AUSVETPLAN

Disease Strategy
Screw-worm fly
Version 3.0, 2007

AUSVETPLAN is a series of technical response plans that describe the proposed Australian approach to an emergency animal disease incident. The documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency-management plans.

Primary Industries Ministerial Council
This disease strategy forms part of:

AUSVETPLAN Edition 3

This strategy will be reviewed regularly. Suggestions and recommendations for amendments should be forwarded to:
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IMPORTANT NOTE: Important regulatory information for screw-worm fly
is contained in the OIE Terrestrial Animal Health Code which is updated
annually and is available on the internet at the OIE website:
http://www.oie.int/eng/normes/en_mcode.htm. Further details are given in
Appendix 3 of this manual.
Preface

This disease strategy for the control and eradication of screw-worm fly (SWF) is an integral part of the Australian Veterinary Emergency Plan, or AUSVETPLAN (Edition 3). AUSVETPLAN structures and functions are described in the AUSVETPLAN Summary Document.

This manual has been produced in accordance with the procedures described in the AUSVETPLAN Summary Document and in consultation with Australian national, state and territory governments and the relevant industries. This version of the manual was approved by Primary Industries Ministerial Council out-of-session at meeting 09/48 (2007).

The OIE (World Organisation for Animal Health, formerly Office International des Epizooties) has included both New World SWF and Old World SWF in the OIE list of notifiable diseases. This obliges OIE member countries, previously considered free of SWF, to notify the OIE within 24 hours of confirming the presence of SWF.

The principles contained in this document for the diagnosis and management of an outbreak of SWF are consistent with the OIE Terrestrial Animal Health Code (see Appendix 3).

In Australia, SWF is included as a Category 2 emergency animal disease in the Government and Livestock Industry Cost Sharing Deed In Respect of Emergency Animal Disease Responses (EAD Response Agreement). Category 2 diseases are emergency animal diseases that have the potential to cause major national socioeconomic consequences through very serious international trade losses, national market disruptions and very severe production losses in the livestock industries involved. Category 2 also includes diseases that may have slightly lower national socioeconomic consequences, but also have significant public health and/or environmental consequences. For this category, the costs will be shared 80% by governments and 20% by the relevant industries (refer to the EAD Response Agreement for details).

Detailed instructions for the field implementation of AUSVETPLAN are contained in the disease strategies, operational procedures manuals, management manuals and wild animal manual. Industry-specific information is given in the relevant enterprise manuals. The full list of AUSVETPLAN manuals that may need to be accessed in an emergency is:

1 Information about the EAD Response Agreement can be found at: http://www.animalhealthaustralia.com.au/programs/eadp/eadra.cfm
Disease strategies
Individual strategy for each disease
Response policy briefs (for diseases not covered by individual manuals)

Operational procedures manuals
Decontamination
Destruction of animals
Disposal
Public relations
Valuation and compensation

Management manuals
Control centres management
(Parts 1 and 2)
Animal Emergency Management
Information System
Laboratory preparedness

Enterprise manuals
Artificial breeding centres
Dairy processing
Feedlots
Meat processing
Poultry industry
Saleyards and transport
Veterinary practices
Zoos

Wild animal manual
Wild animal response strategy

Summary document

In addition, three publications are sources for some of the information about the aetiology, diagnosis, epidemiology and control of the disease and should be read in conjunction with this strategy:


The complete series of AUSVETPLAN documents is available on the internet at:
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1 Nature of the disease

Screw-worm flies (SWF) are ‘blowflies’ of the family Calliphoridae. The larval stages of SWF are obligate parasites of warm-blooded animals, including humans. Infestation and damage of animal tissues by SWF larvae (myiasis) causes serious livestock production losses in countries where the flies occur.

1.1 Aetiology

SWF myiasis is caused by the larvae (maggots) of two species of flies: *Chrysomya bezziana* (Old World SWF) and *Cochliomyia hominivorax* (New World SWF). After hatching, SWF larvae feed on fresh tissues and associated fluids of live animal wounds. The adult fly of both species is typical of calliphorid blowflies in shape and basic colour, having a metallic blue/green/black body with a yellowish-orange face. Both species have similar biological and climatic requirements and, although they normally exist in different geographical regions of the world, there is no reason why their respective geographical ranges could not increase and/or overlap, especially from the movement of SWF-infested animals.

1.2 Susceptible species

All warm-blooded animals are susceptible, although the greatest economic losses are experienced in cattle, sheep and goats. Australian native fauna have been shown to be susceptible, but the degree of susceptibility for most species is unknown. Humans are occasional hosts.

1.3 World distribution and occurrence in Australia

The Old World SWF occurs throughout much of Africa, the Middle East, the Indian subcontinent and much of Southeast Asia, including Indonesia, Timor Leste, the Philippines and Papua New Guinea (PNG). The New World SWF is endemic in parts of Central and South America as far south as Argentina. Figure 1 shows the world distribution of both species. New World SWF has been eradicated from the United States, Mexico and several Central American countries, where it was previously endemic, by using the sterile insect technique (SIT). An outbreak in Libya in 1988 was eradicated using SIT (utilising sterile flies sourced from the American New World SWF program). A significant increase in Old World SWF myiases and its spread to previously free areas was recorded in Iraq in 1996 and subsequent years, prompting urgent action to control the fly using conventional (non-SIT) methods, and limit its spread to neighbouring countries (Al-Izzi 2002).
Figure 1  World distribution of screw-worm flies

Source: Mahon (2005)
While there have been two reported detections of SWF in Australia, SWF has never become established. In 1988, several adult Old World SWF were trapped in an empty livestock vessel in Darwin harbour. The vessel had just returned from delivering cattle to Brunei (Rajapaksa and Spradbery 1989). In 1992, New World SWF larvae were identified in a lesion on the back of the head of a person who had just returned to Australia from a visit to Brazil and Argentina (Searson et al 1992). The Darwin harbour incident led to a re-examination of the SWF risks posed by the Australian livestock export trade. This included intensive monitoring of 18 livestock shipments from Darwin to 39 Southeast Asian ports. However, no on-board SWF activity was detected during any of those shipments (Thompson 1992).

While Old World SWF has been regarded as the same species throughout its range, its broad geographic distribution (from southern Africa to PNG) and the likely long-term nature of that distribution, raises the possibility of evolving strain divergence (sibling species) between regions. Such differences, if present, could impair the effectiveness of a SIT response if the SIT colony were sourced from a population different from the incursion strain. Several studies, using different analytical techniques, have attempted to identify differences between strains sourced from various locations throughout the Old World SWF range. Studies discussed by Mahon (2002a) demonstrated a surprisingly high degree of genetic similarity between regions. In contrast, analyses by Hall et al (2001) of mitochondrial DNA indicate that Old World SWF from sub-Saharan Africa is a different race from Old World SWF in the Persian Gulf region and Asia, and that this latter race has two distinct groupings — one from mainland Asia and the other from PNG. An earlier study by Spradbery (1988) clearly demonstrated that Old World SWF strains derived from diverse geographical regions would mate under laboratory conditions, and produce viable, fertile offspring.

1.4 Diagnostic criteria

For terms not defined in the text, see the Glossary.

1.4.1 Clinical signs

Infestation with SWF may be insidious, covert and readily missed, even with close examination. The disease is not necessarily spectacular and may not occur on an epidemic scale. Given suitable environmental and host circumstances, however, SWF infestations can be dramatic and devastating.

SWF is an obligate wound parasite, requiring soft tissue of living warm-blooded animals for larval development. Clinical signs are frequently related to the site and severity of infestation. Thus, a severe infestation will cause systemic disease in its own right, irrespective of the site, while a light, superficial infestation may go unnoticed, unless it results in functional disturbance (for example, infestation of a limb).

Apart from infestations of sheep, and the umbilical region of newborn animals (a common site for SWF infestation), SWF infestations are usually associated with traumatic injury, erosive or ulcerative lesions of the skin, or haemorrhage. In sheep, SWF has the ability to strike the intact inner corner (medial canthus) of the eye and the perineal region of ewes without obvious trauma or haemorrhage. Foot abscess is another source for myiases in sheep. Purulent lesions (that is, lesions with pus) can also become infested. Myiases are frequently observed in companion
animals in endemic areas. For a description of Old World SWF myiases in dogs in an Old World SWF infested region see Chemonges-Nielsen (2003) and McNae and Lewis (2004).

Signs of infestation include the presence of a ragged, foul-smelling lesion containing larval SWF, constant licking of the lesion by the animal, initial hypersensitivity followed by apparent decreased sensitivity of the lesion, restlessness of affected animals, fever, lethargy, loss of appetite, debilitation, decreased growth rate, anaemia and hypoproteinaemia. Expansion of lesions into body cavities is common, and peritonitis following navel infestation, sinusitis following dehorning and pleuritis following thoracic infestation all occur. Infestations of the muscles can result in restricted movement.

1.4.2 Pathology

Gross lesions

Lesions caused by SWF commence with early larval invasion of the disrupted epidermis and aggregation of the larvae in small cavities. The larvae are bathed in small quantities of watery fluid and are visibly active in the cavities. With their hook-like mouth parts they rasp living, soft tissue and feed on the resulting secretions, growing quickly. Within 24 hours, the cavities enlarge and extend laterally and deeply into subcutaneous tissue and muscle. A serous blood-stained exudate is evident at this stage due to progressive liquefactive necrosis of muscle, skin and other tissues. Continuing larval growth and invasion can cause large cavernous lesions (provided there is sufficient soft tissue available) with irregular ragged edges. The depths of the lesion contain a mass of larvae immersed in copious quantities of necrotic, fibrino-purulent or liquefied tissue and blood. Bleeding from the lesion may be severe, and the surrounding tissue is tense, oedematous and hot to the touch. Lesions emit a characteristic pungent sickly odour.

By 6–7 days, in uncomplicated cases, mature larvae actively migrate from lesions and recovery occurs. Fibrous granulation tissue grows beneath the infested areas, with attempts at muscle and epithelial regeneration. Uncomplicated lesions will resolve. An initial large infestation and/or further strikes on an already struck wound can lead to massive soft tissue destruction and wound expansion. Associated functional impairment and necrosis can result in severe clinical disease, debility and death. Earlier studies suggested that wound attractiveness for SWF was greater if SWF larvae were already active in a wound (Spradbery 1994). More recent evidence (Mahon et al 2004) indicates that wound attractiveness is more a function of ageing of a wound (for at least three days).

Myiasis due to SWF must be differentiated from myiasis due to other blowfly larvae. Often, SWF myiasis is complicated by secondary blowfly strike. The secondary larvae are normally present towards the surface of the lesions and not deeply embedded, as is the case for SWF larvae.

Humans

In human cases, which are not uncommon in endemic areas, myiasis often occurs in the neck or scalp, but may occur in other parts of the body. Serious complications, including death, have resulted from infestations of the nose, eyes, ears and mouth. Any weeping sores in people recently returned from regions
where SWF is endemic should be closely examined for larvae (see Appendix 6 for medical management of SWF myiasis in humans in Australia).

1.4.3 Laboratory tests

Intact SWF larvae can usually be identified by their morphological features. For diagnosis, 5-20 larvae should be collected from deep in the suspect wound. Forceps may be used, but care must be taken to avoid damage to the larvae. Larvae on the surface of wounds are usually from secondary strike flies and are best avoided.

The larvae should be dropped into water that has just boiled and left for 1–2 minutes to kill them and preserve their shape and colour. They should then be transferred to a container of 70% alcohol, such as methylated spirits (see Appendix 5 for an example of information provided with kits for the identification of maggots).

Wild adult flies are seldom seen in the field, but can be caught in traps baited with specific attractants and occasionally in ultraviolet (UV) light-based insecticutors. State veterinary entomologists trained in the diagnosis of SWF can identify both larvae and adults that are intact and relatively free of contamination.

A procedure using DNA technology is now available for diagnosis of Old World SWF, either individual flies or parts of them (CSIRO Entomology and Biosecurity Australia 2004).

