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Thematic Plan for the Sterile Insect Technique for Old and New World Screwworm

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EXECUTIVE SUMMARY

Objective

To support livestock development programmes aiming at controlling or eradicating key insect pests. This involves the application of the sterile insect technique (SIT) into area wide integrated pest management and eradication systems. The sustainability of eradication activities has been demonstrated for a number of insect pests under various national settings where the application of SIT has produced significant impact on socio-economic development, in terms of both cost-savings and environmental quality.

In line with the TC strategy, this thematic plan reviews best practices and experience gained in field operations, identifies stakeholders and common objectives in new and old world screwworm control and outlines a strategy for implementing integrated pest control programmes at the regional, sub-regional and national level. Synergies are sought with partner organisations to expand the knowledge base and capabilities for SIT based pest control activities and to strengthen TCDC.

The New World Screwworm, *Cochliomya hominivorax* (NWS) and the Old World Screwworm, *Chrysomya bezziana* (OWS) are major parasitic pests that profoundly affect the livestock sector in many countries. They also affect humans. The Office International des Epizooties classifies NWS and OWS as a List B disease - a transmissible disease which can be considered to be of socioeconomic and/or public health importance within countries and which is significant in the international trade of animals and animal products.

Countries requiring management of this pest can be grouped as follows:

endemic countries require definition of the problem, assessment of the benefit–cost of control and eradication options and, if feasible, an area wide approach utilizing the sterile insect technique (SIT), usually within a regional strategy;

free *c*ountries within the potential range of NWS or OWS, including countries that have been freed after a SIT campaign, require monitoring/surveillance and preventive measures, and;

expanded range countries, previously free but experiencing an introduced infestation, require an emergency response and similar measures as endemic countries

To effectively address this transboundary issue, regional strategies are required as well as active and sustained international co-operation. Important considerations in developing a strategy are:

- NWS and OWS are two distinct insects species with differing natural geographic ranges;
- There is a broader current knowledge base for NWS than for OWS where a major need for data exists;
- SIT is a mature technology for NWS but needs to be validated for OWS. SIT is a key component of a technological package involving surveillance, suppression and regulatory measures required for control or eradication programmes;
- country commitment (from both the government and the livestock industries);
- favourable benefit/cost assessment;

- potential public health impact;
- potential threat to wildlife;
- if there is an expansion of the range of the pest, especially if this is into a new region (for example, the infestation of NWS into Libya in 1988).

Technical solutions should ideally be used in the following scenarios to gain the most benefit from an investment:

- islands, including ‘ecological islands’ due to natural barriers or ones established with SIT at narrow interfaces between zones;
- on the edge of the distribution of the pest;
- as part of a regional approach.

Drawing on the considerations above, the strategic priorities for future programmes for each pest is as follows:

<u>NWS</u>

1. Caribbean
    a) Cuba
    b) Hispaniola (Dominican Republic and Haiti)
    c) Trinidad and Tobago (in conjunction with control in Venezuela; subject to further experimentation and risk analysis of the reinfestation potential)

2. South America (subject to availability of additional rearing facility; detailed field studies are essential before eradication programmes are attempted), approached could be:
    a) from the south upwards
    b) from north downwards
    c) west of the Andes

<u>OWS</u>

1. Middle East region;
2. South East Asia, preferably initially in infested nations with islands;
3. South Asia (Indian sub-continent);
4. Africa.

The IAEA is the leading technical organization for the application of SIT. It seeks to collaborate with other partners on co-ordinated efforts aimed at eradicating and controlling screwworm in Member States.

Lead agencies for overall NWS programme activities are the US Department of Agriculture (USDA) and the Food and Agriculture Organization of the United Nations (FAO), and the International Atomic Energy Agency (IAEA) for SIT. To assist these activities two Support Centers were identified. These are the Mexico–United States Screwworm Commission (COM), in Tuxtla Gutierrez, Chiapas, Mexico, for sterile fly production activities and the Panama–United States Commission for the Eradication and Prevention of Screwworms (COPEG), in Panama City, Panama, for other aspects of eradication programmes and production of sterile flies in the future.

Lead agencies for overall OWS programme activities are FAO, the IAEA for SIT and the Arab Organization for Agricultural Development (AOAD) for programme development in Arabic countries. To assist in these activities two Support Centers were identified. They are the Institut Haiwan, Kluang-Johor, Malaysia and CSIRO Australia, for sterile fly production and biological studies including field ecology, lures and attractants, and other aspects of eradication programmes.

For NWS the focus for IAEA TC should be to facilitate establishment or implementation of eradication campaigns when the required conditions are met, particularly the transboundary dimensions of the problem. For OWS, the focus should be to validate the technique, support economic and population-genetic assessments and increase awareness of the problem.

THE DEVELOPMENT NEED, TECHNICAL SOLUTION AND ROLE OF NUCLEAR TECHNOLOGY

The New World Screwworm, *Cochliomyia hominivorax* (NWS) and the Old World Screwworm, *Chrysomya bezziana* (OWS), are major parasitic insect pests that profoundly affect livestock and therefore the economic development of the agriculture sector in major parts of the world. The disease caused by the infestation of living vertebrate tissue by the larvae of screwworm flies is called myiasis. The magnitude of the cutaneous myiasis problem dictates that its control be a prerequisite to the maintenance of a viable livestock industry and the increasing need for agricultural production. The disease also affect humans.

