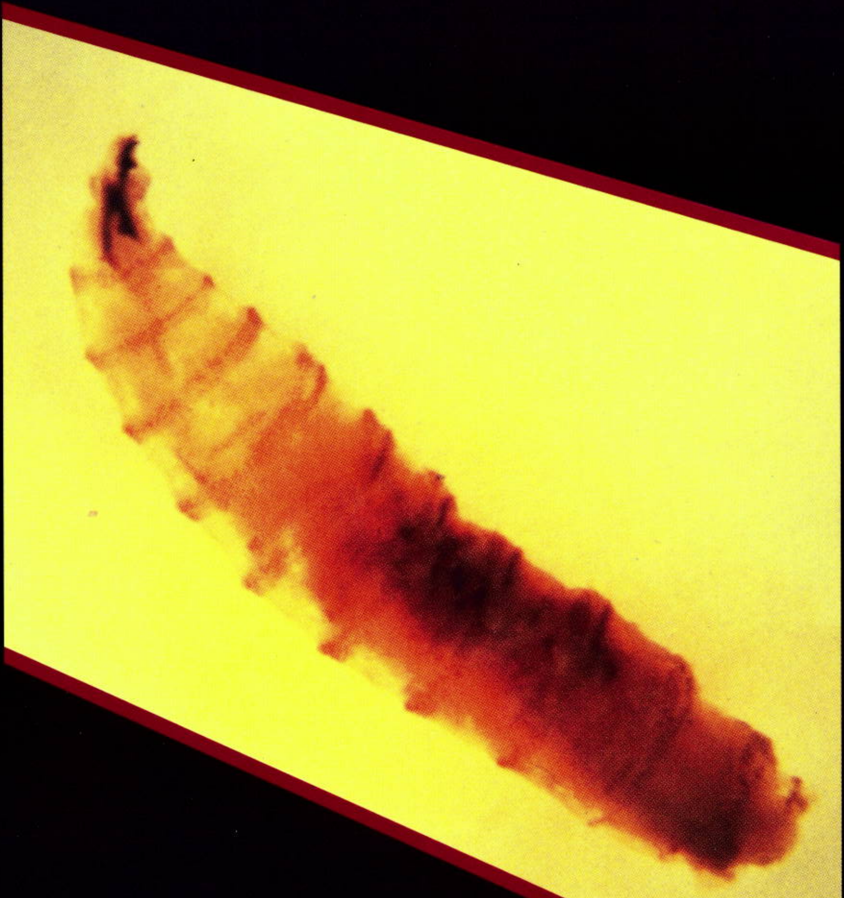
THE NEW WORLD SCREWWORM ERADICATION PROGRAMME

NORTH AFRICA 1988-1992



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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

ROME 1992

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Preface

While the great majority of our work in FAO is aimed at the steady improvement of the world's capacity to feed its people, we are also on occasion challenged to respond to situations of great and immediate danger. The discovery of the New World screwworm in North Africa in 1988 was one such emergency. It rapidly became clear that the price to be paid for the persistent and inevitable spread of this pest from its beachhead in the Libyan Arab Jamahiriya would have been very great indeed — in terms of suffering and loss in domestic animal populations and devastation of wildlife as well as the recurrent cost of containment far into the future. It was also clear that an eradication campaign could be costly: prudent estimates put the costs in international funds at close to US$100 million.

It is a tribute to all concerned that successful eradication has been achieved more rapidly, and at less cost, than might have been expected. The international funds required have come to less than US$35 million. Independent economic appraisal has shown the programme to have been a remarkably profitable investment.

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. I would like to extend my thanks to the donors for that essential support; to our sister United Nations agencies, IAEA, IFAD and UNDP, for their active collaboration; and to all those who carried this campaign through to such a successful conclusion.

Edouard Saouma
Director-General

Introduction

This book documents a programme which was unusual in several respects. The campaign to eradicate the New World screwworm from North Africa was unusually large in financial terms. At the same time it was unusually short. Eradication itself took about six months, although it was preceded by one year of preparation and followed by one year of continued surveillance and preventive actions. It involved an unusually large array of partners: 22 donors, eight countries at immediate risk, four UN agencies and several contractors from the private sector.

What have been the main factors contributing to the success of the programme? To begin with, a certain amount of good luck was involved. It was fortunate that the initial outbreak occurred in the Libyan Arab Jamahiriya, a relatively wealthy country with good infrastructure and, in particular, a strongly developed national veterinary service. The early and effective response of the Libyan authorities was undoubtedly a major factor in containing the outbreak within a limited area, eventually making possible a successful eradication programme. While conditions in the coastal area where the outbreak first occurred were highly suitable for screwworm establishment, this zone is fortunately bounded by areas which are much less suitable: sea to the north, desert to the south and east, and semi-desert to the west. The western limit of the infested area extended almost to the Tunisian border, and the active cooperation of the Tunisian authorities helped to prevent spread in that direction. Despite these factors limiting its spread, the successful overwintering of screwworm in Libya for three years — and the explosive expansion in the number of infested animals in the second year of *infestation — demonstrated the seriousness and the scale of the problem.*

The other major element of good fortune was that the technology for eradication had already been developed and was available. Three decades of research lay behind the successful use of the sterile insect technique for screwworm eradication, first in the United States and then in Mexico. The knowledge built up through that research and the experience gained from the campaigns in North America were made fully available for use in North Africa. Furthermore, with the support of the Mexican and United States governments, the only sterile screwworm plant in the world, at Tuxtla Gutierrez, was authorized to provide flies under contract to the programme.

While it is now clear that the containment activities carried out by the Libyan authorities from 1989 were very effective, this was by no means certain in the early stages of the campaign. Substantial animal inspection and surveillance activities were therefore undertaken in all of the surrounding countries. Meanwhile, a sterile insect eradication campaign was actively being prepared. Because the final campaign was so dramatically successful, it is easy to overlook the importance of the planning and preparation which made success possible. From the beginning, it was clear that massive operations on the ground would be needed. These included improved animal inspection, surveillance and quarantine arrangements; the establishment of a laboratory to carry out the necessary quality control measures; the installation of environment-controlled handling and storage facilities for sterile flies; a capacity to assemble, analyse and interpret the masses of data which the programme would produce; and an elaborate information campaign, using all media, to prepare the population for the aerial distribution of sterile insects as well as to ensure the cooperation of livestock owners and the public generally. All of these elements were as necessary as the sterile insects themselves.

While sterile flies had been widely and successfully used in the Americas, those campaigns had been conducted close to the plant that produced the insects. The long-distance transport involved in the North African programme introduced a totally new dimension and, with it, great uncertainty. The key to the success of sterile insect eradication is the competitive ability of the sterile insects when dispersed. Their quality is adversely affected by suboptimal handling at any stage up to the dispersal point. Much experimentation was required with shipping routines and environmental controls, and very detailed interaction was required at all stages with the contract companies providing the air transport and distribution. This attention to detail paid off: the quality of flies distributed was maintained at a very high level throughout the programme — undoubtedly a key element in the programme's rapid success.

Apart from technical matters, some of the most anxious moments throughout the campaign arose from difficulties on the diplomatic front. It is a tribute to common sense that the difficult diplomatic climate between certain countries involved was not allowed to impede progress. Even the outbreak of hostilities in the Persian Gulf, just as the programme was moving into high gear, did not cause interruptions, although the associated fluctuations in air freight and insurance rates caused much financial uncertainty. A particularly diffi-

cult issue arose over the question of liability in the event of a claim that flies distributed had not been properly sterilized. The probability of this actually happening was effectively zero, but it gave rise to a very critical legal question. It was eventually resolved on the initiative of Mr Said El-Mabrouk, who tragically died in a motor accident within hours of that meeting.

Despite the generous response of the donors to the call for support, anxieties over finances were myriad, particularly in the early stages of the programme. The campaign was launched with the full authority of the Director-General, specifically to take advantage of the fact that fly numbers would be low in the winter, although at that time the necessary funds to see the campaign through to completion were far from secure.

As the campaign progressed, regular budgetary revisions were carried out, while the funds pledged by donors were gradually made available. The budgeted requirements and funds available have converged at US$35 million — less than half the amount originally thought necessary. In addition to these international funds must be added the US$25 million of expenditure by Libya, together with about US$18 million in cash and kind required for the earlier phases of the programme and for activities in surrounding countries. Thus, the total cost is approximately US$78 million. An independent economic appraisal of costs and benefits has shown the return to investment, for North Africa alone, to be in the region of 50:1.

The programme had many of the elements of a military campaign, and to some extent its success is also attributable to the fact that it was managed along those lines. The key factor was the clear delineation of responsibilities — among other agencies and FAO, and within FAO to the specially established SECNA team. Once the lines of responsibility were clearly drawn, the partners could effectively cooperate. In particular, the partnership with the Libyan authorities worked extremely well.

A further essential element was the good quality and use of information, both financial and technical. Considerable effort was made to ensure that information was well communicated, both to those working on the programme and to those supporting it or affected by it. This book is the final part of that information exercise.

Acronyms

AfDB. African Development Bank

APHIS. Animal and Plant Health Inspection Service (United States)

ARS. Agricultural Research Service (USDA)

CAB. Commonwealth Agricultural Bureau

CSIRO. Australian Commonwealth Scientific and Industrial Research Organization

EEC. European Economic Community

FAO. Food and Agriculture Organization of the United Nations

IAEA. International Atomic Energy Agency

IBAR. Inter-African Bureau for Animal Resources

IFAD. International Fund for Agricultural Development

IsDB. Islamic Development Bank

IUCN. International Union for the Conservation of Nature and Natural Resources

MACES. Mexico-United States Commission for the Eradication of the New World Screwworm

OAU. Organization of African Unity

OIE. International Office of Epizootics

SECNA. Screwworm Emergency Centre for North Africa

SIDA. Swedish International Development Aid

UNDP. United Nations Development Programme

USAID. United States Agency for International Development

USDA. United States Department of Agriculture

WHO. World Health Organization

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Chapter one

The New World screwworm

1. The New World screwworm adult fly

The New World screwworm (NWS) has been referred to as a "flesh-devouring insect monster, straight out of a horror story" and "the worm of death". Historically one of the most destructive and costly insect pests of warm-blooded animals in the western hemisphere, the screwworm is an obligate parasite, known to science as *Cochliomyia hominivorax* (Coquerel).

The fly itself is harmless. Its reputation as a deadly parasite comes instead from its larvae, which are totally dependent on the living tissue of host animals for survival. The wound they cause is known as a myiasis, the presence of dipterous larvae in the tissues of animals or humans.

While most other agents of myiasis can survive on both dead and live tissue, NWS larvae penetrate and eat only living flesh and the resulting secretions. As they feed, they dramatically enlarge wounds, creating a pocket-like cavity and producing exudates that give rise to secondary infections and prevent the wound from healing.

Wounds infested by NWS larvae are generally very deep (up to 10 cm), resulting from the extensive tissue destruction. The excretions from the larvae produce necrosis of the tissue, which is also a lure for other flies. The wounds have a characteristic odour, resembling that of putrefaction, and the larvae are generally found in the deepest part of the wound, unlike the larvae of other, secondary parasitic species, which generally stay near the surface. The extreme damage caused by the feeding of the larvae, combined with resulting secondary bacterial infections, frequently causes the death of the host animal.

The screwworm fly is about two-and-a-half times larger than the common house fly. It has a blue-green body, with three distinct stripes, and orange-red eyes (see Photo 1). Its larva has large, backward-projecting spines (see Photo 2), which earned it the name screwworm.

The awful destruction and suffering caused by the screwworm larvae were graphically described by the much-quoted Texas rancher, Charles Scruggs, who wrote of the death of a young buck in his 1975 book, *The Peaceful Atom and the Deadly Fly*: "The wound in his head was now several inches deep. Screwworms now numbered in the thousands. The writhing, tearing pests had made a round wound three inches across." Scruggs reported that in bad years, up to 80 percent of newborn deer in the southern United States died from screwworm infestation.

An intensive and highly successful 30-year programme using the sterile insect technique (SIT) eradicated the pest from the southern United States and Mexico, with the last endemic case recorded in the United States in 1982. Mexico was declared screwworm-free on February 25, 1991, although an outbreak occurred in January 1992.

Before its discovery in the Libyan Arab Jamahiriya in 1988, the NWS had been confined to the tropical and subtropical Americas, in a range extending from the southern border of Guatemala and Belize in Central America, to South America beyond Uruguay.

Economics

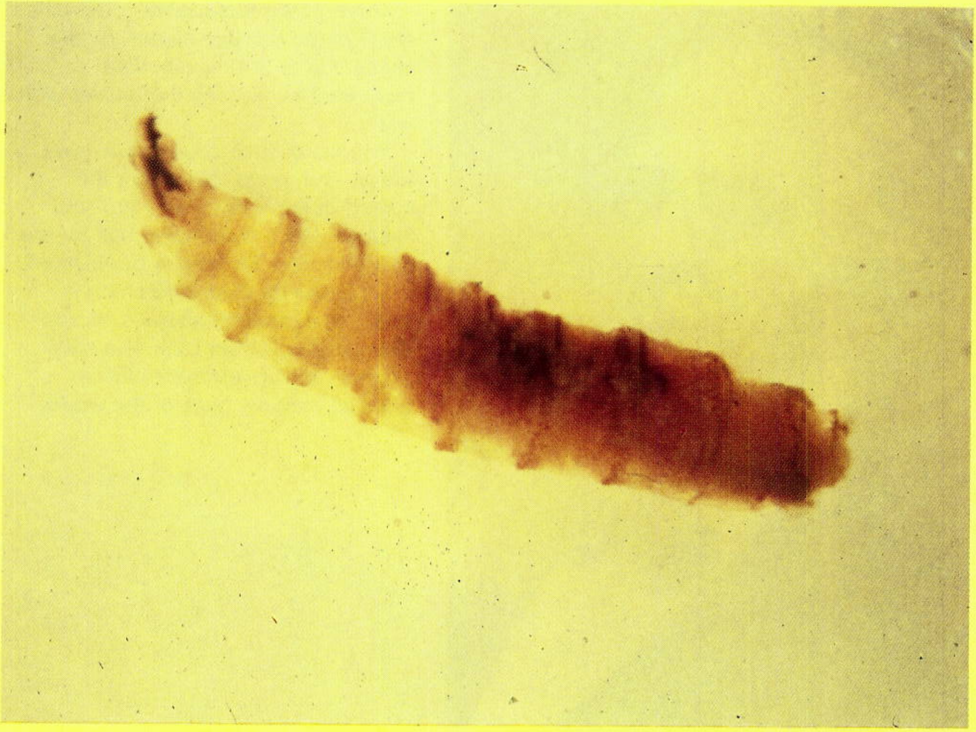
The cost of living with the NWS, in terms of surveillance and animal treatment, animal death and loss of production, is enormous. In 1976 the annual cost of the disease in Texas alone was estimated at US$300 million. By 1980, the cost estimate of a possible reinfestation was US$378 million annually.

Even when an infested animal does not die, it is more susceptible to other diseases, and milk and meat production can be seriously affected. Damage to hides and the cost of inspection and treatment amount to significant economic losses to livestock owners.

Based on an annual cost range of US$4 to US$10 per animal for inspection and treatment against NWS, it was estimated that living with the pest would cost Libya more than US$28 million annually. The five countries in the North African region, with 70 million head of livestock, would incur a combined cost of US$280 million annually.

History of the screwworm

The New World screwworm has existed on the American continent since ancient times, and its name is found in all the principal indigenous dialects. Throughout North and South America it is known by various local names, including *gusanera, queresa, bichera* and *bichiera* and, most commonly, in



2. The NWS larva has backward-protruding spines which earned it the name screwworm

Early screwworm cases

Dr Coquerel, a surgeon in the French Imperial Navy, had good reason for giving the newly identified screwworm fly the name *hominivorax*. It literally means "maneater". In a report which he published on the fly in 1858, Dr Coquerel gave details of five men who were brought to the Cayenne hospital suffering from screwworm infestation.

Cayenne at that time was a French penal colony, with a well-deserved reputation for being hell on earth. Four of the five patients were transportees. Three had French names, one Arab and one African. In each case a screwworm fly had laid eggs in the patient's nostrils, and the larvae had developed in the nasal sinus. The results, published in Dr Coquerel's report, make horrific reading.

Three of the five patients died as a result of the damage caused by the larvae. Up to 300 larvae were recovered by flushing the sinuses with water.

Reports of such cases occur even today, and it was feared that the spread of the screwworm into sub-Saharan Africa could have had severe consequences for human populations.

Dr Coquerel died in Réunion in 1867, of dysentery, after a long and distinguished career both as a naval surgeon and government official working in many parts of the world.

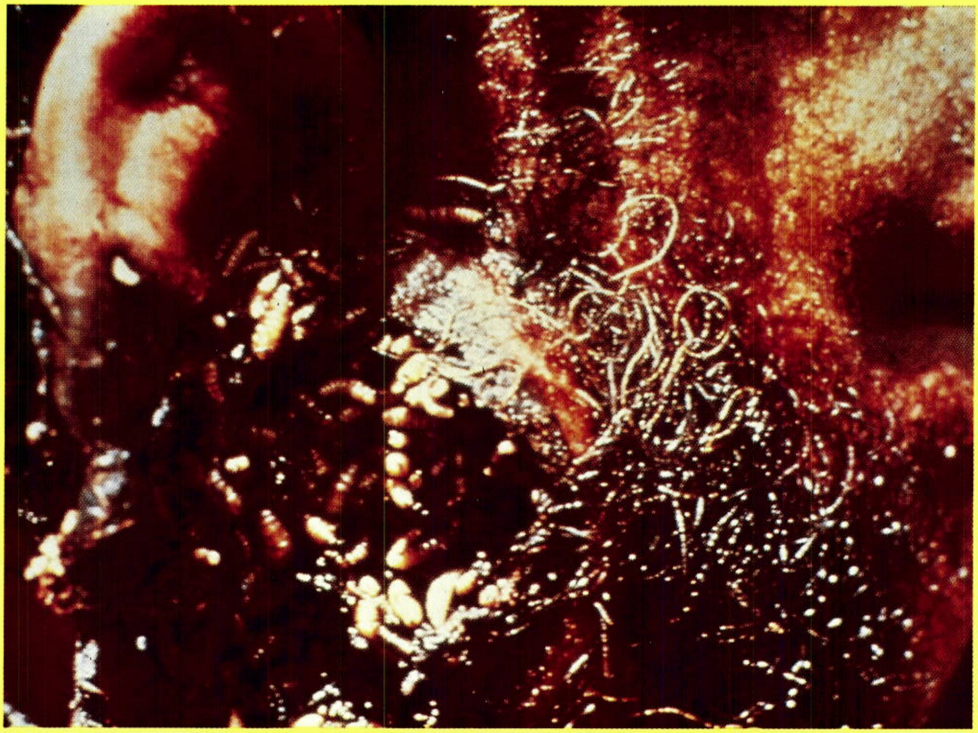
French naval surgeon, Dr Charles Coquerel, who identified the NWS in 1858

English, the screwworm. References to the species have also been found in documents from the period of Spanish colonization.

The species was first described in 1858 by the French naval surgeon Dr Charles Coquerel (see box on page 18), in his records of myiasis cases in men in Cayenne, French Guiana. After studying specimens of a fly collected at the French penal colony on Devil's Island, Coquerel declared a new species, giving it the name *Lucilia hominivorax*. *Hominivorax* means "devourer of man".

However, the fly was for many years confused with the relatively unimportant scavenger fly, *Cochliomyia macellaria*, a carrion breeder which is a secondary agent of myiasis, although morphologically very similar to the NWS. It is, in fact, often referred to as the secondary screwworm.

The confusion had resulted from the mistaken identification of the NWS in the late eighteenth century by Danish entomologist, Johann Christian Fabricius. He had observed a metallic, green-coloured fly with three dark stripes down its back, a yellow face and brick-red eyes. He determined that the fly was *C. macellaria*. It was many years before entomologist Col.



3. Humans also can suffer NWS infestations

Emory Cushing, under the direction of Prof. W.S. Patton at the University of Liverpool's School of Tropical Medicine, discovered significant differences in the genital structures of the two flies. In 1933 they identified NWS as a distinct species (which had already been named by Dr Coquerel) and named it *Cochliomyia americana*. Some years later, the scientific community adopted the name *C. hominivorax*.

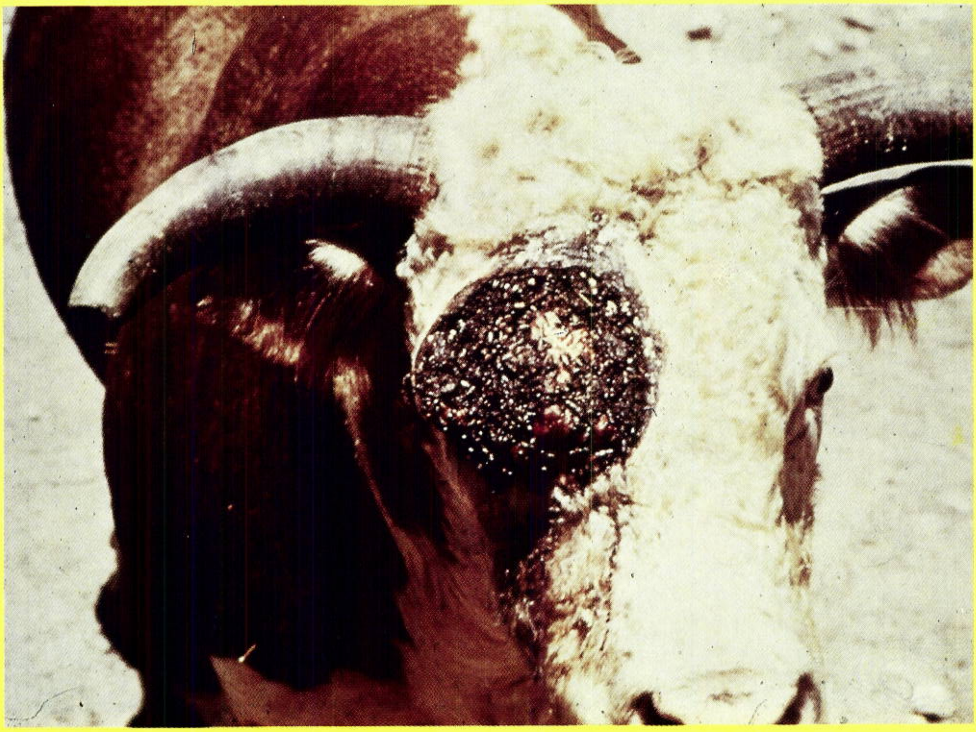
The NWS is classified as follows:

Order: Diptera
Family: Calliphoridae
Genus: *Cochliomyia*
Species: *hominivorax* (Coquerel)

NWS biology and life cycle

Cochliomyia hominivorax (Coquerel) has been recorded in a wide range of livestock and wildlife. Humans are particularly at risk of being infested when living in conditions of poor hygiene and close to infested livestock. If not treated immediately, screwworm infestations in humans (see Photo 3) can become debilitating and can lead to death, especially when larvae are present in the nasal and frontal sinuses, eyes, ears or mouth.

However, the screwworm is primarily a veterinary pest, as was demon-



4. Adult flies will lay their eggs in the body orifices of hosts. This infestation started in the eye strated during an epidemic in Texas in 1935, when approximately 230 000 cases were recorded in livestock, compared to only 55 in humans.

All warm-blooded animals may be attacked, including cattle, horses, sheep, goats, pigs and dogs. In North Africa, the screwworm infested camels and placed a variety of wildlife at risk, both in zoos and in nature. The eradication of the NWS from North America resulted in an increase in populations of larger wild animals. Photos 4 to 6 illustrate the damage that can be caused by screwworm infestation.

A specialist was employed as a consultant during the North African screwworm campaign to assess the potential impact of the NWS on wildlife in Africa, the Mediterranean basin, the Near East and Asia (see box on pp. 22-23). The study concluded that, had the NWS managed to break out of its Libyan bridgehead, the impact on wildlife in the Old World and, especially, in tropical Africa would have been catastrophic.

Gravid female screwworm flies are attracted to open wounds: essentially all wounds are attractive, including accidental lacerations such as those caused by barbed wire, or wounding

5. Multiple infestations will lead to a wound of this size in a matter of days; the host animal in this case, a cow, died as a result of the wound caused by feeding screwworm larvae

Impact of NWS on wildlife

This study was undertaken by Dr M.W. Woodford, chairman of the Veterinary Services Group in the Species Survival Commission of the International Union for the Conservation of Nature and Natural Resources (IUCN). Its results were published in March 1992.

The study drew on the somewhat scarce accounts of the impact of NWS on wildlife in subtropical North America, which were made by biologists and foresters when NWS was enzootic in that region. Most of these accounts concerned the effects of screwworm on the indigenous white-tailed deer. There was no hard data available on the likely impact of the NWS on wild mammals in the Old World, and it was necessary to extrapolate descriptions of NWS infestations of the wild fauna in Texas, Florida and Alabama. The study also utilized the equally scarce data available on the effects on wildlife of the Old World screwworm, *Chrysomya bezziana*. It also took into account climatic conditions likely to constrain or augment a hypothetical spread of the NWS from its Libyan focus.

The study concluded that much of lowland tropical Africa and subtropical Africa would have provided an ideal environment for the pest. Parts of Mediterranean Africa and Europe as well as the Near East would also have been able to sustain the fly. It predicted opportunistic, seasonal incursions into the hinterland of continental Europe.