CSIRO Division of Entomology is recognised as a centre for SWF identification, using both morphology and DNA testing.

For further details on the morphological diagnosis of SWF, see Spradbery (1991).

1.4.4 Differential diagnosis

SWF should always be included as a differential diagnosis whenever flystrike occurs in cattle and whenever there are deep flystrike lesions in any other animal or in humans.

Under extensive grazing conditions such as occur in Australia, the first indication of SWF strike might be a heavy loss of neonatal calves or lambs, or debility and occasional losses throughout the herd or flock.

The clinical signs of SWF myiasis, including its characteristic smell, should arouse suspicion even though the entry wound may be small and unobtrusive. Weeping skin sores in recently imported pet animals should be closely examined for larvae.

1.5 Resistance and immunity

Different species of animals vary in their susceptibility to SWF strike, but this variation is often correlated with their susceptibility to wounding or their provision of favourable sites for oviposition by SWF in the absence of wounds. Cattle seem a particularly favoured host and, along with sheep, which are often struck in the absence of an obvious wound, produce a multiplying effect on fly populations.
Certain breeds of cattle, such as the Bali breed (*Bos javanicus*), are reputed to be highly resistant to Old World SWF, although the mechanism of this resistance is unknown. It is not known whether this alleged resistance is due to immunological factors or other innate host factors developed by natural selection.

### 1.5.1 Vaccination
To date, no commercial vaccine has been developed to protect against SWF myiasis. However, work on the feasibility of such vaccines for Old World SWF indicates that it may be possible to use various larval antigens to inhibit larval growth and even to increase larval mortality. Willadsen (2002) provides an overview of recent work on, and possible future directions for, the development of Old World SWF vaccines.

### 1.6 Epidemiology

#### 1.6.1 Infestation
Wounding is usually a prerequisite for SWF strike, except in newborn animals and sheep (see Section 1.4.1).

In all animal species, infestation commonly follows parturition. The navel region of the newborn and the vulval or perineal region of the dam, particularly when traumatised, are principal sites of infestation. Husbandry procedures such as dehorning, castration, branding, tail docking and ear tagging can lead to SWF infestation. In Australia, the technique of ‘mulesing’ sheep, without adequate prophylaxis, would provide ideal sites to establish SWF infestations. Traumatic injuries due to barbed wire or other penetrating objects are also commonly infested. Skin punctures caused by cattle tick and the lesions associated with buffalo fly infestations are known to be attractive to SWF.

These conditions could produce substantial SWF populations in northern Australia. The ability of SWF to establish strikes in sheep without obvious wounding is potentially significant for the Australian sheep industry.

#### 1.6.2 Life cycle
The life cycle of Old World SWF and New World SWF is illustrated in Figure 2. The eggs are laid on the edges of wounds or in body orifices in masses of up to 250 for Old World SWF and up to 400 for New World SWF. The eggs are cemented tightly together like a shingled roof. The egg mass is characteristically white and compact compared with those of secondary *Chrysomya* species, which lay yellowish eggs in loose masses that can be readily brushed off the host’s body. SWF eggs hatch in approximately 12–14 hours (10 hours at 37°C).
The first-stage larvae begin feeding superficially on wound fluids. Within 24 hours of hatching, the larvae penetrate the wound and moult into the second stage. Some 42–45 hours after hatching, the larvae enter their third and final stage. Larval development occurs over 5–8 days, and most have evacuated the wound after 7 days of feeding. Larval evacuation occurs mainly during darkness, peaking between midnight and dawn. Female larvae tend to evacuate wounds earlier than males. The majority of larvae leaving the wound after 6 days of feeding are female, with a high proportion of males on day 8.

After larvae vacate their wound and fall to the ground, they burrow 2–3 cm into the soil, turn around in the tunnel they have created and, within 24 hours, pupate. Pupariation is the formation of a hard sclerotised pupal case from the larval cuticle. Within the puparium, the insect changes into an adult fly. Adult emergence occurs after 7 days at 28°C, but may be considerably delayed if the weather is cool.

Most flies emerge just before dawn, with little or no emergence during daylight hours when sunlight and diurnal predators could affect fly survival. The sex ratio of emerging adults is 1:1.
During the first few days of adult life, females become sexually mature and receptive to mating. Little is known of the behaviour of the male SWF, for they are very reclusive in the field and seldom trapped. American studies on New World SWF suggest that males form mating aggregations on bushes and trees and fly at any small object passing by. If it should be a female SWF, they fly to nearby vegetation to mate.

The female SWF does not normally require protein in her adult diet to develop her first batch of eggs, but will feed on protein if it is available. This speeds egg development and matures more eggs. Females normally mate only once, but a male can inseminate several females during its lifetime.

The various stages in the development of the ovaries can be used as a means of ageing females, an important factor in ecological studies. When the females become gravid, they search for suitable hosts upon which to lay their eggs. Observations carried out on the hot coastal plain around Port Moresby in PNG, together with laboratory experiments, have shown that oviposition occurs mainly in the late afternoon and continues until dusk. In this way, most egg masses are not exposed to lethal amounts of solar radiation.

SWF can lay several egg masses during their lifetime, although it is rare to find females in the field laying more than two masses. The average lifespan of Old World SWF adults is 15 days, but some flies have survived 40 days in the laboratory at 28°C. The life cycle can be completed in 20 days under ideal conditions.

The single mating of the female SWF forms the theoretical basis of SIT — formerly known as the sterile insect release method (SIRM). Saturation of the environment with artificially reared sterile SWF results, theoretically, in the majority of wild females mating with sterile males and thereby producing sterile eggs. This can dramatically reduce SWF populations and, if maintained for several generations, can achieve eradication. See Section 2.2.6 for details of SIT.

### 1.6.3 Factors influencing transmission

The SWF is an opportunist and can survive in the right environment both at very low adult fly density and at very low host density.

Adult SWF occur in relatively low numbers in the wild and are not readily found by field observation. Natural population densities are not considered to exceed 200 flies per square kilometre. Adults prefer well-wooded riverine areas and moist, well-shaded areas and are unlikely to survive in completely open country, particularly if subjected to intense heat and low humidity. However, they will survive in hot and dry conditions provided some vegetation is available as shade and as a carbohydrate source. The optimal temperature range for the fly is 20–30°C. Cold has a very adverse effect. Flies will not move at temperatures below 10°C, and in the range 10–16°C they are very sluggish and probably will not mate. Significantly, no stage of the fly’s life cycle is resistant to freezing, so overwintering in frost areas does not occur. In Malaysia’s tropical environment, adult Old World SWF abundance was strongly influenced by weather conditions (rainfall and average daily temperature) 15–28 days earlier (Mahon et al 2004). Similarly, increased Old World SWF strike rates were observed in dogs in Hong Kong when weather conditions were wetter and warmer (McNae and Lewis 2004).
While it is known that the number of SWF an area can support is very much dependent on the availability of wounded hosts, there is little information on the minimum density of hosts required to sustain a population. The fly can persist without domestic livestock, provided there are populations of wild animals.

SWF do not actively migrate, but female flies may disperse widely in search of wounded animals. Old World SWF has been found to disperse over distances of more than 100 km, while a single specimen of New World SWF was reported to have dispersed 290 km (Spradbery 1991). Such dispersal is more likely when the density of likely host animals is low and the female has to range widely to complete her life cycle. Rapid, long-distance spread of the disease in Australia could certainly result from transport of infested animals.

Predicting the likely rate of spread of an incursion without intervention, especially some time before the event, would be difficult because the rate of spread is dependent on various and variable factors. Rates of 10–25 km per week (favourable conditions for spread) and 2–10 km per week (less favourable conditions) were used for SWF preparedness planning purposes in 1990 (DPIE 1990). In the absence of any relevant findings since then, it would seem reasonable to use similar rates as guides for any further planning (provided that the uncertainties of the estimate were clearly understood).

The incidence of SWF strikes in livestock is influenced by husbandry practices. In Southeast Asia, where the majority of cattle and buffaloes are owned by smallholder farmers, there is little economic impact when animals are closely supervised. On the other hand, SWF has become a serious problem where animals are grazed extensively and are not closely supervised to identify the need for early treatment.

### 1.6.4 Susceptibility to insecticides

SWF are highly susceptible to a broad range of insecticidal chemicals. For practical purposes, insecticides are predominantly targeted at the larval stages. Some insecticides, however, do have a significant repellent effect against adult SWF. The use of insecticides, for treatment and prophylaxis, would be essential in any program to control an SWF incursion in Australia and to minimise its economic impact.

Insecticide resistance, if present (or if it develops) in an introduced strain of SWF, could impact on programs where insecticides are used to control or eradicate the incursion. Where there is widespread use of particular insecticides, there is always the potential for resistance to develop in both the target and nontarget species. In spite of widespread use of insecticidal chemicals in both Old World and New World SWF-infested areas in the world, relatively little insecticide resistance has been reported for either species. However, experience with other insect pests suggests that resistance would develop with extensive use of a limited range of insecticides in Australia.

For further information on disinsection, see Sections 2.2.4, 2.2.5 and 2.2.8.
1.7 Manner and risk of introduction to Australia

For many years, it was speculated that Old World SWF would advance across the Torres Strait and enter Australia via Cape York. Although long and intensive monitoring has confirmed that there is not a major risk (except for the possibility of an infested animal being illegally transported from countries to Australia’s north), vigilance needs to be maintained. Dead Old World SWF adults have been collected from livestock vessels returning from the Middle East and Southeast Asia and from aircraft. The only two known incursions of SWF into Australia (see Section 1.3) illustrate the diverse risks of introduction of the pest.

Past experience in the United States and Mexico suggests that the primary risk of SWF introduction in those countries was associated with the importation of infested animals. Infested humans and other means of entry present a lower risk.

Figure 3 shows the predicted Australian distribution of SWF in the tenth year following an incursion commencing in January (year 1) through Brisbane. Provided the same modelling parameter settings (such as time of incursion, weather conditions, stock densities, control strategies) are used, the distribution patterns predicted for most other coastal entry points in northern Australia, given time, would be similar to this simulated incursion.

Source: JC Walthall, Animal Health Australia, 2005

**Figure 3** Predicted Australian distribution of screw-worm flies in the tenth year following an incursion through Brisbane, given ‘average’ weather conditions each year
2 Principles of control and eradication

2.1 Introduction

If screw-worm fly (SWF) entered Australia, it would not necessarily become established. The response to an incursion would depend on the circumstances of the incursion. For example:

- **Adult flies identified through trapping on a vessel or aircraft at or near an Australian port.** An appropriate control response should include intensive surveillance around the entry port, supplemented with a public awareness campaign over a wider area to alert primary producers, veterinarians, stock and meat inspectors, health workers, wildlife rangers, companion animal owners and others to be on the lookout for myiasis in animals and humans.

- **Adult flies identified through trapping at or near an Australian port.** In such circumstances it would, in all probability, be difficult to determine the immediate origin of the flies (for example, they might be escapees from a vessel recently returned from an SWF area or a subsequent generation of introduced SWF). In addition to the elements listed above, an appropriate response should also consider the immediate implementation of animal movement controls (see Section 2.2.1).

- **SWF myiasis identified.** This would be an indication that SWF had become established, and immediate consideration should be given to the implementation of
  - animal movement controls (see Section 2.2.1);
  - intensive tracing and surveillance programs (see Sections 2.2.2 and 2.2.3);
  - control and prophylaxis programs (see Sections 2.2.4 and 2.2.5); and
  - a sterile insect technique (SIT) program (see Section 2.2.6).

After detection, the initial aim would be to define the geographical distribution of the adult SWF while limiting the dispersal of SWF by myiasis cases. The natural dispersal of adult females in search of a suitable host would be difficult, if not impossible, to control, but adults are unlikely to disperse widely if suitable hosts are readily available.

The ultimate tool in SWF control and eradication is SIT (see Section 2.2.6), which can achieve eradication if maintained for several generations. SIT would take some time to initiate and gear up to a level of production necessary to attempt either the creation of a buffer zone to limit spread, or total eradication.