The impact of screwworm flies on the livestock sector is influenced by husbandry practices. Economic losses are important where extensive farming systems are practiced and animals are not closely supervised to identify the need for early treatment. In smallholder farming systems, control procedures, such as intensive animal inspection and treatment of wounds with insecticides, are applicable but involve significant recurrent expenditures. Both systems therefore warrant labour intensive interventions which carry high financial and productivity costs.

The world organization for animal health, Office International des Epizooties (OIE), classifies NWS and OWS as a List B disease - a transmissible disease which is considered to be of socioeconomic and/or public health importance within countries and which is significant in the international trade of animals and animal products. The Food and Agriculture Organization of the United Nations (FAO), under its special programme for Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases (EMPRES) which involves early warning and reaction systems as well enabling research, lists the NWS as a priority transboundary animal disease for the Americas.

The aims of the veterinary services of the affected countries are focused on the development of sustainable animal agriculture and food security. The incidence and severity of the disease are modulated by existing local conditions such as :

1. livestock population, distribution , density and husbandry procedures;
2. wildlife population and their migratory habits;
3. human population density and the effectiveness of public health service;
4. climate and geography.

In addition to direct losses and the financial cost of control, cutaneous myiasis indirectly affects:

1. human health, through protein deficiencies caused by shortage of meat and milk ;
2. livestock production, since it causes morbidity and mortality;
3. agricultural production, through the lack of draught animals and manure;
4. rural economy, by preventing integrated agriculture and livestock production;
5. national economy, since the national deficit in animal production compels affected countries to import living animals and their products.
6. environment, through the use of insecticides.

At present, it is impossible to assess the losses caused by the NWS and OWS in the infested zones. However, an indication of the magnitude may be gained by an evaluation carried out in the Caribbean Region during the 1980s. The annual estimate of losses (US $) due to surveillance and medication ranged in several countries from $4.82 to $10.71 per animal. Concerning the NWS in the Americas, it is estimated that the annual losses for South America are $3600 million and $135 million in the Caribbean Region.

Unfortunately, no economic data are available for OWS in endemic countries. However, Australia has estimated producer losses of AUD $281 million per year under average climatic conditions if OWS became established in that country.

The substantial sums involved would clearly justify the eradication of the disease from the endemic areas and the prevention and rapid response to invasions into screwworm free areas. Such an objective has already been practically realized in the case of the NWS in North and Central America.

NWS and OWS are different species, albeit with a similar ecological niche. They appear to have evolved along converging evolutionary paths but in separate geographical regions. The development of the Sterile Insect Technique (SIT) in the 1950s created a revolution in the methods available to control major insect vectors of animal diseases and now forms the basis for NWS national and regional eradication programmes in the Americas. The SIT is a promising technology for the control and eradication of OWS, but requires validation.

The SIT is often the only tool available to achieve the eradication of major insect pests in an environmental friendly way. It consists of the systematic release, on an area wide basis, of sterile insects as the final component of a technological package involving surveillance, suppression and regulatory measures.

The SIT component involves the mass production of the target insect pest (NWS or OWS) followed by sterilization and release. When the sterile insects mate with fertile insects, no progeny is produced. Providing that the ratio of sterile to fertile insects is maintained at a high level within the target area, reproduction in the target pest population can be reduced significantly from generation to generation, eventually leading to eradication.

Sterilization is accomplished by exposing insects to a specific dose of gamma radiation emitted by radioisotopes (caesium-137 or cobalt-60). No other methods are available or appropriate to achieving insect sterilization. Chemical sterilants cause environmental contamination, as they accumulate in the food chain, and linear accelerators have not shown sufficient operational applicability and reliability in consistently achieving the desired levels of sterility.

Nuclear technology has not only a clear comparative advantage in sterilizing mass reared insects, but is, at present, the only technology available for this specific purpose.

DESCRIPTION OF THE SUBSECTOR

The measures required to manage this pest in individual countries which can be grouped according to their infestation status are as follows:

- ***endemic*** countries
  - ⇒ require definition of the problem, assessment of the benefit–cost of control and eradication options and, if feasible, an area wide approach utilizing SIT, usually within a regional strategy
- ***free*** *c*ountries within the potential range of NWS or OWS, including countries that have been freed after a SIT campaign
  - ⇒ require monitoring/surveillance and preventive measures;
- ***expanded range*** countries, previously free but experiencing an introduced infestation
  require an emergency response and similar measures as endemic countries

1. REQUIREMENTS FOR ENDEMIC COUNTRIES

A. <u>NWS</u>

Public awareness and training

Despite the fact that the NWS is on list B of the OIE, the perception that the costs of this disease in endemic areas are acceptable has to be changed. This can be done on the basis of accurate and reliable figures relating to current costs of control and associated costs relating to trade issues. These data have to be translated into policy documents which can be presented to decision makers to emphasize the importance of the problem and to mobilize the required support. This an essential first step in the development of a sustainable approach to the control or eradication of the NWS.

