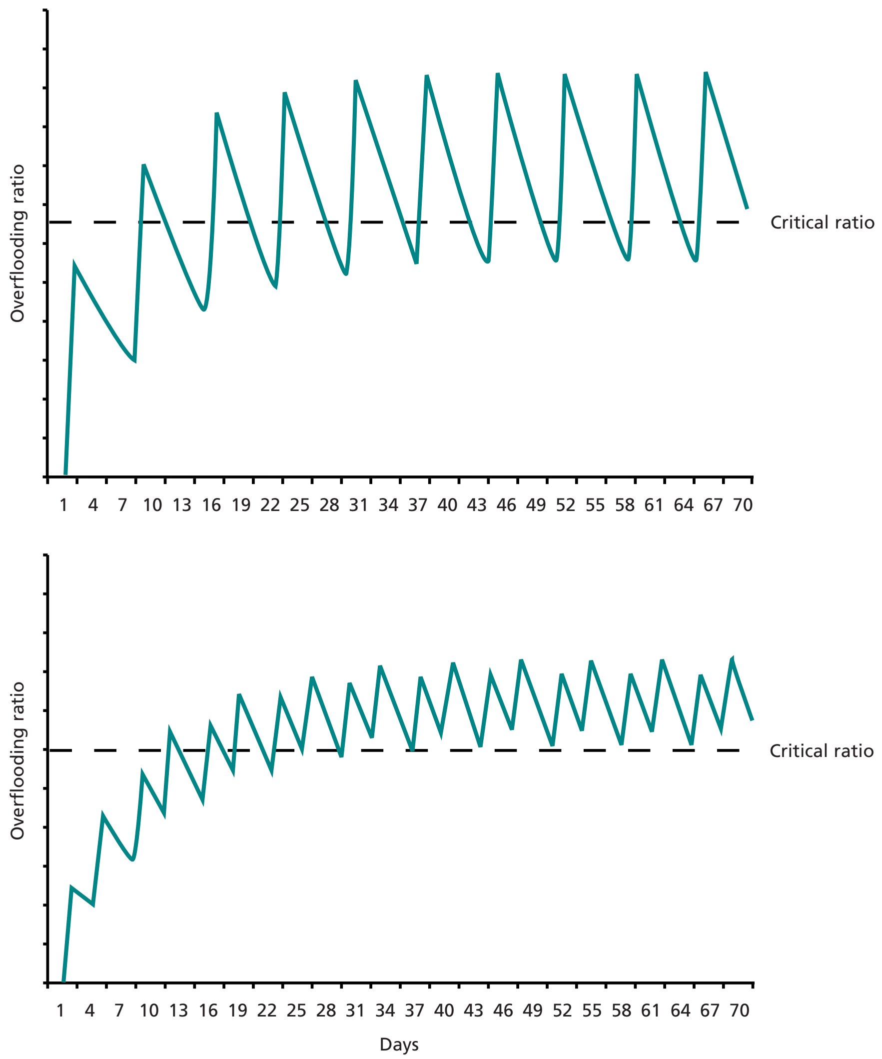

FIGURE 9.1
Effect of sterile insect longevity (assume daily mortality rate of sterile males is 0.1) on sterile to wild over-flooding ratio. Upper: Due to only weekly releases, sterile insect population routinely decreases significantly below the critical over-flooding ratio; Lower: twice-a-week releases overcome this problem (from Hendrichs et al 2005).

9.1.3 Topography and other conditions of target area

The topography of the target area, combined with the density of roads, has major implications for programme implementation and the selection of an intervention strategy. A flat terrain and a good road network will facilitate most field activities (including ground release in some cases), whereas mountainous areas, dense vegetation, and the absence of roads will complicate implementation. In most of the larger programmes, releases and some of the population reduction activities use aircraft (usually with fixed wing), and the topography and presence/absence of a road network are less critical. Monitoring, however, is mostly ground-based, and extreme terrain conditions make eradication campaigns (which have a more intensive monitoring component) much more complex and costly than programmes following a suppression strategy (which have less intensive monitoring

TABLE 9.1
Minimum recommended initial release ratios depending on the action programme objective.

