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The South African Fruit Fly Action Plan – Area-wide Suppression and Exotic Species Surveillance

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ABSTRACT: Two species of tephritid fruit flies of economic importance, Mediterranean fruit fly (Medfly, *Ceratitis capitata* [Wiedemann]) and Natal fruit fly (*C. rosa* Karsch) cause economic losses in the South African deciduous fruit industry of approximately US$3 million per annum. A third species, marula fruit fly, *C. cosyra* (Walker), causes damage to citrus and sub-tropical fruits in the north-eastern part of the country. In 1999 a sterile insect technique (SIT) programme against Medfly was initiated over 10,000 ha of table grapes with a goal of cost-effective, ecologically compatible suppression of Medfly. The SIT programme was extended to two other fruit production areas in 2004. Although results in all three SIT areas have been mixed, populations of wild Medflies, as well as associated pesticide usage and control costs, have been reduced since the start of sterile fly releases. Reasons for the partial degree of success and the relatively slow expansion of Medfly SIT to other areas include economic, operational and cultural factors, as well as certain fruit production practices. Before fruit fly-free areas can be created, deficiencies in the ability to mass-rear Natal fruit fly need to be overcome so that an SIT programme against this species can be initiated. Any fruit fly suppression or eradication campaign will be severely compromised by any introductions into South Africa of exotic fruit fly species. The risk of such introductions is increasing as trade with and travel to the country increases. A Plant Health Early Warning Systems Division has been initiated to formulate fruit fly detection and action plans. Melon fly (*Bactrocera cucurbitae* [Coquillett]), Asian fruit fly (*B. invadens* Drew, Tsurutu & White) and peach fruit fly (*B. zonata* [Saunders]), which are all well established in parts of Africa and/or Indian Ocean islands, have been identified as presenting the highest risk for entering and becoming established in South Africa. An exotic fruit fly surveillance programme has been started, focusing on detection at ports of entry and in fruit production areas. Any detection of an exotic fruit fly will trigger a reaction plan involving a delimiting survey, a feasibility study, quarantine measures and control actions. These initiatives signal significant progress towards implementing programmes aimed at creating fruit fly-free areas and putting in place exotic fruit fly detection and action plans that will protect the valuable South African export fruit industry.

Key Words: Mediterranean fruit fly, Natal fruit fly, sterile insect technique, area-wide management, exotic fruit fly surveillance

INTRODUCTION

South Africa's main deciduous fruit-producing area, the Western Cape, is host to two species of tephritid fruit flies of economic importance, Mediterranean fruit fly (Medfly, *Ceratitis capitata* [Wiedemann]) and Natal fruit fly (*C. rosa* Karsch). A third species, marula fruit fly, *C. cosyra* (Walker), causes damage to citrus and sub-tropical fruits in the north-eastern part of the country. Medfly tends to dominate in many fruit production areas, with Natal fruit fly more predominant in the milder, coastal areas. Between them they attack a wide variety of subtropical, tropical and deciduous fruits in this area (Annecke & Moran 1982), with crop losses and control costs exceeding US$3 million per annum (Mumford & Tween 1997). Further details of their occurrence, behaviour and management in the Western Cape is given by Myburgh (1964) and Barnes (1994).

The South African export deciduous fruit industry is of significant economic importance to the country. Nearly 90 million cartons are exported annually, with gross export earnings of approximately US$1 billion per annum. The Western Cape is the most important region for the production of deciduous fruit, with about 74,000 ha under cultivation (Optimal Agricultural Business Systems 2005). Most fruit is grown in valley systems, some of which are in many respects ideal for area-wide pest management such as the sterile insect technique (SIT) due to their relative isolation.

In 1999 the Hex River Valley SIT Pilot Project, covering approximately 10,000 ha of table grapes, was initiated with the goal of cost-effectively suppressing Medfly in the area. Natal fruit fly occurs in very small numbers in the Hex River Valley, and in very few localities.

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Despite the fact that SIT for Natal fruit fly is not yet feasible, and that this species is thus only controlled by bait applications, there has not yet been any indication that this species is increasing in numbers in the Hex River Valley.

Despite a number of constraints, the Hex River Valley Pilot Project achieved its goal. Further details are provided by Barnes *et al*. (2004) and Barnes (2007). Aerial releases of sterile flies were carried out until 2003, when the high cost of hiring the release plane for just this one area forced the release strategy to be changed to ground releases, primarily in home gardens and backyards on farms and in urban areas (Barnes 2007; Barnes *et al*. 2006). Also due to economic forces, the production and distribution of sterile Medflies was commercialized in 2003 through the formation of a private company – SIT Africa (Pty) Ltd (Barnes *et al*. 2006). After the Hex River Valley Pilot Project became fully commercial in 2003, the sterile fruit fly release programme was extended to two additional fruit production areas.