North Africa, Europe and the Near East

The study noted that wildlife populations in these areas were small and often widely dispersed. Several species classified as vulnerable or endangered by the IUCN are found in the North African region, including the Barbary hyena (said to survive in Algeria, Morocco and Tunisia), the Barbary deer (Tunisia) and the Barbary macaque, Cuvier's gazelle and the Barbary ground squirrel (Morocco).

Seasonal incursions by the NWS into the habitats of these threatened species would have had a serious impact on the viability of their populations.

Red foxes and golden jackals, common throughout North Africa, as well as the Barbary sheep in Libya and Algeria, could have become infested and spread NWS over wide areas, although infestations would not have threatened the survival of the species, the study found.

Among the other countries of the Mediterranean basin, the study suggested that only southwestern Spain, Sardinia, Sicily, southern Greece, Lebanon and Israel would have provided suitable environments for permanent colonization by the NWS. The study concluded that seasonal incursions by NWS would have been widespread and serious if they had occurred when wildlife was breeding.

The study found that several vulnerable and endangered species would have been threatened, including the ibex in southern Spain and the Spanish lynx in western Spain. The endangered Corsican red deer, which still exists in small numbers in Sardinia, would have been affected. Sardinia supports a large population of wild boar, a target of heavy infestation by NWS when it existed in the southern United States.

as a result of animal husbandry practices such as castration, dehorning and branding. Many screwworm infestations result from natural wounding. In some affected areas, 90 percent of infestations start at the site of tick bites; among newborn animals the most frequently infested site is the unhealed umbilical scar (see Photo 7).

Larvae may also invade body orifices such as nostrils, eyes, mouth, ears and vagina. Invasion of the nasal fossae is the most common site of infestation in humans.

Mr D.D. Strode made some interesting comments at the 1959 annual conference of the Southeastern Association of Game and Fish Commissioners (United States) on the ability of large mammals to survive a screwworm infestation. After observing adult white-tailed deer in the United States, he noted that repeated infestations were required to kill an animal of that size. "Two hundred screwworms will destroy body tissues two inches in diameter and two inches in depth. Many repeatedly infested wounds may contain 2 000-3 000 screwworm maggots, which will destroy tissues up to seven inches in diameter and seven inches in depth. Few deer can withstand such

6. Another example of the damage that screwworms can cause tissue destruction and most will die before this stage is reached."

Screwworm larvae begin their development only on live animals. However, they may complete their development on the host even if it dies as a result of the infestation, provided they have reached the second larval instar stage, and the body of the host remains warm.

Egg laying lasts an average of 15 minutes and may be preceded or followed by feeding at the wound. A female lays between ten and 490 eggs (usually around 200) in a flat, shingle-like mass at the dry edge of the wound (see Photo 8). All of the eggs are oriented in the same direction, while the ovipositor (the organ with which the female deposits its eggs) is swept from side to side. Egg clutches are frequently divided into two or more masses, which can be laid several minutes apart at the same or a different wound. When females oviposit on a wound already occupied by an egg mass, they will invariably deposit their eggs in direct contact with the older egg mass. Thus one apparent mass could originate from two or more females.

The females lay their eggs at approximately three-day intervals. A female

7. The navels of newborn mammals are a favourite site for female screwworm flies to lay their eggs. Before the NWS was eradicated from the United States, up to 80 percent of newborn white-tailed deer died from NWS infestations during particularly bad years

has been recorded as laying eight separate clutches of eggs over a 33-day period, but an average female will lay about four clutches.

First instar larvae hatch 11-24 hours after laying and immediately start feeding on the living tissue. Like the Old World screwworm *Chrysomya bezziana* (see box opposite), they have a gregarious method of feeding, burrowing head-downwards into the tissue, with just their posterior tips protruding for respiration. If larvae become immersed in wound fluids they will literally "come up for air", raising the posterior tip, which contains the posterior spiracles, above the liquid.

Once embedded in the flesh, the larvae do not move around in the wound, as do many secondary agents of myiasis, and their large, backward-projecting spines prevent them from being easily removed.

The larvae grow to the third instar stage while feeding in the wound; the exudates produced promote secondary bacterial infections, which prevent healing. Larger infested wounds discharge pus and blood and have a characteristic bad odour, which is particularly attractive to NWS female flies. As more egg masses are laid and hatched,

8. The NWS adult female lays its eggs at the edge of the wound in a shingle-like mass the wound is greatly enlarged and deepened by the increasing number of growing larvae. Secondary agents of myiasis may also be attracted to the necrotic tissue of the wound, but, unlike the screwworm, their larvae remain near the surface and are not generally found deep in the wound. The rate of development of larvae is influenced by the size and nature of the wound and by the number of larvae present.

After feeding for four to eight days, the larvae leave the wound and drop to the ground, burrowing several centimetres into the soil to pupate (see Photo 9). The depth of burrowing is affected by the type of soil and by vegetation cover. The texture and temperature of the soil are important factors for the survival of the pupae.

The duration of the pupal period depends heavily on temperature, ranging, for example in Texas, from seven days in summer to 54 days in winter. Under controlled laboratory conditions of 100 percent relative humidity, the pupal period varies from six days at 34.5°C to 32 days at 15°C. The life cycle (see Figure 1) is completed in about 21 days under favourable conditions, at 22°C, but may extend to two or three months in cold conditions.

The Old World screwworm

The Old World genus *Chrysomya* is analogous to the New World genus *Cochliomyia*. It includes the Old World screwworm fly, *C. bezziana*, an obligate parasite in wounds. Its life cycle and habits and the appearance of wounds infested by it are very similar to those of *Cochliomyia hominivorax* and, therefore, it is the species with the most potential to be mistaken, in the larval stage, for the New World screwworm.

There is a remarkable parallel between the two screwworm species, which appear to occupy an exactly equivalent parasitic niche in their natural ranges. Adult female *C. bezziana* only lay their eggs on live mammals, depositing 150-500 eggs at sites of wounds or in body orifices. The larvae hatch after 18-24 hours, moult once after 12-18 hours and a second time about 30 hours later. They feed for three to four days and then drop to the ground to pupate. The pupal stage lasts for seven to nine days in tropical conditions and up to eight weeks in subtropical winter months.

Like the NWS, the Old World screwworm is catholic in its selection of hosts. It was first given the name of screwworm in 1909 in association with a human infestation in India, although it was not named *C. bezziana* until 1914. Other hosts include cattle, water buffalo, sheep, goats, horses, donkeys, dogs, camels, elephants, impala, bushbuck, waterbuck, giraffe, lion, white rhinoceros, eland, black rhinoceros and many others.

It is widely distributed over the tropical and subtropical parts of Africa and Asia. In Africa it has been recorded as far south as northern Transvaal and northern Natal in South Africa and, in Asia, it reaches eastward to Taiwan (province of China), the Philippines, Celebes and Papua New Guinea. It has also been introduced into several countries on the west coast of the Persian Gulf.

Adult flies generally emerge in the early morning and burrow to the soil surface. During the first two days they will disperse over a wide area. Males are sexually mature within 24 hours and are polygamous, mating five or six times. Females usually mate only once, on about the second or third day after they emerge, and the female is ready to lay her first batch of eggs about four days later. At this time she will begin searching for a host and, if none are available nearby, she will travel great distances to find one. Individual flies have been observed to travel up to 290 km in less than two weeks.

Female flies require protein, which they obtain by feeding on the wounds of animals. However, they have already taken in the protein necessary to lay their first batch of eggs during the larval stage. In addition to protein, adult flies require sources of carbohydrates and water, which they obtain by feeding on the flowers of a wide range of plants.

Flowering shrubs and trees are also used as sites for mating and resting. Males establish "waiting stations" from where they strike at any passing, flying object about the same size as a female NWS. They have even been known to

9. NWS pupae

chase small pebbles tossed in the air.

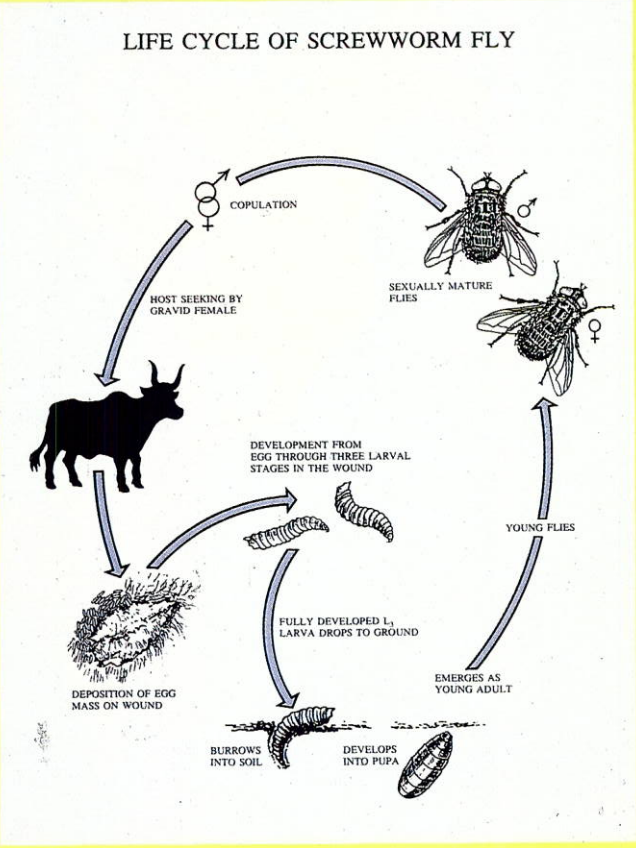
In the laboratory, pupal fat stores are exhausted within three days of emergence. Honey is often used as a carbohydrate source for flies in culture. Adult flies live for two to three weeks in the wild and can live for up to two months in the laboratory.

The screwworm is an opportunistic species. Its longevity and ability to lay many egg batches, combined with its great ability to disperse, allows it to exploit intermittently favourable environments. This capacity was well demonstrated by the regular summer advances made each year into the central United States from overwintering sites in Texas, Mexico and Florida before the screwworm eradication program began.

Geographic distribution

Before its appearance in North Africa, the screwworm was endemic only in the tropical and subtropical regions of the New World (Central and South America and the Caribbean islands) (see Figure 2). Its distribution is determined largely by its inability to survive persistently cold weather. Warm, moist

Figure 1. Life cycle of the screwworm

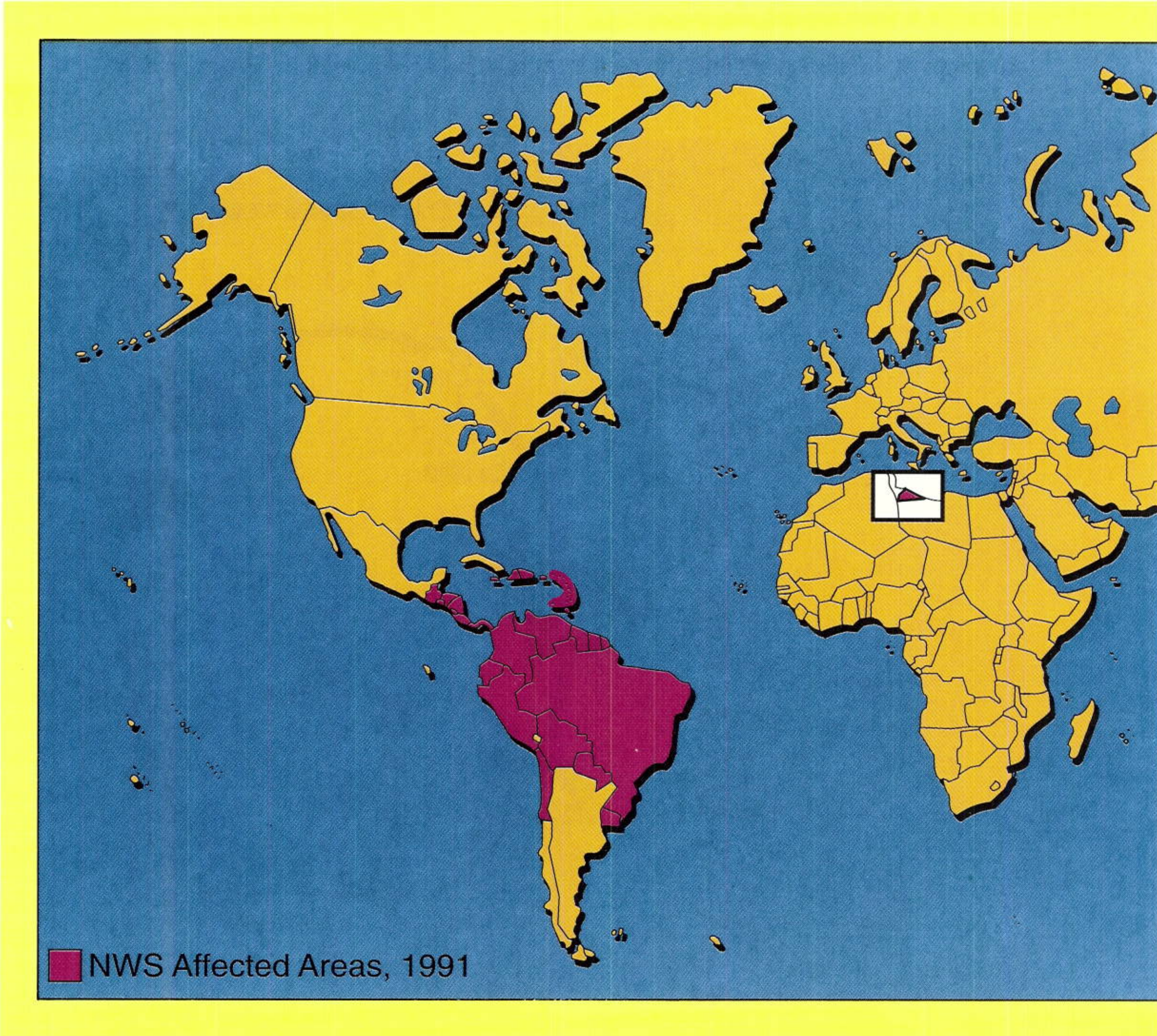


conditions are optimal, while prolonged dry heat or cold are suboptimal. Fly activity decreases when the temperature is below 21°C, and flies cannot survive in areas where the mean temperature is below 9°C for three months, or 12°C for five consecutive months of the year.

In favourable conditions, the fly can spread rapidly far beyond its overwintering limits. This penetration occurred annually in North America before eradication. The fly has now been pushed to the southern borders of Mexico; from there it extends into Chile, Argentina and Uruguay.

Use of insecticide to control NWS

Surveillance and treatment of infested animals and use of insecticides to control the screwworm involve significant

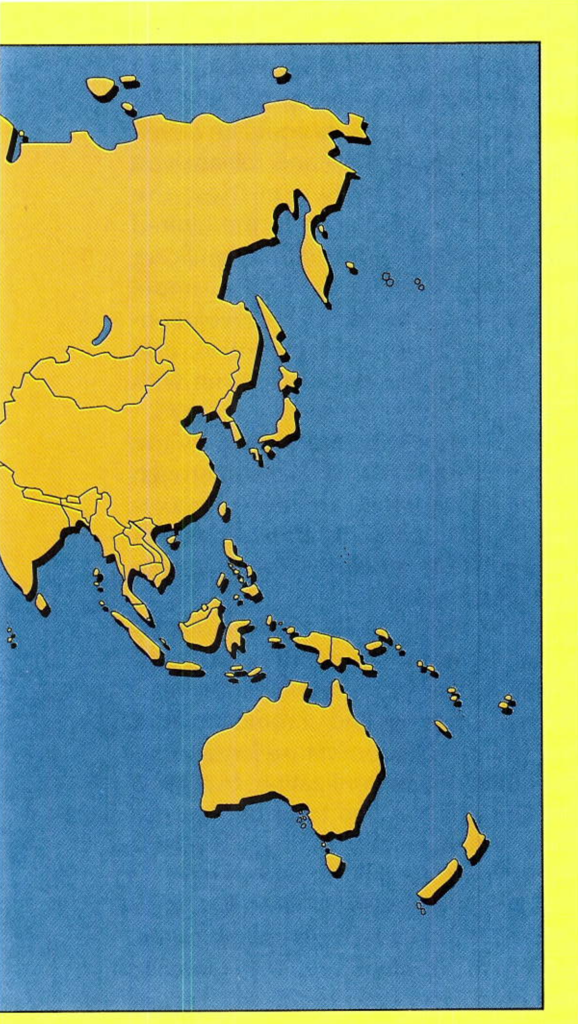


recurrent expenses. The impossibility of controlling wild animal populations means that they are a constant reservoir of reinfestation.

It is of primary importance that all animals are carefully inspected to locate any open wounds, which are then treated with an organophorous compound such as coumaphos, which was used in Libya. A 5-percent powder is applied directly to the wound, or mixed with cooking oil and applied with a brush. It acts as both a curative for treatment of infested wounds and as a prophylactic to prevent infestation.

Herds of animals are treated by dipping or spraying with a 50-percent wettable powder, applied at a 0.25-percent concentration. Dipping is considered the most efficient and economic method for screwworm control.

Insecticides have also been used to reduce adult fly populations, through the use of the screwworm adult suppression system (SWASS), which are pellets comprising a mixture of dried blood, sugar, corn cob grits, the insecticide dichlorvos and wax impregnated with an adult NWS attractant known as swormlure-2. The pellets have been used successfully to reduce screwworm fly populations in the southern United States and northern Mexico but were less effective in the more humid regions of central and southern Mexico. SWASS was not used in Libya during the eradication programme.



Development of the sterile insect technique

The sterile insect technique (SIT), the first insect pest control method involving genetics, can most simply be described as a form of birth control. Combined with surveillance, wound treatment, animal movement control and quarantine, the use of SIT has been phenomenally successful, as demonstrated in the Americas and in North Africa.

The technique involves mass rearing of the target pest species, sexual sterilization by radiation (using caesium 137) and the release of vast numbers of sterile insects into the infested area

Figure 2. Areas affected by the NWS, 1991

with a ratio of sterile to wild of 10:1. When a wild female mates with a sterile male, she will lay infertile eggs, and thus will not produce offspring. If sufficient numbers of sterile males are released, so that most indigenous females are mated by them, numbers in the wild population will be consequently reduced. Continued release of sterile flies over consecutive generations will progressively reduce the reproductive capacity of the wild population and eventually result in its extinction.

Unlike many other methods of pest control, the sterile insect technique is environmentally friendly. No chemicals are used, no residues are left behind, and there are no ill-effects on non-targeted species.

Apart from its use in eradication of the NWS, SIT has been used to eradicate the Mediterranean fruit-fly from Mexico and parts of Guatemala and California, the melon fly from Okinawa, the Mexican fruit-fly from areas of the United States adjoining Mexico, as well as to clear the tsetse fly from areas of the United Republic of Tanzania, Nigeria and Burkina Faso. In 1992, it was being used to combat the pink bollworm in California, the codling moth in Canada and the onion fly in the Netherlands.

From theory to reality

The idea that economically important insects, such as the NWS, could be controlled or eradicated through genetic manipulation, a theory known as autocidal suppression, was first developed by the American entomologist Dr Edward F Knipling in the late 1930s. Knipling's ability to test his theory was greatly assisted by the work of his colleague, entomologist Dr Raymond C Bushland.

In 1936, Bushland had developed laboratory techniques for culturing the screwworm on ground meat, facilitating mass production of the flies for research. This was a major breakthrough, since nobody had previously been able to rear an obligate parasite except on a live host animal.

In 1937 Knipling observed the extreme sexual aggressiveness of the male screwworm as well as the normal refusal of the female to mate more than once. He had also noted that the NWS, in comparison to other blowflies, had a low population density in the wild. He realized that if a means could be developed to rear, sterilize and release vast numbers of screwworm flies, the screwworm population in the United States could be reduced to insignificant numbers. Knipling devised a simple mathematical model of his revolutionary concept for insect control, and Bushland began experimenting with chemicals to induce sterility in NWS.

Their work was interrupted by the Second World War. The breakthrough came in 1950, when a fellow entomologist Dr A.W. Lindquist drew Knipling's attention to an article by Nobel laureate Dr Herman Muller.

In the 1920s, Muller had conducted experiments using a dentist's X-ray machine, which produced bizarre mutations in the genes and chromosomes of the fruit-fly *Drosophila melanogaster*, including sexual sterilization. In a 1950 article, Muller called for a ban on nuclear testing because of the possible effects of nuclear fall-out on humans.

Knipling consulted with Muller, who assured him that radiation would sterilize NWS; Bushland and D.E. Hopkins began experiments to confirm this, at first using borrowed time on a hospital

An award for developing sterile insect technique

Following the successful conclusion of the SIT programme in North Africa, the Director-General of FAO presented special awards to Dr Knipling and Dr Bushland, in recognition of over 50 years' work in developing the technique for pest control.

During the award ceremony, the two scientists were praised for their insight, persistence and dedication; the Director-General commented that their work was a striking example of how a scientific idea could be nurtured, developed and, finally, brought to bear on problems of real concern.

They were presented with silver Leonardo da Vinci medals, which were struck by FAO in 1986 to underline the importance of science in the historical development of agriculture and in improving agriculture for the future.

On receiving their awards, the scientists commended eradication programme of the Screwworm Emergency Centre for North Africa (SECNA). Dr Knipling said that the achievement of eradication in such a short period was clear evidence that the programme was well planned and well executed. He expressed hopes that such cooperative efforts would continue.

"It is my conviction that we have the knowledge and technology for dealing with many other important insect problems more effectively," Dr Knipling said. "To achieve this we must be bold in our thinking, and provisions must be made so the technology we have can be applied in the proper manner."

Supporting Dr Knipling's comments, Dr Bushland said he believed the NWS could be eradicated from the world. "It may seem impossible today, especially in places the size of Brazil, but I am sure it can be done," Dr Bushland said.

The scientists were presented with silver medals and a scroll in recognition of their work.

From left, SECNA director Dr E.P. Cunningham, Dr Edward F. Knipling FAO Director-General Edouard Saouma, and Dr Raymond C. Bushland

X-ray machine and later gamma rays produced from cobalt 60. After a few months they demonstrated that adults of both sexes were sterilized with relatively low irradiation doses to pupae. Laboratory experiments in which sexually sterile and untreated males were placed in cages in various ratios to compete for females demonstrated the essential validity of Knipling's mathematical model. For example, when sterile males outnumbered fertile males in a 9:1 ratio, only 10 percent of the females produced fertile egg masses.

Award. Drs Knipling and Bushland were presented with Special Science Awards by FAO in November 1991 for their work in developing the sterile insect technique (see box on page 33).

Testing the technique

The first field trial was carried out in 1953 on Sanibel Island (36 km^2), 5 km off the coast of Florida. The release of 38 sterile males per square kilometre per week for several months achieved some success, causing about 80 percent of egg masses to be infertile. However, the trial did not achieve full eradication because, it was believed, fertile females that had already mated were migrating to the island from the mainland.

The opportunity arose in 1954 to conduct a more decisive field test on the 440 km^2 island of Curaçao, 64 km off the coast of Venezuela. The initial release of 78 flies per square kilometre per week, which had little impact, was increased to about 150 flies per square kilometre, and eradication was achieved in seven weeks.

The success of the experiment so impressed livestock owners in Florida that they persuaded their state legislature and the United States Congress to provide funds for a control programme in that state in 1957. The massive task of eradicating the NWS from the southern United States began.

NWS eradication in the United States

Before the successful eradication programmes in the southeastern and southwestern United States, the NWS caused massive losses estimated in 1960 at US$100 million annually, making livestock production difficult and labour-intensive and causing untold losses in wildlife. Its presence dictated animal husbandry methods and, in areas where screwworm occurrence was seasonal, practices such as calving, branding, shearing and castration were scheduled to avoid infestation by the parasite. The advent of modern insecticides made treatment possible, but the cost of continued surveillance and treatment of wounds became prohibitively expensive (estimated at US$4 to US$10 per animal annually).

Screwworms regularly overwintered in southern Florida, Texas, California and Arizona and were commonly reported in the central United States. Occasional cases were reported as far north as the Canadian border, and most of this northward movement was caused by the transport of screwworm-infested animals.

Higher survival in the overwintering areas during the winter months resulted in earlier and more expansive migration. Hot, dry weather slowed the process, while warm, moist weather throughout the year consistently resulted in explosive outbreaks. In the temperate regions of the United States, populations were destroyed by prolonged cold during late autumn and the winter months.

The southeastern United States

After the successful eradication of the screwworm from Florida, an eradication programme jointly funded by the state and federal government was finally approved for the southeastern United States.

The winter of 1957-1958 was one of the coldest in Florida's history. Taking advantage of the consequent reduction in the screwworm population, the team began distribution of 14 million sterile flies per week in the southern part of the Florida peninsula, establishing a "barrier zone" that virtually stopped the usual northward migration of the flies and spared the states north and east of Florida from their usual summer screwworm infestations.

A new, larger rearing facility was established at an airbase at Sebring, Florida in 1958, which was able to produce from 50 to 75 million sterile flies per week. Sterile flies were packaged 400 to a box and released over treatment areas in Florida, southern Georgia and southern Alabama. Fly distribution was supplemented by livestock inspection, education of owners and monitoring of sterile and wild fly activity. Quarantine lines were operated across northern Florida and along the Mississippi River from Memphis, Tennessee, south to the Gulf of Mexico, where all livestock moving into the eradication area were inspected and treated.