Programme objective	Avg. Ratios* (for Medfly)
Suppression	25–100:1
Eradication	100–150:1
Containment	50–150:1
Preventive Release**	25–50:1

* Minimal S:W ratio. This ratio will continue to increase as $FTD_{fertile}$ is reduceddue to suppression and SIT application.
**Suggested ratio to ensure a minimum amount of sterile flies required to outnumber potential entry. Based on the assumption that one wild fly is caught per trap per cycle, irrespective of whether a wild fly is caught or not.

activities). Conversely, the absence of a good road network is advantageous for the establishment of efficient quarantine procedures in support of an eradication strategy. Travellers frequently carry fruit (some of which is infested with fruit flies), and visitors bringing fruit as gifts are common in some cultures. While some fruit flies generally do not fly very far, they are commonly transported in infested fruit by travellers on road networks (Dominiak *et al.* 2000). Irregular reintroductions of infested fruit may act as a source of reinvasion after eradication has been achieved. The regulation or exclusion of this risk fruit via roadways is a key component of any sterile programme.

Likewise, topography influences the requirements of sterile insects or bait sprays, e.g. mountainous areas have a larger surface area per square kilometre as compared with two-dimensional conditions, demanding higher sterile insect release rates. Furthermore, helicopters, which are more expensive to operate than fixed-wing aircraft, are often needed in difficult terrain for safety reasons and to properly treat narrow valleys.

Some production areas are surrounded by desert conditions (Mavi and Dominiak 2001) in what may be described as production oasis surrounded by rural deserts. These conditions occur for example in Australia, Chile, Mexico, and there is no need to treat the surrounding areas as both wild and sterile fruit flies will not survive. In most tropical and subtropical situations, however, where conditions are similar to the surrounding areas, larger areas need to be treated. Modelling can be used to evaluate if this desert and oasis principle is present (Yonow and Sutherest 1998, Yonow *et al.* 2004, Dominiak *et al* 2003a)

9.2 ASSESSING RELEASE DENSITIES

To establish sterile insect release densities for action programmes that work in fruit fly infested areas, it is important to determine, first, the level of the wild population (for methods to accurately determine the absolute population density, see Ito and Yamamura 2005). It can be also roughly estimated by using a trapping scheme as described in IAEA (2003).

The procedure is as follows:

This procedure assumes that the response of the sterile released flies and the wild flies to traps is equal.

a) Determine the fly/trap/day (FTD) value for the fertile (wild) population:

$$FTD_{wild} = \frac{\text{Total captured wild flies}}{\text{(Total No. Traps) (avg. days in field)}}$$

b) Determine FTD value for released sterile flies, as follows:

$$FTD_{sterile} = \frac{\textit{Total re-captured sterile flies}}{\textit{(Total No. Traps) (avg. days in field)}}$$

c) With the information from (a) and (b) calculate the sterile:wild ratio present in the field.

$$FTD_{sterile}/FTD_{wild} = \text{Ratio}$$

d) Determine an appropriate S:F ratio according to the action programme objective (Table 5).

e) If the calculated ratio S:F does not meet the objective of the action programme (see **Table 9.1**) additional non SIT suppression measures need to be implemented before sterile insects can be released (i.e. bait sprays) or additional sterile flies have to be released to increase the over-flooding ratio. Only when the target of $FTD_{fertile}$ of 0.1 has been achieved, should sterile releases be initiated. 0.1 is a rough FTD value, above which it is normally recommended not to use sterile insects except for hotspot situations, (IAEA 2003).

Example:

Assuming that 5 traps in 1km² (100 ha) exposed in the field for 7 days captured 3 wild flies, then:

a) $FTD_{fertile}$ = 3 flies/(5 traps × 7 days) = 0.085
b) *The same calculation using* $FTD_{sterile}$

Assuming 1,000,000 sterile flies were released in the same 1 km² area and that 3,000 flies were recaptured.