The possible introduction of new exotic fruit fly pests into the country is a potential threat to the export fruit industry. The recent introduction and spread of exotic fruit flies onto the African continent has emphasized the need for South Africa to develop a prevention and reaction programme to improve the awareness, detection and control of exotic pests. The exotic fruit fly species that have been introduced into Africa are melon fly, *Bactrocera cucurbitae* (Coquillett); peach fruit fly, *B. zonata* (Saunders), and most recently the Asian fruit fly, *B. invadens* Drew, Tsurutu & White. *B. zonata* and *B. cucurbitae* currently cause great economic losses in Africa over a wide range of hosts. Although little is known about the biology of *B. invadens*, all indications are that it is highly invasive and extending its host range (Drew *et al*. 2005). These species constitute the basis of the South African exotic fruit fly action plan. The early detection of any pest incursion provides for quicker, easier and low cost eradication. Quarantine measures are aimed at preventing exotic fruit fly introductions, but introductions still take place worldwide. The quicker they can be detected, the better eradication programmes can be implemented as part of a country's contingency plans.

This article describes the evolution of the South African fruit fly SIT programme, the challenges facing the programme, and outlines the National exotic fruit fly detection programme.

STERILE MEDFLY PRODUCTION, DISTRIBUTION AND VENDING

The SIT Africa Medfly rearing facility in Stellenbosch currently produces 15 million sterile male Medflies per week. Production procedures, quality parameters and release procedures are discussed in detail by Barnes *et al*. (2006). These flies are eclosed at the SIT Africa facility and transported weekly to three release areas – the Hex River Valley, the Elgin/Grabouw/Vyeboom/Villiersdorp (EGVV) area, and the Riebeek Valley area. They are released by hand ('ground releases') and almost exclusively in the main fruit fly breeding areas, i.e. home gardens and backyards on farms, in other neglected host plants such as fruiting ornamental plants in natural vegetation, and in urban areas – at a density of up to 5,000 flies per ha (Barnes *et al*. 2006). The objective of these ground releases is to reduce wild Medfly populations in the Medfly breeding grounds before the flies move to the commercial orchards and vineyards during fruit-ripening and harvest.

Buy-in into the SIT programme and payment mechanisms for sterile flies by the three areas differed. In the case of the Hex River Valley, where the SIT pilot project was initiated before commercialisation of the programme, 100% commitment by the approximately 140 growers was obtained with the help of the Hex Valley Table Grape Growers Association, and the funding to finance the programme was raised through a levy on cartons of export grapes from the valley (Barnes *et al*. 2004). In the case of the other two release areas – the EGVV area and the Riebeek Valley area which joined the programme after commercialisation – 100% buy-in by all growers was not obtained and as a result an across-the-board levy in each area was not possible. Growers made individual decisions whether or not to join the programme, and payment for sterile flies was through contracts between individual participating growers and SIT Africa (Barnes 2007).

SIT RELEASE AREAS

Progress with the Hex River Valley programme up to 2002, and the subsequent challenges following the privatisation of SIT in South Africa in 2003, are fully described by Barnes *et al*. (2004) and Barnes (2007). After the privatisation of SIT, two additional fruit production areas joined the Medfly SIT programme in 2004 – the EGVV area in January and the Riebeek Valley area in August. The three areas are between 100 and 200 km distant from one another. The total area of fruit protected by SIT in these areas is approximately 15,000 ha. Each area had an SIT coordinator who was supported by laboratory and field staff.

HEX RIVER VALLEY

The areas treated with sterile Medflies, and all procedures except for the release technique, have remained as described by Barnes *et al*. (2004). In 2003 aerial releases were replaced by ground releases as described above for economic reasons. The release strategy was as follows (I. Sutherland, personal communication):

In De Doorns town: 1 bag of sterile males (5,000 fliers) in each of 12 strategic hotspot localities, distributed over the whole town. Extra bags allocated to sites with higher wild fly populations. Approximate average release rate = 2,000 sterile males/ha.

In rural (e.g. farm) gardens and hotspots: An average of 1 bag per average-sized garden/hotspot in each of 340 release sites. Extra bags allocated to sites with higher wild fly populations. Approximate average release rate = 5,000/ha.

Commercial plantings: No sterile flies were released in these areas.

Releases continued throughout the year. Each week 352 bags of flies were released by hand into approximately 500 ha of backyard and hotspot areas in the three sub-areas. Releases over these 500 ha therefore 'protected' commercial fruit plantings of approximately 7,000 ha in extent.