Florida livestock producers reported only 864 cases of screwworm infestation in 1958, and the last endemic case was recorded in Florida on June 17, 1959.

The southwestern United States

Prior to 1962, livestock owners estimated that one million cases of screwworm infestation were treated in Texas, the most heavily infested state, in a normal year. Screwworm migration from Texas also caused thousands of cases each year in Louisiana, Arkansas, Oklahoma, Kansas and Missouri.

A campaign by livestock owners in the southwestern states led to the approval of an eradication programme, again jointly funded by the US Congress and state governments, on February 8, 1962. The aim was not only to eradicate the pest from Texas, Arizona, New Mexico and California, but also to prevent its reintroduction into the southeastern states and to prevent a reinvasion of the United States from Mexico.

The severe winter of 1961-1962 reduced the screwworm population in its overwintering area to an unusually low level, and distribution of sterile flies was begun over central Texas. After construction of a new plant at Mission, Texas, the distribution area was expanded to cover 388 500 km^2 of Texas, New Mexico and a small area of Mexico near the Texas border.

During 1963 many livestock owners reported no screwworm cases for the first time in recent history and, in 1965 Texas and New Mexico were declared free of endemic screwworm infestation. After successful cooperative eradication programmes in Arizona and California, the United States Department of Agriculture (USDA) declared the entire United States screwworm-free in 1966.

The problems, however, were not over. Unfavourable weather conditions kept remaining populations low until 1971-1972, when an abundance of rain and a warmer than normal winter contributed to a major outbreak in Texas in 1972. The favourable weather also contributed to an increase in numbers of Gulf Coast ear tick, which infested large areas of Texas. Ticks created record numbers of wounds for screwworms from late July to the end of October each year from 1972 to 1976, resulting in a consequent reduction in the effectiveness of the screwworm control and eradication campaign.

The earlier success of the programme had meant a reduction in animal surveillance activities, with livestock owners reducing the amount of labour devoted to surveillance and control. The number of absentee livestock owners had increased, and both cattle and deer populations were significantly higher since screwworms had been brought under control.

By mid-May 1972, the screwworm problem was completely out of hand in Texas, but sterile fly releases, which continued until the end of the year in Texas, Louisiana and Arkansas, prevented the reintroduction of the pest into the southeastern states. Outbreaks continued to occur in the southwest, notably in 1976, when almost 30 000 cases were reported.

The last endemic case in the United States was recorded in August 1982. The need for continued surveillance to prevent reintroduction of the screwworm has been demonstrated by the discovery of infestations in animals entering the United States.

The eradication programme in Mexico

A cooperative agreement between the USDA and the Mexican Secretary of Agriculture and Livestock (SAG) had been in existence since 1966, with the dual aim of controlling the NWS and reducing economic losses caused by the pest in Mexico, while attempting to prevent its natural migration to the United States.

The agreement achieved little success, and in 1966-1967, a study on the seasonal abundance and geographic distribution of the pest in Mexico (to evaluate the feasibility of implementing an eradication programme) found that it was distributed throughout 95 percent of the country.

Mexican livestock owners, alarmed by the results of the study and aware of the success of the SIT eradication programme in the United States, combined forces with their US counterparts to convince their governments to use SIT in Mexico.

Recognizing that the NWS would continue to make its away into the United States unless eradicated from the adjacent areas of Mexico, government officials from both countries began discussing the feasibility of implementing a programme in Mexico.

In 1972 the joint Mexico-United States Commission for the Eradication of the New World Screwworm (MACES) was established with the initial aim of eradicating the pest to the Isthmus of Tehuantepec.

The Puerto Rican trial. In 1971 a trial was initiated to evaluate the SIT in a tropical environment, similar to that of central and southern Mexico. It involved the dispersal of sterile insects over the islands of Puerto Rico, Mona, Culebra, Vieques and the United States and British Virgin Islands. The programme had achieved success by 1975, and the experience gained both in eradication from a tropical environment and in long-range aerial transport

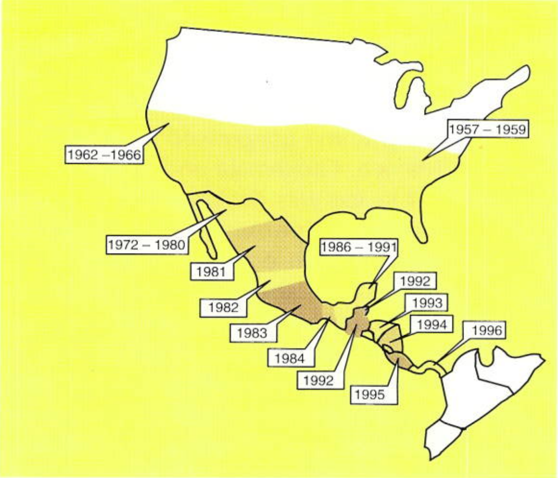


Figure 3. Chronological summary of the NWS eradication and future plans in the Americas

of flies was to be valuable in the Mexican eradication programme.

Progress in Mexico. A production plant with a capacity to produce 600 million flies per week was opened at Tuxtla Gutierrez, Chiapas, in August 1976.

Combining its efforts with intensive inspection and treatment of animals, the Mexican eradication programme progressively moved south; in 1984, a year ahead of schedule, all of Mexico north of the Isthmus of Tehuantepec

10. The Mexico-United States Commission for the Eradication of the New World Screwworm sterile NWS production plant at Tuxtla Gutierrez, Mexico was declared free of screwworms. A sterile fly barrier zone and an animal quarantine and inspection programme was maintained at this point, as the SIT programme progressed into southern Mexico, Guatemala and Belize.

Mexico was declared free of screwworms in February 1991. However, there was an outbreak in early 1992, which probably originated from the introduction of screwworm-infested animals from Central America. The infestation spread quickly through three states in southern Mexico: Campeche, Tabasco and Chiapas. MACES was conducting a hotspot SIT programme in the infested zone in March and April 1992, releasing a total of 58 million sterile flies per week to eradicate the pest.

Eradication programmes are continuing in Central America, with the aim of pushing the NWS to the Isthmus of Panama by 1996 (see Figure 3).

The Mexican production plant

The Tuxtla Gutierrez sterile fly production plant (see Photo 10) is involved in three main activities: NWS rearing, irradiation and packaging for distri-

11. Larvae are reared at the Mexican plant on a gelled diet, which is a mixture of dried blood, milk substitute, spray-dried egg, a gelling agent, water and formaldehyde bution. It also operates a major research and development programme to ensure an output of consistently high-quality sterile insects.

Biological security is extremely important at the plant because of the risk of reinfestation by escaping fertile flies. The plant therefore maintains strict security measures in and around the rearing areas.

Rearing. The plant's brood stock in 1992, known as OW-87, originated from a strain collected in Orange Walk, Belize, in 1987 by the Agricultural Research Service (ARS) of the USDA. A strain collected from Guatemala in 1988 was maintained for back-up purposes and, in 1991, a new strain from Costa Rica (CR-91) was being developed by the ARS-USDA.

NWS larvae are reared at the plant (see Photo 11) on a gelled diet (consisting of dried bovine blood, milk substitute, dried egg, formaldehyde, a gelling agent and water), which replaced a less efficient hydroponic diet in April 1990.

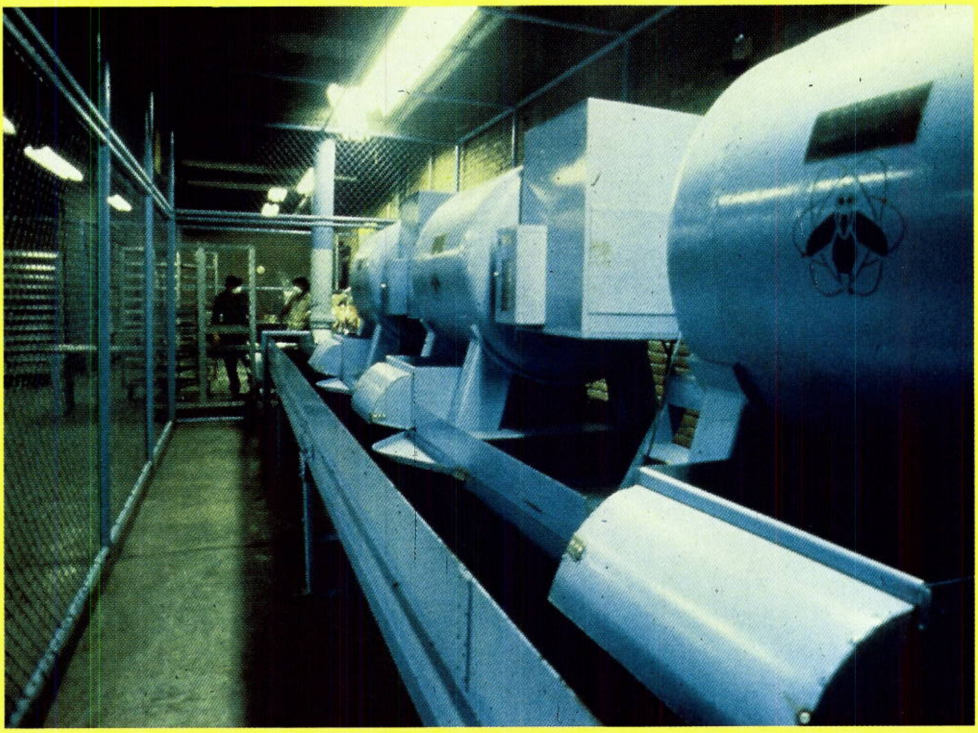
NWS eggs are placed on ground horsemeat patties, which are then placed in feeding trays containing the gelled diet. These infested trays are then stored in racks placed in special

larva rearing rooms, where a temperature of 36.7-37.8°C with 65 percent humidity is maintained. Fresh gelled diet is added to the trays at regulated intervals until, after 64 hours, the racks containing the rearing trays are moved to another rearing room, where a temperature of 32.2°C with 70 percent humidity is maintained.

After a total of 88 hours, they are placed in a larva collection area, and a three-day larval crawl-off period begins. The larvae leave the feeding trays and fall on to collector belts; from there they are moved in bulk to a pupation room.

Within 16 hours of transfer to the temperature-controlled rooms, approximately 99 percent of the larvae will have pupated. Three to five percent of the pupae are diverted at this stage for use as brood stock.

Radiation. Once fully developed, about five days after pupation, the remaining pupae are placed in stainless steel cylindrical canisters and irradiated, using caesium 137, in the four specially designed Husman radiators at the plant (see Photo 12). The irradiated pupae are then stored for 72 hours at 10°C, before being packaged (see



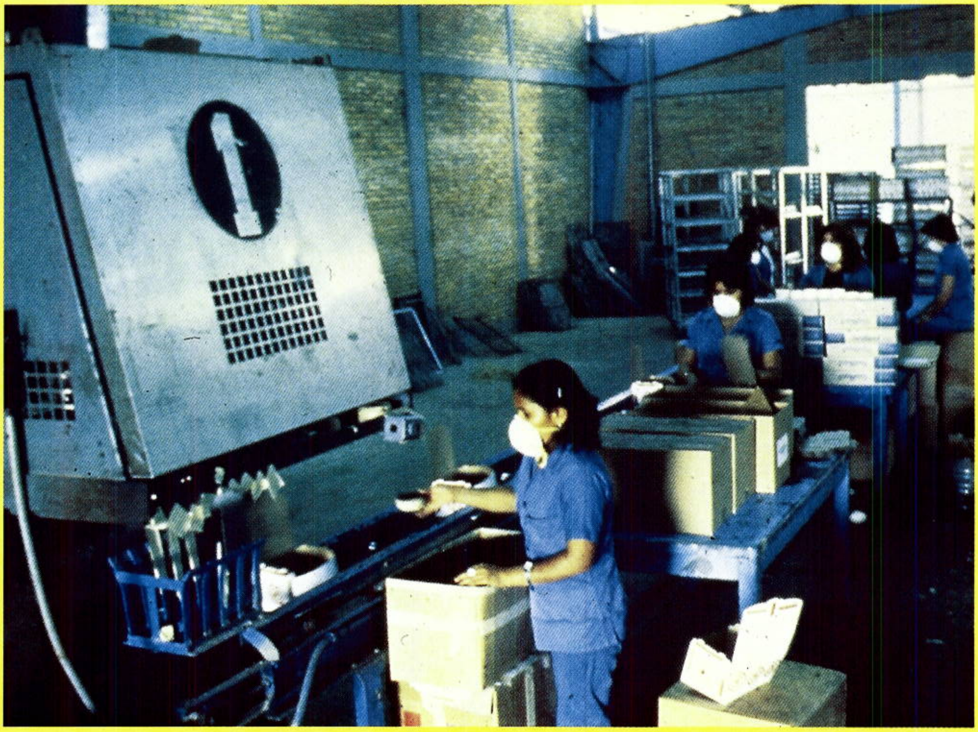
12. The plant's radiation chambers; pupae are exposed to eight rads of radiation, produced from caesium 137

Photo 13) and transported to distribution centres for dispersal.

Egg harvesting. Those pupae retained as brood stock are placed in cages until adult emergence, when they are then held for five days to allow for mating and egg development. When the females are fully gravid, the cages are equipped with an oviposition device, known as an egging board, and transferred to the oviposition room. Positive phototropism and a spent-diet bait are used to attract females to the egging board. Eggs are harvested from the boards for subsequent rearing, and the adult flies are destroyed.

Methods development. The department is concerned with the development of new technologies that increase programme efficiency while minimizing expenditure. It is involved in quality control, research and development, and strain maintenance.

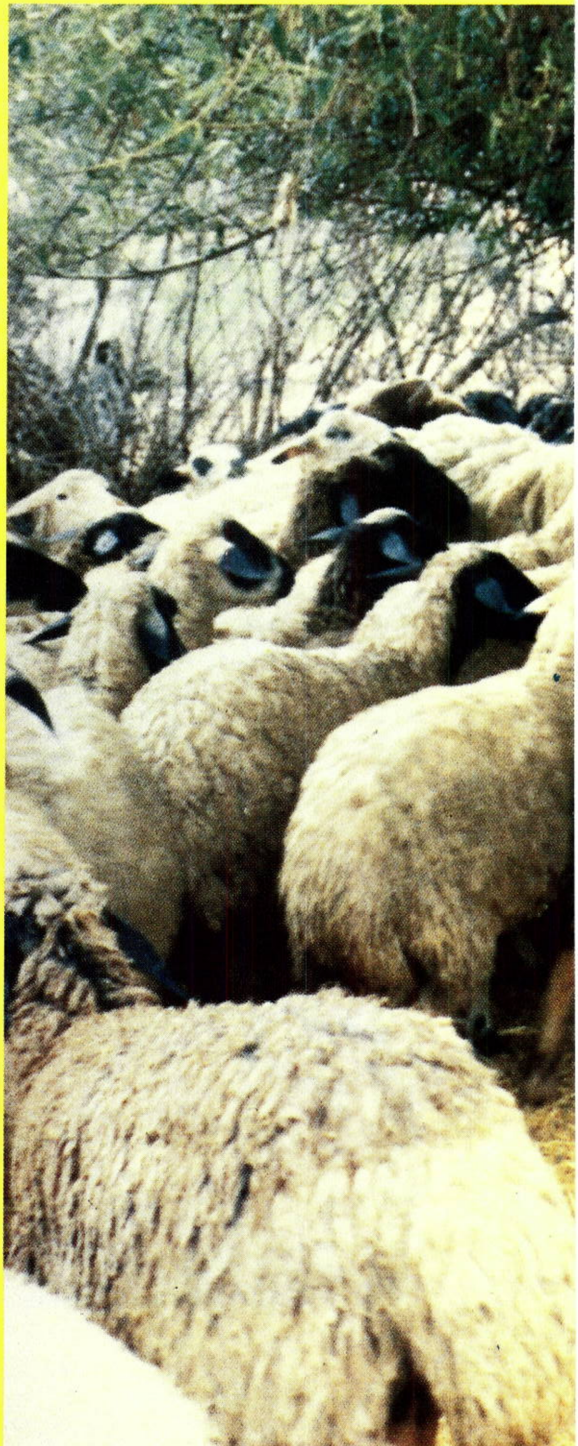
Production. In April 1992, the plant was producing 300 million sterile flies per week for eradication programmes in Guatemala, Belize, Honduras, El Salvador and Mexico.



13. Packaging the pupae at the Mexican production plant

Chapter two

The North African emergency



14. Sheep being inspected for wounds and any evidence of NWS infestation

The discovery of the New World screwworm in the Libyan Arab Jamahiriya in the spring of 1988 represented an emergency not only for Libya, but for the entire North African region.

For the first time in history, this relentlessly destructive pest had become 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.

By early 1989 the Libyan government had developed plans for a surveillance and treatment programme to control and contain the screwworm and requested United Nations assistance.

Consequently, the Food and Agriculture Organization of the United Nations (FAO), the International Fund for Agricultural Development (IFAD), the International Atomic Energy Agency (IAEA) and the United Nations Development Programme (UNDP) became involved to varying degrees in the early stages of the emergency, with FAO taking the lead in developing plans first to control and then to eradicate the pest, with the support of the other three United Nations agencies.

The implementation of these plans represented an enormous technical, logistical and diplomatic challenge. Since the screwworm had previously been found only in the Americas, the only countries with expertise in screwworm biology and with the capacity to produce sterile flies were the United States and Mexico.

While FAO and other UN agencies could employ Mexican and United States experts, and did so from the early stages of the programme, action by the US Congress and the Mexican government was required before sterile flies could be obtained for an eradication programme in Libya.

In an extraordinary example of politics being put aside in the face of an international emergency, all obstacles to implementing the eradication programme were eventually overcome and, while red tape may have caused frustration and delays during the two-and-a-half years before eradication

TABLE 1: LIVESTOCK CENSUS IN INFESTED AND BORDER AREAS (1987)

Municipality	Sheep	Goats	Cattle	Camels	Other*	Total
Zawia	460 730	80 220	12 150	16 630	n.a.	569 730
Al-Jabal al-Gharbi	417 550	224 580	340	5 150	n.a.	647 620
Tripoli	907 200	160 300	39 210	5 110	n.a.	1 111 820
Khalije Sirte	341 460	47 450	6 350	1 020	n.a.	396 280
Total	2 126 940	512 550	58 050	27 910	≈ 20 000	2 745 450
Proportion (%)	77.5	18.7	2.1	1.0	≈ 0.7	100

* Horses, donkeys and dogs.

TABLE 2: LIBYAN IMPORTS OF CATTLE, IN HEAD

Source	1986	1987	1988	1989	1990
Austria	5 528	13 055	13 767	4 637	
Bulgaria	7 715	9 429	15 232	n.a.	
Denmark	233				
Germany, F.R.	1 498	3 910	2 097	42	
Hungary		2 531	3 457	n.a.	
Ireland	46 366	30 149	15 982	36 057	
Italy	1 201	105			
Yugoslavia			2 252		
Netherlands				814	
Total	62 541	59 179	52 787	41 550	
Trade yearbook figures (FAO estimates)	70 000	60 000	55 000	45 000	55 000

TABLE 3: LIBYAN IMPORTS OF SHEEP, IN HEAD

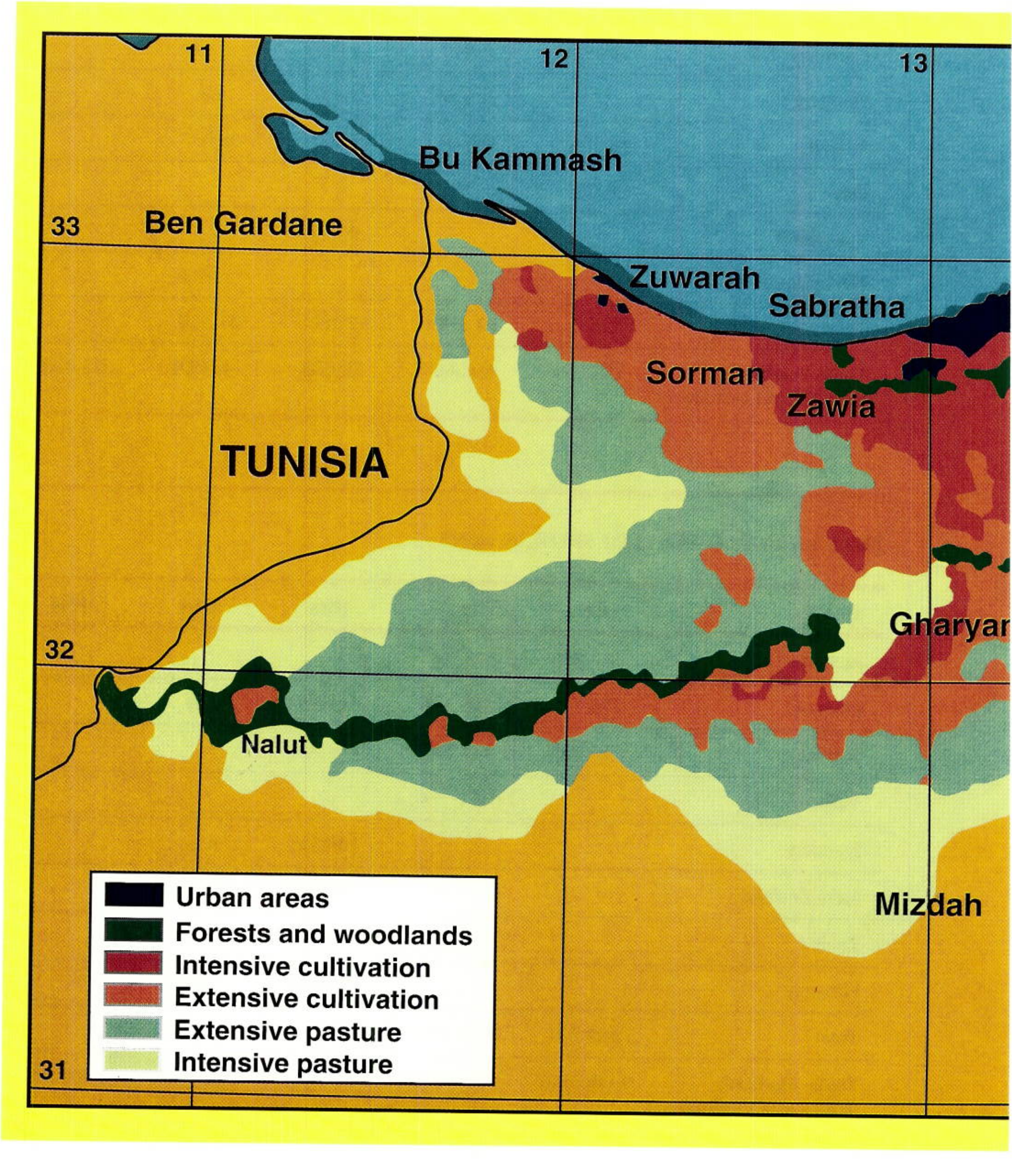
Source	1986	1987	1988	1989	1990
Australia	357 056	586 387			
Bulgaria	276 110	586 336	743 820	n.a.	
Turkey	63 685	147 505	118 334		
Malta		4			
Hungary			108 545	n.a.	
New Zealand			66 000	66 000	
Tunisia			6 500	43 274	
Uruguay			236 628	16 661	
Total	696 851	1 320 232	1 279 827	125 935	
Trade yearbook figures (FAO estimates)	1 000 000	1 800 000	2 000 000	2 300 000	2 000 000

was achieved, it never threatened the success of the operation.

Livestock production in Libya

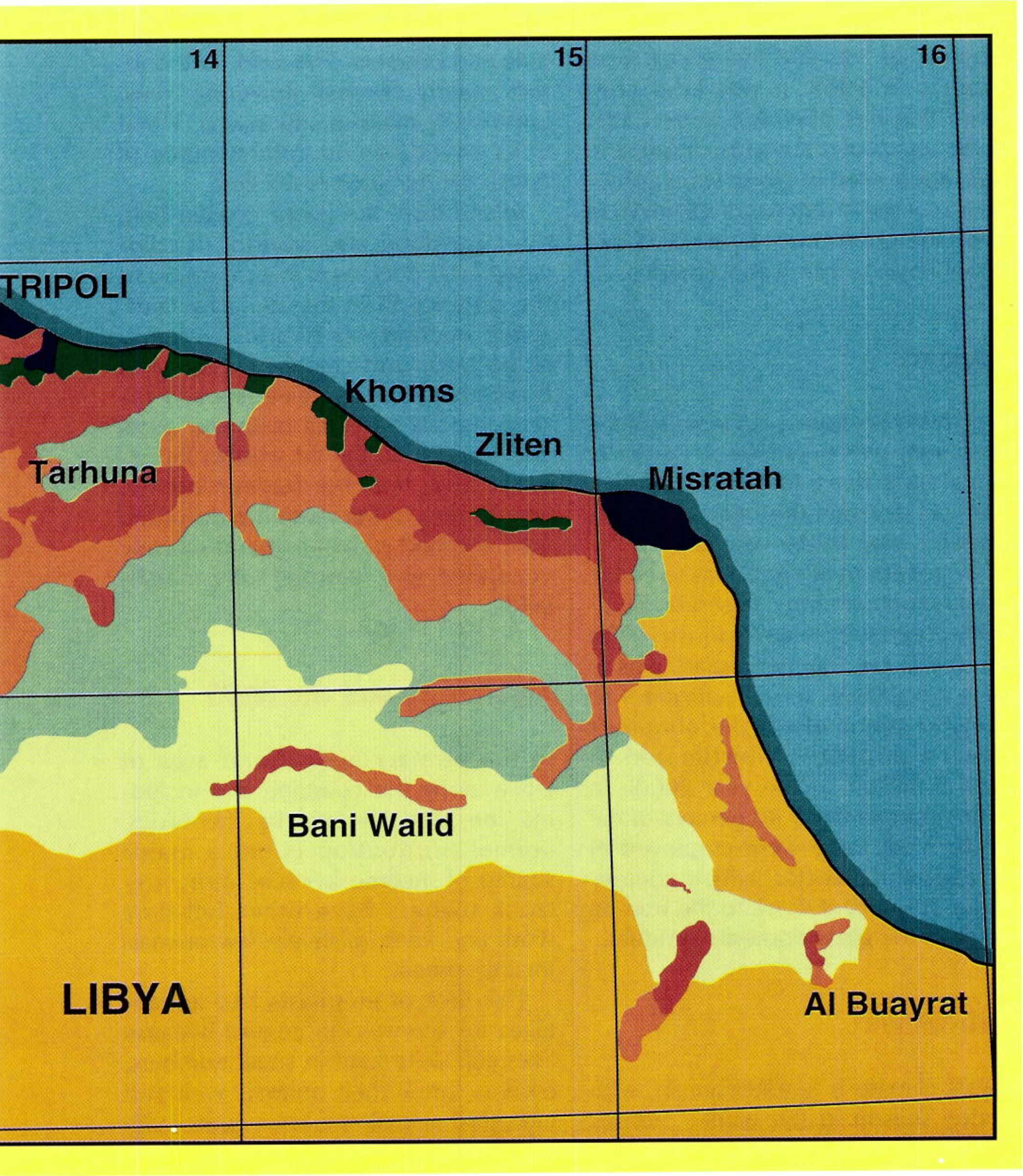
Agriculture in Libya, although diverse, relies heavily on livestock production, mainly sheep. In 1991, there were an estimated 2 million head of livestock in the infested area, with a total of about 7 million in the entire country, of which 80 percent were sheep (see Table 1).