$FTD_{sterile}$ = 3,000 flies/(5 traps × 7 days) = 85.71

c) *Current sterile:*fertile ratio
FTD_S/FTD_F = 85.71/0.085 = 1008 (1008_S:1_F)

d) *Required number of sterile flies for a 50:1 ratio*
1,000,000 released sterile flies
1008 current sterile:wild ratio
50 required sterile:wild ratio
(1,000,000 × 50)/1008) = 49,600 sterile flies
in 100 ha (1 km²)

e) *Number of sterile flies per hectare*
(49,600/100) = 496 sterile flies/ha

If the ratio S:W needs to be increased there are two options to achieve the desired ratio:

a) *Additional suppression measures (i.e. bait sprays) can reduce* FTD_{wild} *from 0.085 to* FTD_{wild} *= 0.03, therefore the new S:W ratio is, 142:1 (0.085/0.03 × 50)*

TABLE 9.2
Release densities for different fruit fly SIT programmes and their respective programme objectives.

Country	Fruit fly species	Objective	Aerial Release Density (Male Flies[1]/Ha)	Main Host and Area Characteristics
Argentina	Medfly (C. capitata)	Eradication Prevention	500–3,000 250–1500	Stone and soft fruit (peaches, plums, apples and others)/Oasis–Valleys with extreme high/low temperatures.
Australia	Qfly (B. tryoni)	Prevention Eradication	1,000 Not available	Soft fruit (tomatoes)/stone (peaches, plums)/Flat and dry area.
Brazil	Medfly	Suppression	1,000–2,000	Mango and grapes subtropical conditions in a valley
Chile	Medfly	Prevention Eradication	1,500–2,500 >3,000	Guava, mangoes/isolated valleys surrounded by mountains and desert.
Guatemala	Medfly	Containment Eradication	5,000	Continuos coffee, mixed host rural areas/ coastal, valley and mountanous area.
Israel	Medfly	Eradication Suppression	1,000	Citrus and urban backyard hosts
Japan (Okinawa)	Melon fly (B. cucurbitae)	Prevention	Not available	Garden crops and urban backyard hosts
Jordan	Medfly	Eradication	1,000	Citrus and urban backyard hosts
Mexico	Medfly	Eradication	5,000	Continuos coffee, mixed host rural areas/ coastal, valley and mountanous area.
	Mexfly (A. ludens)	Suppression	2,500	Citrus, Guava, mangoes production areas/ coast, oasis, mountainous area.
	West Indian fruit fly (A. obliqua)	Suppression	2,500	Mangoes, coast and mountainous areas.
Peru	Medfly	Eradication	1,000–2,000	Olives/oasis
Portugal (Madeira)	Medfly	Suppression	3,000–5,000	Mixed fruits and vegetables
South Africa	Medfly	Suppression	1,200	Grapes/isolated valleys — dry with irrigation
Thailand	Oriental fruit fly (B. dorsalis)	Suppression	5,000	Pilot areas of mango orchards with no isolation
	Guava fruit fly (B. correcta)	Suppression	5,000	
USA California	Medfly	Prevention Eradication	250 1,000	Urban (Jungle) fruit and vegetables. Variable climate and topography.
USA Florida	Medfly	Prevention Eradication	500 1000–1400	Citrus and urban host/Coastal area, tropical.
USA Hawaii	Melon fly	Suppression	Not available	Experimental — Tropical, melon, squash.
USA Texas	Mexfly	Suppression	650	Citrus and urban host/semi-arid with irrigation

[1]Adjusted for percent emergence, however, not for flying males.

b) Increase the sterile fly numbers to achieve the required ratio of steriles (ie. 142); to calculate the new release numbers, substitute the new ratio in d) above.

1,000,000 × 142)/1008) = 165,675 sterile flies in one km² or 1,657 in one hectare

As the control process progresses the initial S:W ratio will increase. This ratio will continue to increase as long as the $FTD_{fertile}$ constant (**Figure 9.2**).