Given that considerable time (several years) would be needed to establish and implement a SIT program, active control and preventive programs would be required to minimise the impact and spread of SWF during this period.
2.2 Methods to prevent spread and eliminate SWF

Early detection of an incursion would greatly assist a successful outcome for any control strategy. Good public awareness (see Section 2.2.12) and widespread, targeted surveillance (see Section 2.2.3) are central to such detection. Areas for targeted surveillance should include those considered to be at higher risk, for example northern Cape York, the ‘Top End’ of the Northern Territory and Western Australia, as well as ports of entry for returning livestock vessels or international travellers.

2.2.1 Quarantine and movement controls

An important principle of control is to limit the size of the outbreak and to minimise SWF population growth, given the tools available at the time. This is assisted by declaration of infested premises (IP) as well as any dangerous contact premises (DCPs) and suspect premises (SPs). A restricted area (RA) will be declared around the IP and, depending on circumstances, a control area (CA) may also be declared outside the RA (see Appendix 1 for further information on declared areas). Movement controls should be applied to ensure that animals with SWF myiasis are not transported within or out of any declared area (see Appendix 2). Of course, adult female SWF dispersal will still occur, but experience has shown that short-term widespread dispersal of SWF is largely due to the movement of infested animals.

Predictive modelling of Old World SWF outbreaks in Australia has shown that, without intervention, dispersal will eventually allow Old World SWF to occupy the full extent of its bioclimatic niche (Atzeni et al 1993). This modelling also indicates that, given time (and no SIT-based intervention), the final distribution of an Old World SWF incursion into Australia would be independent of the incursion’s entry point. Experience overseas, however, shows that quarantine and movement controls can dramatically slow the spread of the infestation by means other than natural dispersal.

For an example of the predicted distribution of an incursion of Old World SWF in Australia, see Figure 3. Note that this prediction is based on an assumed incursion via Brisbane, in its tenth year, with ‘average’ weather conditions throughout and no SIT-based controls.

Provided the wounds of infested animals in a movement group are treated and all animals in the group are treated prophylactically, the whole group may be moved once reinspection shows that no viable SWF material remains.

While movement restrictions needed for SWF control may not be as onerous or strict as for many other diseases, the overall response to an incursion, especially in the earlier phases when SIT is not available, will be very dependent on effective movement controls.

2.2.2 Tracing

Trace-back for SWF is a useful surveillance and monitoring tool. The disease can remain undetected for considerable periods, especially when at low prevalence or in remote areas where there is little opportunity to closely inspect animals for evidence of disease.
In the Americas, public cooperator provide trace-back data for infested animals when submitting larval specimens. A questionnaire normally seeks details of all animals that have moved onto infested premises during the previous two weeks.

Consideration should be given to extending trace-back periods in more extensive or remote areas to at least six weeks (equivalent to two generations of SWF), given the lower probability of detecting the introduced generation of SWF in such areas.

### 2.2.3 Surveillance

It is important to establish the geographical distribution of SWF as soon as possible after initial detection and to continue to monitor its spread thereafter. Active surveillance should be implemented in an area around the detection. In determining the size of the surveillance area, consideration needs to be given to the likely dispersal of female SWF from the area. Where the density of appropriate hosts is low, the surveillance area needs to be extended to at least 150 km (to allow for two generations of infestation and dispersal of 25 km per week) from the detection site to take into account the likely dispersal of the female SWF. The surveillance techniques used for initial detection are also appropriate for determination of the geographical extent of an outbreak.

**Sentinel animals**

Wounded cattle, sheep or goats, which are preferred hosts of SWF, may be used as sentinels. Where available, naturally wounded animals (eg animals exposed to ticks or buffalo fly, animals undergoing routine husbandry procedures) can be efficient lures for SWF. Neonatal calves and lambs are useful because they provide a very attractive natural wound in the umbilical stump and are relatively easy to handle. Dogs would also be useful sentinels.

To be effective, a sentinel group of animals would require a susceptible wound to be available within the group at all times. If enough naturally wounded animals are not available, consideration may have to be given to deliberate wounding of sentinels. However, such action would require prior approval of relevant animal welfare authorities. Where deliberate wounding is utilised, several animals are required for each sentinel group so that at least one wound is available while surveillance is undertaken. All sentinel animals should be provided with appropriate care and protection. Animals can be rotated.

A sentinel animal grid (up to 150 km radius) maintained around the initial focus for 12-16 weeks will provide useful monitoring of SWF activity. Sentinels should be concentrated according to livestock density and other factors such as meteorological conditions, geography (eg river systems, accessibility) and personnel availability. As a rough guide, provide for:

- 30 sentinel groups within 50 km radius of initial detection focus;
- a similar number of sentinel groups between 50 and 100 km radii; and
- a similar number of sentinel groups between 100 and 150 km radii.

The emphasis of the above strategy is to detect if spread has occurred from the initial focus (higher concentration of sentinel groups closer to initial focus). Once spread from the initial focus is established, surveillance emphasis should be
altered to assess the extent or rate of spread. This would require the concentration of sentinel groups to be redirected away from the initial focus. However, such a change would require more surveillance groups to maintain a similar surveillance density as was initially applied within the 50 km radial.

Sentinels can be kept in existing yards or in portable yards and, if possible, should be placed under light vegetation near watercourses. Wounds should be monitored daily, with any egg masses or larvae collected for identification. Larvae should not be allowed to fully develop outside a secure laboratory.

**Adult SWF traps**

Various systems are available for trapping adult SWF. Some traps utilise combinations of organic chemicals as attractants, while others rely on ultraviolet (UV) radiation to attract. Different trapping mechanisms are used, including sticky boards, enclosures with insecticide strips, and electrocution. Adult SWF traps can be used to supplement sentinel animal surveillance. Whether such traps could completely eliminate the need for sentinel animal surveillance remains unclear, as current understanding is that surveillance based on adult trapping is inferior to that based on wounded animals.

Where adult traps are used for surveillance, their exact positioning would depend on geographical and stock density considerations at the time of the outbreak. As a guide, a network of 80 traps is distributed within a radius of 150 km from the initial focus as follows:

- 30 within 50 km radius;
- 30 between 50 km and 100 km radii; and
- 20 between 100 km and 150 km radii.

As with sentinel animal groups, the above trapping strategy is designed for detection of spread from an initial point, with trap density being greater closer to that point. To assess the extent or speed of spread from a known point, trapping density should ideally be the same, irrespective of the distance from the last known point. However, such a strategy would be demanding of resources.

Preferably, traps used for active surveillance would be serviced daily. This servicing, which can be extended, and the consequent laboratory examinations of trapped flies will require considerable resources, especially if other related calliphorid flies are plentiful. The traps are best positioned in light tree cover such as thickets, as adult SWF tend to avoid areas devoid of cover. It may also be preferable to modify the trap pattern according to the location of watercourses in the area.

Any improvements to attractants would be beneficial. It is theoretically possible that a very efficient attractant could have a major effect on adult female densities, especially in areas of intense activity (‘hot spots’).

Insecticutor traps will catch SWF, as the flies are attracted to UV light. However, UV traps are inefficient in most situations where adult SWF density is comparatively low. In certain situations (such as on ships, in stables and in other
enclosed areas), insecticutors may be used to supplement a grid of traps using chemical attractants.

**Inspection of animals**

An important surveillance technique is the regular inspection of animals on premises such as farms, feedlots, abattoirs, saleyards, livestock export facilities and zoos. SWF-infested wounds produce a characteristic odour that, to an experienced ‘nose’, can be an initial indication of infestation in a group of animals. Extensively grazed animals can be inspected from horseback or vehicle. While not developed for SWF to date, other very sensitive technologies for detecting specific smells, such as ‘sniffer’ dogs and ‘electronic noses’, should be able to assist in the detection of SWF lesions. SWF surveillance could be complemented by surveys of feral animals and wildlife. (See the [Wild Animal Response Strategy](#) for survey techniques.)

**Community-assisted (passive) surveillance**

As well as the active surveillance techniques described above, an appropriate public awareness program should be implemented. The program should describe the signs to look for and encourage reporting by healthcare providers, veterinary practitioners, farmers, owners of pets and the community (see also Section 2.2.12). This should cover a much larger area than active surveillance.

Well-informed and cooperative members of the public can effectively carry out inspections, especially if they are likely to suffer economic loss from the disease. All myiasis cases should be treated as suspect and investigated.

### 2.2.4 Treatment of infested animals

In any incursion of SWF into Australia, the use of chemical pesticides to treat infestations and to protect animals from strike will be a significant component of the response. The strategic use of insecticides was pivotal to the successful eradication of New World SWF from the United States, northern parts of Central America, and Libya.

The general principles for myiasis treatment include the following steps:

1. preliminary cleaning of the wound and its surrounds with warm water and mild antiseptic;
2. physical removal, using forceps, of as many larvae as possible;
3. collection and destruction of removed larvae (eg using hot water or insecticide);
4. retention of 10 or more killed larvae in 70–80% alcohol for identification and surveillance (Spradbery 1991);
5. application of effective topical treatment to the wound to kill any remaining larvae; and

For further information on treatment of Old World SWF myiases in animals, see Ahmad (2002), Chemonges-Nielsen (2003) and McNae and Lewis (2004).
Australian registered chemicals with known efficacy against Old World SWF are listed in Table 1.

The range of chemicals available for the control of Old World SWF in Australia was reviewed in 2005 (Green et al 2005). This work assessed chemical products under the following categories:

1. registered for animal use in Australia and with a claim against Old World SWF;
2. registered for animal use in Australia, with known effectiveness against Old World SWF but with no current claim;
3. registered for animal use in Australia, with likely effectiveness against Old World SWF but with no current claim;
4. chemicals registered outside Australia for Old World SWF or New World SWF control; and
5. other chemicals that might be effective but have yet to be evaluated.

The full review, plus any subsequent updates, is available on the Animal Health Australia (AHA) website.2

The review concluded that many chemicals previously identified for possible use against Old World SWF are no longer available in Australia. The review also found that most products registered in Australia and identified as being effective against Old World SWF have not been registered in Australia for Old World SWF control. Given an incursion, however, these products could be approved for emergency use by the Australian Pesticides and Veterinary Medicines Authority at short notice.

At June 2005, ivermectin, administered by subcutaneous injection, was the only active constituent of any product registered in Australia with a claim against Old World SWF. Comprehensive in vitro, pen and field trials, including dose titration studies, demonstrated the efficacy of injectable ivermectin (Spradbery et al 1985). At 200µg/kg bodyweight, the residual protection provided against Old World SWF was a minimum of 14 days in pen trials and 16–20 days in field trials using cattle with castration and branding wounds. Treatment of Old World SWF strikes containing larvae 2–5 days old demonstrated complete mortality of larvae up to 2 days old and a progressive decline in mortality with age of larvae to 21% at 5 days old. Injectable ivermectin at 200µg/kg bodyweight protected newborn calves against navel strike and prevented reinestation of Old World SWF wounds for 10–11 days (Perkins 1987). Injectable formulations of ivermectin are currently available for use in beef and dairy cattle.

The attractiveness of wounds to SWF does not appear to be affected by ivermectin, so gravid females will still oviposit on the wounds of treated animals. However, the larvicidal effect of ivermectin is such that, for 16–20 days after treatment, no emerging larvae will survive. The use of ivermectin requires a withholding period, and this needs to be considered for animals moving for slaughter. There are no registered products for sheep with a claim against Old World SWF. However,

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there are many products containing a range of chemical classes that are registered for the control of other parasites and that could be utilised in the event of an SWF incursion. These include products based on organophosphates, synthetic pyrethroids, insect growth regulators, macrocyclic lactones, closantel and spinosad.