Libyan livestock are used mainly for production of meat and milk, with



domestic production of red meat estimated in 1988 at 18 kg per person. The country imported an approximately equal amount per person, about 15 percent of it in the form of live animals. In 1988, Libya imported about 59 000 cattle from European countries and more than 1.2 million sheep from countries including Bulgaria, Turkey, Hungary, New Zealand and Uruguay (see Tables 2 and 3).

Figure 4. The western part of Libya showing different agriculture levels, 1989



The source of the screwworm infestation in Libya remains an unresolved question. There has been the suggestion of possible shipments of live animals from the Caribbean and Latin American countries which were not reflected in official trade figures; however, these have not been confirmed. It was initially thought that the screwworm could have entered Libya with a shipment of 236 000 live sheep from Uruguay in 1988. It was later confirmed that this shipment arrived after the first cases of screwworm infestation were discovered in Libya. As a consequence of the discovery of the NWS in Libya, the government banned all live animal imports from Latin America.

Economy

The Libyan economy, at the time of the infestation, was based on a system of annual objectives, formulated in five-year cycles within the framework of a long-term plan to the year 2000.

The government's goal was to create a diversified economy, based on modernized agriculture and industry. The aim, under the long-term plan, was to reach a high level of self-sufficiency to meet the demands of the country's growing population (estimated to reach 5 million by the year 2000). In 1990, approximately 40 percent of the Libyan work force were employed in the agricultural sector, which contributed a 20-percent share to the non-oil sector of the gross domestic product.

Environment

Libya's climate is Mediterranean, with a rainy season in the winter months (December to February). The soil is sandy and there are no rivers or high mountains in the area of the NWS infestation (see Figure 4).

Much of the region where the screwworm appeared in Libya is irrigated and rich in vegetation, with extensive agriculture, horticulture and livestock breeding. Crops produced include wheat, barley, olives, oranges, lemons, plums, grapes, almonds, carrots, tomatoes and peppers. The wild flora consists mainly of small flowering trees, particularly mimosa and acacia. These trees provide an important source of nectar for the adult NWS flies.

Inland from the green coastal belt, the vegetation and amount of cultivated land decreases in proportion to the distance from the sea. The landscape becomes semi-arid, with few or no trees and scattered grass and bush-shrubs. The land is used for semi-nomadic grazing of sheep, goats and camels. To the far west of the infested area, near the Tunisian border, and in most of the eastern parts of the area, the land is semi-arid and sparsely vegetated and features salty marshlands.

Agriculture and the NWS

In the primary agricultural area of Libya along the coastline and including the area infested by the NWS, animal production is not a major source of income because most livestock owners have other full-time work and keep relatively few animals (mainly sheep).

This lack of emphasis had advantages for screwworm control because livestock were kept in small numbers, owners knew their animals well and individual animals could be more easily inspected.

Animal husbandry practices

Libyan livestock owners do not castrate their animals, and dehorning and branding are practised only on a limited basis. Generally, wounds caused by human intervention occur as a result of transporting animals or of tying their front legs together to prevent movement (used to restrain camels, cattle, horses and donkeys). The shearing season is from April to early June and is normally combined with spraying of animals against ectoparasites such as ticks, mange and fleas.

Veterinary services

Libya has an extensive network of veterinary clinics – even the smallest villages generally have their own clinics.

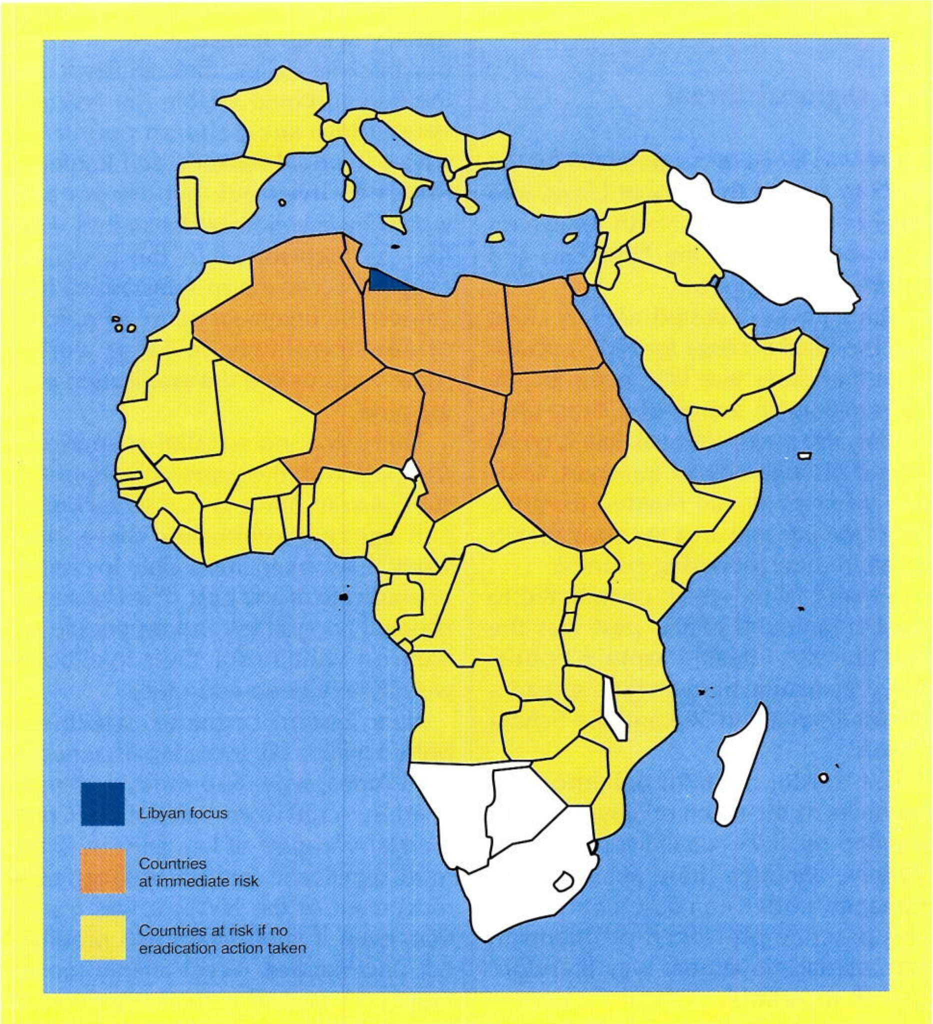


Figure 5. Countries at risk from potential spread of the screwworm

Treatment and drugs were provided free of charge by the Libyan government until 1992, when it was decided that animal owners should pay for drugs. Operated by the Libyan Secretariat of Agriculture's Department of Veterinary Services, the network provided an important basis for the early surveillance and control activities organized by the Libyan authorities and later for the surveillance, prevention and control aspects of the eradication programme.

The regional threat

There was a disastrous potential for the NWS to spread throughout Libya, into other countries of the North African region and then into the Near East and Europe (see Figure 5).

Although the infested area in Libya had the ideal ecology for NWS subsistence and there was little need for the fly to migrate in search of suitable conditions, the major risk was that it could spread through animal transport. Only one infested animal needed to move out of the infested area to cause an outbreak in a neighbouring country.

A major factor which contributed to the containment of the pest was the fact that the infested zone was bordered by natural barriers to its spread – the Mediterranean Sea and the Sahara Desert.

The border areas of neighbouring countries to the south of Libya are arid and had relatively small livestock populations, although these animals were managed under nomadic conditions. This practice presented problems in that animal movement was therefore difficult to control.

There was, however, considerable potential for the pest to spread easily into Tunisia, although Libya had closed its border with Tunisia to live animal transport following an outbreak of foot-and-mouth disease in November 1989.

During the eradication campaign, positive cases of NWS myiasis were found within 40 km of the Tunisian border. Sterile fly distribution was in fact expanded during the campaign to include a buffer zone inside Tunisia.

In the United States and Mexico, river valleys provided an important channel of migration for the NWS; it was quickly acknowledged in North Africa that the Nile Valley, through Egypt and the Sudan, could enable the NWS to spread into sub-Saharan countries, where it would have caused immense losses to livestock producers and would have seriously threatened wildlife. As mentioned in the previous chapter, screwworm infestations had caused the deaths of up to 80 percent of newborn fawns in Texas during some years before the eradication programme.

There was no parallel scenario to compare with the game-rich regions of sub-Saharan Africa and, if screwworms had become established there, they would have been impossible to control or eradicate at any cost. The impact on national economies and on people reliant on wildlife for their livelihood would have been enormous.

Near Eastern countries, which imported millions of live animals annually from Africa, were also seriously threatened by screwworm infestation. Commercial transport of live animals is the most significant method of long-range movement of the NWS. It was feared that, even if importation was prohibited, uncontrolled illegal animal movement and gradual natural migration of the flies would mean their inevitable introduction into the Near East.

NWS colonization of Africa and Europe

A report by two Australian scientists, prepared in late 1990, showed that climatic conditions would have allowed permanent colonization by the NWS in tropical Africa. The report also indicated that the pest could have become permanently established along the Mediterranean coasts of Africa and Europe.

The scientists, Drs R. Sutherst and G. Maywald, of the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO), used a computer model for climate-matching projections, known as CLIMEX. The model had been developed originally to estimate the potential geographic distribution of the Old World screwworm (*Chrysomya bezziana*). Results of CLIMEX projections for North America showed similar distribution patterns by both the Old World screwworm and the NWS. After making adjustments to temperature and moisture parameters to match the life cycle of *Cochliomyia hominivorax* better, the scientists ran a model for NWS. The model is based on climatic factors and cannot readily account for the effects of non-climatic environmental change such as tree-planting or irrigation programmes. Models were run, however, to simulate the effects of irrigation schemes, rainy seasons and climate change.

The countries of Mediterranean Europe were also susceptible if the NWS was allowed to become established in the North African region. It was anticipated that the pest could be introduced into Europe by the transport of live animals and, based on the experience in the United States, it appeared certain that under favourable conditions the NWS could spread far into the temperate regions of Europe.

During the screwworm outbreak in North Africa, Australian scientists reported that climatic conditions would allow permanent colonization of tropical Africa and the coastal areas of the Mediterranean basin by the NWS (see box above).

Discovery

The presence of the NWS in Libya first came to the attention of veterinarians in early 1988, when several farmers brought cases of an "unusual" myiasis to the attention of Dr O.M.E. El-Azazy, of the department of parasitology, Faculty of Veterinary Medicine, Al-Fateh University in Tripoli.

Specimens were collected in March 1988 at Hadba, 10 km south of Tripoli; and later in the year samples of larvae from myiases were collected from cattle and sheep in an area which extended from Zuwarah, 100 km west of Tripoli, to Gharyan, 80 km south of the capital, and Khoms, 100 km to the east. Cases were also reported at this time at Benghazi, to the east of Tripoli. However, later investigations failed to confirm that these latter cases of myiasis were caused by NWS, and no confirmed NWS infestations were ever found in the area.

Scientists in the Faculty of Veterinary Medicine, Al-Fateh University, including Drs El-Azazy and M.M. Gabaj, identified *Cochliomyia hominivorax* as the causative agent of the myiasis cases.

During 1988, some cases of human myiasis caused by the NWS were reported in towns and villages within a 100 km radius of Tripoli.

Analysis of specimens

Specimens collected in the Tripoli area in November and December 1988 were sent by Dr El-Azazy to both the British Museum (Natural History) and the Commonwealth Agricultural Bureau (CAB), International Institute of Entomology, London. Drs N.P. Wyatt, I.M. White and A.C. Pont of the British Museum identified the specimens as *C. hominivorax*. The Institute circulated notification of the identification of NWS in Libya to Dr El-Azazy, Drs W.N. Beesley and M.M. Gabaj of the Liverpool School of Tropical Medicine, UK, and to FAO and the USDA.

On January 28, 1989 Dr El-Azazy reported in the *Veterinary Record* the existence of the pest in Libya.

In February the *Veterinary Record* published another report giving further details of the NWS and its worrisome spread in Libya (Gabaj and Beesley, 1989). The writers noted infestations in cattle, sheep, goats, camels and a monkey in the Tripoli zoo, as well as four cases in humans.

The *New Scientist* published a report in its edition of February 18, 1989 on the appearance of the NWS in Libya.

International agencies are notified

On February 1, 1989, FAO, IFAD and other organizations were notified of the existence of NWS in Libya, when they received copies of the report from CAB, International Institute of Entomology, on the identification of the Libyan samples.

After advising IAEA, the International Office of Epizootics (OIE), the Organization of African Unity (OAU), the Inter-African Bureau for Animal Resources (IBAR) and the World Health Organization (WHO) of the situation, FAO requested confirmation of and details on the screwworm problem from the Libyan government.

The first mission

The first action by FAO was to send a mission to Libya, from April 15 to 22, 1989, to investigate and confirm the existence of the NWS in Libya.

The mission members were Dr V. Kouba, chief of the Animal Health Service in FAO's Animal Production and Health Division and Dr S.M. Toure, FAO's project manager based in Burkina Faso.

FAO also called in a screwworm expert, the general subdirector of the Mexico-United States Commission (MACES) in Mexico, Dr M. Vargas-Teran, who began work as a consultant in April. He later travelled to Libya to assist in training the local personnel and to advise on the implementation of surveillance and prevention activities.

NWS presence confirmed in Libya

The members of the mission spent one week in Libya, hosted by the government and veterinary authorities. Their programme, prepared by Libyan authorities, included discussions with the

General Secretary of Agriculture and Land Reclamation, H.E. Ing. Abdelmajed El-Gaud, and leading veterinary specialists as well as visits to the nine districts in the Tripoli area.

By the second day of the mission, after studying specimens of adult flies and larvae taken from four cases of human myiasis in 1988, the FAO representatives confirmed that the New World screwworm was present in Libya. The specimens were held at the department of parasitology, Faculty of Medicine at Al-Fateh University in Tripoli, where they had already been identified by Libyan scientists as *C. hominivorax*.

The Libyan authorities informed the mission that 2 000-3 000 cases of screwworm myiasis in animals and some cases in humans had been reported in less than one year within a 100 km radius of Tripoli. The mission members also discussed with the Libyan authorities an emergency programme for the control and eradication of the screwworm and the need for emergency international assistance in establishing a surveillance, prevention and control programme.

On completing the mission, the representatives urged that the situation be regarded as an emergency.

The Libyan government requested immediate FAO assistance on April 22, 1989.

FAO approved the first Technical Cooperation Programme (TCP) project, on April 27, for emergency assistance to Libya. The eight-month project provided an initial US$182 000 (later increased to US$345 000) to assist Libya in establishing of an intensive campaign of animal surveillance, quarantine and treatment, with the aim of containing the screwworm and preventing its spread to other African countries. It provided three consultants as well as insecticides and essential equipment.

Following the mission, several important recommendations were made which, to varying degrees, were acted on in the early stages of the emergency. They included a recommendation that a project document be prepared for the eradication of the screwworm in Libya and that, in agreement with OIE and WHO, animal myiasis caused by *C. hominivorax* be included in the list of internationally notifiable diseases.

Initial activities

Little time was wasted as emergency measures were enacted to deal with the screwworm problem in North Africa. Within days of the return of the first mission, FAO had notified countries bordering Libya (Algeria, Chad, Egypt, the Niger, the Sudan and Tunisia) of the threat, both by telex and through their representatives to FAO in Rome.

The governments of neighbouring countries were urgently requested to assist in determining whether or not the NWS had already spread from Libya. They were asked to initiate surveillance of myiasis cases in animals and humans, coordinated by veterinary, entomological and medical services. They were also informed of the need to collect larvae samples for identification and were urged to notify FAO of any suspected or confirmed cases of NWS infestation in order to coordinate national and international surveillance of the problem.

IFAD had also responded promptly to the emergency. Following the notification by the CAB of NWS presence in Libya, IFAD's Technical Advisory Division director, Dr A. Kesseba, discussed the situation with the Libyan Minister of Agriculture in early March. Consequently, IFAD received a formal request from the Libyan government for assistance on May 3, 1989 and responded by sending a mission to Libya later that month (see Chapter nine).

The Screwworm Action Group

A special Screwworm Action Group was formed within FAO on April 27. Apart from coordinating FAO activities in relation to the screwworm problem, the group was to begin preparing a programme to eradicate the NWS from Libya, based on use of the sterile insect technique.

During May, FAO missions to Tunisia, Algeria and Egypt found no evidence of infestation and recommended surveillance and prevention programmes in these countries.

Inclusion in OIE List B

An FAO recommendation that screwworm myiasis caused by *C. hominivorax* be included in the list of international notifiable animal diseases (List B) was approved by the general session of the International Office of Epizootics in Paris on May 12, 1989. This meant that the disease would be included in the international reporting systems, occurrence data would be published in the FAO/WHO/OIE *Animal Health Yearbook* and that special recommendations for export and import of animals would be included in the OIE International Zoosanitary Code.

In September 1990, international requirements for the import and export of live animals were finalized and adopted by OIE. FAO participated in

A report from the infested zone

When the chief of the Zawia Animal Protection Service, Mr Garib Elgelidi, was called to Tripoli in May 1989 by the Department of Veterinary Services to discuss the discovery of a new, unusual animal myiasis, he was already aware of the problem. Farmers had reported incidences of these strange myiases to local veterinary clinics, and there was concern about the severe damage caused to livestock.

Following the Tripoli meeting, the National Screwworm Committee was established. Mr Elgelidi was appointed regional supervisor for Zawia and given responsiblity for establishing a surveillance, treatment and control programme in the municipality, based on the network of local veterinary clinics.

Farmers were informed that the new, strange pest was the New World screwworm and were encouraged to report unusual cases of myiasis to veterinary clinics. Inspection teams were established, which were sent immediately to farms where cases had been reported.

Animals were inspected, wounds treated and samples of myiases taken for identification; reports were made for submission to the regional supervisor, who then passed weekly reports on to the national committee.

In early 1989, the number of screwworm cases in Zawia was limited, enabling prompt treatment of infested animals and transfer of larvae to Tripoli for identification.

Mr Elgelidi was shocked when he first saw an animal infested by the larvae of the NWS. "I had a very strange feeling about this kind of pest which was eating through the animal's flesh. It made me very afraid for the future," he said.

His fears were shared by local farmers. During 1990, Zawia was one of the worst-affected areas and, as the number of myiasis cases increased, farmers bringing myiasis samples jammed the corridors of local veterinary clinics.

"We were worried (in 1990) that things would get out of control and extra effort, great effort, was made to control the pest," he said. "We knew from very early times that it wasn't possible to get rid of this pest by normal means, by traditional ways of treating wounds. Its way of reproducing was so fast."

Surveillance and control activities were increased and most of the local veterinary resources were directed toward the emergency situation.

Mr Elgelidi was one of a group of Libyan professionals who travelled to the Tuxtla Gutierrez sterile fly production plant in Mexico during the SIT programme.

Zawia regional supervisor Mr Garib Elgelidi (centre) hands screwworm information to a local farmer

the process of drafting the requirements.

Libyan government action

In the meantime, the Libyan authorities were working to establish the infrastructure to handle the emergency. They had identified a control zone, which included the three infested municipalities of Tripoli, Zawia and Margeb and part of the the municipalities of Al-Nekat al-Khams and Al-Jabal al-Gharbi.

A central National Screwworm Committee was established by the government in late May. The national committee, which operated within the Libyan Ministry of Agriculture, was complemented by subcommittees in each of the five municipalities and supported by the Department of Veterinary Services.

Libya also pledged to cover part of the expenses for a screwworm control programme.

By early June 1989 the government of Libya had initiated a formal surveillance, prevention and control programme, concentrated in the infested zone, approximately 25 000 km^2 centred on Tripoli (see box on pp. 54-55).

Fifty-five surveillance teams, each with two veterinary assistants and a driver, began operating in the infested zone (the number was increased to 94 teams by August with the teams being reduced to two veterinary assistants). Seventeen animal checkpoints were established in September on roads connecting the infested area with the screwworm-free areas.

In addition, the staff at the 104 veterinary clinics within the control zone were required to combine their normal work with screwworm surveillance and treatment and to report any cases of myiasis to the central committee.

A screwworm diagnosis and identification laboratory was established in June at the veterinary services headquarters in Tripoli.

To strengthen screwworm control activities, a stray dog control programme was further implemented in the municipalities of Tripoli, Zawia and Margeb.

Libya's total contribution to the screwworm programme in 1989 was approximately $7.5 million.

Technical assistance

FAO provided funds for the employment of experts and provision of insecticides and equipment through its Technical Cooperation Programme. The first project for Libya was approved in April 1989, with the aim of developing control measures to contain the screwworm and prevent its spread to other areas of Africa. Much of the funds allocated for the project were to be used for the employment of three Mexican screwworm experts as consultants in Libya.

The project was revised in June 1989 and its funding increased to US$345000 to enable the three Mexican experts to work in tandem with a US$1.25 million project, jointly funded by the Libyan government and the United Nations Development Programme (UNDP).

Under the cost-sharing arrangement, UNDP provided US$250 000, while the Libyan government provided US$1 million in cash as well as support in kind, covering provision of personnel, office space, laboratory facilities and storage space for project materials and equipment.

The Libyan government/UNDP project, executed by FAO, was essentially a control project, specifically aimed at containing the NWS within the identified infested zone. It provided essential support for the consultants, a significant amount of chemicals and equipment for treatment of livestock and for the training of Libyan personnel.

The Libyan government organized the required infrastructure by consolidating existing staff and providing others as needed. Support was provided in the form of junior and field staff as well as office, laboratory and field trial facilities.

It had been acknowledged that, since the NWS had never before been found outside the Americas and thus presented an entirely new problem in Libya, experienced personnel was lacking to plan and implement preventive and treatment programmes and to initiate appropriate quarantine measures.

The Mexican experts, who were employed as consultants by FAO, therefore played an important role during the initial phase of the programme, in assisting the Libyan government to determine the distribution of the pest in Libya, implement a surveillance and control programme, put in place quarantine measures and, finally, evaluate the feasibility of eradicating the pest.

The consultants were: screwworm epizootiologist Dr L.F. Liera; screwworm control specialist Dr J.E. Rios and screwworm entomologist, Dr A. Martínez y Tapia. All three had worked for the Mexico-United States Commission for the Eradication of the New World Screwworm in Mexico.

Their work also involved entomological investigations into the biology and behaviour of *C. hominivorax* in Libya. The information gained was useful in devising practical control procedures and to assess the possibility of using SIT. They also assisted in the development and execution of specimen collection and identification.

The collection of live screwworm material in Libya was extremely important at that time. It was necessary to rear larvae to pupa stage, which could then be transported to the United States for tests to determine the mating compatibility of the Libyan NWS strain with the Mexican-reared strain. These tests, later conducted in the United States, were crucial if SIT was to be applied successfully in Libya.

Among the first priorities of the project was the employment of a chief technical advisor (CTA) who, in collaboration with Libyan authorities, would oversee the project in Libya.

Activities

The consultants worked in Libya from July to September 1989. While the Libyan government had been working to establish surveillance and control activities and to set up the infrastructure to handle the emergency, the consultants found that much work was needed to develop the expertise and methods to deal with the NWS as well as to identify and obtain the necessary equipment.

Although NWS larvae had been tested and identified, no accurate records had been kept of the exact locations of confirmed cases, and no maps of the infested area were available.

Working with Libyan authorities, the experts helped to establish a system of collection and identification of myiasis cases where the names of the municipality, branch (subdivision) and farm where larvae had been gathered were recorded. The boundaries of the infested area were then determined.