EGVV AREA

The area comprises three sub-areas, viz. Groenland, Vyeboom and Villiersdorp, which are approximately 10 km apart. There are 13,000 ha under fruit cultivation in these areas, of which 90% comprise apples and pears, and the remainder, plums, canning peaches, nectarines, apricots, and table and wine grapes. Due to economic forces, not every farm took part in the sterile fruit fly release programme, so there were many non-SIT zones within each sub-area. In the Groenland area there were 45 farms in the programme, comprising 3,205 ha of fruit; in the Vyeboom area, 25 farms comprising 860 ha of fruit; and in the Villiersdorp area, 35 farms comprising 1,520 ha (De V. Jooste, personal communication). The total area of commercial fruit under 'protection' by the SIT programme was therefore 5,585 ha.

There are two small towns in the area, Grabouw in Groenland, and Villiersdorp in the Villiersdorp area. Villiersdorp had significantly higher fruit fly populations (a mean FTD of 3.03 over 3 years) than Grabouw (mean FTD of 0.31 in 2002) due to the higher number of fruit fly host plants in home gardens, more commercial stone fruit in the immediate area, and higher temperatures. Both Medfly and Natal fruit fly occur in the area, but, as in the Hex River Valley, Medfly predominates. Typical of most fruit production areas in the Western Cape, fruit fly populations were lowest from June to February, and reached a peak from March to May (De V. Jooste, personal communication).

Before SIT. Fruit fly population fluctuations were monitored weekly with Chempac Yellow Delta Traps baited with trimedlure, at a density of 1 trap per 25 ha. This density was increased in areas where populations were higher, and in the towns was 1 trap per 5 ha.

Up to December 2003 the only fruit fly control intervention was the application of a protein + malathion bait, weekly in summer, and every 2 to 3 weeks during the rest of the year. Bait was applied only to commercial orchards by the individual growers according to their routine programme.

During the SIT programme. Digital maps comprising colour ortho photos of the area were obtained and the SIT areas were divided into 50 ha grids. An area SIT Co-ordinator and four Sub-area Co-ordinators were appointed. The Sub-area Co-ordinators distributed the sterile flies to the release points, and conducted the trapping and baiting of gardens and backyards, and host plant management and sanitation of these areas and commercial orchards. The last two actions were carried out in conjunction with the participating growers. Four Assistants helped with baiting and host plant management.

Fruit flies were monitored using Multilure traps baited with the 3-component lure, at a density of 1 trap per 50 ha in commercial orchards and 1 trap per 25 ha in urban areas. Bait was applied to all home gardens and backyards on participating farms, and to host plants in other fruit fly hotspots such as neglected fruit trees and along rivers etc. Either a protein + malathion bait or GF-120 was used, as well as attract-and-kill bait stations in the town of Villiersdorp.

Sanitation comprised clean-picking all fruit from the trees after harvest (i.e. removing all fruit left behind on the trees by the pickers), and picking up all fallen fruit. This fruit was either sealed in large plastic bags and left in the sun or taken to a local dumpsite.

The first releases of sterile Medflies took place in January 2004. Sterile flies were released in all gardens and backyards (farm and town) in the three areas, and in stonefruit orchards on all participating farms due to the host suitability of these fruits for fruit flies. The release strategy was as follows (De V. Jooste, personal communication):

In Villiersdorp town: 1 bag of sterile males (5,000 fliers) per every 2nd house in every street. Approximate average release rate = 3,400 sterile males/ha.

In rural (e.g. farm) gardens and hotspots: 1 bag per average-sized garden. Approximate average release rate = 4,190/ha.

In stonefruit orchards: Goal – 2,000 sterile flies per ha. In practice, 1 bag per ±2.5 ha; flies were hand-released in two 'bursts' of flies from each bag, each burst about 50 to 100 m apart in the rows. Approximate average release rate = 1,870/ha.

Each week 576 bags of flies were released by hand into approximately 980 ha of backyard and hotspot areas in the EGVV. In other words, releases over these 980 ha protected commercial fruit plantings of approximately 5,585 ha in extent.

As commercial fruit orchards were harvested, sterile flies for these areas were diverted from harvested orchards to hotspots, home gardens and backyards in the area. Releases were stopped entirely for 3 weeks in June, being mid-winter and when field staff took leave. When releases were resumed, all sterile flies were placed in the hotspot areas; releases resumed in commercial orchards in November.

RIEBEEK VALLEY AREA

This area was also divided into three sub-areas; Riebeek Kasteel, Halfmanshof (about 20 km from Riebeek Kasteel), and Piketberg (about 30 km from Riebeek Kasteel). There was 2,183 ha under fruit cultivation in the SIT programme, of which 80% consisted of table grapes, 17% citrus, and 3% stonefruit. In the Riebeek Kasteel sub-area there were 15 farms in the SIT programme comprising 312 ha of fruit; in the Halfmanshof sub-area, 30 farms comprising 1,013 ha of fruit; and in the Piketberg sub-area, 15 farms comprising 858 ha of fruit. There are two small towns a few kilometres apart in the Riebeek Kasteel sub-area, Riebeek Kasteel and Riebeek West which supported large populations of fruit flies. Both Medfly and Natal fruit fly occur in the area, but Medfly again predominates. Natal fruit fly occurred in low populations from about October to February, and appears to be associated with the ripening of loquats and quinces at that time. Fruit fly populations were once again lowest from June to February, and reached a peak from March to May (J. Geldenhuys, personal communication).