Once this awareness has been created training components can be developed at many levels to ensure that the necessary expertise is available for any proposed eradication campaign. This training can take the form of hands on experience in essential technical skills and the development of a culture in which the principles and practice of eradication campaigns are well understood.

Baseline data collection

The development of an eradication programme for endemic areas requires a detailed knowledge of the pest and its interaction with livestock. The distribution, density and other important population parameters are required together with data on the incidence of damage and costs associated with control. In many areas of South America this data is not available.

Availability of sterile flies

An eradication campaign using SIT can either purchase flies from an existing facility or include the construction of a rearing facility in the financial plan. Which option is chosen will depend on many factors, and it will be up to the programme planners to decide on the best option. In some areas the purchase of flies will be the obvious strategy (long distance shipment of sterile pupae for Lybia SIT programme) but in others the size of the problem to be addressed or the geographical location will dictate the construction of one or more rearing facilities.

Eradication strategy

On the basis of a benefit–cost analysis, armed with the appropriate baseline data and supported by a public and professional awareness of the importance of the problem, it is possible to outline a plan for an eradication campaign. The plan should indicate the scope of the programme, the costs and the number of sterile flies required or the size of the facility required to implement the release of sterile flies. The eradication strategy must be based on the area wide concept and be fully supported by the beneficiaries, namely the livestock owners. Such support translated into a financial contribution to the programme can be a guarantee of success. The eradication strategy should also be based on the particular ecological and geographical characteristics of the area.

Special administrative arrangements

All area wide eradication programmes require an adjustment to the way that business is traditionally done, especially in terms of decision making and responsibilities. Project managers must have sufficient control of resources and credible support from the national governments in order that timely operational decisions can be taken.

Funding

Adequate funding must be available at the start of the programme to ensure its successful completion. If an eradication programme is not completed the initial investment is completely wasted.

Implementation of an eradication programme

For NWS, there are established protocols for a successful programme which can be used to provide a framework for implementation. Management procedures become critical and technical issues are to a large extent solved.

B. <u>OWS</u>

Baseline data collection

In many areas where this species is endemic there is a paucity of information as to its significance for livestock production. This is the essential first requirement before an action is planned. The collection of this baseline data should include ecological and genetic studies to delineate the relevance of the problem and the economic and environmental cost of the pest.

Validation of the SIT

For this species there has not been a credible demonstration of the efficacy of SIT, although the similar biology of the two species would indicate that this technique should be successful. This demonstration has a high priority in order to initiate pilot eradication programmes in selected areas.

Regional co-ordination

The very wide distribution of this species in the Old World and the paucity of information on its importance make it desirable that a regional approach is taken during the initial collection of the baseline data to ensure that all important ecological areas are included. Subject to validation of the technology the same requirements listed above for NWS will apply.

2. REQUIREMENTS FOR NWS / OWS FREE COUNTRIES

The steps that are recommended for NWS/OWS free countries depend on their respective risk regarding pest introduction and establishment. A thorough assessment of this risk, considering the situation in neighbouring countries and key trade partners, is a prerequisite for any subsequent action. Risk assessment could also include use of Geographic Information Systems (GIS), with particular emphasis on annual / seasonal climatic / habitat suitability profiles using differential vegetation indices (NDVI). If a country or any of its partners in a common market agreement provide suitable conditions for NWS/OWS introduction and establishment, the following steps are recommended :

- Establishment of and adherence to adequate quarantine procedures (Chapter 3.18 of the International Animal Health Code);
- Introduction of routine veterinary and entomological monitoring;
- Emphasis on pubic information campaigns, particularly addressing various groups involved in holding and trading of susceptible vertebrate hosts;
- Holding workshops and disseminating information to decision makers and public and private sectors involved;
- Development, approval, introduction and operation of an emergency response system, describing in detail the priority and sequence of actions to be taken and defining the responsibilities of the public and private sectors involved;
- In connection with the above, the pest must be integrated into national exotic pest prevention programmes and any change in the pest free status must be immediately reported to regional / international centres (e.g. OIE);
- Training courses should be held on differential diagnosis and on processing / forwarding samples for reconfirmation and centralized registration;
- International Reference Centres for NWS / OWS identification or case reconfirmation need to be identified / contracted as part of an emergency prevention and response system.

PROGRAMME PRIORITIES

Important considerations in developing a strategy are:

- NWS and OWS are two distinct insects species with differing natural geographic ranges;
- the vastly different current knowledge bases for the two species;
- SIT is a mature technology for NWS but has not yet been fully validated for OWS.

Both NWS and OWS are free flying insects, with distributions usually extending broadly across their respective environmental ranges and habitats. This means that regional approaches are usually needed for control or eradication programmes rather than stand-alone individual country programmes. However, it is appropriate to undertake basic studies into the biology and ecology of the pests and undertake model programmes in a single country. This is particularly relevant in respect of OWS where there is a major need for more data.

Technical solutions should ideally be used in the following scenarios to gain the most benefit from an investment:

- islands, including 'ecological islands' due to natural barriers or ones established with SIT at narrow interfaces between zones;
- on the edge of the distribution of the pest;
- as part of a regional approach.

Other important considerations are:

- country commitment (from both the government and the livestock industries);
- favourable benefit/cost assessment;
- potential public health impact;
- potential threat to wildlife;
- if there is an expansion of the range of the pest, especially if this is into a new region (for example, the infestation of NWS into Libya in 1988).