They also advised on how further to develop and strengthen surveillance and control activities, which had been established by the Libyans in early June 1989. They introduced the use of coumaphos 5-percent powder for treatment of wounds and advised on how to streamline prevention and control activities to enable inspection teams to complete their inspection of an area within 21 days (the average life cycle of the NWS).

Inspection teams were encouraged to spray animals only on farms where positive cases of NWS had been identified. Previously the teams had sprayed all animals, regardless of whether or not NWS cases had been confirmed on a farm, and had also sprayed the soil.

The consultants helped determine appropriate locations for the 13 animal checkpoints, which were established to control animal movement (quarantine stations were established at these sites during the pilot phase of the eradication programme).

Sentinel sheep pens were established in an attempt to gather live NWS material for use in sexual compatibility tests. Three sheep were placed in each pen and one was surgically wounded to provide an attractive site for a female NWS to lay her eggs. The sheep were inspected twice daily, to keep the wounds fresh and to collect any egg masses. The wounded sheep were rotated after three days.

Because of low NWS fly activity during the period of the consultancies, no live NWS material was gathered at the time.

The experts collaborated with the Joint FAO/IAEA Division mission, which had been sent to Libya to conduct a preparatory investigation into the potential use of the sterile insect technique for eradication.

One expert also participated in the regional training course on surveillance, control, prevention and eradication of screwworms, held in Tripoli in July 1989, lecturing on the subject of the methods development division in a screwworm eradication programme.

UNDP/Libyan government project: ongoing activities

Although designed to assist in controlling and containing the screwworm infestation, this project eventually helped to lay the groundwork for the main eradication programme using SIT. It continued into 1990 to strengthen prevention, control and surveillance activities in preparation for the use of SIT; to advise on methods to streamline further the reporting and recording of NWS cases; and to develop maps of the infested area. During this period, screwworms were reared to the pupa stage for use in sexual compatibility tests.

In August 1990 wind-oriented traps (WOTs) baited with the NWS fly attractant, swormlure-4, were set up to test their suitability for use in an eradication programme in North Africa. The results were good, and WOTs were used to trap flies during both the pilot phase and the main eradication programme.

Early problems

While the response to the screwworm emergency in North Africa had been prompt and decisive to a great extent, there were also considerable problems to be dealt with, not only in the technical and logistical areas, but also in breaking through political and bureaucratic barriers.

The Action Plan

The main points of the Action Plan were to:

- prepare complete project documentation for the eradication of the screwworm from North Africa, for submission to potential donors;
- with IAEA, contact various organizations and manufacturers to solve the problem of producing sterile flies for the eradication campaign in Libya;
- prepare a regional training course on the screwworm for specialists from North African countries;
- arrange to distribute specific insecticides for preventive and curative treatment of individual animals and kits for collection of specimens for laboratory investigation;
- elaborate a uniform questionnaire for monitoring and reporting on the screwworm situation in North Africa and other countries at risk;
- publish on a regular basis a screwworm information document to keep the relevant organizations, countries and officers informed on developments in the screwworm situation and programme;
- prepare and distribute suitable materials for training and extension activities in both infested areas and free zones – the main target group to be farmers;
- select a top-level entomological institute as the FAO reference laboratory for screwworm identification; the British Museum (Natural History) was eventually selected;
- publish and distribute a manual for screwworm diagnosis and control (in Arabic, English and French);
- prepare a proposal for presentation to the OIE Zoosanitary Code Commission on veterinary conditions for the export and import of animals, with the aim of protecting screwworm-free countries (following inclusion of the NWS in OIE List B of internationally notifiable animal diseases);
- prepare a programme for the research of NWS biology under specific North African conditions;
- consider the establishment of a special temporary screwworm control unit;
- arrange for closer cooperation in the screwworm eradication campaign between international organizations including WHO, OIE, IAEA, OAU, UNDP, IFAD, the European Economic Community (EEC), the World Bank and donor organizations.

While the government had undertaken significant action, particularly in the areas of surveillance and control, authorities remained cautious and were often reluctant to release details of these activities. The Libyan government, in fact, did not officially recognize the presence of NWS in the country until one month after the FAO mission confirmed its presence in April 1989.

Authorities remained suspicious of recommendations by consultants that the sterile insect technique was the only way to eradicate NWS until well into 1989. However, intensive efforts to inform Libyan authorities about the details of SIT, which included the regional training programme in July and a study tour by Libyan officials to the sterile fly production plant in Mexico, successfully alleviated Libyan concerns about the technique.

The Action Plan

Preparatory meeting and formulation of the screwworm action plan. This important meeting, held at FAO headquarters on June 5 and 6, 1989, outlined the Screwworm Action Plan and initiated discussions on the formulation of an eradication programme using the sterile insect technique. It also resulted in recommendations for follow-up actions for Libya and other countries at risk, including importation requirements from countries infested by screwworm.

The meeting was attended by top-level international screwworm experts, senior veterinary officers from Libya and other countries at risk as well as FAO representatives.

Following the meeting, FAO outlined the details of its Screwworm Action Plan for the control and eventual eradication of the NWS from North Africa.

The plan outlined projects and activities which were already under way and plans for both a trial SIT programme in Libya and a full eradication programme (see box on page 59).

Liaising with other organizations. The demanding programme would be implemented in close cooperation with the affected countries and with other international organizations, which would participate mainly in the following areas:

IFAD: fundraising and preparation of a pilot phase programme;

IAEA: production of sterile flies and their use in affected and threatened zones;

OIE: preventive measures in exporting and importing animals, world monitoring of screwworm occurrence, scientific publications;

WHO: alerting human populations in affected and threatened countries and monitoring screwworm occurrence in human populations;

OAU: executing and monitoring regional screwworm programmes in Africa.

The Joint FAO/IAEA Division mission

As early as April 1989, the Joint FAO/IAEA Division had begun planning the research necessary to apply SIT in Libya. The United States/Mexican experience with the NWS had already demonstrated that livestock inspection and treatment alone could not eradicate the pest; it had been apparent from the earliest investigations in Libya that the use of SIT, in conjunction with surveillance, control and quarantine, would be necessary.

The FAO/IAEA expert mission. Following the preparatory meeting in Vienna on the formulation of a regional strategy for the control/eradication of screwworm in North Africa, an expert mission was organized through the Joint FAO/IAEA Division. A primary aim of the mission, which visited Libya from June 18 to 22, 1989, was to conduct a preparatory investigation into the potential use of the sterile insect technique in Libya and to collect live NWS material for sexual compatibility tests.

The expert mission divided its time between meetings with senior government and veterinary officials, field trips in the infested area and laboratory observations and work.

During a meeting with the National Screwworm Committee, the mission members discussed the primary problems that needed to be resolved in preparation for the implementation of the sterile insect technique. They emphasized the need for:

- transfer of screwworm material from Libya to Fargo, North Dakota, for sexual compatibility testing;
- preliminary research and development work and the initiation of small-scale screwworm rearing in Libya;
- the development of methods for shipping sterile screwworm flies.

During a field trip on the fourth day of the mission to Ain Zara, 30 km southeast of Tripoli, mature third instar larvae were found in the wound of an infested sheep and identified as *C. hominivorax*.

Conclusions. The mission reported that the Libyan Secretary of Agriculture and Land Development, H.E. Ing. Abdelmajed El-Gaud, was receptive to the idea of using the Mexican mass-reared strain of the NWS to eradicate the North African strain. However, the Libyan authorities were still concerned about the use of SIT in Libya and stressed that it should be properly prepared and implemented with the involvement of a Libyan scientist.

The national committee told the mission members that consideration would be given to the establishment of a biological security facility in Libya where experimental rearing and testing of sterile screwworm flies could be conducted.

The mission had recommended that the national committee designate a person to coordinate the screwworm control programme and advised on ways to avoid delays in control activities. It also targeted the urgent need for comprehensive recording of all survey data and the use of operational survey maps with well-defined reference grids.

Other missions

From June to the end of September 1989, three further missions to Libya were conducted to assist in preparing and running the regional training programme and to advise Libyan authorities on control measures. They also assisted in the supervision of field activities, advised on specific methods to treat animal wounds and acted as the liaison between FAO and the Libyan government on all technical matters relating to the screwworm.

Regional training course

The need to train veterinary specialists from the North African region in the specific areas of screwworm surveillance, control, eradication and prevention had been outlined in the Screwworm Action Plan. Funding for a regional training course had been provided under the FAO-financed regional project, and the course was conducted from July 22 to 27 in Tripoli, in conjunction with another mission to Libya.

The mission had the dual role of conducting the training course and continuing to assist in the development of surveillance, control, entomology and quarantine activities.

The course

The objective of the course was to train two individuals from each of the countries in from each of the countries in North Africa – Libya, the Niger, Egypt, Algeria, Chad, the Sudan and Tunisia – and one individual from Morocco in the identification, surveillance, prevention and control of the New World Screwworm fly.

It was anticipated that, after completing the course, the participants would be equipped to organize surveillance and prevention programmes and train national personnel in their own countries. They would also be able to organize area and national screwworm notification systems for their countries and for international notification.

In all, 23 representatives of the eight countries (including 12 from Libya) attended the course. The dean of the parasitology department, Faculty of Medicine, Al-Fateh University (Tripoli), Dr M. El Heggiagi, acted as director of the course. Participants were presented with the first draft of the *Manual for Control of the Screwworm Fly,* Cochliomyia hominivorax (*Coquerel*), which was being prepared by FAO consultants specifically for use in North Africa. It was published in Arabic, English and French in December 1989.

During the four-day course, participants attended lectures on a wide range of topics, covering screwworm biology, distribution and identification; animal treatment and control; and all aspects of the application of the sterile insect technique. There were also discussions, film and slide shows and demonstrations. Participants were also taken on field trips to observe the use of sentinel sheep, the treatment of wounds and the spraying of animals.

Missions to neighbouring countries

During 1989 several missions were conducted to the countries bordering Libya, which were considered at immediate risk of infestation by NWS. FAO representatives travelled to Egypt, Algeria and Tunisia to discuss the emergency with governments and advise on introducing surveillance, treatment and control activities.

In total, FAO approved eight projects to fund screwworm surveillance and prevention programmes in neighbouring countries during the initial phase of activities. Funding totalled more than US$2 million (including the project for regional support and training, which also assisted Libya).

Collection of live screwworm larvae

With the completion of the training programme and the continued liaison by FAO consultants with Libyan authorities, the initial phase of the screwworm programme in North Africa was well under way.

In October, an IAEA expert collected NWS pupae reared in Libya, which were then transported to the Agricultural Research Service of the USDA, at Fargo, North Dakota, for mating compatibility testing. In December, tests confirmed that Mexican and Libyan NWS strains were compatible.

Moving closer to eradication

In response to the urgent need to get an eradication programme under way in North Africa, the Joint FAO/IAEA Division employed three consultants in January 1990 to prepare a programme to eradicate the pest using the sterile insect technique.

The document they prepared, entitled *A Programme for the Eradication of the New World Screwworm from North Africa*, was published in April 1990 for use by the Joint FAO/IAEA Division as a guide in its support activities for FAO in North Africa. However, it also provided an important basis for development of the actual eradication programme.

15. Animal wounds were cleaned, treated with insecticide and larvae samples taken for identification

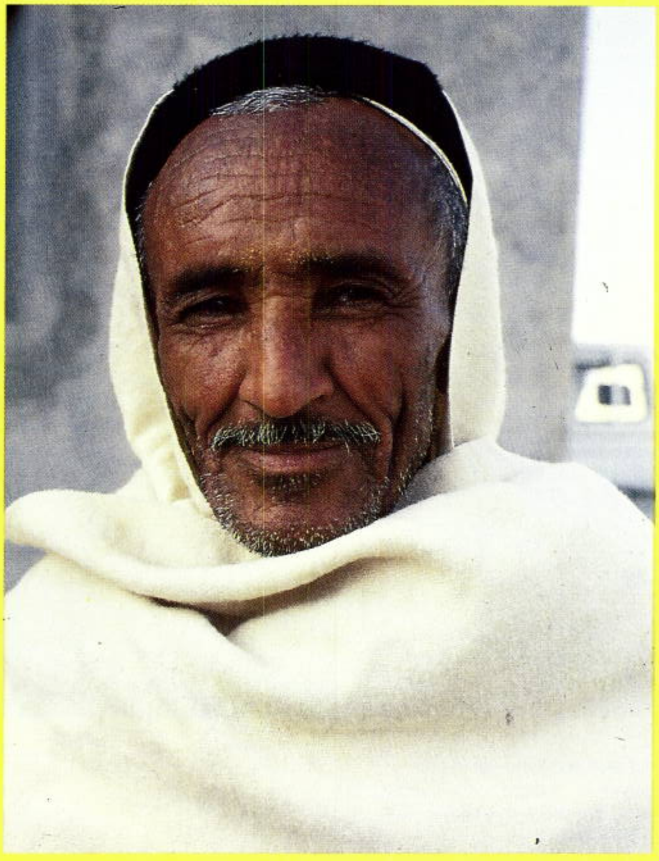
The situation in the field

Sporadic cases of NWS myiasis in animals continued to be recorded in late 1989 in northeastern Libya, confirming the persistence of the infestation in the Tripoli area. However, the pest remained contained within the boundaries of the identified infested zone. During the autumn, favourable weather conditions, coupled with the lambing season, saw an increase in the number of screwworm infestations.

Of 721 samples of myiasis collected in August 1989, 29 were positive for NWS; in September, 75 positive cases were recorded from 561 samples collected. In October, the number of confirmed NWS cases jumped to 419, and in November cases peaked at 796. Cooler weather saw the number of cases drop to 607 in December.

From the commencement of myiasis reporting in July 1989 to the end of the year, 5 805 cases of myiasis were examined and 1 937 were confirmed as caused by NWS. Three percent of these cases occurred in Zawia, only 100 km from the Tunisian border.

16. A Libyan farmer



In addition to the resources provided by FAO projects and the UNDP/ government cost-sharing project, the Libyan government had committed significant funds and resources to the screwworm control programme.

By the end of September 1989, there were 12 animal-movement control sites operating in the infested zone (see Photo 14 on pages 42-43 and Photos 15 and 16), comprising five of Libya's 13 municipalities – Al-Nekat al-Khams, Al-Jabal al-Gharbi, Tripoli, Zawia and Margeb. While only the latter three municipalities were actually infested by the screwworm, the other two were considered quarantine/buffer zones and consequently were given the same level of attention.

By the end of the year, 94 roving inspection teams – each with at least three technicians, a four-wheel drive vehicle, insecticides and a sprayer – were working in the infested zone. As recommended by FAO consultants, the teams were completing their inspection rounds in 21 days, treating animal wounds with coumaphos 5-percent powder (see Photos 17 and 18) and spraying with insecticide herds in which positive NWS myiasis had been found.

17. A wounded camel is inspected and treated

A step ahead

The confirmation that the Libyan wild screwworm fly was sexually compatible with the mass-produced Mexican sterile fly had given the green light to the use of the sterile insect technique to eradicate NWS in North Africa. However, extensive planning and preparation were necessary before SIT could be applied in Libya and considerable work was still needed to strengthen the surveillance, prevention and control activities which would support fly dispersal.

Before the programme could start, an agreement had to be reached with MACES, which would supply sterilized NWS for the programme, requiring complex negotiations with both the United States and Mexican governments. It was also necessary to determine how the pupae would be transported to Libya and then dispersed over the infested zone.

The Screwworm Emergency Centre for North Africa (SECNA) field programme director, Dr D.A. Lindquist, later commented that the programme would never have succeeded without the intensive and detailed planning that was done during the early months of 1990.

18. Coumaphos powder is a larvicide that kills screwworms and protects against reinfestation

"There was planning and more detailed planning, and hours of arguments about how the programme should be run," Dr Lindquist said. "We had bushel baskets full of documents, but one of the reasons why the programme worked was because of the planning. When it went, it went picturebook," he said.

As planning proceeded, FAO launched its public information campaign in April with a highly successful press conference in Rome, during which it announced its intention to eradicate the pest in North Africa. In Libya, livestock owners and the public were being informed about the screwworm and urged to cooperate in surveillance and prevention activities.

In May, FAO began seeking funding for the programme, holding a donors consultation at its Rome headquarters, followed by a pledging conference in July, convened jointly with IFAD at IFAD headquarters. In a major gesture of support for the programme, donors pledged a total of US$30.5 million.

Discussions were also proceeding in early 1990 to finalize arrangements for the preparatory phase, including the pilot release of sterile flies.

The formation of SECNA by the FAO Director-General in June, followed by the establishment of the field programme in Tripoli in August, marked a crucial turning point. Plans for the eradication programme began to be translated into practice as international experts arrived in Tripoli to make the physical and logistical preparations for the use of the sterile insect technique.

NWS sexual compatibility tests

The four tests used were:

Free-choice mating: males from the Mexican strain mated freely with females from both the Libyan and Mexican strains, indicating that the factory-produced males would mate as readily with the Libyan females as they would with those of their own strain.

Genetic compatibility: crosses in both directions between unsterilized Mexican and Libyan strains were fertile and produced fertile offspring, which indicated that there was no genetic incompatibility between the strains.

Chromosome morphology: further evidence for genetic compatibility was obtained by studying the chromosomes at microscopic level. There was no evidence of difference between the two strains.

Mitochondrial DNA: this specialized segment of DNA is often used in studies to detect genetic differences between strains. The Mexican and Libyan strains were compared by looking at the similarity of the pattern of fragments produced when the DNA of each strain was digested with particular enzymes. Some differences were observed, but it was concluded that the level of difference should not inhibit the success of SIT in North Africa.

Green light for SIT in North Africa

The Libyan screwworm strain had been reared from egg masses collected near Tripoli in October 1989, while the Mexican strain, known as Orange Walk or OW-87, was a standard factory-reared population originating from egg masses collected at Orange Walk, Belize, in 1987. Four different measures of compatibility were used to show that the two strains were sexually compatible (see box on page 67).

Obtaining sterile NWS

Even before the final results of the sexual compatibility tests were available, FAO had taken early steps to organize the provision of flies from Mexico.

In a letter to the Minister Counsellor of the United States Permanent Representation to FAO, Mr G.J. Monroe, in November 1989, FAO requested sterile flies for the planned eradication programme. The original agreement between the United States and Mexican governments, under which MACES was formed, specifically prevented the sale of sterile NWS outside the Americas. The letter also requested permission for US nationals to take part in the campaign in Libya, as the United States government had barred all of its citizens from entering Libya.

On March 15, 1990, United States President Bush signed legislation permitting the sale of sterile NWS anywhere in the world – another crucial green light for the North African SIT programme. The President's signature, however, was only the first in a long list of signatures that were required before an operational agreement between FAO and MACES was finally reached in December 1990. The complex negotiations necessary for a contract agreement suitable to all parties, which included FAO and several government departments in both the United States and Mexico, took five months. They are detailed in Chapter five.

Activities in Libya

A chief technical advisor (CTA), responsible for overseeing the implementation of both the US$345 000 FAO Technical Cooperation Project and the US$1.25 million Libyan government/UNDP joint project, had been posted in Tripoli in early 1990. The CTA, Dr A. Martínez, worked in close liaison with Libyan authorities, providing advice and assistance where necessary.

Second training programme

A second training course was held in Tripoli in March 1990, funded under the FAO regional Technical Cooperation Project, which had been approved in early 1989. While the first training course in July 1989 had been conducted for representatives of Libya and neighbouring or "first-line" countries, the second course was aimed at "second-line" countries (Burkina Faso, Cameroon, Djibouti, Ethiopia, Mali, Morocco, Mauritania, Nigeria, Senegal and Somalia).

Project document

Probably the most important FAO mission to Libya during the planning phase was the formulation mission in June 1990. The mission was assigned the task of preparing the project document and budget for the operation of the SIT eradication programme.

The resulting document was the culmination of all the planning and research undertaken since FAO, IFAD, IAEA and other international bodies had become involved in the North African emergency. The document's detailed plan of action and budget estimates were to provide the guidelines for the implementation of the eradication programme in 1991.

Chapter three

Preparing for eradication

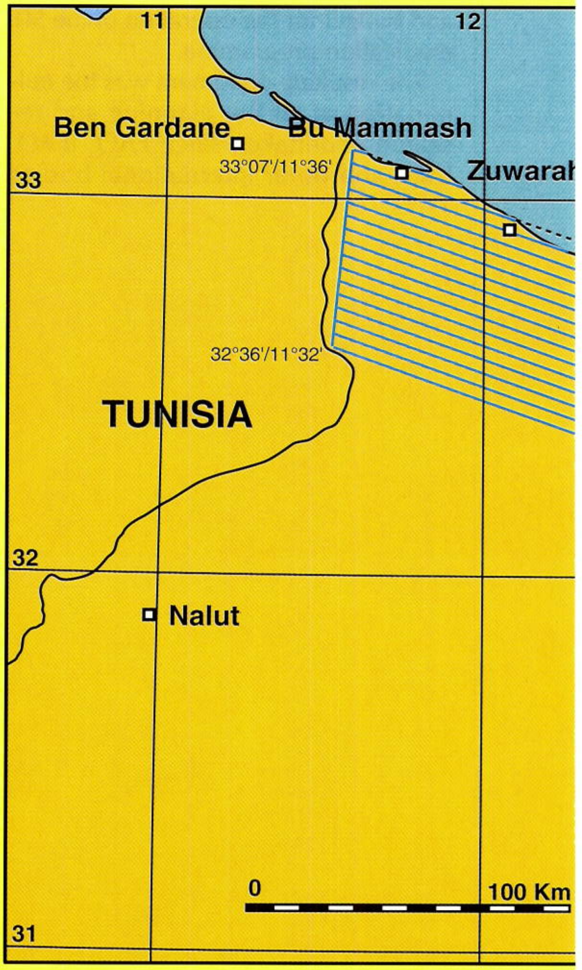
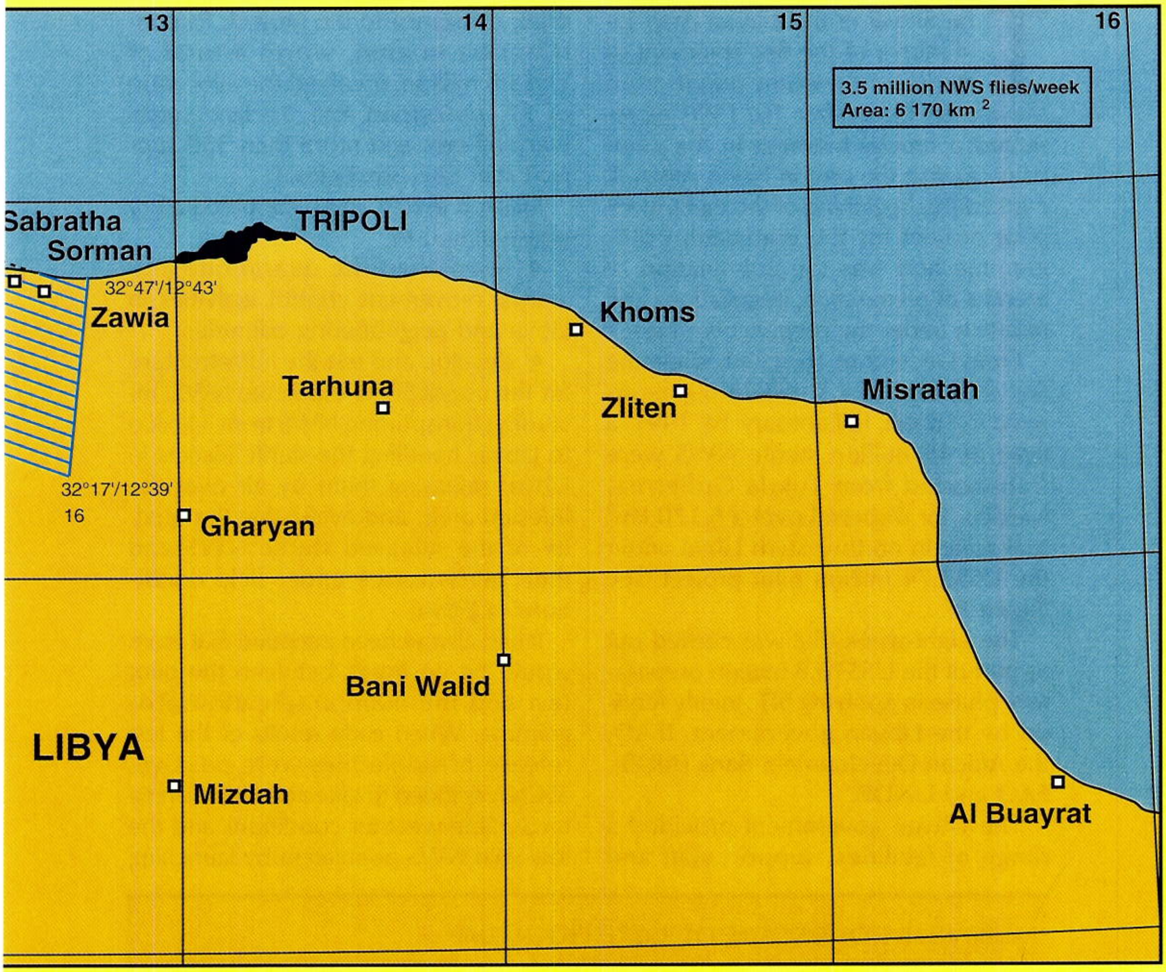


Figure 6. The trial zone for dispersing flies during the pilot project



13
14
15
16
3.5 million NWS flies/week
Area: 6 170 km 2
Sabratha
Sorman
TRIPOLI
32°47'/12°43'
Zawia
Khoms
Tarhuna
Zliten
Misratah
32°17'/12°39'
16
Gharyan
Bani Walid
LIBYA
Mizdah
Al Buayrat

The arrival in the Libyan Arab Jamahiriya of the first shipment of sterile screwworm pupae from Mexico on December 16, 1990 represented a crucial moment in the campaign against the pest in North Africa. It marked the beginning of the eight-week pilot project for the eradication programme and was the culmination of months of preparation, negotiations and research under the preparatory phase.