Before SIT. From August 2003, when preparations for the SIT programme were initiated, fruit fly population fluctuations were monitored weekly with Chempac Yellow Delta Traps baited with trimedlure, at a density of 1 trap per 25 ha. This density was increased in areas where populations were higher, and in the towns was 1 trap per 10 ha.

Until July 2004 fruit fly control was as for the EGVV area – ground applications of a protein + malathion bait to commercial orchards by individual growers according to their routine programme. In addition, a single aerial application of a protein + malathion bait was applied in December.

During the SIT programme. As in the case of the EGVV area, the SIT areas were divided into 50 ha grids on colour ortho photos. An area SIT Co-ordinator, an Assistant Co-ordinator, two sterile fly Release Assistants and one Laboratory Assistant were appointed. The Assistant Co-ordinator was also responsible for fruit fly monitoring, baiting of fruit fly hotspots on farms, sanitation and host plant management, data management and public relations. The Release Assistants distributed the sterile flies to the release points, and assisted with sanitation and bait application in the towns.

Monitoring, sanitation and bait application was as described for the EGVV area. The first releases of sterile Medflies took place in August 2004, and was carried out in a similar way to the EGVV area with the following differences (J. Geldenhuys, personal communication):

In the two towns: 1 bag of sterile males (5,000 fliers) per every 2nd house in every street. Approximate average release rate = 3,000/ha.

In rural (e.g. farm) gardens and hotspots: 1 to 2 bags per average-sized garden. Approximate average release rate = 5,000/ha.

Commercial orchards: No flies were released in these areas.

Each week 500 bags of flies were released by hand into approximately 500 ha of backyard and hotspot areas in the three sub-areas. Releases over these 500 ha therefore 'protected' commercial fruit plantings of approximately 2,180 ha.

Releases continued throughout the year. However, for 2 weeks in June all sterile flies were released in the two towns only.

RESULTS OF STERILE FRUIT FLY RELEASES

HEX RIVER VALLEY

Figure 1 illustrates the fluctuation in the wild Medfly population from 3 years before to 7 years after the start of the sterile release programme. Before releases Medfly populations peaked at between 3.5 and 4.5 flies/trap/day (FTD). With one exception (2005), the populations after sterile releases were always smaller than before sterile releases, peaking at between 0.5 to 3.5 FTD. The 2005 season was an exception, with wild Medfly populations at least as high as before releases. This was an exceptional fruit fly season throughout all Western Cape fruit production areas and is ascribed to an unusually warm and dry winter when fruit fly survival would have been higher than during the normal cold and wet winter.

Wild fly populations in the town of De Doorns have been substantially reduced to the point that the town is no longer considered a fruit fly hotspot (data not shown). Most wild flies were found in farm gardens and backyards in the rural areas (I. Sutherland, personal communication).

EGVV AREA

The fluctuation in the wild Medfly population from 3 years before to 3 years after the start of the sterile release programme is given in Figure 2. Before sterile releases wild fly populations peaked at between 5 and 6.5 FTD. After releases, with the exception of the first year (2004) there was a marked reduction in the wild Medfly populations during 2005 and 2006 (peak FTDs of just over 2 and 0.5 respectively). The high population in 2004 is ascribed to the fact that releases commenced in January 2004, shortly before wild fly populations normally peak. The sterile males were therefore released into an environment which already had substantial populations of wild females, and could not have been expected to affect the wild fly population to any great extent.

RIEBEEK VALLEY AREA

Figure 3 shows the average wild fly populations one season before and two seasons after sterile releases in the Riebeek Kasteel sub-area. The 35 farms on which traps were placed were divided into two groups – 13 farms in relatively close proximity to the towns of Riebeek Kasteel and Riebeek West, and 22 farms situated further away from these urban areas. This was done to illustrate the effect of the proximity of an infested urban area on wild Medfly populations in commercial plantings in the area.