<table>
<thead>
<tr>
<th>Active constituent</th>
<th>Class/MOA</th>
<th>Formulation</th>
<th>Registered claim for Old World SWF</th>
<th>Registration status (protective period in days)</th>
<th>Cattle</th>
<th>Sheep</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prophylactic efficacy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ivermectin</td>
<td>ML/6</td>
<td>Injection</td>
<td>Yes</td>
<td>R (16–20)</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ML/6</td>
<td>LA injection</td>
<td>No</td>
<td>R</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ML/6</td>
<td>SR bolus</td>
<td>No</td>
<td>NR(^a)</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ML/6</td>
<td>CR capsule</td>
<td>No</td>
<td>–</td>
<td>R (135)</td>
<td></td>
</tr>
<tr>
<td>Doramectin</td>
<td>ML/6</td>
<td>Pour on</td>
<td>No</td>
<td>R</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>Closantel</td>
<td>Salicylanilide/NA</td>
<td>Oral</td>
<td>No</td>
<td>NR</td>
<td>R (8–15)(^b)</td>
<td></td>
</tr>
<tr>
<td>Zeta-cypermethrin</td>
<td>SP/3</td>
<td>Ear tag</td>
<td>No</td>
<td>R</td>
<td>NR (150)</td>
<td></td>
</tr>
<tr>
<td><strong>Treatment of existing strikes (little residual protection)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diazinon</td>
<td>OP/1B</td>
<td>Wound dressing</td>
<td>No</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Chlorfenvinphos</td>
<td>OP/1B</td>
<td>Wound dressing</td>
<td>No</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Spinosad</td>
<td>Spinosyn/5</td>
<td>Wound dressing</td>
<td>No</td>
<td>NR</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td><strong>Concurrent treatment: acaricides (little residual protection)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cypermethrin</td>
<td>SP+OP/3+1B</td>
<td>Dip/spray</td>
<td>No</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Chlorfenvinphos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CR = controlled release; LA = long acting; ML = macrocyclic lactones; MOA = mode of action classification (see IRAC website www.irac-online.org); NA = not available; NR = not registered; OP= organophosphate; SP = synthetic pyrethroids; SR = slow release; R = registered

\(^a\) Registered in New Zealand

\(^b\) 15 mg/kg dose rate

**2.2.5 Prophylaxis and suppression of SWF populations**

Australia’s key SWF stakeholders (livestock industries and governments) have agreed on a new preparedness strategy for SWF (PISC 2004). One of the decisions underlying that strategy is that an SWF-specific sterile insect production facility will not be built before an incursion of SWF into Australia. Given the time required to plan, build and commission such a facility (estimated to be several years), a SIT response is, therefore, unlikely to be implemented until three or more years after the initial detection. During this time, SWF control will depend on preventing the movement of infested animals (quarantine); detecting and treating infested
animals; continuously redefining the limits of infestation; forecasting likely future areas of infestation and spread (through predictive epidemiology); providing timely and relevant information; treating individual animals prophylactically; and limiting the growth of SWF populations through large-scale preventive (prophylaxis) activity.

To maximise the potential of larger-scale prophylaxis (across herds or regions) to minimise the spread and impact of SWF, authorities will need to ensure that the prophylaxis is implemented, especially where and when it is recommended from epidemiological prediction. This may require the authorities to officially order the prophylaxis. Clearly, such strategies should be based on sound epidemiological analysis.

Chemicals that provide prolonged protection against SWF strike will be vital in minimising the impact of an incursion on individual animals, herds and flocks, and in restricting the overall availability of suitable wounds. Some SWF population control might be possible if such chemicals are used broadly across herds, flocks and regions.

Currently, registered chemicals that provide residual protection against Old World SWF are limited to ivermectin, closantel and zeta-cypermethrin. Slow-release bolus formulations of the macrocyclic lactones, which can give more than 100 days protection in cattle, are registered in New Zealand (Holdsworth 2002), although not in Australia. Slow-release capsules are registered for endoparasite control in sheep and offer the possibility of prolonged protection, but have not been assessed against Old World SWF. Slow-release ear tag formulations of zeta-cypermethrin, currently registered in Australia for buffalo fly control in cattle, have been reported to provide extended protection for treated animals against SWF infestation (Tozer and Spradbery 2002), and therefore could play an important protective role against Old World SWF.

Some caution has been expressed that zeta-cypermethrin protection may be due to a repellent property of the pyrethrins rather than insecticidal action, and that this may cause adult SWF to disperse more widely (Wardhaugh and Mahon 2002). There are very few proven, long-acting chemicals for SWF protection and zeta-cypermethrin ear tags are already registered for buffalo fly control in Australia. It is expected, therefore, that the tags would be used widely for SWF prophylaxis, especially in areas where frequent mustering is impractical. Clearly, any dispersal effect would need to be assessed as part of an ongoing research and development program.

Although efficacy against Old World SWF is the prime consideration in choice of chemicals, other aspects must also be considered. These include residues in meat and milk and consequent market restrictions; the impact on dung-breeding fauna; and the potential for chemical resistance development (Wardhaugh and Mahon 2002).

The review by Green et al (2005) concluded that there is relatively little insecticide resistance in Old World SWF populations around the world. Thus, an incursion of Old World SWF is unlikely to have pre-established resistance, especially for the chemicals that would be used in Australia. However, any control program that relied heavily on a limited range of chemicals for an extended period would exert strong selection pressure for resistance in the introduced strain (and other
parasites). According to these authors, some insecticide resistance has been detected in some strains of New World SWF in the Americas. However, macrocyclic lactone resistance had not been reported, in spite of the widespread use of these chemicals in South America.

The potential for residues will be a particular issue in lactating dairy cattle and will limit chemical options. However, dairy cattle are yarded frequently and can readily be inspected, and any new infestations can be treated with nonpersistent chemicals. Zeta-cypermethrin ear tags have a nil milk withholding period and may be a particularly useful tool for managing SWF in dairy cattle. Most meat withholding periods are 6 weeks or less and are probably manageable in an incursion, although the ivermectin bolus has a 180-day withholding period.

There are many other chemicals that are not currently registered with the Australian Pesticides and Veterinary Medicines Authority but that could be potentially useful to combat SWF if the pest becomes established in Australia.

2.2.6 Sterile insect technique

SIT is currently the only method of SWF control that has the capacity to eliminate the pest. The technique, which was first developed for New World SWF in the United States, is greatly enhanced by the fact that female SWF mate only once. Saturation of an infested area with artificially reared sterile SWF results in the majority of wild females mating with sterile males, thereby producing sterile egg masses. This can dramatically reduce SWF populations in treated areas and, if maintained for several generations, can achieve eradication. The technique is applicable to other insects, and there is now a substantial body of research and development evidence demonstrating the feasibility of SIT-based eradication for Old World SWF (Spradbery et al 1989, Mahon 2001).

The effectiveness of SIT depends heavily on the mating competitiveness of sterile male flies compared with their wild counterparts. Studies with sterile Old World SWF have shown relatively poor competitiveness values. Further research and development work is needed to improve the competitiveness of factory-reared flies and solve some residual production process problems (see Mahon 2002b). If not completed before an incursion, this work would be crucial to the delivery of an effective and efficient SIT response.

Overseas use

Using SIT in combination with intensive animal inspection, wound treatment, animal movement controls and quarantine, New World SWF has been eradicated from the United States, parts of Central America and from several Caribbean islands. An incursion of (exotic) New World SWF into Libya in 1987 was also eradicated using sterile flies from the North American program.

Sterile New World SWF used in the North American program have been produced at a factory in Mexico for more than 20 years. Now that New World SWF has been eradicated from North America and the northern part of Central America, authorities intend to maintain an SWF-free zone in Panama through ongoing release of sterile flies. Production of sterile New World SWF for the SWF-free zone will move to a smaller facility that is being established in Panama. The North American program has been an enormous undertaking. It began in Florida in the 1950s and has since operated virtually nonstop, with factory production operating...
24 hours a day, seven days a week. A factory for the production of sterile Old World SWF would operate on similar lines, with modifications of the rearing system.

The economics of New World SWF eradication programs have been very favourable, despite the high costs involved. Benefit–cost ratios in the United States exceeded 10:1. Bio-economic analyses indicate that eradication of Old World SWF from Australia using SIT (and complementary controls) would be both feasible and economic, despite the cost and time that would be required to mount and implement an effective SIT program. The Australian SWF bio-economic model (originally developed by the Queensland Department of Primary Industries and Fisheries on behalf of the Australian Department of Agriculture, Fisheries and Forestry [DAFF]) provides a tool for examining possible strategies for controlling an incursion of Old World SWF into Australia.

The costs involved in SIT are very high but worthwhile when considered in terms of a benefit–cost analysis and the chances of a successful outcome (see Anaman et al 1993 for more detail).

Colony establishment

Genetic material for establishing a large-scale SIT colony in Australia could be sourced initially from an overseas colony (if available) or from the incursion. Even if material is imported, a very high priority would be to establish one or more colonies based on genetic material obtained from the incursion. Selection over several generations (at least 6 months) is necessary to adapt wild strains to an efficient laboratory colony. Given the time needed to construct a production facility and Australia’s policy of not building a facility before an incursion, there should be ample time to develop colony strains adapted from the incursion.

Production and emergence facilities

Engineering design briefs for an Australian SIT program for Old World SWF have been developed for a large-scale (250 million flies per week) production facility (APC 2001a) and multiple emergence facilities (APC 2001b). These design briefs, as well as cost estimates for the proposed facilities (APC 2001c), are held by DAFF and AHA. Biological aspects of large-scale Old World SWF mass rearing are described in Spradbery (1990) and Mahon (2001).

Sterile insect production

Rearing involves obtaining eggs from egging cages, incubating the eggs on a starter diet in an initiation room, transferring the young larvae to a finishing diet, harvesting the mature larvae, providing a suitable substrate for pupation, allowing the pupae to mature, and using gamma irradiation to sterilise the pupae 48 hours before adult emergence. The pupae are then packed in fly release boxes (1500 per box) or placed in bulk on trays, and placed in climate control rooms where the adult flies emerge.

Sexual sterilisation of SWF

SWF pupae are subjected to sufficient irradiation to induce total sexual sterility in the resultant adults, hopefully without inducing other significant deleterious effects. Adult males thus produced must be able to actively seek and mate with
wild females for SIT to have any chance of success. The irradiator to be used must be large enough to meet the requirements of the SIT program and provide the correct dose of radiation with appropriate operator safety. Provision of an appropriate irradiator could be a limiting factor in delivering a SIT program.

Sterile flies are perishable, and their use requires strict adherence to temperature, packaging, shipping, storage, handling and time criteria. Quality control tests should be carried out on representative samples of each day’s production of irradiated pupae to demonstrate the sexual sterility of both male and female SWF by crossing them with fertile flies.

**Transport of pupae to emergence facilities**

Irradiated pupae can be transported safely if they are packaged appropriately (to allow sufficient ventilation) and held and shipped under controlled temperature and humidity. The North American program used refrigerated semitrailers to transport irradiated pupae from Texas to southern Mexico, a trip of over 24 hours. The small size and weight of pupae also enable them to be transported efficiently by aircraft. Irrespective of the mode of transport, economic analysis indicates that very large numbers of pupae could be transported large distances for relatively little cost. In fact, the distance between production and emergence facilities has virtually no impact on predicted benefit–cost ratios for any particular SIT program in Australia.

**Emergence facilities**

Sterile flies are normally released as young adults. As adult flies are far more susceptible to damage than pupae during storage and transport, standard practice is to emerge sterile flies close to release areas.

The essential elements of the design brief for emergence facilities are:

- each facility to be capable of emerging and packaging for release 125 million adult sterile SWF per week;
- facilities to operate 24 hours per day;
- irradiated pupae to be delivered daily from production facility; and
- emergence facilities (buildings, modules, etc) to be transportable and relocatable.

Preferably, emergence facilities should be located close to release areas to optimise the use of release aircraft and to minimise damage to flies during transit. As release areas will vary as the SIT program progresses, the benefit of having emergence facilities close to release areas will need to be ‘traded’ with the logistical costs of facility relocation.