Recapture of sterile flies is affected by the release mechanisms, release rates, seasonal changes in trapping efficiency and the environmental conditions of the area such as topography, vegetation and host density. **Figure 9.3** illustrates the effect of the release

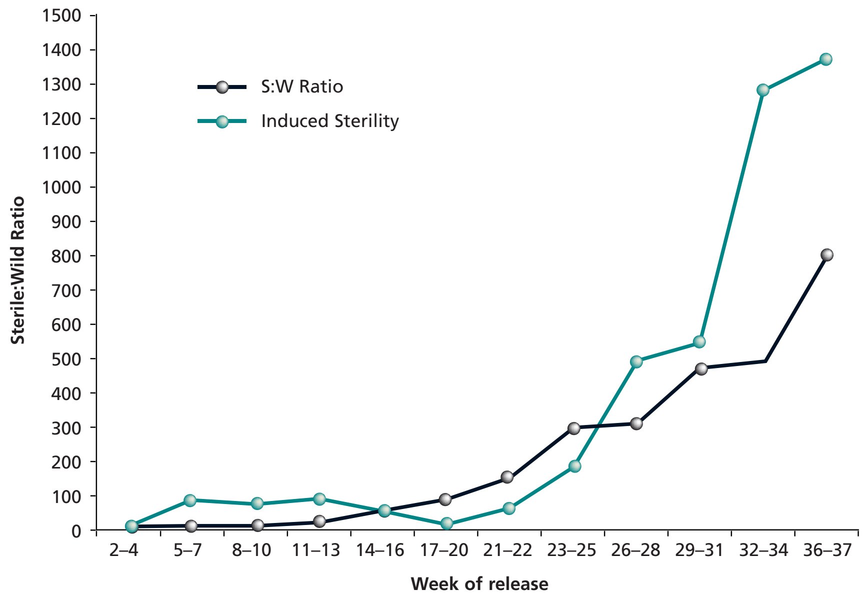

FIGURE 9.2
Increased S:W ratio as result of SIT control.

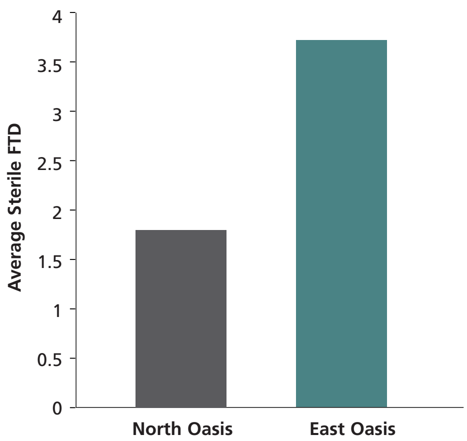

FIGURE 9.3
Effects of release densities on the number of sterile flies per trap per day (FTD) using the bag release system in the North (500-1000 sterile flies/ha) and East Oasis (1000 sterile flies/ha) in the Province of Mendoza, Argentina, 2004 – 2005.

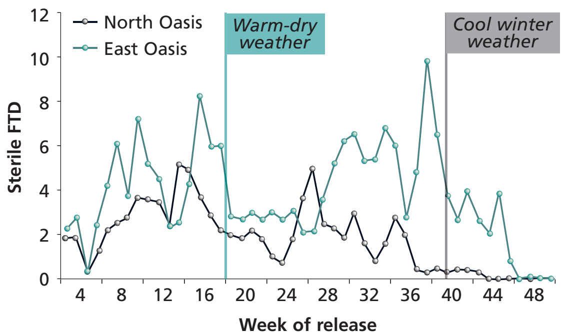

FIGURE 9.4
Fluctuations of sterile flies per trap per day due to changes in the climatic conditions in the North and East Oasis in the Province of Mendoza, Argentina, 2004 – 2005.

rate on the number of sterile flies/trap/day (FTD) in an oasis environment where a range of 500 to 1000 sterile flies per hectare where released in Oasis North and 1000 in Oasis East. **Figure 9.4**, illustrates the sterile FTD fluctuation due to changes in climate conditions of the same areas presented in **Figure 9.3**. Managers should be aware of these variations to decide on the most appropriate number of sterile insects to be released in order to maintain the required sterile:wild ratio.

The list of existing SIT programmes, their objective and actual sterile insect release densities are shown in **Table 9.2**. New prgrammes should determine their required release densities considering the conditions under which activities will be conducted, objectives of the programme and established over-flooding ratios. In practice over-flooding ratios (sterile:wild) have varied from as low as 50:1 (Wong *et al.* 1986) to 200:1 and as high as 1000:1 (Fisher *et al.* 1985, McInnis *et al.* 1994).

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