The effect of the very high wild Medfly populations in 2005, the first year of sterile releases, is clearly evident in Figure 3 – there

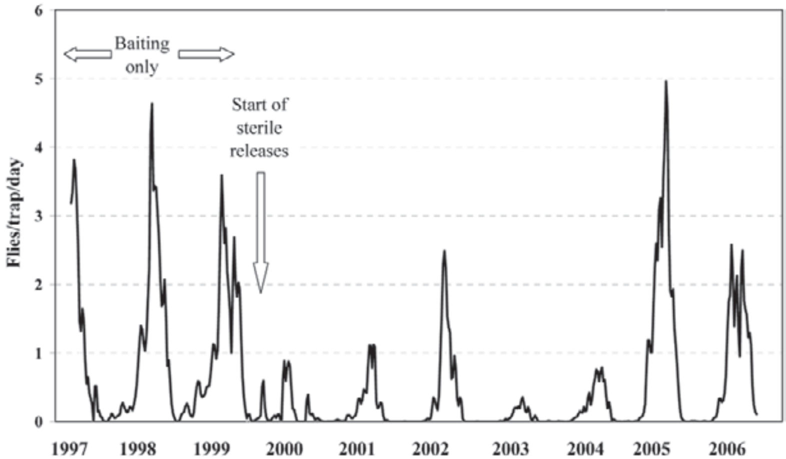

Figure 1. Average number of wild Medflies per trap per day in the Hex River Valley before and after the release of sterile males (2-week moving average).

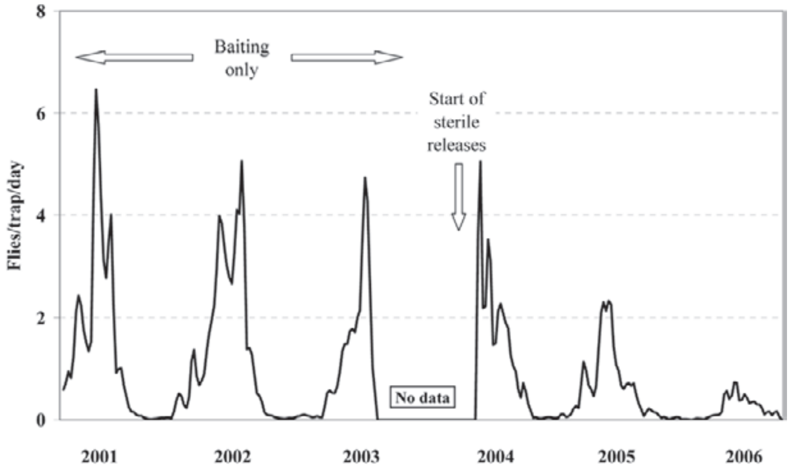

Figure 2. Average number of wild Medflies per trap per day in the Elgin, Grabouw, Vyeboom and Villiersdorp area before and after the release of sterile males (2-week moving average).

was no decrease in wild fly numbers in areas either close to or further away from the urban areas; there was in fact a significant increase in the area close to the towns, to a peak of 30.5 FTD. In 2006, however, the situation was different. Close to the urban areas the population peak was lower than in either 2004 (before releases) or 2005, but still very high at a level of 17.6 FTD. Away from the towns the release programme suppressed the peak to 5.8 FTD, considerably lower than the 15.5 FTD in the year before releases.

A similar pattern was evident from the Halfmanshof sub-area (far from any urban area), although in this area the only pre-SIT figures were from 2002. Populations peaks were as follows: 2002, 14.4 FTD; 2005, 4.8 FTD, 2006, 2.7 FTD (graph not shown).

CONSTRAINTS COMPROMISING SUCCESS OF SIT PROGRAMME

While reductions in wild Medfly populations did occur following the implementation of the SIT programme, populations have not been reduced to the low levels normally associated with a highly successful SIT suppression programme – e.g. below 1 FTD. Besides the very high wild fly populations throughout the Western Cape fruit production areas in 2005, there are a number of economic, operational and cultural factors which have compromised the success of the SIT programme in South Africa. These have been discussed at length by Barnes (2007). Other factors include:

- Poor compliance with good fruit fly management practices such as host plant management, sanitation and baiting.
- The use of cross-pollinators in orchards. These trees are interplanted with the commercial varieties and can comprise up to 10% of the trees in an orchard. The fruits ripen early and are generally not removed from the orchard, thus serving as ideal fruit fly hosts. Examples are Santa Rosa plum, Keiffer pear and hillierii crab apple.

THE FUTURE OF SIT IN SOUTH AFRICA

Due to financial constraints the current objective of the SIT programme is the cost-effective suppression of Medfly using an ecologically compatible technique. However, the ultimate goal of the programme is the creation of one or more fruit fly-free areas or areas of low fruit fly prevalence, whichever is acceptable and applicable to importing countries. In order for the programme to progress towards this goal it will be necessary i) to develop and implement SIT for Natal fruit fly, and ii) to extend the area under SIT so that there is a sufficiently large area under SIT for both species to justify the implementation of quarantine measures.