**Sterile insect aerial release**

Two technologies are currently available for the dispersal of sterile flies. The first involves placing a predetermined number of pupae in small cardboard boxes, then dropping the boxes from aircraft after the flies have emerged. This is labour intensive and has largely been replaced by the ‘chilled fly’ method.
The ‘chilled fly’ method entails emerging flies in bulk in a small room and then chilling them so that they become virtually immobilised. When ready for dispersal, chilled flies are loaded into a metal box that is placed in an aircraft designed to hold three boxes, or approximately 4.4 million flies.

Sterile flies are normally distributed by specially modified aircraft with a dispersal machine and fabricated chute to the exterior. Boxed flies are fed into the chute, where the venturi effect pulls the box apart as it exits the aircraft. Chilled flies are fed (sucked by the same venturi effect) into a tube leading to the exterior of the aircraft. Infested zones and surrounding buffer areas are traversed by parallel flight lines 1.5 km apart. These lines are drawn to minimise deadhead (the distances between the airport and the start of the dispersal line and between the end of the dispersal line and the airport). Sterile flies are dispersed at predetermined aircraft speed and height and at a rate that will result in a ratio of 10–20 sterile flies for every estimated wild fly. Dispersal crew ensure that assigned rates of fly release are achieved and that sampling for quality control is undertaken. When ambient temperatures exceed 25°C, flights are made during the earlier, cooler part of the day. Precise details of procedures are available for New World SWF from the United States Department of Agriculture. Very similar procedures would likely be adopted for Old World SWF.

Monitoring of SIT effectiveness

Sentinel animals throughout the infested area are monitored on a daily basis or twice daily if possible. Oviposition occurs more often in the late afternoon, so wounds are best examined in the evening. Egg masses are removed carefully from the edge of the wound with a sharp instrument and sent to the laboratory for culture. If no hatch occurs within 12–24 hours, it can be assumed that the fly that laid the egg mass has mated with a sterile male. Records of each collection and hatch or non-hatch are kept by location and date.

SIT information campaign

The public should be advised of the technical reasons for the SIT program and that the released sterile flies are not harmful. Animal owners must be encouraged to submit samples, as they will play a major role in assessing the effectiveness of the SIT program. Culture of egg masses from sentinels and submission of larval samples by the public and animal health authorities are used to monitor the effectiveness of the program.

2.2.7 Treatment of animal products and byproducts

As larvae of SWF are obligate parasites of living animals, there is little risk of viable larvae being transported on or in animal products or byproducts. There is a theoretical risk, however, that larvae could be moved on the carcases of recently killed animals, especially if the carcases are chilled soon after death. Therefore, carcases of animals should be inspected before removal from RAs and CAs. This is particularly important for game animal carcases.

After larvae vacate a wound, they seek a suitable environment in which to pupate, usually 2-3 cm deep in nearby soil. If larvae leave a wound while the host animal is confined (eg while in a stockyard or being transported), pupation can occur in cracks or crevices or in other areas where there is a buildup of protective organic
material such as faeces. Consequently, vehicles that may have carried infested animals need careful cleaning and sterilising (see Section 2.2.8).

Material that could contain viable SWF pupae, such as soil or manure from stockyards or washings from livestock transport equipment, should not be removed from declared areas.

2.2.8 Decontamination/disinsection

Evacuating larvae may contaminate livestock transport vehicles and examination areas where inspections are being performed. To minimise the likelihood of these larvae burrowing into soil and successfully pupating, as far as possible, all inspections and cleaning of transport vehicles should be conducted in yards or washdown areas with concrete or otherwise toughened and sealed floors.

Because of their maturity, these larvae are more likely to resist the toxic effects of many of the commonly used insecticides/acaricides. Of the chemicals currently registered in Australia, the combination of chlorfenvinphos and cypermethrin (e.g. Barricade S Cattle Dip and Spray, Blockade S Cattle Dip and Spray), while having no label claim for Old World SWF control, does have known (significant but not absolute) efficacy for Old World SWF larvae. Inspection areas that are likely to be contaminated with evacuating larvae should also be regularly steam cleaned and sprayed with an appropriate insecticide. Faeces and soil deposits in livestock transports are best removed by steam cleaning followed by high-pressure hosing to ensure not only larval destruction but destruction of any pupae as well.

2.2.9 Vaccination

There is no commercial vaccine currently available to protect against SWF strike or SWF myiasis (see Section 1.5.1).

2.2.10 Wild animal control

Native and feral animals should be left alone, and any control should be confined to activities that are unlikely to result in animals dispersing from the RA or being injured, thereby producing additional oviposition sites.

Recreational and commercial hunting should be prohibited in the RA.

Native and/or feral animals may be useful for surveillance.

2.2.11 Sentinel animals and restocking

Sentinel animals should be used for 16 weeks after the last clinical case. Sentinel animals are also used in surveillance for SWF and for monitoring the progress of a SIT program (see Sections 2.2.3 and 2.2.6).

Because SWF control measures do not involve destruction of livestock, restocking would not be necessary.

2.2.12 Public awareness

Publicity should be widespread, especially in the extensive farming areas of Australia. The aim is to make all members of the animal-owning public, and those whose work entails the inspection or examination of animals or people, fully
conversant with the clinical disease and how to report it (see Appendix 5). All myiasis cases should be investigated as a matter of course, with the possible exception of superficial myiasis in sheep.

Public awareness must be a key element of surveillance, and its importance, as evidenced in the United States and Mexico, cannot be overstated. For further information, see the Public Relations Manual.

### 2.3 Feasibility of control in Australia

Bio-economic modelling studies for Old World SWF have shown that eradication of an SWF incursion will be biologically and economically feasible using a SIT-based eradication program (Anaman et al 1993, Atzeni et al 1993). These estimates are subject to a level of uncertainty associated with the assumptions used in the models.

Where a SIT response is not implemented for several years after an incursion, as would be the case with Australia’s new policy for preparedness (see Section 2.2.5), more recent modelling studies indicate that a later, SIT-based eradication program would still be feasible and would be economical using a larger scale (~200 million/week) production facility. The success of such a program would depend on the released flies being competitive.

If SWF became geographically widely established, it would be necessary to undertake a progressively staged eradication program using SIT to provide a buffer zone, taking into account natural environmental barriers to the spread of the disease (eg cold, dry, stock-free areas) while using quarantine and movement controls and other strategies on the ground. The Australian SWF bio-economic model can be used to predict the likely spread of an Old World SWF outbreak. The model also provides a tool for examining alternative strategies and developing the most effective and economical approach.

With some other species of insect pests, highly effective attractants enable populations to be controlled, and even eradicated, using combinations of those attractants and insecticides. If similar attractants were available for SWF, large-scale control using baits could become a possibility. No suitable attractant is currently available.
3 Policy and rationale

3.1 Overall policy

Old World and New World screw-worm fly (SWF) have the potential for spread in tropical and subtropical areas and, in summer, could extend into the major livestock production areas of southern Australia. SWF would have significant impact on livestock production and public health. Both New World and Old World SWF are listed OIE diseases.

The policy is to eradicate SWF as soon as possible to minimise its economic and ecological impacts, initially using a combination of strategies, including:

- **quarantine and movement controls** in declared areas to prevent the movement of infested animals;
- **tracing and surveillance** to determine the source and extent of the infestation, and to provide proof of freedom from the disease;
- **population suppression** by large-scale prophylaxis in declared areas, where appropriate;
- **treatment** of individual animals and groups to prevent or cure infestation, especially before movement;
- **decontamination and disinsection** of larval-contaminated areas, equipment and other materials;
- **zoning** to define infested and disease-free areas; and
- **a public awareness campaign** to encourage rapid reporting of suspected infestations, and to encourage cooperation from industry and the community.

In addition, once suitable facilities are established, the following may be implemented:

- **sterile insect technique** (SIT) to control and eradicate the fly.

Successful implementation of the policy will depend on total industry cooperation and compliance with all control and eradication measures. Successful eradication could take several years to achieve.

Old World or New World SWF could cause major disruption to many animal industries if either became established. It is difficult to predict exactly how SWF disease might behave in Australia, although modelling predicts a huge suitable habitat over much of the continent, especially during summer.

The trade in the export of live animals may be marginally affected.

SWF is a Category 2 disease under the government–industry Emergency Animal Disease (EAD) Response Agreement for cost-sharing arrangements. Category 2 diseases are those for which operational costs will be shared 80% by government and 20% by industry.
The chief veterinary officers will implement disease control measures as agreed in the EAD Response Plan and in accordance with relevant legislation. They will make ongoing decisions on follow-up disease control measures in consultation with the Consultative Committee on Emergency Animal Diseases (CCEAD) and the National Management Group (NMG). The detailed control measures adopted will be determined using the principles of control and eradication (Section 2) and epidemiological information about the outbreak.

The initial phase of the EAD Response Plan will establish surveillance, quarantine and livestock movement controls around the initial incursion, and implement insect (SWF) controls in and around the incursion area. As SIT-based control will not be possible until a source of sterile SWF is available, and this is likely to take several years (see Section 2.2.6), initial insect control will be based on treatment of infested animals (see Section 2.2.4) and prophylaxis (see Section 2.2.5).

Given the expected time required to implement a SIT response to an SWF incursion, it is recognised that much of the tropical and subtropical areas of northern Australia and, seasonally, parts of New South Wales would be affected by SWF. As soon as possible after authorities have agreed to pursue an eradication response (including SIT), negotiations will be started to establish a national facility for the production, emergence and release of sterile SWF, as outlined in Section 2.2.6.

For information on the responsibilities of the state or territory disease control headquarters and local disease control centres, see the Control Centres Management Manual.

### 3.2 Strategy for control and eradication

The overall objective of an SWF response will be eradication. This will ultimately involve the implementation of an appropriate SIT program. In 2004, the Primary Industries Standing Committee agreed to a new national SWF preparedness strategy whereby a SIT facility will not be built unless an incursion occurs. The reasons for such a policy are the high costs of building and maintaining such a facility and the low risk of an SWF incursion. To minimise delays in constructing a facility should it be needed, substantial planning arrangements (eg engineering design briefs, identification of possible sites and draft funding arrangements) have been put in place (Section 2.2.6). Even with this preplanning, a SIT response is unlikely to be implemented for several years after an incursion.

The initial response to an incursion, therefore, will include a control and containment program with movement restrictions, trace-back, surveillance, a public awareness campaign, and treatment and prevention regimens designed to limit SWF population buildup, spread and impact (see Section 3.3). These strategies will be of prime importance during the pre-SIT period and need to be implemented rapidly in the state or territory of the initial incursion. Similar activities will need to follow in other at-risk jurisdictions, and it is vital that these activities are coordinated across state borders.

Complementary strategies will continue during the SIT program (see Section 3.4).
3.3 Initial program (before implementation of SIT response)

3.3.1 Containment and control

Stamping out (slaughter of all infested and exposed animals, disposal and decontamination) is not needed for the control or eradication of SWF. Some individual animals may need to be destroyed for animal welfare reasons.

3.3.2 Quarantine and movement controls

Immediately an animal infestation is reported and SWF is suspected as a possible cause, quarantine and movement controls will be imposed on all animals in the area. Quarantine actions will be taken concurrently with other measures.

Declared areas will consist of restricted areas (RAs), with suggested radii of 150 km from known infested premises (IPs), and control areas (CAs) surrounding each RA. The dimensions of CAs will depend on local circumstances but could extend up to 150 km from the RA.

Where animals have moved from an IP within three weeks before the presumed infestation of the IP, destination premises will be declared dangerous contact premises (DCPs). Until the SWF status of moved animals is resolved, an RA should be declared around the DCP.

All livestock and livestock vehicle movements associated with any declared area will be subject to permit.

Movement within or out of RAs and from IPs will be allowed subject to an initial inspection and treatment, and a further inspection before movement. All animals to be moved will be treated with ivermectin, and movement will be allowed after a further inspection 7–14 days later. Animals showing clinical evidence of SWF infestation will be sampled and treated with approved insecticidal smears/pressure packs (and also treated with systemic insecticide). All animals are to be reinspected immediately before movement.