Drawing on the considerations above, the strategic priorities for future programmes for each pest is as follows:

NWS

1. Caribbean
    a) Cuba
    b) Hispaniola (Dominican Republic and Haiti)
    c) Trinidad and Tobago (in conjunction with control in Venezuela; subject to further experimentation and risk analysis of the reinfestation potential)

2. South America (subject to availability of additional rearing facility; detailed field studies are essential before eradication programmes are attempted)
    a) from the south upwards
    b) from north downwards
    c) west of the Andes

OWS

Subject to validation of SIT for OWS:

1. Middle East region;
2. South East Asia, preferably initially in infested nations with islands;
3. South Asia (Indian sub-continent);
4. Africa.

BASIC COMPONENTS OF NATIONAL ACTIVITIES

The following components are required to undertake a control/eradication programme in a country:

Epidemiological surveillance system
Communication and information
Trained personnel
Control of livestock movement and quarantine system
Sanitary activities
Public health and economic risk analysis
Economic impact study
SIT operations

Countries or members of a common market which want to develop a NWS/OWS control or eradication programmes, or which want to import livestock from a country where screwworms are endemic, should consider appointing a committee to evaluate the screwworm threat and propose methods for dealing with it.

- The committee should comprise representatives from the livestock producers, the veterinary profession, government human and animal health authorities, those involved in marketing and transportation of animals and other related industries. It is important that the committee generate the widest possible grassroots level support for programmes to control and eradicate the screwworm. For example, a livestock producer may be more willing to take action that will cost money or temporarily decrease his profit, if he is convinced that, in the long term, his profits will increase. The appointment of influential livestock producers and representatives of livestock associations to the committee is therefore particularly important to its success.

- The committee should seek advice in organizing its activities from experts in organizations such as FAO, the Mexican and Central American Departments of Agriculture and the United States Department of Agriculture, IAEA (International Atomic Energy Agency), CSIRO, who have in-depth knowledge and experience of screwworms control and eradication activities. With the assistance of these experts, specific goals for the committee can be established.

- The committee needs to become familiar and gather as much information as possible on the current or potential screwworm situation throughout the country. With this preliminary information, the committee can develop a plan for control or eradication (as appropriate) and an analysis of the benefit/cost of control or eradication. The first priority should be to recommend that the following actions be initiated quickly :

- Develop or revise livestock import and export laws and regulations;
- Recommend methods to control the spread of screwworm from infested areas to free areas within the country;
- Recommend methods to reduce wild fly populations existing in the country;
- Outline an approach for screwworm control and/or eradication

The strategic inclusion of the SIT as a final component in a national or regional eradication programme for both species dictates capital intensive investments. There is a need to undertake

B/C analyses as data on this aspect do not exist in may areas of the world. Financing of such programmes should be secured before initiation. Existing benefit–cost (B/C) analyses of previous and future NWS eradication programmes have all been favourable. Examples of B/C ratios are 10:1 for the USA, 4:1 for Mexico, 5.5:1 for Jamaica , and as high as 50:1 when viewed in a regional context for the Libya programme.

It should be borne in mind that following eradication, a low level of recurrent costs for monitoring and surveillance must be maintained. Experience in Central America has shown that these activities can be integrated into existing veterinary infrastructures addressing other major diseases.

A model national NWS/OWS eradication strategy for a screwworm free country is available within the Australian Veterinary Emergency Plan (AUSVETPLAN) Disease strategy for Screwworm. This plan is available on the Internet at:
http://www.brs.gov.au/brs/aphb/aha/ ausvet.htm

LIMITATIONS AND CONSTRAINTS FOR IAEA TC

The SIT technique for NWS has been used effectively in eradication campaigns covering North and Central American countries and is now considered a mature technique than can be used for this purpose in the Caribbean subregion and the remainder of Latin America. For OWS, the effectiveness of SIT needs to be established.

There are five main limitations that are constraints to achieving programmatic objectives in the use of SIT in the eradication/control of NWS and OWS in Member States. It is also recognized that without active and sustained international co-operation programme progress will not be effective.

1. Lack of data;
2. Limited number of centres that could play a leading role in this field;
3. Insufficient funds;
4. Political problems in some parts of the range of both species;
5. For OWS, lack of sufficient trained staff with the necessary experience in the use of this technique.

The IAEA is the leading technical organization for the application of SIT for eradication/control programmes. It is recognized that the IAEA is prepared to complement and support co-ordinated efforts aimed at eradicating and controlling screwworm in Member States, including area wide campaigns, through its normative technical work, training activities and public information. It is eager to elaborate these activities in collaboration with other organizations. However, because of the level of field management required for control/eradication activities, and the limited resources available to IAEA for field assessments and preparatory activities for the use of SIT, the technical co-operation role of the IAEA is somewhat limited to instances where the conditions or urgency for eradication of the screwworm using SIT are established. Therefore, the IAEA seeks the role of facilitator to such campaigns.

It is further recognized that a well co-ordinated programme could provide an opportunity to agree upon strategies, tasks and responsibilities in fulfilment of common objectives. Such an approach could build upon the leadership roles already established by USDA, FAO and other international and bilateral organizations and gain from their experience, planning and feasibility activities.