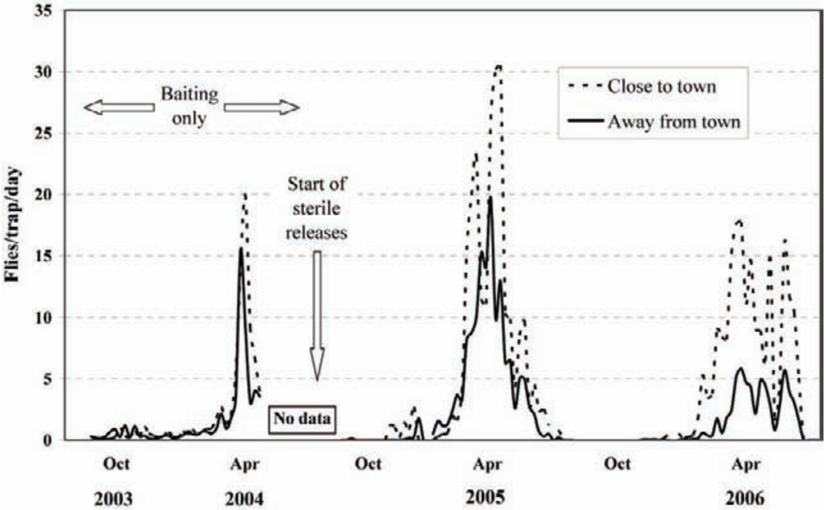

Figure 3. Average number of wild Medflies per trap per day in the Riebeek Kasteel area before and after the release of sterile males, nearby and further away from the urban area.

SIT FOR NATAL FRUIT FLY

Research is still needed to enable SIT for this species to be implemented. An artificial larval diet for Natal fruit fly has been developed (Barnes 1976), but needs to be refined to make large-scale mass-rearing of this species feasible. Unlike Medfly, Natal fruit fly females do not oviposit through gauze screens, and so a different technique will be needed to harvest eggs in large numbers from this species. For small-scale rearing Barnes (1976) developed an egg collection method for this species using plastic funnels, but a more cost-effective method will be needed for the large-scale rearing necessary for an SIT programme. This will be researched in the near future.

EXTENSION OF SIT TO OTHER PRODUCTION AREAS

Besides the research and development needed to implement SIT for Natal fruit fly, Medfly SIT will need to be extended to many more fruit production areas in South Africa in order to create one or more fruit fly-free areas. A number of challenges will have to be met to achieve this, including the production of less expensive sterile Medflies and greater buy-in into SIT by growers. The lack of sustainable funding for SIT is one of the greatest deficiencies in the quest for fruit fly-free areas. The many factors influencing the wider use of SIT in South Africa are discussed in greater detail by Barnes (2007).

However, advances in the application of SIT must be accompanied by systems to prevent exotic fruit fly species entering and becoming established in South Africa. The establishment of even one such species would severely compromise any area-wide fruit fly management programme.

THE NATIONAL EXOTIC FRUIT FLY ACTION PLAN

Pest fruit flies are spreading easily from one country to another through accidental introductions via infested fruit. The risk of introducing new fruit fly species into South Africa is increasing as trade with and travel to the country increases. The implications of an exotic fruit fly pest entering and becoming established in South Africa are significant. Firstly, there will be a loss in local production capacity that will likely affect food security in especially rural areas. Secondly, the possible introduction of an exotic fruit fly pest into the country can potentially ruin the export fruit industry which is currently worth approximately US$1.2 billion annually. It would also severely compromise the current fruit fly SIT programme, the ultimate purpose of which is to establish fruit fly-free areas. The recent introduction and spread of exotic fruit flies onto the African continent has emphasized the urgent need for South Africa to develop a fruit fly prevention and reaction unit to better the awareness, detection and control of such exotic pests.

Two Directorates in the National Department of Agriculture, viz. the Directorate Plant Health (PH) and Agricultural Product Inspection Services (APIS), jointly form the National Plant Protection Organization (NPPO) of South Africa. As a signatory member of the International Plant Protection Convention (IPPC) the NPPO is obligated to have surveillance programmes to detect pests as far as its capacity allows. Declaration of pest free areas has an added advantage for trade. The Division PH Early Warning Systems has been initiated to develop detection and contingency plans that will eventually form part of the country's Disaster Management Plans.

Due to a lack of capacity, the fruit fly action plan not only focuses on an integrated approach for the surveillance of fruit flies, but also on generic capacity building and training.

The generic focal areas identified are to:

- develop standard operating procedures
- develop surveillance protocols
- increase diagnostic capacity
- determine roles and responsibilities within contingency plans
- ensure data management
- develop an alert web-based system
- ensure that the legislative capacity is in place in terms of the disaster management actions, and to ensure funding for the expansion of the projects, and to expand all of this to a regional level
- increase pest awareness.