Movement within or out of a CA will be by inspection and permit. Prophylactic treatment is normally not required.

Special arrangements will have to be made for animals to be sent for slaughter. It is essential that treatments for these classes of animals ensure that hidden cases of myiasis are not inadvertently transported, while observing the withholding period and/or slaughter interval for the product.

See Appendix 1 for further details on declared areas, and Appendix 2 for further details on quarantine and movement controls.

3.3.3 Tracing and surveillance

To detect an outbreak

Surveillance for early detection of outbreaks will rely on:

- use of sentinel animals and/or herds in high-risk areas (eg Torres Strait, Cape York, and the ‘Top End’ of the Northern Territory);
• public awareness programs for people in risk areas (e.g., rural and Torres Strait communities and pastoralists, veterinary practitioners and human health workers across northern Australia), seeking their help in reporting all possible useful information;
• monitoring at abattoirs, saleyards, livestock export facilities, ports, etc.; and
• trapping for adult SWF.

Monitoring during an outbreak

All animals that have moved from the IP during the period of at least three weeks before the presumed first infestation will need to be traced and examined. Disease control authorities will need to consider further tracing if findings from surveillance suggest that other properties in the area may have been infested by SWF during that three-week period or earlier.

Although adult SWF traps are considered less efficient than wounded (sentinel) animals for attracting and detecting adult SWF, traps still have a role to play in determining the extent of the outbreak and its rate of spread. A grid of 80 traps will need to be strategically located within the RA (see Section 2.2.3). The traps will need to be serviced on a daily basis. This servicing, and the subsequent laboratory examinations of trapped flies and other material, will require considerable trained labour resources, especially if other, related calliphorid flies are plentiful.

Adult trap grids will supplement sentinel animal grids, and will extend into CAs (see Section 2.2.3). With the concurrence of animal welfare authorities, specially prepared wounded sentinel animals will be monitored for myiasis and serviced by dedicated response teams in the field. In the case of at-risk animals such as neonatal calves, most inspection and servicing will be done by members of the public, particularly pastoralists and farmers, who will make regular telephone reports to disease control authorities.

Surveillance must include areas such as saleyards, abattoirs and livestock export facilities where large numbers of animals from a wide area congregate, providing a high-density source of stock. Surveillance using traps and animal grids, including nondedicated animal sources and areas of high livestock concentrations, must continue throughout the control/eradication campaign and for a period following eradication, to provide evidence for proof of freedom.

See Appendix 4 for further details on surveillance.

3.3.4 Prophylaxis

No vaccine is available for control of either Old World or New World SWF (see Section 1.5.1).

If epidemiological studies indicate that significant benefits would be gained from coordinated control of SWF over large areas, authorities will need to officially order animal owners in those areas to treat their animals. The treatment and its timing would need to be prescribed.

Injectable ivermectin, for cattle, is the only chemical currently registered in Australia with a claim for SWF control. However, synthetic pyrethroid ear tags,
registered for buffalo fly control in cattle, reportedly provide extended, but incomplete, protection against Old World SWF.

As animals can be wounded during mustering and yarding, routine husbandry practices should be performed with care. Provided effective prophylactic treatment, such as ivermectin, is used, normal husbandry procedures can continue. Mustering will be required if prophylaxis is to be applied on a broad scale.

The widespread use of aerial insecticides is expensive, resource intensive, nonselective, dangerous to operators and the environment, and unlikely to be efficient for use against adult SWF over extensive areas. Therefore, it is not recommended.

3.3.5 Treatment of infested and at-risk animals

Treatment of individually infested animals is effective, provided appropriate wound therapy is applied. Insecticidal wound dressing or pressure packs, combined with a systemic insecticide, are recommended (see Sections 2.2.4 and 2.2.5 for SWF treatments and prophylaxis). Injected ivermectin (200 µg/kg) provides protection against new infestations in cattle for 16–20 days, and is also recommended.

When animals are prepared for movement, treatment may need to be carried out under supervision in order for permits to be issued.

3.3.6 Treatment of animal products and byproducts

The treatment of animal products and byproducts will not be necessary.

3.3.7 Decontamination/disinsection

Manure or soil in vehicles or contained areas where infested animals have been held could act as a medium for pupation, and should be decontaminated. Decontamination of inspection areas and vehicles may be achieved by steam cleaning, followed by spraying with insecticide. Because faeces and soil deposits accumulate in livestock transports, these vehicles require high-pressure hosing between steam cleaning and insecticide spray. See Section 2.2.8 for chemical sprays to kill any remaining larvae or pupae.

3.3.8 Wild animal control

Control measures for feral animals during the pre-SIT phase should be aimed at containing them within restricted areas.

Wild and feral animals should not be disturbed unless it is absolutely necessary. All warm-blooded animal species may be affected by SWF, and any disturbance may increase dispersal of the flies. Wildlife officers would be involved.

3.3.9 Public awareness and media

Public awareness will be critically important for the surveillance and control of SWF. While resources will be limited, public cooperators can assist by servicing adult SWF traps, by maintaining sentinel animals and submitting appropriate samples, by regularly inspecting pets and recreational animals, and by immediately reporting myiases in these animals, wild animals or humans.
The industry, public and media will need to be informed about the disease and the control/eradication measures being adopted. Wide use of media resources will be required in the initial phase of the control program to keep the public clearly informed and to seek their cooperation and assistance, including the submission of samples.

3.4 Sterile insect technique

SIT has been the only method that has been able to control and eradicate the New World SWF. Australia has undertaken substantial research and development to apply SIT to the Old World SWF. While some technical issues remain to be resolved, this work has established that the eradication of an incursion of Old World SWF in Australia would be feasible.

However, an SWF-specific SIT facility will not be built in Australia before an incursion (PISC 2004). Once an incursion has been confirmed in an area and predictive epidemiology indicates that the incursion will be permanent, a SIT capacity will be developed as soon as is practical.

SIT will provide an aid to control, a means to reduce the extent of an outbreak, and eventual eradication.

See Section 2.2.6 for details of SIT planning work already done and work still required.

3.5 Social and economic effects

Using a ‘worst case’ scenario of SWF entering Australia through Brisbane, Anaman et al (1993) estimated the projected annual direct producer losses to be about $281 million. Using 2003 livestock prices, the 2005 version of the Australian SWF software model and ‘average’ seasonal conditions, direct producer losses are now estimated to be $361 million per year in this scenario. Extensive cattle properties would suffer the highest losses (73% of total producer losses). The increased costs of mustering over extensive areas, together with projected lower turn-off rates due to higher mortalities, account for a high proportion of the projected losses.

A major social impact could also be expected, especially in extensive cattle areas where, in many cases, economic viability is currently both variable and marginal.

The presence of SWF will require a change in the normal husbandry methods used in extensive areas, and add to operational costs. Animals will need to be treated prophylactically where husbandry results in wounds (eg dehorning, castration, spaying). Greater care and attention will be required for newborn animals. In more intensively farmed areas, stock will need to be regularly handled and inspected.

SWF will have little direct impact on exports, except to require certain assurances about treatments and examination to ensure freedom for livestock exports.

While Australian native animals are known to be susceptible to SWF strike (as evidenced both experimentally and at overseas zoos), the impact of an SWF outbreak on the wildlife population has not been evaluated. It is conceivable that the effects could be significant in some species and that surveillance activities by
wildlife authorities might be necessary. For further details, see the Wild Animal Response Strategy.

SWF myiasis in people and companion animals would be a concern to the public and human health authorities.

Control measures for SWF will generally be less restrictive than for most other diseases, and animal movements will not be curtailed to any great degree. However, inspections and supervised treatments will be needed and will have both economic and social impacts.

Benefit–cost analyses of previous eradication programs for New World SWF have been uniformly favourable. In the United States, they exceeded 10:1 in programs in which the pest was progressively eradicated from infested areas. Operational costs to eradicate from a limited area of infestation would, clearly, be less than for a larger area. In the Australian context, however, the economics of overall SWF preparedness depend on various factors, including the cost to establish a SIT production facility, the time from incursion to implementation of a SIT program, the size of the area to eradicate, and, very importantly, the risk or likelihood of an incursion.

All recent incursions of New World SWF into the United States have resulted from the movement of infested animals from endemic areas. Some of these cases involved legitimate movement of animals in which covert cases of SWF myiasis had escaped detection at inspection. The smuggling of animals, especially companion animals, may be significant and could have dire consequences.

### 3.6 Criteria for proof of freedom

SWF can be difficult to detect at low levels of infestation, as would occur towards the end of an eradication program. For this reason, all forms of surveillance must be continued for up to 16 weeks after the last clinical case or fertile egg mass is detected.

With SIT eradication, the aerial dispersal of sterile flies will be continued for a minimum of 8 weeks after the last evidence of fertility in SWF egg masses. As is not the case for many other diseases, proof of freedom from SWF in Australia would be more important to us than to our trading partners.

See Appendix 4 for further details on proof of freedom.

### 3.7 Funding and compensation

SWF is classified as a Category 2 emergency animal disease under the EAD Response Agreement between the Australian national, state and territory governments and livestock industry organisations.

Category 2 diseases are emergency animal diseases that have the potential to cause major national socioeconomic consequences through very serious international trade losses, national market disruptions and very severe production losses in the livestock industries that are involved. Category 2 also includes diseases that may have slightly lower national socioeconomic consequences, but also have significant
public health and/or environmental consequences. For this category, the costs will be shared 80% by governments and 20% by the relevant industries (refer to the EAD Response Agreement for details).³

As there will be no compulsory destruction of livestock in operations to control or eradicate SWF, compensation will not be available to owners for any livestock deaths that occur, and owners would have to bear the costs of management and treatment of clinical cases.

Further information on cost-sharing arrangements can be found in the Summary Document and in the Valuation and Compensation Manual.

### 3.8 Strategy if the disease becomes established

Initial studies with the Australian SWF bioeconomic model (Anaman et al 1993, Atzeni et al 1993) indicated that SWF eradication using SIT would be biologically and economically feasible, even if an outbreak became extensive. These studies confirmed that the costs of eradication would be substantial and that eradication might extend over several years.

More recent studies with the 2005 version of the model and using much longer delays in implementing SIT (to simulate the 2004 preparedness strategy of not building a SIT facility until after an incursion) indicate that eradication will remain feasible and cost-effective if the competitiveness of released sterile flies is 0.1 or greater.

Any program to control SWF rather than to eradicate it would need to be considered in consultation with the industries affected by the disease, so that planning for control will be effective and relevant (see Section 2.3).

Appendix 1 Guidelines for classifying declared areas

Premises

Infested premises (IP)
A premises classified as an IP will be a defined area (which may be all or part of a property) in which screw-worm flies (SWF) or SWF myiasis exist, or are believed to exist. An IP will be subject to quarantine served by notice and to eradication and control procedures. Movement will initially be prohibited but may be allowed after inspection and treatment.

Dangerous contact premises (DCP)
Premises will be classified as DCPs if animals have moved there from an IP within three weeks before the presumed infestation of the IP. Movement of live animals will be restricted until a definitive diagnosis of SWF is made or excluded.

Suspect premises (SP)
Premises classified as SPs, including those holdings within 50 km of the IP, will be those on which animals exhibiting signs suspicious of SWF strike are present. Movement will be restricted until definitive diagnosis of SWF is made or excluded.

Areas

Restricted area (RA)
An RA will be declared over an area of approximately 150 km radius from the IP. Movement within or out of the area will only be permitted after an initial inspection and prophylactic treatment, followed by a further inspection 7–14 days later. Movement will be subject to permit.