From December 16, 1990, when the first shipment of 3.5 million pupae arrived in Tripoli, to February 14, 1991, a total of 49 million sterile NWS were transported from Tuxtla Gutierrez, Mexico, for dispersal over a 6 170 km^2 trial zone in northwestern Libya under the US$2.74 million pilot project (see Figure 6).

The eight-week trial was carried out as part of the US$10.8 million preparatory phase in applying SIT, jointly funded by the Libyan government, IFAD, the African Development Bank (AfDB), FAO and UNDP.

The Libyan government provided a range of facilities, support staff and other assistance to the project. Its contribution in kind, worth a total of US$3.9 million, involved the allocation of 13 counterpart staff, 15 field veterinary officers and more than 350 support staff (see box below).

Initiated in July 1990, the preparatory phase aimed to:

- strengthen the quarantine and animal movement control activities in Libya and neighbouring countries;
- develop and test the infrastructure for the use of SIT to eradicate NWS, including transporting NWS from Mexico to Libya; handling the sterile insects in Libya; releasing them by air over the infested area; and evaluating the quality of the released sterile NWS and their performance under field conditions in Libya.

It had always been intended that there would be no break between the pilot test and the main eradication programme. When early results of the test release of sterile flies were positive, SECNA decided to take advantage of the favourable weather conditions and the low wild NWS population by launching

Libyan government contribution

Libyan government inputs (in kind) to the preparatory phase were:

- landing, take-off, parking, servicing, refuelling and repair facilities for project aircraft;
- facilities for unloading, storage and loading of boxed flies;
- flight control through aeronautic maps and ground-to-air communications;
- access to national and international communication facilities for project staff;
- ground support staff to assist with air dispersal and biological and veterinary monitoring;
- sentinel animals for biological assessment;
- office, laboratory and storage facilities for diagnosis and identification.

the main eradication programme earlier than planned. The first shipment under the main programme left Tuxtla Gutierrez on February 1, 1991.

The preparatory phase

The first proposal for a pilot eradication programme had been prepared in June 1989. This in effect formed the basis of formal plans for the preparatory phase prepared by FAO and IAEA in July.

IFAD involvement

In August 1989, IFAD, which had joined the Screwworm Action Group on July 31, drafted its own plan for a pilot project, taking account of the earlier FAO/IAEA document. IFAD pledged to provide US$1.5 million for the project.

A formal agreement between FAO and IFAD on the conduct of the project was reached in May 1990, when the two bodies signed a Technical Assistance Execution Agreement (Regional Pilot Biological Control Programme for the NWS in North Africa). Under the agreement FAO would execute the pilot project, with funds to be provided by IFAD, UNDP, AfDB and the Libyan government.

The subsequent tripartite project agreement between the Libyan government, FAO and IFAD, signed in June 1990, provided the legal and financial support required to start the project, which consequently got under way in July 1990.

Establishing the infrastructure

The preparatory phase was partially conceived to ensure that the necessary equipment, facilities and personnel were in place to test the feasibility of SIT in Libya.

In line with the aims of the preparatory phase, SECNA staff worked to establish the infrastructure that would support the SIT programme, including the establishment of:

- facilities to receive sterilized pupae from Mexico and hold them until adult flies emerged;
- facilities for the release of sterile insects over the infested area;
- laboratory and other required facilities for quality control;
- traps and a system for weekly monitoring of fly catches (two sets of traps were established, with ten in Zawia and five in Sabratha).

Fly purchase, transport and distribution

Complicated contractual arrangements were necessary for the purchase, transport and distribution of NWS flies in Libya. These were developed and finalized during the early months of the preparatory phase.

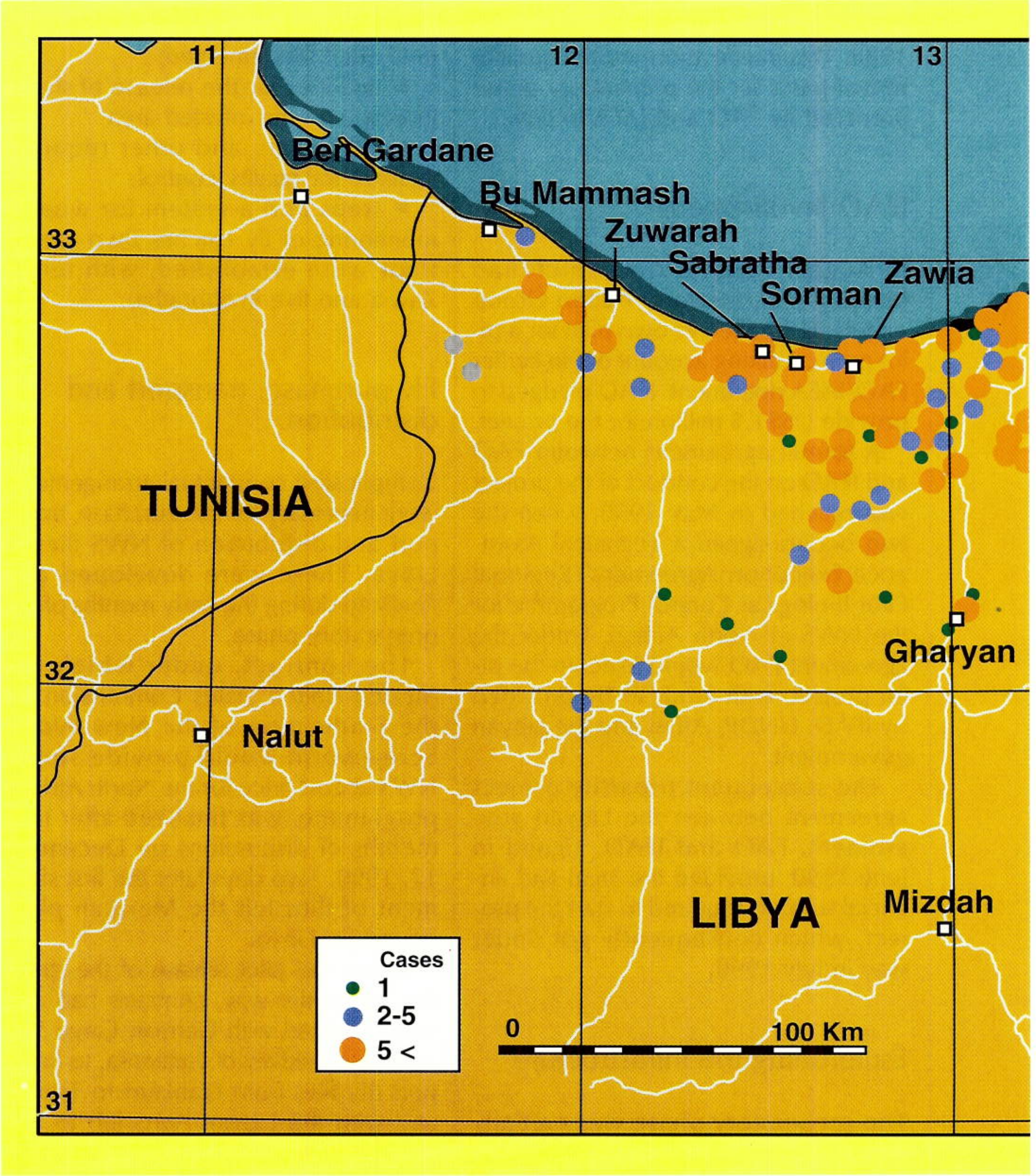
The contract, under which the Mexico-United States Commission for the Eradication of the New World Screwworm would provide sterile NWS at cost price for the North African programme, was finalized after four months of discussions on December 12, 1990. Two days later the first shipment of flies left the Mexican plant bound for Libya.

Before the pilot release of the sterile flies got under way, contracts had also been finalized with German Cargo Services, a subsidiary of Lufthansa, to transport the flies from Frankfurt to Tripoli, and with the Libyan Aeroclub to disperse the flies over the infested zone.

NWS cases reported

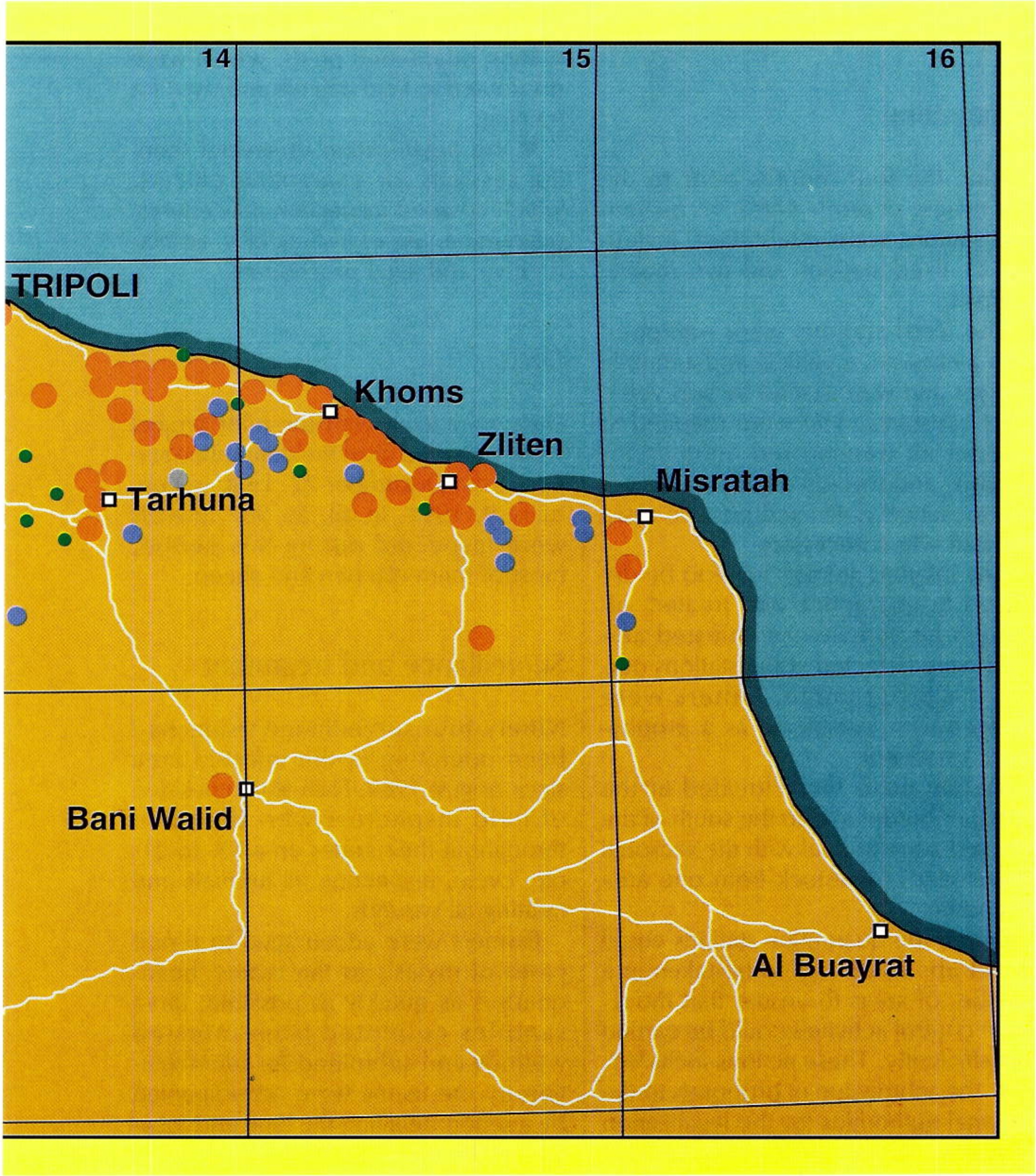
The number of confirmed NWS cases had been increasing steadily throughout the summer of 1990, peaking at just under 3 000 new cases in September and then dropping to 1 700 new cases in October. During each of these months, between 1 million and 1.8 million animals were inspected. The main animal species affected was sheep.

Favourable weather conditions had undoubtedly contributed to the increase in the NWS population, and the



peak infestation period coincided with the warmer months. However, intensified animal surveillance resulted in more cases being recorded (see Figure 7). Comparisons between figures for 1989 and 1990 showed an overall increase in the number of infested animals in 1990. Most of the cases during the period of high infestation in 1990 occurred in the municipalities of Zawia, Tripoli and Margeb.

Figure 7. Positive cases in 1990



The project in action

Surveillance and control activities were already being carried out in Libya, but successfully implementing SIT meant streamlining and strengthening these procedures as well as developing quarantine stations to control animal movement both into and out of the infested area.

Quarantine

During the four months prior to the first release of sterile NWS, 13 quarantine stations were established, including 11 fixed stations and two mobile stations.

The fixed stations were equipped with a caravan, a vehicle and a mobile sprayer and were staffed by two veterinary assistants, who were required to inspect all transported animals for wounds and myiasis. There was a police presence at all fixed posts to assist the staff when necessary.

Any infested animals were to be detained in quarantine and treated, although no screwworm-infested animals were detected at the stations during the programme. Others were sprayed with insecticide as a prophylactic treatment.

Mobile posts were located at the Tunisian border and to the south of the infested zone to deal with the seasonal movement of livestock from one area to another.

Before the quarantine stations could be set up, action had to be taken in a number of areas to ensure that movement control activities could be carried out efficiently. These actions included:

- the submission of proposals to the national authorities for the legalization of specific actions such as compulsory inspection throughout the country, quarantine of infested animals for three days and restriction of animal movement at night from infested municipalities into the free zones;
- the preparation of administrative forms related to transport and quarantine, which were then put into use;
- the preparation of documents containing detailed procedures for operating quarantine posts, which were distributed to field officers and used for training;
- the organization of several training sessions for quarantine officers, which covered inspection procedures, quarantine, use of insecticides, administrative and legal procedures.

Data

Data coinciding with the pilot project were collected from the quarantine stations from December 22, 1990 to February 9, 1991. In all, 56 537 animals were inspected during this period, most of them (86 percent) sheep.

Surveillance and treatment

Ninety-four surveillance teams had been operating in the infested area since August 1989. Each team consisted of field inspectors who travelled throughout their zones on a 15- to 21-day cycle, inspecting all animals and treating all wounds.

Farmers were encouraged to report cases of myiasis to the teams' headquarters as quickly as possible; larva samples collected from infested wounds and submitted for identification by the teams were accompanied by a report detailing the time and location of the case.

Municipal supervisors had been appointed, who received daily inspection reports from the teams and then compiled weekly reports for submission to the SECNA field programme in Tripoli, where a weekly resumé of results and activities from all municipalities was compiled. This report detailed the numbers and species of animals inspected (compared with the previous week) and samples taken (including results) by animal species and by the municipality. Each laboratory-confirmed screwworm infestation was recorded as one positive case, and a record of the number of NWS cases by month, municipality and animal species was compiled.

The field programme staff developed a consistent system of weekly reporting from the municipalities. Maps were also drawn up in preparation for the eradication programme, based on a scale of 1:50 000. The staff required that all positive cases of myiasis were reported with map coordinates.

During 1990, a total of 16 220 090 animals were inspected and a total of 12 556 samples were taken and reported, of which 12 068, or 96 percent, were confirmed to be NWS through laboratory identification.

Sterile fly shipment and dispersal

During the eight-week SIT trial in Libya, there were eight weekly shipments of sterile NWS. The first two shipments contained 3.5 million sterile pupae, but the number was increased to 7 million for the subsequent six shipments. The last two sterile fly shipments for the pilot release project overlapped with the full-scale eradication programme. The number of flies dispersed in each of those weeks was increased to 10.5 million, which included 3.5 million shipped for the main programme.

Shipment

At the MACES sterile fly production plant in Tuxtla Gutierrez, Mexico, the pupae were packed in small cardboard boxes (1 600 per box) containing gelled food and water for emerging flies and then transported by refrigerated truck to Mexico City. They were flown by scheduled air freight to Frankfurt, and then by German Cargo Services charter to Tripoli. Throughout the journey they were kept at a regulated temperature of 10°C to control their development into adult flies.

Distribution

A distribution centre had been established at Tripoli airport, where the boxed pupae were held in temperature-controlled trailers until they emerged into adults.

Procedures for unloading and storing the sterile flies were established during the preparatory phase and maintained during the main eradication programme. They are detailed in Chapter four.

When 80 percent or more of the flies had emerged, the boxes were loaded on to twin-engine aircraft, each fitted with a specially designed chute through which the boxes were released at a predetermined rate.

The cardboard boxes, about half the size of a shoebox, were designed to open during their fall from the aircraft, or on impact with the ground, thus releasing the flies.

The dispersal aircraft flew along predetermined flight paths, 4 km apart, and boxes were dispersed at a rate of three to ten per minute as the plane flew at 240 km/hour at an altitude of 500 m. On each dispersal day an area of approximately 6 400 km^2 was covered, with an average distribution of 800 flies per km^2.

Quality control

Laboratory facilities were established for identification of NWS and quality control. In October 1990, the laboratory staff began limited rearing of NWS for experimental purposes, particularly to obtain base-line data for quality control testing (the colony was destroyed in June 1991).

A comprehensive quality control programme was conducted during the pilot phase, with tests being carried out at each stage of the transport and distribution of the sterile NWS.

The tests involved analysing emergence, mortality, flight agility and longevity and were conducted both in Libya and Mexico. The tests in Libya were the same as those carried out on samples retained in Mexico and were conducted on the same production lot, so that comparisons could be made of any change in fly quality caused by transport, handling and release.

Test results

The results of quality control tests on emergence, flight agility and longevity were similar in Mexico and Libya, indicating that the quality of flies received from Mexico was of a good standard and similar to those distributed by the Mexico-United States Commission.

The percentage of malformed pupae varied between shipments, while overall mortality rates were low in all shipments.

Monitoring the wild and sterile NWS populations

Fifteen wind-oriented traps, baited with an attractant for adult NWS (swormlure-4), were set up in the dispersal area, and captured flies were examined in the laboratory for sterility. The main purpose of the traps was to monitor the activity of sterile flies. However, these tests were also valuable in determining the ratio of sterile to fertile flies in each area.

Most of the flies captured were sterile, which indicated a high level of activity by the released NWS and low numbers in the wild population.

Eight pens, each with three sentinel sheep, were also set up in the distribution area. The sheep were surgically wounded to attract NWS flies and examined twice daily to detect egg masses. The purpose was to measure the number of sterile egg masses produced by the wild population. However, low temperatures and the naturally low wild NWS population during winter meant that no egg masses were collected.

Information

An intensive information campaign was launched in Libya as part of the preparatory phase. The campaign, using both printed material and the mass media, informed the public, in particular livestock owners, about prevention, control and eradication of the NWS using SIT and prepared them for the field activities.

SECNA commenced publication of a

monthly NWS newsletter in November 1990 to provide up-to-date reports on the progress of the eradication programme. The newsletter was a continuation of an earlier publication called *Screwworm Information*, which was started in May 1989.

Overlap period

While the pilot phase was still in operation, the main eradication programme was launched on February 1, 1991. The first shipment of 10.5 million sterile flies arrived on February 3, for distribution over the entire known infested area in Libya.

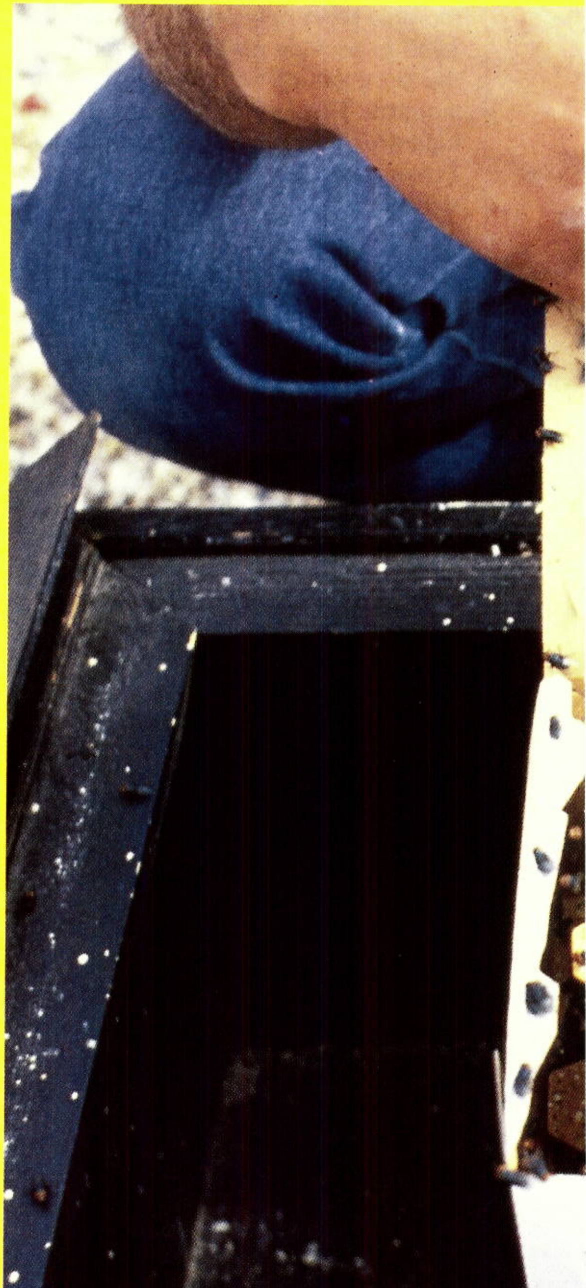
The eighth and final shipment under the pilot phase arrived on February 11, and distribution was completed three days later, marking a smooth transition into the full programme.

The pilot phase had shown that boxed, sterile NWS could be shipped from Mexico to Libya, handled and then released with no measurable loss in fly quality. Information based on trap catches had demonstrated that the flies dispersed and survived in Libya well enough to eradicate the indigenous population.

The preparatory phase overall had achieved its objective of establishing the infrastructure necessary to run the main eradication programme, including the strengthening of quarantine and surveillance activities and the development of the necessary physical and human resources.

Chapter four

The eradication programme



19. A box of emerged flies

The smooth transition from the preparatory phase into the main eradication programme clearly demonstrated the value of the intensive planning and preparation for the use of SIT to eradicate the screwworm.

By the time the first shipment of 10.5 million sterile flies for the main programme arrived in Tripoli on February 3, 1991, SECNA had shown that it was well prepared to implement the essential components of a successful SIT programme.

Just over nine months later, following the release of more than 1 300 million sterile flies, supported by intensive surveillance, treatment and quarantine activities, the SIT programme was brought to a successful conclusion.

Sterile fly releases ended on October 15, six months after the last case of screwworm myiasis had been found. The victory was achieved far more rapidly than might have been expected and well under budget. This success was made possible by a combination of factors. By commencing sterile fly releases in winter, the SIT campaign had taken advantage of the naturally low population of wild NWS during those months. Effective surveillance, treatment and quarantine activities had kept the NWS population within the limits of the identified infested zone, and a well-organized communication campaign had enlisted widespread public support and cooperation for the programme.

TABLE 4: MYIASIS CASES IN LIBYA

	1989		1990		1991		1992	
	NWS	Other	NWS	Other	NWS	Other	NWS	Other
Jan			102	15	3	17	0	11
Feb			94	28	2	17	0	6
Mar			190	73	0	128		
Apr			289	50	1	221		
May			371	42	0	191		
Jun			917	65	0	158		
Jul			1 570	53	0	105		
Aug			2 154	65	0	87		
Sep			2 932	45	0	61		
Oct			1 701	23	0	37		
Nov			1 566	25	0	41		
Dec			191	5	0	21		
Total	1 937	0	12 068	489	6	1 084	0	17

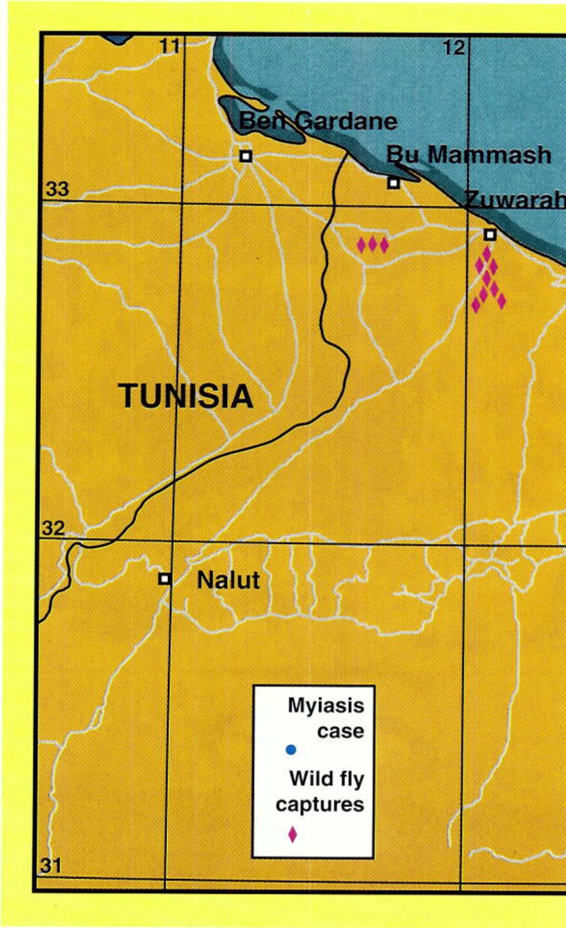


Figure 8. NWS myiasis and wild fly captures, January-June 1991

The situation in the field

The incidence of confirmed NWS infestations had declined steadily from the peak of September 1990, when almost 3 000 screwworm myiasis cases were recorded (see Table 4).