THE EXOTIC FRUIT FLY THREAT

The melon fly (*Bactrocera cucurbitae* [Coquillett]), Asian fruit fly (*B. invadens* Drew, Tsurutu & White) and peach fruit fly (*B. zonata* [Saunders]) have been determined as posing the highest risk for entering and becoming established in South Africa. These species are well established from East Africa to West Africa and as far south as Tanzania. *B. cucurbitae* has also become established in Egypt and on the Indian Ocean islands of Mauritius, Réunion and Seychelles (CABI 2005). *B. invadens* was first detected only 3 years ago and has rapidly spread in and between East and West African countries as well as in the Comores. It readily attacks domesticated fruit such as mango, guava, citrus and tomato, as well as wild fruit such as marula and monkey orange (Drew *et al*. 2005). It appears that the rapid spread was due to truck traffic between African countries. Roadside fruit sellers contributed to the spread when truck drivers purchased fruit from these sellers to eat along the way and then drove from one country to another.

B. zonata also poses a high risk as it occurs in Egypt, the Indian Ocean islands of Mauritius and Reunion. It has a wide host range, is economically important, and could become established in the subtropical areas in the Eastern parts of South Africa, and in the Mediterranean climate of the Western Cape (IAEA 2000).

The highest risk in South Africa for *entry* of exotic fruit flies is at Johannesburg, Cape Town and Durban (all with international airports), based on the high international traveler frequency, and the Beitbridge and Lebombo border posts, based on the high frequency of vehicular traffic from other African countries. The highest risk areas for *establishment* of exotic fruit flies, based on suitable climatic and host plant conditions, are Durban (KwaZulu-Natal province) and Lebombo, Komatipoort, Malelane and Nelspruit (Mpumulanga province), and in the fruit-growing areas of the Western Cape province.

SOUTH AFRICAN SURVEILLANCE PROGRAMME FOR EXOTIC FRUIT FLIES

The surveillance programme started as a new project in April 2006. Trapping protocols, procedures and training have been provided by the Directorate PH Early Warning Systems. Execution of the programme is effected by the Directorate APIS, research institutes, universities, fruit industry organisations and provincial departments of agriculture.

The surveillance programme is divided into two protocols.

Protocol one: Port of entry (POE) detection. This protocol covers the possible introduction of exotic fruit flies at and close to POEs. It includes the POE itself plus the area around it, normally an urban area. A 5 km grid system is used to establish trapping points in urban areas. The POE itself, hotels and refuse dumps are targeted selectively regardless of the grid interception points. The number of trapping sites is allocated as objectively as possible and based on availability of funds and capacity. Some of the towns close to border posts are also targeted as they often serve as an overnight stop and as a dump for excess or infested fruit (Table 1).

Table 1. Ports of Entry and nearby areas identified and targeted for surveillance of exotic fruit fly species using traps with different lures (2006/07).

Port of Entry or adjacent town	Nº. of trapping sites	Methyl eugenol traps	Cuelure traps	Trimedlure traps
Beitbridge	1	1	1	1
Lebombo	1	1	1	0
Oshoek	1	1	1	0
Groblersbrug	1	1	1	0
Musina	4	4	4	1
Komatipoort	1	1	1	1
Vioolsdrift	1	1	1	1
Nelspruit	7	7	7	1
Durban	25	25	25	2
Cape town	25	25	25	2
Johannesburg	25	25	25	2
Port Elizabeth	12	12	12	1
East London	6	6	6	1
Pretoria	25	25	25	1

Protocol two: Fruit production area and line detection. This protocol covers the establishment of exotic fruit flies in fruit production areas where the most damage can be caused, and covers fruit fly introduction in the production areas and nearby national roads. The objective is to form a line of surveillance traps in production orchards close to national roads between towns. In certain cases the POE also falls inside a production area and a joint approach may be implemented.

Trap and lures used. The type of trap(s) used is based on the IAEA's Trapping Guidelines (IAEA 2003) and depends on the lures available, ease of use, operator expertise, the physical environment, and available funding. These traps include Tephri traps, modified Lynfield traps or Chempac Yellow Delta Traps (modified Jackson traps), or a combination of these.

The traps are baited with one of the following: methyl eugenol (for *B. zonata* and *B. invadens*), and cuelure for *B. cucurbitae* (White & Elson-Harris 1992; Drew *et al*. 2005). There are no naturally occurring fruit fly species of economic importance in South Africa known to be attracted to methyl eugenol, but several of the commonly occurring *Dacus* spp. are expected to be attracted to the cuelure traps (White & Elson-Harris 1992). Ten percent of the total number of traps in any area are baited with trimedlure to serve as controls to attract the three *Ceratitis* spp. that occur in South Africa (*C. capitata, C. rosa and C. cosyra*).

Trapping density at ports of entry. The major challenge in the surveillance programme is to develop a trapping density at POEs that is serviceable with the available capacity. With the current capacity, at a major POE such as Durban, it is possible to handle one methyl eugenol trap and one cuelure trap per 5 km grid in a 400 km^2 block, However, the 5 km distance between traps is so large that a fairly high infestation will already be present in the area if only one fruit fly per trap is detected (Meats 1998). The objective is to increase the trap density on an annual basis until the traps are 1 km apart. The trapping grid is implemented within a 40 km radius of the POE, and the traps within each grid are rotated to increase the sensitivity of the detection system.