Control area (CA)
If necessary, a CA may be declared around an RA, with a boundary up to 150 km from the RA. Movement out will be by inspection and permit, usually without treatment being required.
### Appendix 2 Recommended quarantine and movement controls

#### Premises

<table>
<thead>
<tr>
<th>Quarantine/movement controls</th>
<th>Infested and dangerous contact premises</th>
<th>Suspect premises</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Movement out of:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– susceptible animals</td>
<td>Initial inspection and prophylactic treatment.</td>
<td>As for IPs/DCPs</td>
</tr>
<tr>
<td></td>
<td>If no SWF, movement allowed after reinspection 7–14 days later.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If SWF detected, infested animals treated and held for daily inspection until SWF free. Those animals and companions allowed to move after reinspection 7–14 days later.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Permit required.</td>
<td></td>
</tr>
<tr>
<td>– specified products</td>
<td>Movement of soil or faeces prohibited; no movement restrictions for other products.</td>
<td>As for IPs/DCPs</td>
</tr>
<tr>
<td>– hay, crops, grains, wool, eggs, milk and meat</td>
<td>Permitted</td>
<td>Permitted</td>
</tr>
<tr>
<td><strong>Movement in and out of:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– people</td>
<td>Permitted</td>
<td>Permitted</td>
</tr>
<tr>
<td>– vehicles and equipment</td>
<td>Livestock transport vehicles to be cleaned and sprayed with appropriate insecticide after each journey. Other movements permitted.</td>
<td>As for IPs/DCPs</td>
</tr>
<tr>
<td><strong>Containment of:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– susceptible animals</td>
<td>Wounded animals sampled if myiasis detected, treated, then retained to ensure that treatment has been effective.</td>
<td>–</td>
</tr>
</tbody>
</table>
### Area

<table>
<thead>
<tr>
<th>Quarantine/movement control</th>
<th>Restricted area (if declared)</th>
<th>Control area (if declared)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Movement out of:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– susceptible stock</td>
<td>Initial inspection and prophylactic treatment. If no SWF, movement allowed after reinspection 7–14 days later. Permit required.</td>
<td>Controlled by inspection and permit. Prophylactic treatment not usually required.</td>
</tr>
<tr>
<td><strong>Movement within or through of:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– susceptible stock</td>
<td>Controlled by inspection, prophylactic treatment and permit.</td>
<td>Controlled by inspection and permit. Prophylactic treatment not usually required.</td>
</tr>
<tr>
<td><strong>Movement of:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– specified products</td>
<td>No restrictions.</td>
<td>No restrictions.</td>
</tr>
<tr>
<td>– people or equipment</td>
<td>No restrictions.</td>
<td>No restrictions.</td>
</tr>
<tr>
<td>– vehicles</td>
<td>Livestock transport vehicles in and out must be cleaned out and sprayed with appropriate insecticide after each journey. Permit required.</td>
<td>As for RA</td>
</tr>
</tbody>
</table>
Appendix 3  OIE animal health code and diagnostic manual for terrestrial animals

OIE Terrestrial Code

The objective of the OIE Terrestrial Animal Health Code is to prevent the spread of animal diseases, while facilitating international trade in live animals, semen, embryos and animal products. This annually updated volume is a reference document for use by veterinary departments, import/export services, epidemiologists and all those involved in international trade.

The OIE Terrestrial Code is amended in May each year. The current edition is published on the OIE website at:

http://www.oie.int/eng/normes/mcode/A_summary.htm

The following chapters are relevant to this manual:

Chapter 2.2.8   New world screwworm (Cochliomyia hominivorax) and old world screwworm (Chrysomya bezziana)

Chapter 1.3.5   Zoning and compartmentalisation

Appendix 3.8.1   General guidelines for animal health surveillance

OIE Terrestrial Manual

The purpose of the OIE Manual of Standards for Diagnostic Tests and Vaccines for Terrestrial Animals is to contribute to the international harmonisation of methods for the surveillance and control of the most important animal diseases. Standards are described for laboratory diagnostic tests and the production and control of biological products (principally vaccines) for veterinary use across the globe.

The OIE Terrestrial Manual is updated approximately every four years. The current edition is available on the OIE website at:

http://www.oie.int/eng/normes/mmanual/A_summary.htm

The following chapter is relevant to this manual:

Chapter 2.2.8   New world screwworm (Cochliomyia hominivorax) and old world screwworm (Chrysomya bezziana)
Appendix 4 Procedures for surveillance and proof of freedom

Proof of freedom

The World Organisation for Animal Health (OIE) has not defined freedom from SWF. Presumably, proof of freedom for Australia would depend on:

- SWF being a notifiable disease in all states and territories;
- regular monitoring of livestock (eg at abattoirs, saleyards and live export facilities);
- active surveillance at or near higher risk areas; and
- no evidence of SWF infestation for an extended period.

Procedures for surveillance

To detect an incursion

Australia maintains active surveillance for SWF in identified high-risk areas (such as the Torres Strait, the northern Australian coastline and ports) through the Northern Australian Quarantine Strategy and the Ports Surveillance Program. These programs use sentinel animals/herds and adult trapping as key detection tools. This activity is complemented with SWF-specific surveillance at all northern export abattoirs and livestock export facilities. Periodic extension activity is designed to maintain SWF awareness among target groups in northern Australia (such as livestock owners, veterinary practitioners and human health workers). This surveillance is supported by an integrated system of diagnostic laboratories.

These activities are reported in Australia’s National Animal Health Information System.

During an incursion

The critical requirements for a surveillance program during an SWF incursion are:

- to be able to initially define the boundaries of SWF-infested areas;
- to readily redefine infested areas;
- to assess whether SWF populations are expanding or contracting in those areas;
- to measure the impact of control/eradication activities; and
- to be able to verify when areas are free of SWF.

While some of these requirements could be achieved using adult SWF trapping, wounded sentinel animals would be needed for most. See Section 2.2.3 for recommended protocols for surveillance traps and animals.
Appendix 5 Screw-worm fly detection information

Individual states and territories have produced information kits for screw-worm fly detection. This is an example of the information supplied by the Queensland Department of Primary Industries and Fisheries.

BE ALERT FOR SCREW-WORM FLY
SURVEY OF FLY-STRIKE MAGGOTS
QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES AND FISHERIES

Screw-worm (*Chrysomya bezziana*) is present in Papua New Guinea where it causes severe disease in cattle. If this fly reaches Australia it will have disastrous effects on the cattle industry unless quickly controlled.

In the event of screw-worm fly entering Australia, its early detection provides the best opportunity for quick eradication.

Screw-worm fly maggots closely resemble other blowfly maggots and identification requires laboratory examination.

**PLEASE HELP IN THE EARLY DETECTION OF SCREW-WORM FLY STRIKE BY SENDING MAGGOTS FROM WOUNDS IN ANY SPECIES OF ANIMAL FOR IDENTIFICATION**

For maggot collection kits or information contact:
Queensland Department of Primary Industries and Fisheries
Oonoonba Veterinary Laboratory PO Box 1085 Townsville Q 4810
Phone 07 47222624 or DPI Call Centre 132523

**COLLECTION REQUIREMENTS**
1. COLLECT LARGE MAGGOTS FROM LIVE ANIMALS ONLY.
2. COLLECT MAGGOTS FROM DEPTH OF WOUND.
3. DROP THE MAGGOTS IN NEAR BOILING WATER TO KILL THEM.
4. PLACE MAGGOTS IN VIAL CONTAINING METHYLATED SPIRITS.
5. PROVIDE THE DETAILS LISTED BELOW.
6. SEND VIAL AND DETAILS TO DPI&F TOWNSVILLE (OR TO NEAREST DPI&F OFFICE FOR FORWARDING).

**FLY STRIKE MAGGOTS**

<table>
<thead>
<tr>
<th>ANIMAL STRUCK</th>
<th>........................................................................................................</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE OF WOUND</td>
<td>........................................................................................................</td>
</tr>
<tr>
<td>DATE OF COLLECTION</td>
<td>........................................................................................................</td>
</tr>
<tr>
<td>PROPERTY NAME AND NUMBER</td>
<td>........................................................................................................</td>
</tr>
<tr>
<td>NAME OF SENDER</td>
<td>........................................................................................................</td>
</tr>
</tbody>
</table>
Appendix 6 Suggestions for the medical management of screw-worm fly myiasis in humans in Australia

The following information was provided in August 2005 by:

Professor Rick Speare
Acting Head, School of Public Health, Tropical Medicine and Rehabilitation Sciences, and Acting Director, Anton Breinl Centre for Public Health and Tropical Medicine
School of Public Health, Tropical Medicine and Rehabilitation Sciences
James Cook University
Townsville Qld 4810, Australia

The principles of management are:
- appropriate wound care for the individual; and
- public health and veterinary considerations to ensure the fly larvae are killed, in view of the potential for introduction into local animals.

Wound care can be with standard antiseptic agents. The need for either surgical debridement or antibiotic therapy is assessed as with any wound.

Maggots can be removed either live or dead. Although live maggots resist removal, this is not of such force that removal is prevented. However, maggots deep in wounds may not be seen or may be unable to be grasped by forceps as they retreat into crevices in the wound. Maggots are typically removed by standard plain forceps or rat-tooth forceps.

On application of antiseptic or alcohol solutions or solutions containing hydrogen peroxide, the maggots are likely to become irritated, crawl out of the wound and possibly drop off. Exposure of a few minutes to such solutions will not kill the maggots and therefore it is critical that they are individually removed as they migrate or sit in the wound. Any that fall off or become attached to clothing must also be collected.

Maggots can be killed by two techniques: 1) suffocation and 2) application of mineral turpentine or low aromatic white spirits. These techniques are most often used for maggots that are deep in the wound and unseen or unable to be initially removed by forceps. To suffocate maggots the spiracles must be covered with a layer that prevents oxygen exchange. Typically, covering the wound with an oil-based cream such as lanolin in sufficient quantity will cause suffocation of the larvae. Application of a thick layer of antibiotic ointment can have the same effect. The maggots attempt to extrude their spiracles through the obstructing layer of cream or ointment and often move closer to the surface of the wound. This can afford an opportunity to grasp maggots that were previously hidden, but are now in a terminal state.

In Asia, topical plant turpentine, mineral turpentine or low aromatic white spirits have all been successfully used to kill maggots by instilling the liquids into the wounds. Dead maggots are subsequently removed by use of forceps. Even if all...
maggots cannot be removed, subsequent standard wound care should lead to removal of the larval products and eventual healing.

Larvae should be preserved in 70% alcohol for subsequent identification. In order to kill larvae that have been removed or have fallen off or are attached to clothing, standard household insecticide spray can be used or larvae can be placed in near boiling water. It is critical that all larvae are accounted for and killed. A sample of any preserved larvae should also be submitted for identification.
# Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal byproducts</td>
<td>Products of animal origin that are not for consumption but are destined for industrial use (e.g., hides and skins, fur, wool, hair, feathers, hooves, bones, fertiliser).</td>
</tr>
<tr>
<td>Animal Health Committee</td>
<td>A committee comprising the CVOs of Australia and New Zealand, Australian state and territory CVOs, Animal Health Australia, and a CSIRO representative. The committee provides advice to PIMC on animal health matters, focusing on technical issues and regulatory policy (formerly called the Veterinary Committee). <em>See also</em> Primary Industries Ministerial Council (PIMC)</td>
</tr>
<tr>
<td>Animal products</td>
<td>Meat, meat products and other products of animal origin (e.g., eggs, milk) for human consumption or for use in animal feedstuff.</td>
</tr>
<tr>
<td>Australian Chief Veterinary Officer</td>
<td>The nominated senior veterinarian in the Australian Government Department of Agriculture, Fisheries and Forestry who manages international animal health commitments and the Australian Government’s response to an animal disease outbreak. <em>See also</em> Chief veterinary officer</td>
</tr>
<tr>
<td>AUSVETPLAN</td>
<td><em>Australian Veterinary Emergency Plan</em>. A series of technical response plans that describe the proposed Australian approach to an emergency animal disease incident. The documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency-management plans.</td>
</tr>
<tr>
<td>Calliphoridae</td>
<td>The insect family that includes ‘bluebottle’ blowflies.</td>
</tr>
<tr>
<td>Chief veterinary officer (CVO)</td>
<td>The senior veterinarian of the animal health authority in each jurisdiction (national, state or territory) who has responsibility for animal disease control in that jurisdiction. <em>See also</em> Australian Chief Veterinary Officer</td>
</tr>
<tr>
<td>Compensation</td>
<td>The sum of money paid by government to an owner for stock that are destroyed and property that is compulsorily destroyed because of an emergency animal disease. <em>See also</em> Cost-sharing arrangements, Emergency Animal Disease Response Agreement</td>
</tr>
<tr>
<td>Consultative Committee on Emergency Animal Diseases (CCEAD)</td>
<td>A committee of state and territory CVOs, representatives of CSIRO Livestock Industries and the relevant industries, and chaired by the Australian CVO. CCEAD convenes and consults when there is an animal disease emergency due to the introduction of an emergency animal disease of livestock, or other serious epizootic of Australian origin.</td>
</tr>
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Control area
A declared area in which the conditions applying are of lesser intensity than those in a restricted area (the limits of a control area and the conditions applying to it can be varied during an outbreak according to need).
See Appendix 1 for further details

Cost-sharing arrangements
Arrangements agreed between governments (national and states/territories) and livestock industries for sharing the costs of emergency animal disease responses.
See also Compensation, Emergency Animal Disease Response Agreement

Dangerous contact animal
A susceptible animal that has been designated, following tracing and epidemiological investigation, as being exposed to risk of SWF infestation.