ROLES AND PARTNERSHIPS

NWS

Lead agencies for overall programme activities are the US Department of Agriculture (USDA) and the Food and Agriculture Organization (FAO), and the International Atomic Energy Agency (IAEA) for SIT. To assist these activities two Support Centers were identified. These are the Mexico–United States Screwworm Commission (COM), in Tuxtla Gutierrez, Chiapas, Mexico, for sterile fly production activities and the Panama–United States Commission for the Eradication and Prevention of Screwworms (COPEG), in Panama City, Panama, for other aspects of eradication programmes and production of sterile flies in the future.

OWS

Lead agencies for overall programme activities are FAO, the IAEA for SIT and the Arab Organization for Agricultural Development (AOAD) for programme development in Arabic countries. To assist in these activities two Support Centers were identified. They are the Institute Haiwan, Johor, Malaysia and CSIRO Australia, for sterile fly production and biological studies including field ecology, lures and attractants, and other aspects of eradication programmes.

PROGRAMME CONVERGENCE

Status

Screwworm eradication in the Americas

Although NWS had long been recognized as a severe pest of animals in the southwestern United States, it was not until 1933, when screwworms first became established east of the Mississippi River in the United States, that they were recognized as having a tremendous economic impact on livestock production. At that time the research community became interested in control and eradication measures for this economic pest. Ideas on such measures were being developed, but all work was suspended because of World War Two. Following the war interest once again turned to screwworm control and eradication, and the development of the sterile insect technique (SIT). This work culminated in eradication of screwworms from the island of Curaçao in 1954, and this success lead to the successful programme in the southeastern United States from 1957 to 1959.

Livestock producers in the southwestern United States watched the eradication efforts in the southeast with much interest, and a screwworm eradication programme was begun in the southwestern United States in 1962. The United States was declared screwworm free in 1966. The plan at that time was to maintain a sterile fly biological barrier, by weekly dispersal of sterile flies along much of the border with Mexico, to prevent the migration of fertile flies from

Mexico into the United States. In addition, animals were inspected and dipped before entering the United States from Mexico. Despite these efforts, cases continued to occur in the United States. Because of these continued outbreaks and the interest of Mexican livestock producers in extending the eradication programme into Mexico, it was decided to move the barrier south to the Isthmus of Tehuantepec in Mexico. This location would be more economical (a 190 km width as compared to 2 400 km at the United States–Mexico border) to maintain and, in addition, a barrier farther from the U.S. border would afford more protection for the United States. An agreement was signed on August 28, 1972, to form the Mexico–United States Commission for the Eradication of Screwworms. The Commission's objective was achieved in 1984. However, the barrier at the Isthmus of Tehuantepec divided the country, with livestock producers to the south claiming the Mexican government was showing favouritism to producers north of the barrier. Further studies showed that Panama was a much better site for a permanent biological barrier. A barrier extending from the Panama Canal to the border with Colombia would require only 40 million sterile flies per week, compared to 150 million per week at the Isthmus of Tehuantepec. Following indications of interest in screwworm eradication from all Central American countries and Panama, a plan was developed in 1985 to extend the Screwworm Eradication Programme through Central America using US–Host Country Cooperative Screwworm Eradication Programmes in Central America; and in Panama, a Panama–United States Commission for the Eradication and Prevention of Screwworms (COPEG) and establish a permanent biological barrier in the eastern half of Panama.

Mexico was declared screwworm free on February 25, 1991; Guatemala on May 20, 1994; Belize on May 22, 1994; El Salvador on June 19, 1995; and Honduras on August 6, 1996. Nicaragua has been free of screwworm since June 1, 1997. Screwworms are well controlled in Costa Rica, and an eradication programme has begun in Panama. All of Central America is expected to be free by the end of the year 2000. A Jamaica–IAEA Screwworm Eradication Project began in Jamaica in July 1998. To protect investments made and countries already freed from NWS, it is time to be thinking about the feasibility of expanding the eradication programme to other infested Caribbean Islands and possibly South America where interest in surveillance activities is mounting.

The Libya experience

The detection of the NWS in the Libyan Arab Jamahiriya in the spring of 1988 represented an emergency not only for Libya, but also for the entire North African Region. It was the first time that this relentlessly destructive parasitic disease became established outside its natural range in the Americas, and if left uncontrolled, it would inevitably spread to neighbouring countries and eventually into sub-Saharan Africa, the Near East and Mediterranean Europe.

Presumably, the NWS was introduced with imported sheep from South America. By 1990, the infestation had spread to an area of 25 000 km^2 containing some 2 million livestock. In early 1991, an internationally funded eradication programme using sterile insects began. Each week 40 million pupae were flown from a production plant in Mexico, and the emerged adults were distributed by air over the infested area. Within a few months, the infestation had been eradicated. Whereas 12 000 infested animals were found in 1990, only 6 were detected in 1991. The programme involved the shipping and distribution of 1.3 billion sterile insects, animal inspections totaling 40 million and laboratory examination of 280 000 trapped flies. While the programme cost close to US $75 million, a benefit–cost ratio of 50:1 has been estimated.