Servicing of traps. Traps are visited once to four times a month, and more frequently whenever adverse weather conditions such as excessive rain occur.

Sampling and Diagnostics. Although South Africa does not have an abundance of fruit fly taxonomists, a line of taxonomic support has been established. All fruit flies collected from traps are collected and sent to the national survey coordinator in Pretoria. Early Warning Systems (EWS) personnel document the information and the fruit fly specimens are sent to the Biosystematics Division of ARC Plant Protection Research Institute in Pretoria for identification. Any fruit flies that cannot be identified locally will be referred to relevant international experts for identification (e.g. British Natural History Museum).

GIS database and spatial analysis. Effective data management is essential to the success of the surveillance program. A GIS substation has been developed within the EWS Division and EWS personnel have been trained to capture incoming pest information such as surveillance programme data. All data are captured and stored on a centralized database.

Future plans allow for increasing the data-capturing efficiency by providing access to the database through a remote internet link where data capturers at remote sites can add or update invasive pest data such as fruit fly surveillance data on a shared web site. This will assist Southern African Development Community (SADC) members to participate in the surveillance.

Fruit fly awareness. The fruit fly action plan has a strong pest awareness component. Most of the EWS Division's awareness support comes from the Plant Health Curriculum and Promotions Division, which helps build relationships with the necessary role-players to ensure adequate pest awareness. EWS personnel are also developing technical information such as posters and pamphlets for distribution by Plant Health Promotions. The EWS Division is expanding its awareness potential by developing a Pest Alert website where new and high priority invasive pest information is placed to facilitate quick, transparent and easy notifications of new fruit fly pest incursions

EXOTIC INCURSION REACTION PLAN

As soon as a suspicious fruit fly species is detected in a trap or from any other source, an emergency fruit fly identification procedure is activated. This identification will take preference over any other species identification in the process.

A single positively identified quarantine species or suspect species can trigger immediate quarantine measures. A delimiting survey of 1 trap per 400 m^2 will follow until a zero trap catch has been maintained within a 5km radius of the last positive catch for two life cycles. An area of 5 km around the incursion will immediately be quarantined. Different quarantine zones (Q zones) around the incursion will be enforced. A 5 km broad buffer zone will be set up starting 5 km from the last positive trap catch determined in the delimiting survey.

Notification of all new pests will be conducted through the International Phytosanitary Portal of the IPPC and directly to neighbouring countries and trading partners.

Control measures. The control action plan will be intiated with a feasibility study immediately after the delimiting survey, to decide which control measures to use. The NPPO will make the decision between containment, eradication or no control measures. Key indicators will be the size of the area infested, environmental conditions and the fruit production activities in the area. If either eradication or containment is considered feasible, population reduction methods will be implemented.

Internationally accepted techniques will be used in a systems approach. Major actions will include male annihilation, the bait application technique, collection and destruction of fallen fruit, and increased public awareness actions. Constant monitoring will take place in the areas to determine population reduction, and the area will be delimited throughout the period that official control measures are active.

The movement of fruit out of the quarantine areas will be controlled. Area-wide control measures such as SIT, where relevant, will also be considered. The possibility of building capacity in SIT within the country is being investigated. The finer details of control procedures are species-specific and will also be dependent on the size of the infestation.

CONCLUSION

Some 10 years ago South Africa had no fruit fly SIT programme and therefore no demonstrated commitment towards ultimately creating fruit fly-free areas to protect its lucrative export fruit industry. Likewise, there was no National Exotic Fruit Fly Action Plan to prevent exotic fruit fly species invading South Africa, thus threatening the fruit industries and the SIT programme. Despite severe budget restrictions and many constraints, significant progress has been made towards both these programmes. The release of sterile Medflies now protects some 18,000 ha of commercial fruit in three production areas, and if additional funding for the programme can be found, it should be extended to additional fruit production areas with the ultimate objective of creating fruit fly-free areas. Research on mass-rearing Natal fruit fly will hopefully enable this species to be included in the sterile fruit fly release programme.

The formation and development of the National Exotic Fruit Fly Action Plan over the past year has seen a significant increase in the country's capability of detecting and eradicating any incursions of exotic pest fruit flies before they can harm the fruit industries. Although budget and capacity constraints are hampering the optimum development of this action plan, the objective is to systematically improve the action plan. The degree of success in sharing costs and responsibilities with all entities involved in the agricultural sector may influence the way South Africa conducts fruit fly surveillance in the future. It is essential for Government to build partnerships with the agricultural industry, research institutions and universities to jointly address and combat exotic fruit fly incursions. This is a sure and sustainable way of building capacity so that an integrated regional fruit fly action plan can be executed.

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