Only six screwworm cases were found in 1991 — three in January, two in February and the last on April 7. The number of fertile flies captured in traps also declined throughout the first months of 1991. Thirty-five wild, fertile females were trapped, the last on April 27. The locations of the positive cases, confirmed by trap data on the wild flies, indicated that the surviving population was widely dispersed throughout the infested area (see Figure 8).

The programme

Few significant problems occurred during the programme. The SECNA field programme operated efficiently, and contract arrangements with MACES, German Cargo Services and the Libyan Aeroclub functioned well.

Throughout most of 1991, a steady supply of high-quality sterile flies was

delivered to an exacting deadline, a significant achievement in view of the complicated logistics of the programme.

After the last case of NWS myiasis was identified in April, and the last fertile flies had been trapped in the same period, a countdown to eradication was begun.

To be absolutely certain that eradication had been achieved, it was necessary to continue sterile fly releases for nine NWS life cycles without the detection of a single case of infestation. In line with this requirement, and supported by a recommendation of the independent Technical Advisory Committee, which had been established to assess the progress of the campaign, the decision was taken to end the SIT programme in mid-October 1991.

From the beginning of May (the first month with no NWS detected) to the end of the SIT programme, 100 000 trapped female flies were dissected, and no fertile flies were found. More than 22 million animals were inspected and 700 larva samples collected with no NWS found. Almost 750 000 animals were inspected at quarantine stations with the same results.

The ending of the SIT phase in October was then followed up by continued surveillance, treatment and quarantine activities, which ended in June 1992 with the declaration that the Libyan Arab Jamahiriya was officially screwworm-free. A preventive programme to secure the region from reinfestation and to minimize the risks of recurrences was put in place.

SIT

The sterile insect technique relies on five major activities to succeed: surveillance (including treatment of animals), quarantine (including animal movement control), the production of sterile flies, quality control and aerial dispersal of the flies in the infested area (see Figure 9).

Just as surveillance, treatment and control alone cannot eradicate NWS, the successful use of SIT relies on the proper implementation of these other activities as well.

Surveillance activities permit the identification of areas where the NWS is active; treatment contributes to reducing the screwworm population by lessening the number of wounds available as breeding sites; animal movement control and quarantine help contain the pest and ensure that it does not spread through animal transport; and quality control ensures that the flies dispersed are of a consistently high standard.

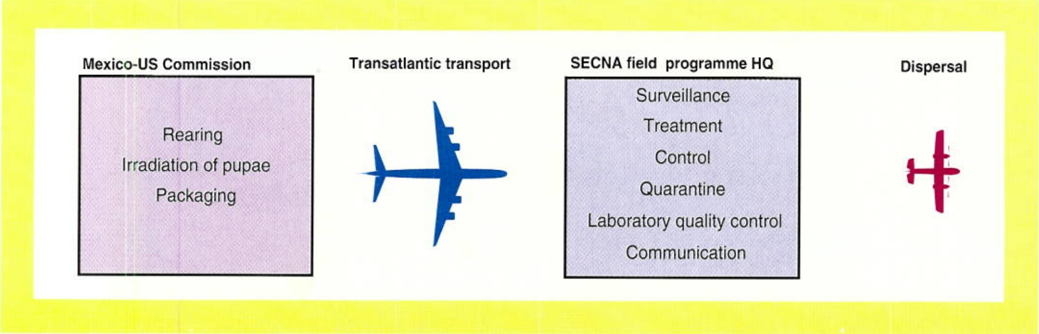


Figure 9. The components of the sterile insect technique programme

SIT programme overview

Under the main eradication programme 28 million sterile flies were initially dispersed weekly by the Libyan Aeroclub over an area of 26 500 km^2 in Libya, the entire known infested area.

The Mexican plant

As outlined in Chapter one, the insects were reared, irradiated and packaged at the sterile fly production plant in Mexico. Each box contained 1 600 sterile pupae and a small cup of special gelled diet for the emerged flies (see Photo 19, the chapter opener).

Transport

Initially, sterile pupae were transported twice weekly in shipments of 10.5 million and 17.5 million, using the system tested during the preparatory phase. The first stage was a 24-hour journey by refrigerated truck from the sterile fly production plant at Tuxtla Gutierrez to Mexico City. This was followed by scheduled flight to Frankfurt, where the pupae were transferred to a German Cargo charter plane for the three-hour journey to Tripoli (see box on page 86).

The twice-weekly deliveries meant that some stage of the transport operation was in effect at all times.

Handling and dispersal

The sterile pupae were maintained at a constant temperature of 10°C during shipment to control their maturation and, on arrival in Tripoli, they were divided and placed in temperature-controlled trailers at different emergence temperatures, with the aim of dispersing emerged adult flies either 30 or 60 hours after their arrival.

The sterile flies were then dispersed twice weekly by the Libyan Aeroclub over the infested area at concentrations ranging from 800 to 1 200 flies per square kilometre, which was calculated on the basis of data indicating the incidence of NWS cases in each area.

The expanded programme

On May 3, 1991 the treatment area was expanded to include a protective barrier around the infested area, including an area of approximately 2 500 km^2 inside Tunisia for a total of 40 000 km^2. The number of flies dispersed weekly was increased to 40 million, and transport arrangements were changed to direct German Cargo charter flights from the airport at Tuxtla Gutierrez to Tripoli, with a refuelling stop at Bermuda (see Figure 10). The total flight time was 14 hours and, after a period of experimentation with different temperatures, the insects were maintained at a constant temperature of 20°C.

Handling

The shipment of such a large number of sterile pupae and the move to the direct charter flights necessitated radical changes in the technical requirements for handling the sterile insects. The flies were now delivered once instead of twice weekly, and the single shipment needed to be stored and programmed for dispersal over as many days of the week as possible.

SECNA had given careful consideration to the matter of single, weekly shipments of the sterile flies, taking into

German Cargo Services

German Cargo Services, founded in March 1977 as a subsidiary of Lufthansa, operates international freight charter flights to supplement Lufthansa's scheduled cargo services.

The company concentrates on markets in Africa, the Near East, Asia and South America and specializes in charter projects requiring high flexibility and expert planning.

Cargoes have included flowers and produce from Kenya to Europe, live cattle from Germany to Jordan, shipments of up to 150 000 live chickens and hatching eggs to Teheran, as well as polo horses from Argentina to Brunei Darussalam.

It was this experience with the transport of live cargo, combined with the presentation of the required specifications, that contributed to German Cargo Services' success in gaining the FAO contract to transport NWS pupae to Libya.

During the SIT operation, German Cargo Services initially transported the pupae from Frankfurt to Tripoli. In May 1991 it began direct charter flights from the airport at the Tuxtla Gutierrez production plant to Tripoli, transporting 40 million flies in one weekly shipment. The introduction of the direct flights needed an international communications system at Tuxtla Gutierrez airport. German Cargo Services set up a link between Mexico's domestic airline communications system and the major international airline system, called SITA, enabling pilots leaving Mexico to receive information on weather as well as to file flight plans for the journey to Tripoli.

The company also established a 24-hours-a-day communications service for the SIT programme, which meant that key personnel were always contactable in the event of any delays or problems with the charter flights to Tripoli.

In total, the company transported 1 300 million sterile NWS flies from Mexico to Libya.

The loss of a single shipment could have set back the eradication programme several weeks, and it was acknowledged that German Cargo Services' high standards made an important contribution to the success of the campaign.

The company operates a fleet of ten aircraft: five DC-8 73Fs, three Boeing 747-200SFs and two Boeing 737-200Fs. During 1990 the fleet logged nearly 18 000 flying hours and flew more than 14 million km.

The shipments of sterile pupae from Tuxtla Gutierrez to Tripoli, using a DC-8 aircraft, accounted for more than 300 hours.

In addition to about 60 crew members who were involved in the SIT flights, SECNA acknowledged the special efforts of German Cargo Services' general manager, marketing and sales, David Keary; project manager Jürgen Stille; operations and handling manager Wolfgang Duffner; cargo handling staff Detlev Schlemmer, Jürgen Weidner and Kerstin Sasse; Michaela Münker from animal handling; aircraft mechanics Falk Trippler and Thomas Schröder in Tuxtla Gutierrez; and cargo manager in Tripoli, Roland Rost.

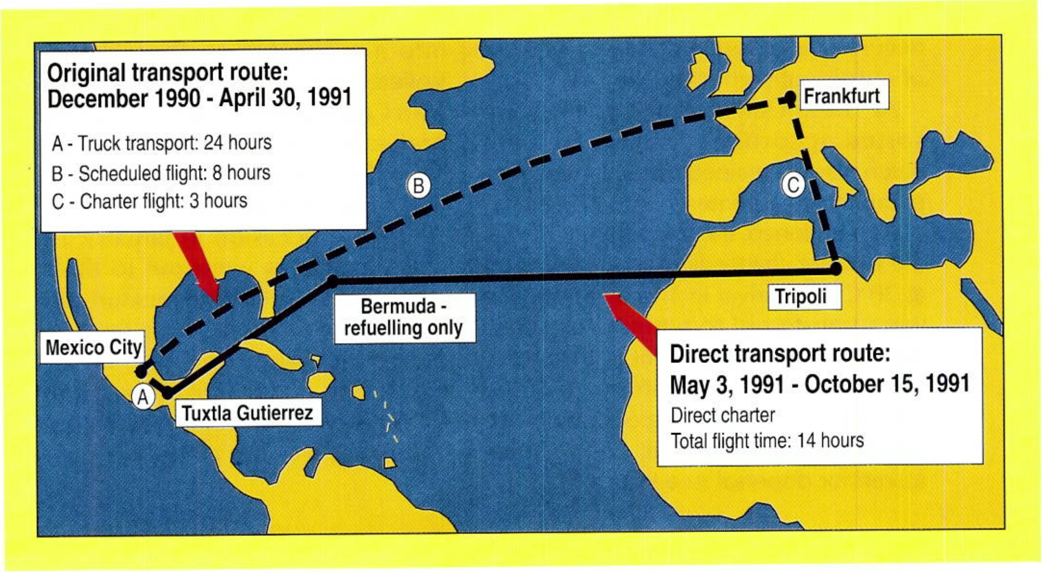


Figure 10. SIT transport arrangements

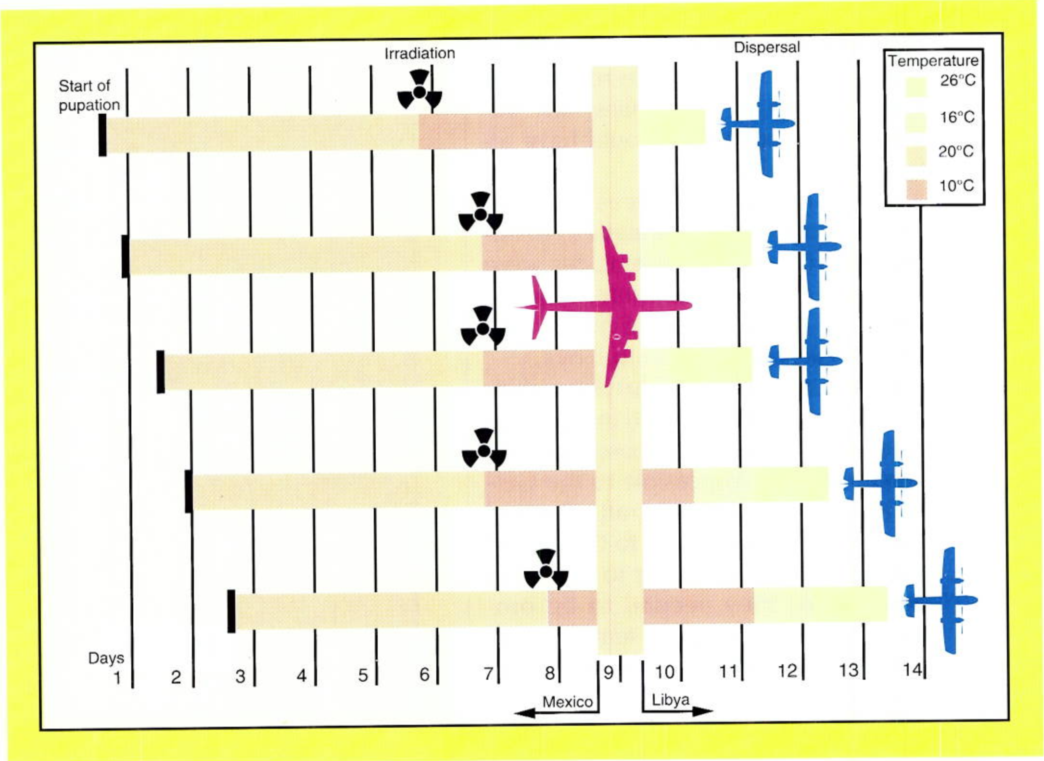


Figure 11. The temperature control programme for once-weekly sterile fly dispersal

account the costs involved and the necessity of ensuring that the flies were of consistently good quality.

At Tuxtla Gutierrez, the pupae were sorted according to age and each batch was maintained on a different temperature programme prior to departure.

As mentioned, the temperature during the 14-hour charter flight was maintained at 20°C. On arrival in Tripoli, the pupae were transferred to temperature-controlled storage trailers, where they were maintained at temperatures of 10°C, 20°C or 26°C, depending on the day on which the emerging adult flies were required for dispersal (see Figure 11).

Transport hitches

It was crucial that the sterile pupae were maintained at a constant temperature during transport. Any increase in temperature would have resulted in early emergence of the flies; any decrease in temperature would have affected fly quality.

German Cargo Services had designed comprehensive measures to ensure that constant temperatures were maintained during the winter months, when the flies were being transported to Frankfurt and then on to Libya.

Each Lufthansa flight carrying a shipment of sterile flies docked in the cargo area, rather than at the passenger terminal, as close as possible to the German Cargo Services aircraft. Thermal blankets were loaded on to the aircraft through a small side door to cover the boxed flies; they needed to be protected from the subzero temperatures outside the aircraft before the main cargo doors were opened.

The flies were then loaded directly into a preheated temperature-controlled truck and transferred to the German Cargo plane, which had also been preheated. All preflight checks had been done in advance and, once loaded, the plane could leave immediately.

On one occasion in January 1991, these measures were put to the test, when heavy snow at Frankfurt airport caused a two-hour delay in the transfer of the flies from one aircraft to the other. The actions taken by German Cargo Services ensured that the quality of the flies was not affected.

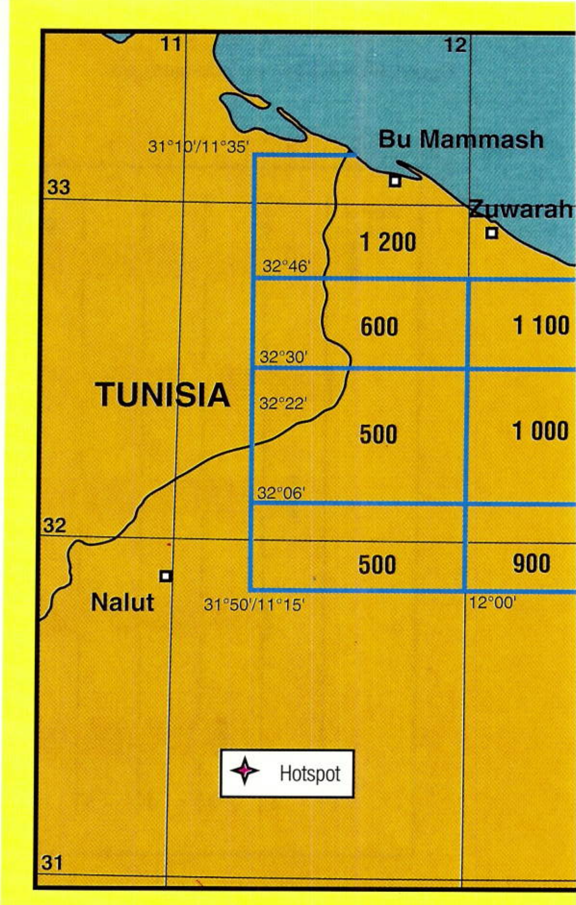


Figure 12. The number of dispersed NWS flies per square kilometre per week

Traffic rights

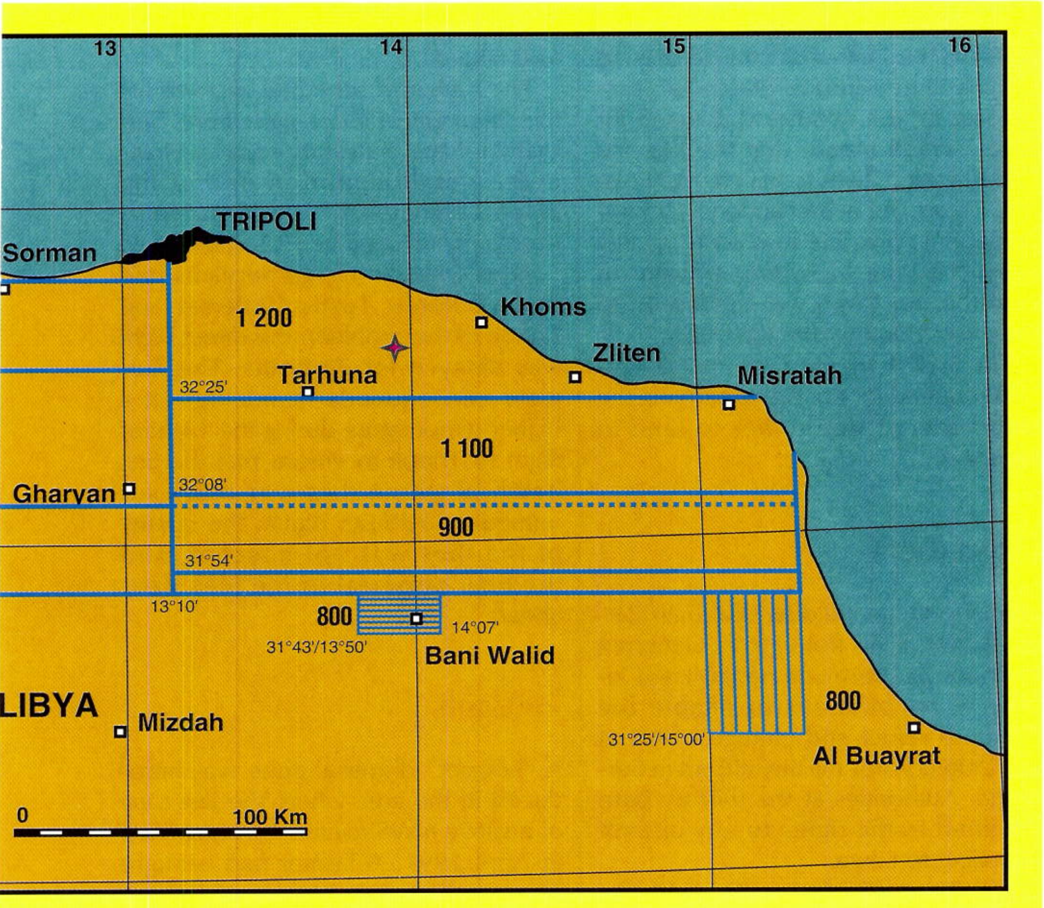
During the same period, German Cargo Services encountered another potentially disastrous problem during a flight from Frankfurt to Tripoli. Each flight was required to have traffic rights to Libya, which were granted on a weekly basis by Libyan airport authorities.

In practice, traffic rights were usually granted within ten minutes of an application being lodged. However, on one occasion the German Cargo Services pilot discovered mid-flight that traffic rights had not been granted. In a radio communication with the Tripoli airport control tower, he requested permission to land, which was refused.

"The pilot then told the control tower that he had 14 million passengers on board," German Cargo Services' general manager, David Keary said. "There were three to four minutes of absolute silence from the control tower and then they granted traffic rights."

The war in the Persian Gulf

The outbreak of war in the Persian Gulf, five weeks into the main eradica-



tion programme, threatened to put an end to the entire SIT operation in Libya. However, Libya's response to the crisis meant that operations were not disrupted.

The war did, however, affect the transatlantic transport of the sterile pupae. Military air traffic increased dramatically in the area of the Persian Gulf, resulting in the blockage of some normal commercial routes. Civilian aircraft flying from the United States to Europe, including those carrying the fly shipments, were required to fly longer routes.

The threat of terrorism during the war resulted in a drastic reduction of the number of passengers on international flights. Lufthansa consolidated its United States-Europe flights to compensate for the decreased demand for seats, which meant that the Mexico City-Frankfurt flight travelled via Houston, Texas. As a precautionary measure against possible loss of fly quality caused by the high temperatures in Houston, no cargo was loaded on to the aircraft during the flight stop.

The USDA secured the transit permits required for the flights carrying the shipments of sterile flies to land in Houston.

Direct flights

The introduction of direct German Cargo charter flights from Tuxtla Gutierrez to Tripoli via Bermuda necessitated intensive negotiations to enable the flights to refuel and change crews at the United States military airport in Bermuda. Authorities at the military base declined traffic rights to any aircraft travelling to Libya.

Mr Keary said that traffic rights for Bermuda had still not been granted three days before the first charter flight was to leave Tuxtla Gutierrez on May 3, 1991.

Following four hours of telephone discussions, involving the USDA, the US State Department, the Pentagon and FAO, traffic rights were obtained.

The last shipment

The efficiency of the German Cargo operation was further highlighted when operational problems caused delays during the final shipment of flies in October. The aircraft, while changing crews at New York before leaving for Tuxtla Gutierrez, was damaged just before take-off.

The transport schedule allowed for the shipment of spare parts from Germany for the necessary repairs. However, a malfunction in one of the plane's communications instruments eventually resulted in a 12-hour delay.

After German Cargo Services had notified Rome, Tuxtla Gutierrez and Tripoli of the problem, the direct flight was delayed for 24 hours. The flies were consequently maintained at a higher temperature during the 14-hour flight to Tripoli to ensure that the first batch of sterile flies was ready for immediate release. Again, the quality of the flies was not affected, and the final dispersal of the flies went ahead.

Hotspots

A "hotspot" dispersal zone was introduced in the area where the last case of positive NWS myiasis was identified in April 1991. A farmer had brought larva samples from a wounded sheep to the Misratah veterinary clinic, which were identified as NWS. The hotspot dispersal of sterile flies was designed to ensure that they were dispersed where they were most needed, which meant scheduling extra flights and dispersing extra flies in an area where an isolated case had been discovered. It involved the dispersal of an additional 100 boxes (160 000 flies) in an area less than 5 km^2. The Misratah case was the only time that hotspot treatment was required during the eradication campaign.

Two special barrier flight grids were introduced at the southern extreme of the dispersal zone on May 14 and continued until the conclusion of the programme, increasing the dispersal area to just over 40 000 km^2. Figure 12 illustrates the flight grids as well as the densities of flies dispersed in each grid area.

SECNA field programme technical units

The SECNA field programme in Tripoli (see Photo 20) was divided into seven units to handle all aspects of the implementation of SIT. They were:

- *Field unit*: responsible for all sur-

20. The SECNA field programme laboratory and offices in Tripoli veillance, quarantine (after April 1991) and animal movement activities, as well as trapping and biological evaluation.

• *Laboratory*: responsible for quality control testing, the identification of larvae and adult flies and research and development.

• *Epidemiology*: responsible for the analysis and interpretation of all data presented by other technical units and, based on results, for preparing plans for fly dispersal and recommending any necessary alterations to the eradication strategy.

• *Distribution centre*: based at Tripoli airport, the unit received NWS shipments from Mexico and was responsible for unloading them from aircraft and placing them in trailers kept at various temperatures. The unit then loaded them on to dispersal aircraft. The unit was also responsible for ensuring the biological quality of the flies and carried out quality control tests before and after fly dispersal flights. It was also responsible for the preparation of fly dispersal grids, based on data received from the field unit.

• *Aviation*: responsible for the aerial dispersal of sterile flies and all aircraft operations.

• *Communication and Information*: responsible for educating and informing livestock owners and the public about the NWS, and encouraging livestock owners in particular to inspect and treat their animals and to report any cases of myiasis to veterinary officials.

• *Administration*: responsible for all matters relating to personnel, purchasing and finance.

Further details of SECNA's structure and role are found in Chapter five.

TABLE 5: SUMMARY OF SURVEILLANCE, QUARANTINE

		Surveillance		
Year	Month	Animals inspected	NWS	Other myiasis
1991	January	1 598 024	3	17
	February	1 487 976	2	17
	March	1 812 782		128
	April	1 779 108	1	221
	May	2 677 191		191
	June	2 834 093		158
	July	2 932 284		105
	August	3 610 805		87
	September	3 388 086		61
	October	3 360 846		37
	November	2 681 430		41
	December	2 354 008		21
	Total	30 516 633		1 084
1992	January	3 031 697		11
	February	2 341 207		6

The field unit

The use of SIT relies heavily on the availability of precise information about the locations and incidence of infestations, which must be continuously monitored and updated. The unit therefore produced maps based on the use of geographic coordinates in case reporting.