FAO undertook this emergency campaign on behalf of the countries threatened by the disease and the 22 countries and agencies that provided the emergency funds required. The UN agencies: IAEA, IFAD and UNDP provided special and essential support.

Australasian activities

OWS is not present in Australia but is considered to be a major threat to livestock and native fauna owing to its presence in Papua New Guinea and Indonesia.

In 1973, the CSIRO Division of Entomology established a small research laboratory in Port Moresby, the capital of Papua New Guinea, to study the biology and ecology of OWS. Subsequently, rearing of OWS was successfully achieved, and sterilization using gamma radiation was evaluated, and the competitiveness of sterile males was determined in laboratory and field studies.

In 1981, a larger facility was established at Laloki, on the outskirts of Port Moresby, and progressively modified into a mass rearing complex. Most of the technology for rearing OWS was based on the USDA experience, but innovations to mass rearing methodology of larvae were developed using polyester instead of acetate blankets. Initially, lower densities of larvae were placed on the growing medium with further young larvae being progressively added for seven consecutive days. This method, which duplicates a natural wound more closely than an 'all-on/all-off' rearing protocol, resulted in an increase of more than 80% in productivity.

A field trial was conducted in 1982 during which a 750 km^2 area in Safia, northern Papua New Guinea, was treated with sterile OWS dispersed by air. Sterilized pupae were released for five weeks. During the final eight weeks, chilled adult flies were released over 20–80% of the treated area at release rates of 316–566 flies per km^2. Sterility was first recorded one week after beginning the release of sterile pupae and the weekly sterility reached 33% after five weeks of adult fly releases. Because of relatively low numbers, no significant upward trend in the percentage of sterile egg masses was established by the time the trial concluded.

Another field trial in Papua New Guinea in 1986 to evaluate the effectiveness of the SIT for eradication of OWS had to be terminated early. Results showed that sterility could be induced in wild population but the efficacy of the SIT for the eradication of OWS to the criteria established by the USDA was not achieved.

In 1990, a major review of Australia's long term screwworm fly (SWF) preparedness was undertaken, and a plan was developed to enhance the state of preparedness. This plan has provided the direction for SWF preparedness activities over recent years. It was also decided to close the Papua New Guinea unit for a series of operational reasons which occurred in December 1991.

A major element of the long term strategy is to validate the SIT for OWS, in light of the earlier failures to scientifically establish its validity for this species, in an endemically infested country and to develop more efficient mass rearing systems based on production engineering principles.

In 1995, a Memorandum of Understanding was entered into between the Government of Australia and the Government of Malaysia to undertake a collaborative *Myiasis Control Research Project* located at the Institut Haiwan, near Kluang in Johor, Malaysia. The project is both assisting Malaysia with the control of screwworm fly myiasis infestations and enabling Australia to undertake research to develop and evaluate improved SWF control and eradication. The objectives of the project are to:

(a) validate the sterile insect technique for the OWS by means of a field trial;
(b) undertake research to develop process engineering systems for the production of sterile flies;
(c) On the basis of the outcome of the project, develop a practical control programme for myiasis; and
(d) develop within the Department of Veterinary Services Malaysia the expertise to manage and operate a SWF project through training and practical attachment programmes.

The project is somewhat behind schedule but the following has been achieved or is scheduled:

I. a pilot OWS production facility has been constructed in Malaysia with a nominal production capacity of 10 million sterile flies per week;
   - at the facility was handed over on 28 September 1998, and initial production system development is proceeding;
   - this phase will continue until October 1999;

II. a laboratory adapted colony of OWS was established in temporary premises while the pilot facility was constructed;

III. a core group of Malaysian Department of Veterinary Services staff have been trained;

IV. a monitoring programme has been established on the target Malaysian cattle breeding farm to provide baseline data for the field trial assessment;

V. mass rearing and sterilisation by irradiation and release of OWS is scheduled to commence in October 1999 for use in a field trial on one cattle breeding farm between October 1999 and March 2000.

The colony has been established with a gel diet, which is being used in the pilot facility also. The work is still largely based on experience with NWS in North and Central America and initially at least extrapolates from techniques developed for that species.

Other activities that have been or are being undertaken include:

- publication of *A Manual for the Diagnosis of Screw-Worm Fly*, prepared by Dr J P Spradbery, CSIRO Entomology and holding of training courses for scientists from all States/Territories of Australia using this manual;
- bioeconomic modelling of a screwworm fly outbreak in Australia;
- biochemical profiles of OWS from different geographic regions;
- research into improved attractants and trap for OWS;
- assessment of moxidectin and new formulations of ivermectin against OWS;
- cryopreservation of embryos of OWS;
- SWF monitoring programme under the North Australia Quarantine Strategy(NAQS);
- educational programmes to make livestock owners and residents of northern Australia and Torres Strait more aware of SWF and to promote the submission of larvae from strikes on animals.

In addition, the Australian Centre for International Agricultural Research (ACIAR) is sponsoring a joint project by the CSIRO Tropical Animal Production, the Research Institute for Veterinary Science, Bogor, Indonesia and the Inter-University Centre on Biotechnology Institute of Technology, Bandung, Indonesia titled *Identification and production of recombinant antigens for a vaccine against screwworm fly, Chrysomya bezziana.* The Australian Quarantine Service (AQIS) is sponsoring a project on improved lures and traps for OWS with Queensland's Department of Primary Industries and XCS Consulting Group.