Dangerous contact premises
Premises that contain, or have contained within the previous 3 weeks, dangerous contact animals or other serious contacts.
See Appendix 1 for further details

Declared area
A defined tract of land that is subjected to disease control restrictions under emergency animal disease legislation.
Types of declared areas include restricted area, control area, infested premises, dangerous contact premises and suspect premises.
See Appendix 1 for further details

Destroy (animals)
To slaughter animals humanely.

Disease Watch Hotline
24-hour free call service for reporting suspected incidences of exotic diseases — 1800 675 888.

Disinsection
The destruction of insect pests, usually with a chemical agent.

Disposal
Sanitary removal of animal carcases, animal products, materials and wastes by burial, burning or some other process so as to prevent the spread of disease.

Diurnal
Active or habitually active during the day.

Emergency animal disease
A disease that is (a) exotic to Australia or (b) a variant of an endemic disease or (c) a serious infectious disease of unknown or uncertain cause or (d) a severe outbreak of a known endemic disease, and that is considered to be of national significance with serious social or trade implications.
See also Endemic animal disease, Exotic animal disease
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<th>Term</th>
<th>Definition</th>
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<tr>
<td>Emergency Animal Disease Response</td>
<td>Agreement between the Australian and state/territory governments and livestock industries on the management of emergency animal disease responses. Provisions include funding mechanisms, the use of appropriately trained personnel and existing standards such as AUSVETPLAN. See also Compensation, Cost-sharing arrangements</td>
</tr>
<tr>
<td>Endemic animal disease</td>
<td>A disease affecting animals (which may include humans) that is known to occur in Australia. See also Emergency animal disease, Exotic animal disease</td>
</tr>
<tr>
<td>Enterprise</td>
<td>See Risk enterprise</td>
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<tr>
<td>Epidemiological investigation</td>
<td>An investigation to identify and qualify the risk factors associated with the disease. See also Veterinary investigation</td>
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<td>Epidermis</td>
<td>Superficial skin.</td>
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<tr>
<td>Exotic animal disease</td>
<td>A disease affecting animals (which may include humans) that does not normally occur in Australia. See also Emergency animal disease, Endemic animal disease</td>
</tr>
<tr>
<td>Exotic fauna/feral animals</td>
<td>See Wild animals</td>
</tr>
<tr>
<td>Gravid female</td>
<td>A female insect ready to oviposit.</td>
</tr>
<tr>
<td>Hypoproteinaemia</td>
<td>Low blood protein.</td>
</tr>
<tr>
<td>Infested premises</td>
<td>A defined area (which may be all or part of a property) in which an emergency disease exists, is believed to exist, or in which the infective agent of that emergency disease exists or is believed to exist. An infested premises is subject to quarantine served by notice and to eradication or control procedures. See Appendix 1 for further details</td>
</tr>
<tr>
<td>Local disease control centre (LDCC)</td>
<td>An emergency operations centre responsible for the command and control of field operations in a defined area.</td>
</tr>
<tr>
<td>Monitoring</td>
<td>Routine collection of data for assessing the health status of a population. See also Surveillance</td>
</tr>
<tr>
<td>Movement control</td>
<td>Restrictions placed on the movement of animals, people and other things to prevent the spread of disease.</td>
</tr>
<tr>
<td>Mulesing</td>
<td>A radical surgical procedure in sheep to remove wrinkled skin and hence decrease susceptibility to fly strike.</td>
</tr>
<tr>
<td>Myiasis</td>
<td>Parasitism of animal tissues by blowfly larvae.</td>
</tr>
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National Management Group (NMG)  A group established to direct and coordinate an animal disease emergency. NMGs may include the chief executive officers of the Australian Government and state or territory governments where the emergency occurs, industry representatives, the Australian CVO (and chief medical officer, if applicable) and the chairman of Animal Health Australia.

Native wildlife  See Wild animals

OIE Terrestrial Code  *OIE Terrestrial Animal Health Code*. Reviewed annually at the OIE meeting in May and published on the internet at: [http://www.oie.int/eng/normes/mcode/a_summary.htm](http://www.oie.int/eng/normes/mcode/a_summary.htm)  See Appendix 3 for further details


Operational procedures  Detailed instructions for carrying out specific disease control activities, such as disposal, destruction, decontamination and valuation.

Oviposition  Deposition of eggs by female insects.

Owner  Person responsible for a premises (includes an agent of the owner, such as a manager or other controlling officer).

Perineal region  The skin surrounding the anus and vulva.

Premises  A tract of land including its buildings, or a separate farm or facility that is maintained by a single set of services and personnel.

Prevalence  The proportion (or percentage) of animals in a particular population affected by a particular disease (or infection or positive antibody titre) at a given point in time.

Primary Industries Ministerial Council (PIMC)  The council of Australian national, state and territory and New Zealand ministers of agriculture that sets Australian and New Zealand agricultural policy (formerly the Agriculture and Resource Management Council of Australia and New Zealand).  See also Animal Health Committee

Prophylactic  Preventive treatment.

Pupa  The inactive stage in insects between larva and adult.
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<th>Term</th>
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<td>Quarantine</td>
<td>Legal restrictions imposed on a place or a tract of land by the serving of a notice limiting access or egress of specified animals, persons or things.</td>
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<tr>
<td>Restricted area</td>
<td>A relatively small declared area (compared with a control area) around an infested premises that is subject to intense surveillance and movement controls.</td>
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<td></td>
<td>See Appendix 1 for further details</td>
</tr>
<tr>
<td>Risk enterprise</td>
<td>A defined livestock or related enterprise, which is potentially a major source of infection for many other premises. Includes intensive piggeries, feedlots, abattoirs, knackeries, saleyards, calf scales, milk factories, tanneries, skin sheds, game meat establishments, cold stores, AI centres, veterinary laboratories and hospitals, road and rail freight depots, showgrounds, field days, weighbridges, garbage depots.</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>The proportion of affected individuals in the tested population that are correctly identified as positive by a diagnostic test (true positive rate).</td>
</tr>
<tr>
<td></td>
<td>See also Specificity</td>
</tr>
<tr>
<td>Sentinel animal</td>
<td>Animal of known health status that is monitored to detect the presence of a specific disease agent.</td>
</tr>
<tr>
<td>Specificity</td>
<td>The proportion of nonaffected individuals in the tested population that are correctly identified as negative by a diagnostic test (true negative rate).</td>
</tr>
<tr>
<td></td>
<td>See also Sensitivity</td>
</tr>
<tr>
<td>Stamping out</td>
<td>Disease eradication strategy based on the quarantine and slaughter of all susceptible animals that are infested or exposed to the disease.</td>
</tr>
<tr>
<td>State or territory disease</td>
<td>The emergency operations centre that directs the disease control operations to be undertaken in that state or territory.</td>
</tr>
<tr>
<td>control headquarters</td>
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<tr>
<td>Subcutaneous</td>
<td>The tissue layers immediately under the skin.</td>
</tr>
<tr>
<td>Surveillance</td>
<td>A systematic program of investigation designed to establish the presence, extent of, or absence of a disease, or of infection or contamination with the causative organism. It includes the examination of animals for clinical signs, antibodies or the causative organism.</td>
</tr>
<tr>
<td>Susceptible animals</td>
<td>Animals that can be infected (or infested) with a particular disease.</td>
</tr>
</tbody>
</table>
Suspect animal  An animal that may have been exposed to an emergency disease such that its quarantine and intensive surveillance, but not pre-emptive slaughter, is warranted.

or  An animal not known to have been exposed to a disease agent but showing clinical signs requiring differential diagnosis.

Suspect premises  Temporary classification of premises containing suspect animals. After rapid resolution of the status of the suspect animal(s) contained on it, a suspect premises is reclassified either as an infested premises (and appropriate disease-control measures taken) or as free from disease.

See Appendix 1 for further details

Topical  Applied to the skin.

Tracing  The process of locating animals, persons or other items that may be implicated in the spread of disease, so that appropriate action can be taken.

Vaccination  Inoculation of healthy individuals with weakened or attenuated strains of disease-causing agents to provide protection from disease.

Veterinary investigation  An investigation of the diagnosis, pathology and epidemiology of the disease.

See also Epidemiological investigation

Wild animals

- native wildlife  Animals that are indigenous to Australia and may be susceptible to emergency animal diseases (eg bats, dingoes, marsupials).

- feral animals  Domestic animals that have become wild (eg cats, horses, pigs).

- exotic fauna  Nondomestic animal species that are not indigenous to Australia (eg foxes).

Zoning  The process of defining disease-free and infected (or infested, in the case of SWF) areas in accord with OIE guidelines, based on geopolitical boundaries and surveillance, in order to facilitate trade.
# Abbreviations

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<td>AAHL</td>
<td>Australian Animal Health Laboratory</td>
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<td>AHA</td>
<td>Animal Health Australia</td>
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<td>AUSVETPLAN</td>
<td>Australian Veterinary Emergency Plan</td>
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<tr>
<td>CA</td>
<td>control area</td>
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<tr>
<td>CCEAD</td>
<td>Consultative Committee on Emergency Animal Diseases</td>
</tr>
<tr>
<td>CSIRO</td>
<td>Commonwealth Scientific and Industrial Research Organisation</td>
</tr>
<tr>
<td>CVO</td>
<td>chief veterinary officer</td>
</tr>
<tr>
<td>DAFF</td>
<td>Department of Agriculture, Fisheries and Forestry (Australian Government)</td>
</tr>
<tr>
<td>DCP</td>
<td>dangerous contact premises</td>
</tr>
<tr>
<td>EAD</td>
<td>emergency animal disease</td>
</tr>
<tr>
<td>IP</td>
<td>infested premises</td>
</tr>
<tr>
<td>LDCC</td>
<td>local disease control centre</td>
</tr>
<tr>
<td>NMG</td>
<td>national management group</td>
</tr>
<tr>
<td>OIE</td>
<td>World Organisation for Animal Health (Office International des Epizooties)</td>
</tr>
<tr>
<td>OP</td>
<td>organophosphate</td>
</tr>
<tr>
<td>RA</td>
<td>restricted area</td>
</tr>
<tr>
<td>SIT</td>
<td>sterile insect technique</td>
</tr>
<tr>
<td>SP</td>
<td>suspect premises</td>
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<tr>
<td>SWF</td>
<td>screw-worm fly</td>
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<tr>
<td>UV</td>
<td>ultraviolet</td>
</tr>
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References


**Further reading**


**Video/training resources**

*Screw-worm fly* (video), Australian Animal Health Laboratory 1992 (available from the Animal Diseases/Incidents Section, DAFF, Canberra; or AAHL)

*Screw-worm fly* (32 slides), available from the Animal Diseases/Incidents Section, DAFF, Canberra.

See the **Summary Document** for a full list of training resources.
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