Infestation of OWS in the Middle East

OWS is endemic in some countries in South Asia and recently has been reported in the Middle East region in Bahrain, Qatar, Saudi Arabia, Arab United Emirates and in Iraq, where 56 543 cases were recorded as of May 1998.

In August 1996 OWS samples were identified in Baghdad and were confirmed by the FAO World Reference Laboratory for the Diagnosis of New World Screwworm and other Animal Myiasis in London at the British Museum of Natural History.

The Iraqi Government requested assistance from FAO and the IAEA to control the OWS which had not previously been reported in the Mesopotamia Valley. Besides providing basic training for identification and surveillance, consultants recommended to the Iraqi Veterinary Services to implement an emergency system for reporting cases and implement control measures using insecticides. At the same time a small scale research rearing colony, unique in the region, was established to learn more about the biological aspects of the insect. Materials provided with clearance from the UN Sanctions Committee included: vehicles, sprayers, zoom stereo microscopes, entomological kits, collection kits , insecticides such as Coumaphos W.P. and A.I., and rearing and laboratory supplies.

OWS infestation in Iraq covers about two thirds of the country. Conditions for infestation containment are very difficult because of the embargo. The OWS is able to prevail in very hot summer or very cold winter conditions according to infestation data. In neighbouring countries, the reports of cases are very sporadic. There is a need for surveillance missions to obtain actualized information on ecology and infestation dynamics of the pest in all the region.

In December 1997, FAO and the Arab Organization for Agricultural Development (AOAD) jointly organized a workshop on OWS in Damascus Syria. Zones were proposed to establish a future programme of control. Representatives from Iran, Iraq, Jordan, Kuwait, Saudi Arabia, Syria and Yemen participated in the workshop. It was concluded that Iraq is infested and Iran, Jordan, Kuwait, Saudi Arabia and Syria are high risk zones, with Bahrain, Lebanon, Qatar, Turkey, United Arab Emirates, and Yemen being at low risk.

The outbreak in Iraq must be considered a priority. There is a severe lack of resources in all the veterinary infrastructure to sustain the surveillance and research activities that could lead to the application of SIT. All neighbouring countries at risk must be encouraged to submit samples following survey missions and regional training courses.

RESEARCH AND DEVELOPMENT

Research into NWS has been underway for over 50 years, mostly by USDA, and there is an extensive literature for this species. By contrast, comparatively little research has been undertaken into OWS. Most of the OWS research was undertaken between 1973 and 1991 in Papua New Guinea by CSIRO Australia.

Current research is a valuable support to ongoing screwworm eradication efforts. Many of the research projects that are ongoing or needed are long term in nature and will require a long term commitment and continued support for this research will be necessary. Screwworm research may become even more important in the future in order to reduce programme costs or if the NWS eradication efforts are expanded to include South America.

Collaborating Institutions

Australia (AUS)
Commonwealth Scientific and Industrial Research Organization (CSIRO)
Food and Agriculture Organization (FAO)
International Atomic Energy Agency (IAEA)
Mexico–United States Screwworm Commission (COM)
National Centre of Animal and Plant Health (CENSA) Cuba
Panama–United States Commission for the Eradication and Prevention of Screwworm (COPEG)
Institut Haiwan, Kluang-Johor, Malaysia (MAL)
University of Panama (UP)
US Department of Agriculture, Agricultural Research Services (ARS)

Ongoing, planned and required research activities were reviewed. It was recognized that most research areas on the NWS might be applicable to the OWS.

Four distinct research areas including priorities within them were identified. In some cases candidate organizations for specific topics were suggested. The organizations' commitment to undertake such research was not taken into consideration.

1. Biology, ecology and population dynamics
2. Strain development, genetics, and molecular biology
3. Improvement of rearing methods
4. Improvements of survey methods and control technologies

2.1 - BIOLOGY, ECOLOGY, AND POPULATION DYNAMICS:

NWS

1. Biological and geographical classification of habitat related to screwworm populations using Geographic Information Systems (GIS) modelling and remote sensing imagery (ARS). High priority.
2. Study other means of transmission based on case studies (UP). High priority.
3. Ecological studies in South America (FAO). High priority.

4. Documenting the eradication of the screwworm from Panama and evaluating and verifying the life cycle model (SWFSIM) as it fits into this eradication (ARS/COPEG).

OWS

1. Distribution and seasonal occurrence (FAO). High priority.
2. Population density High priority.
3. Migration (MAL) High priority.
4. Refine climatic model (IRQ/FAO/IAEA). High priority.
5. Incidence (FAO).
6. Wounds
7. Genetic diversity (FAO)
8. Cryopreservation (ARS/CSIRO)
9. GIS and risk analysis (FAO)

2.2 - STRAIN DEVELOPMENT, GENETICS, AND MOLECULAR BIOLOGY:

NWS

1. DNA fingerprinting of laboratory and field populations of screwworms (ARS/Brazil/FAO). High priority.
2. Genetic sexing (male-only) strain (ARS/IAEA). High priority.
3. Development of new screwworm strains for use in the production plant (ARS).
4. Cryogenic storage of screwworm embryos (ARS/CSIRO).
5. Developing quality-based criteria for changing strains in production.

OWS

1. Population genetic comparison
2. Quality control of lab reared strains

2.3 - IMPROVEMENT OF REARING METHODS:

NWS

1. Identification and development of new biodegradable gelling agents (ARS).
2. Substitutes for dried bovine blood and other dietary ingredients used in screwworm diets (ARS).
3. Evaluation of artificial wound fluid as an ovipositional stimulant in mass rearing (ARS).
4. Identification of the location and chemical name of the larval feeding stimulant (ARS).
5. Development of a larval rearing diet not based on a gelling agent (ARS).
6. Methods for prevention of deterioration in the production plant strain (ARS).
7. Oviposition system optimization (COM/ARS)

OWS

1. Mass rearing (CSIRO/IAEA)

2. Rearing diet (CSIRO)

2.4 - IMPROVEMENT OF SURVEY METHODS AND CONTROL TECHNOLOGIES:

NWS

1. Develop and evaluate SIT dispersal strategies and monitoring in the permanent barrier zone for use in larger areas (ARS/COPEG);
2. Co-operate with programme personnel in studies to improve dispersal equipment (ARS/COPEG);
3. Field level identification methods for primary and secondary screwworm (ARS);
4. Identification of the ovipositional stimulant from wound fluids (ARS);
5. Develop the ELISA procedures for identifying all three larval instars of the screwworm at the field level (ARS);
6. Co-operate with programme personnel in studies to improve yields and quality of flies in emergence chambers at Dispersal Centers (ARS/COPEG);
7. Evaluation and improvement of trapping methods for use in population surveys or for potential screwworm fly suppression on Caribbean islands (ARS);
8. New natural larvicides such as albaca leaves (*Ocinum basilicum*) (Cuba);
9. Long distance transportation of sterile flies under hipoxia conditions (COM/COPEG);
10. Other suppression systems (UP).

OWS

1. Validation of SIT (AUS/MAL/IAEA). High priority;
2. Lures, attractants and traps (AUS/MAL). High priority;
3. Adult suppression;
4. Parasites and predators;
5. Assessment of insecticides (AUS).

VALIDATION OF SIT FOR OWS

SIT has yet to be validated as a tool to eradicate OWS. This is the first and crucial step in any plan to use SIT for OWS.

There is good evidence that would suggest that SIT is likely to be successful with this species. However, the potential exists for differences between the two species that may render SIT less successful or more expensive in OWS. It has similar biology to the NWS, which has been successfully eradicated throughout North and Central America

CSIRO, in collaboration with the Malaysian Department of Veterinary Services, is to conduct a validation trial of SIT in peninsular Malaysia in 1999 to 2000. The trial seeks not to eradicate but to demonstrate mating success between sterile males and native females at a sufficient level (60%) that population collapse will occur. The aims of the trial have been determined by scientific study in Australia, and the criteria for validation have been agreed to by Australian livestock industries and government. If successful, the trial would provide adequate confirmation for Australian authorities to use SIT in the event of an OWS incursion.

If further validation of SIT is required then a pilot eradication programme needs to be conducted, possibly on an island or in an area where a sustainable barrier can be established. The facility in Malaysia could play a central role in such a programme.

ELEMENTS OF AN IMPLEMENTATION STRATEGY

The following three criteria must be met in any SIT programme that seeks to eradicate a species from a region. Prerequisites are adequate funding and existence of mass rearing capacity.

(1) Political feasibility

- the countries involved must show strong commitment to the programme. This includes the government, the livestock industries and any private sector groups that will be involved. SIT programmes require considerable input by the local people in support of surveillance and monitoring programmes and in control of outbreaks of screwworm.

Technical feasibility

- The area must be either an island or surrounded by natural barriers to screwworm movement, or at the edge of the distribution of screwworm. In the latter case, eradication will proceed progressively and each phase must include a region suitable for a maintaining a barrier zone. These features reduce the likelihood of reinfestation of the location by screwworm either by natural means (e.g. insect dispersal) or by movement of animals by humans. Fresh incursions require control and reduce the benefit–cost achieved through SIT.

- Consequently, screwworm control must be tackled by region, where the boundaries of control are delimited by geography, not by political boundaries. Co-operation and co-ordination among neighbouring countries is essential before the beginning of a programme.

Economic feasibility

- The project must be economically favourable. Benefits accrue from reduced pesticide usage, reduced production costs and possible increase of production. The project may aim to contain a major expansion in the range of screwworm. In this case, the benefits accrue not only in the location where the programme is initiated. For example, the eradication of screwworm from Iraq would generate benefits not only in that country but also in neighbouring countries, and possibly southern Europe and northern Africa, all of which are at threat from incursions. The USA and

Mexico benefit from the eradication of screwworm in Central America for similar reasons.

- The project may also have considerable environmental benefits that are hard to quantify economically. The large mammal fauna of northern Africa and Australia are at risk from incursions of screwworms. Reduction in native fauna would have impact on tourism and also on ecosystems.

There may be public health benefits particularly in remote areas or in areas with poor health services. Screwworm strikes in humans resulted in up to 40% mortality rates in poorer regions of Central America.

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