Activities

Surveillance and treatment activities had been conducted since the very early stages of the screwworm emer-

AND TRAP CATCHES (1991 AND 1992)

Quarantine			Flies Captured			
Animals inspected	Wounds treated	NWS cases	Screwworm Male	Screwworm Female	Others	Fertile Female
42 245	203		80	251	455	
52 971	278		1 135	2 923	2 715	15
48 968	412		8 565	11 354	12 349	10
39 110	203		8 972	10 764	17 213	9
62 963	510		11 774	11 231	8 168	
94 096	557		37 659	42 138	10 705	
101 116	544		37 220	44 098	10 463	
125 049	468		21 474	28 312	563	
99 638	308		21 919	29 830	7 656	
124 207	421		28 138	33 029	20 591	
86 894	293				14 775	
40 879	210				5 480	
918 136	4 407	0	176 936	213 930	111 133	34
63 518	331				646	
103 363	245		64			

gency in Libya, first through Libyan veterinary services, under the direction of the National Screwworm Committee and with the advice of FAO consultants. During the preparatory phase, significant resources were directed toward strengthening surveillance and treatment activities in preparation for the main programme.

After August 1990, these activities were incorporated into the SECNA field programme (FP), utilizing the infrastructure of the Libyan veterinary services. Existing inspection teams were maintained and continued to work in conjunction with local veterinary clinics, which in turn reported to regional supervisors, who then made weekly reports to the SECNA FP.

This meant that a good deal of the surveillance unit's work amounted to supervision to ensure that the programme was operating effectively. It also introduced new methods of reporting to streamline surveillance activities.

Streamlining surveillance

The surveillance unit streamlined reporting of cases by introducing a system of geographic coordinates. Maps (1:50 000) were used by the section to mark the locations of confirmed cases.

To simplify the procedure for the field personnel, the maps were divided into a grid. Each square of the grid was numbered and marked with minutes of latitude and longitude, enabling field personnel to report each case with the square's coded number. This reference was then translated into actual geographic coordinates, with the use of tables prepared for each map.

Sampling

A system was developed to monitor the efficiency of sample reporting, to ensure that samples were sent for identification within an acceptable period (three days from the collection date to the date of identification were considered acceptable). Containment measures could therefore be taken when a positive case was found.

Field procedures

Animal inspection in the infested area by teams comprising two Libyan veterinary assistants continued at an intensive pace throughout the eradication programme. The number of teams was

21. Treating a wounded animal with coumaphos powder increased in the early stages of the eradication programme to 94, overseen by 21 regional supervisors. A further 15 inspection teams were added in mid-1991 to undertake surveillance activities outside the infested area.

During 1991 the teams inspected just over 30.5 million animals. They collected a total of 1 028 larva samples, of which six (0.6 percent) were confirmed as NWS and 1 022 (99.4 percent) were the larvae of other flies.

These results should be compared to 16.2 million animal inspections during 1990, resulting in the collection of 12 557 larva samples, of which 12 068 (96 percent) were NWS and 489 (4 percent) were the larvae of other flies.

In 1990, when infested wounds were located and larva samples taken, it was frequently found that the samples contained a mix of both NWS larvae and the larvae of other flies. These cases were always classified as NWS, and no separate records were kept on the non-NWS larvae found in these wounds. Therefore, in 1991, when few cases of NWS infestation were found, the number of non-NWS samples recorded was consequently higher.

Animal inspections rose 153 percent from 1990 to 1991, while the number

22. A wind-oriented fly trap

of positive NWS myiases decreased. A comparison of 1991 inspection statistics with an adapted version of the Libyan Secretariat of Planning's 1987 animal census showed that the population of animals in the infested zone was inspected several times over.

Inspection and sampling methods

Inspection teams assembled at their local veterinary clinic at around 7:30 AM and would leave a map or diagram of the area they intended to visit that day.

They travelled to individual farms to check herds and flocks. All wounds were immediately treated with coumaphos 5-percent powder. If a case of myiasis was found, the wound was treated with coumaphos and a larva sample taken from the deepest part of the wound. The larvae were placed in a plastic tube with 70-percent methanol or 10-percent formalin, and the inspector completed a form supplied with the sampling kit before submitting the sample to the regional supervisor (see Photo 21).

The teams were also responsible for ensuring that livestock owners under-

23. Libyan veterinary staff explain the function of the fly traps to local farmers stood the need to inspect their animals regularly, treat wounds and report any cases of myiasis. They handed out literature prepared by the communication and information unit.

During the programme, coumaphos packets were distributed to farmers. However, the task of collecting samples was the responsibility of the inspection teams.

Biological evaluation

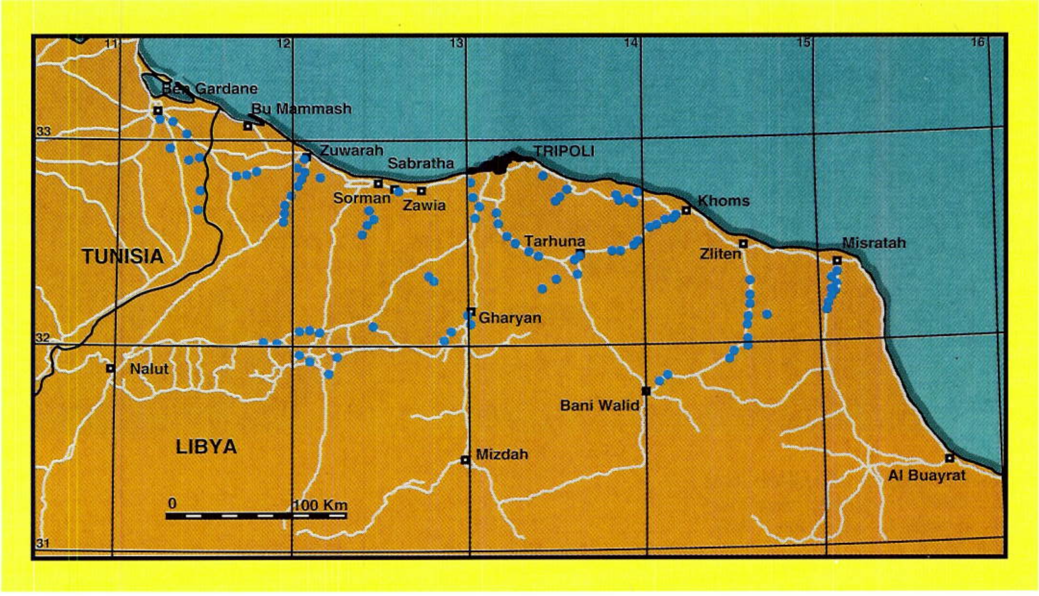
Wind-oriented fly traps (WOTs) were set up in both Libya and Tunisia during the eradication programme for the primary purpose of checking the accuracy of aerial release of the flies and to confirm the proper distribution of sterile NWS flies throughout the dispersal area. Trap catches also gave an indication of the quality of the released flies and how they were moving throughout the release area. A secondary function of the traps was to determine the proportion of sterile to wild female flies.

Each trap (see Photos 22 and 23) resembled a bucket, which was fitted with wind flaps and suspended from a suitable fixed object, such as a tree. Flies were attracted to the traps by an odour bait (swormlure-5).

An average of 82 traps were operated during the programme (see Figure 13), with an average of 87 to 386 sterile NWS flies captured per trap per week. The total number captured per week was as high as 29 400, and the total number per month was as high as 81 318. The number of non-NWS flies trapped was also recorded, since the figures confirmed that the traps were functioning correctly under Libyan conditions. Up to 3 700 non-NWS flies were captured each week.

When judging fly quality and the

Figure 13. Map of infested area, showing main roads and locations of wind-oriented fly traps, September-December 1991



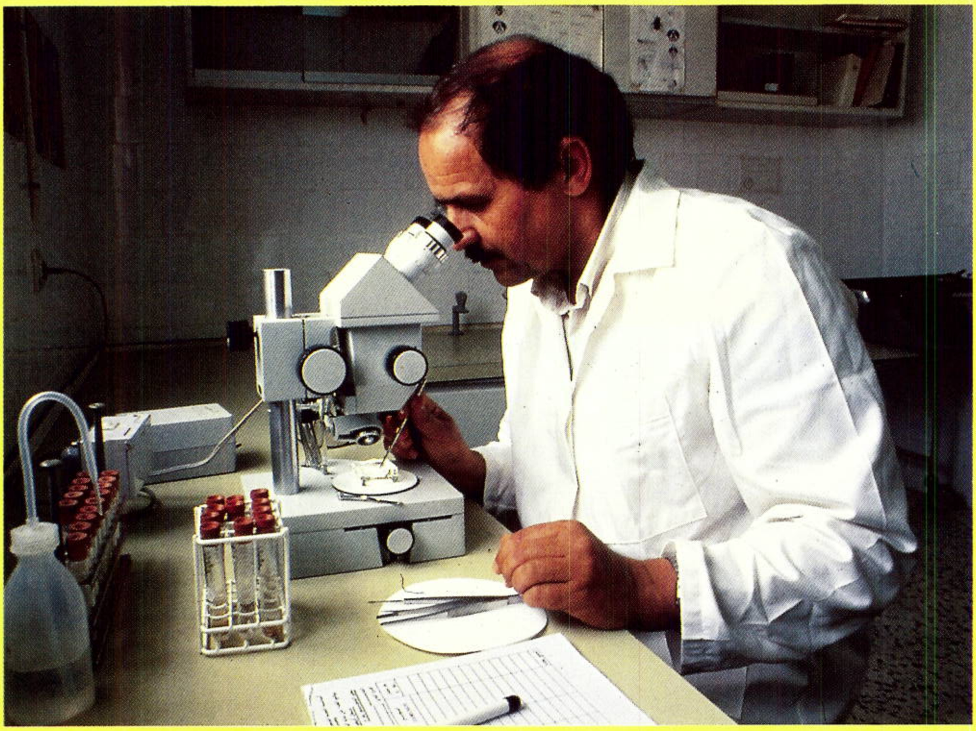
adequacy of dispersal, particular attention was paid to the traps that did not catch NWS flies. Checks were made to determine if these traps were being operated properly and to ensure that their locations were suitable under the prevailing weather conditions. The dispersal activities in the area of the traps were also checked.

During the programme it was found that problems with traps were primarily related to servicing or to location. In one instance where dispersal was identified as the problem, the flight lanes in that particular area were adjusted to ensure a better distribution of the sterile flies.

From 50 to 100 percent of the trapped female flies were examined in the SECNA FP laboratory to determine if they were fertile (see Photos 24 and 25). Results of these examinations in the period up until the last fertile NWS fly was captured on April 27, 1991 showed that the ratio of fertile to sterile female flies was satisfactory to achieve eradication (see Table 6).

Dispersal programme justified

Because the programme required continued distribution of sterile flies, it was

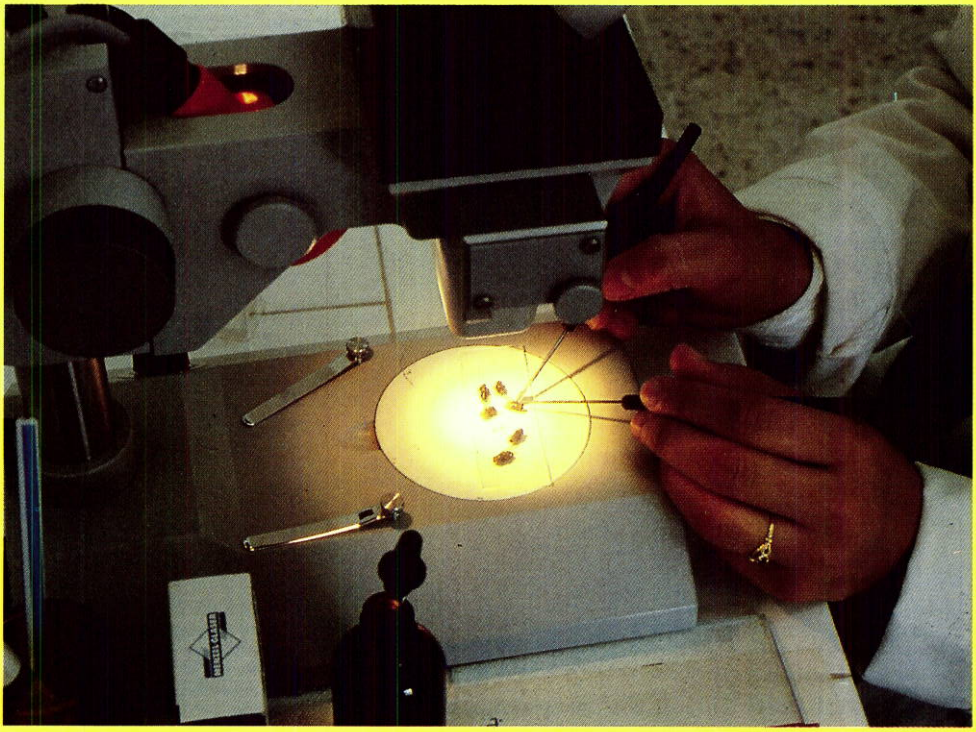


24. Counterpart laboratory chief Dr Khalifa Mughadmi examines fly samples to determine if they are NWS

TABLE 6: NUMBERS OF SCREWWORM FLIES CAPTURED PER MONTH IN 1991

Month	Males	Females		
	Captured	Captured	Dissected	Fertile
February	10 603	3 824	3 824	15
March	8 565	11 354	5 271	10
April	8 972	10 734	5 301	8
May	7 876	7 638	3 792	1*
Total	36 016	33 550	18 188	34

* Caught April 27, 1991.



25. Thousands of trapped female NWS flies were dissected weekly at the laboratory to determine if they were sterile not easy to get an accurate measure of sterile fly survival time after dispersal. However, such an opportunity was presented following the last dispersals. It was found that within three to four days after dispersal of sterile flies ended on October 15, 1991, the number of sterile NWS caught in the traps declined sharply. By October 30, the number of trapped flies was insignificant, and the last sterile fly was trapped on November 7, 22 days after the last dispersal.

The precipitous drop in sterile fly activity within three days confirmed the earlier judgement that twice-weekly dispersion was necessary for NWS eradication.

Sentinel sheep

Twenty-eight sentinel sheep pens were maintained in the infested area to obtain larva samples until June 1991. Normally information on the ratio of sterile to fertile egg masses would be recorded to monitor the progress of an eradication campaign. However, the rapid success of the eradication programme and the fact that the last case of NWS myiasis was found in April meant that no NWS egg masses were collected from sentinel sheep during the main eradication programme.

Quarantine

Thirteen quarantine stations (11 permanent and two mobile) which had been established during the preparatory phase were maintained throughout the main eradication programme (see Figure 14). Their primary purpose was to control the movement of live animals between the infested zone and the screwworm-free zone. Prior to the establishment of the stations, Libyan authorities had operated checkpoints at roughly the same locations, without facilities for quarantine.

The majority of the quarantine stations were located on main roads along main animal transport routes and were initially operated by two veterinary assistants at each station.

In mid-1991, nine of the 11 permanent stations increased their operations from daylight hours only to 24 hours a

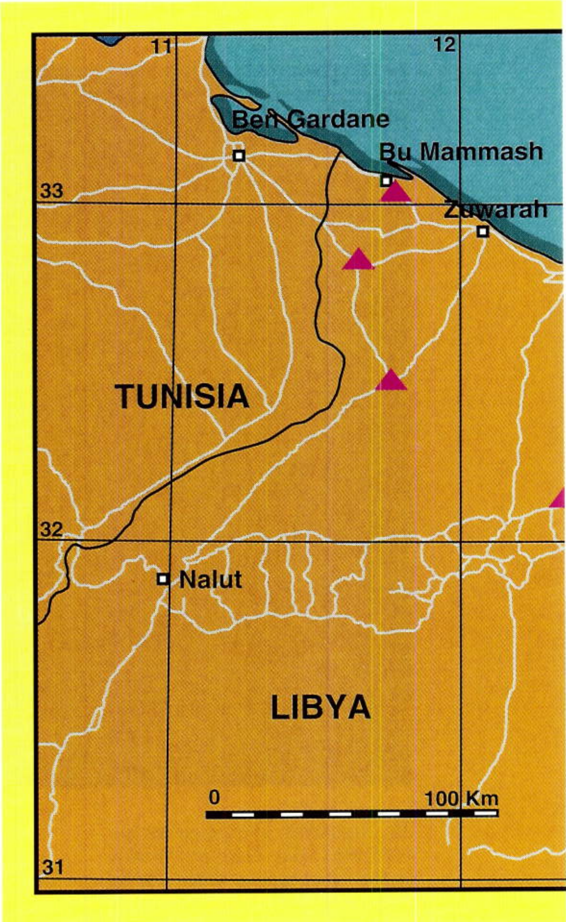


Figure 14. The location of fixed quarantine stations, 1991

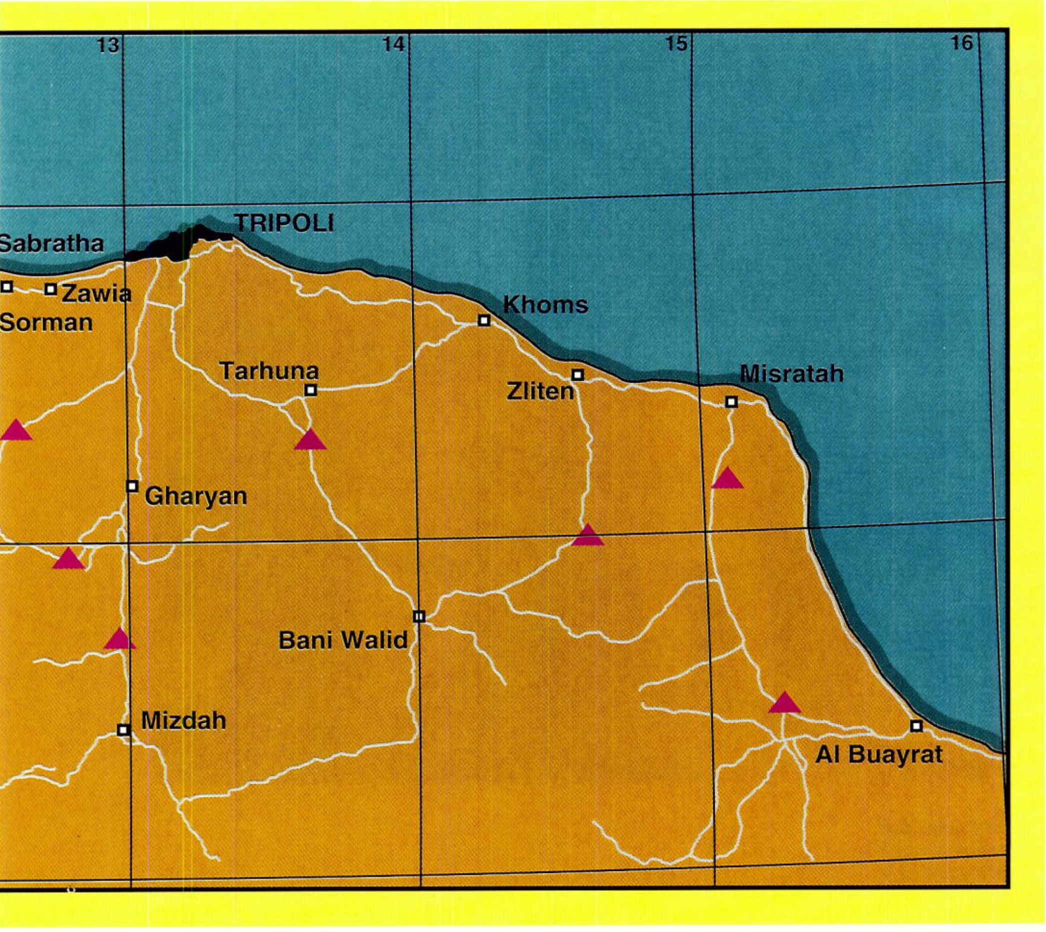
day. Data on animal movement from the infested zone indicated that about 19 percent of animals were transported at night. By September, all of the permanent stations were operating 24 hours a day, with four staff members at each station.

All transported animals were checked by quarantine station staff for wounds and myiasis. Wounds were treated with coumaphos, and animals leaving the infested area (with the exception of those going immediately to slaughter) were prophylactically sprayed (see Photos 26 and 27).

Data recording

Quarantine station staff were required to fill in reporting forms on each group of animals passing through the station, detailing whether wounds or infestation were found. These forms were sent to the regional supervisor, who compiled data on a weekly basis for submission to the SECNA FP.

Any infested animals were to have been placed in quarantine for a period of three days, and larva samples were sent to SECNA for identification. However, during the main eradication



programme no NWS-infested animals were found at the quarantine stations.

Owners were issued a special health certificate, valid for one day only, if their animal was NWS-free.

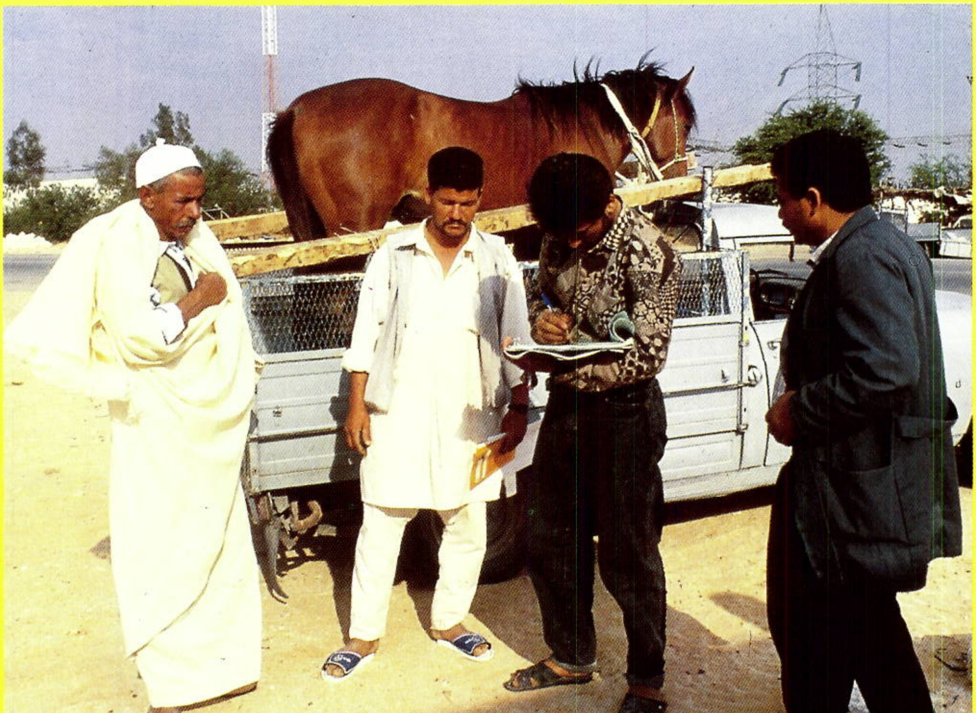
Figures from the stations showed that the number of animals moving into the infested area was consistently higher than those leaving the area (see Figure 15).

Special study

The quarantine station at Abu Qrayn, in the southeastern corner of the infested zone, was selected for a pilot study on animals leaving the zone. The study was conducted from April 13 to July 26, 1991. Its objective was to determine the origin, destination and distribution of animal species and, if possible, the purpose of their transport.

The information was considered vital in identifying the areas into which animals from the infested zone were moving and in quantifying the risk of NWS spread by animal movement.

Abu Qrayn had been selected for the study because 46 percent of the animals passing through the station were in transit to NWS-free areas. The



26. Quarantine station staff record information about the origin and destination of a transported horse study showed that 11 percent of the animals came from high-risk areas in the infested zone, while 89 percent came from low-risk areas. The main destination of the animals was the Sabha region for slaughter.

Handling and release of sterile flies

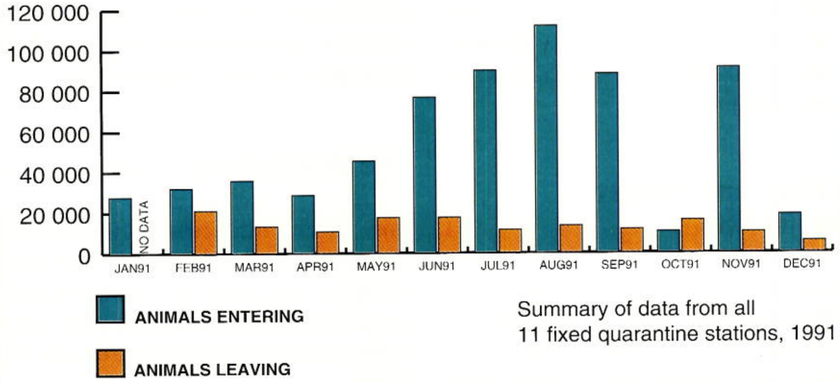
Two units — the distribution centre and the aviation unit — worked in close cooperation to ensure the correct handling and distribution of the sterile insects. In addition to its handling activities, the distribution centre was responsible for preparing fly dispersal grids, based on data received from the field and epidemiology units, which it then gave to the aviation unit.

The distribution centre

The centre had two main functions: handling and storage of the sterile NWS (as the point of receipt of the insects from Mexico); and quality control testing of the flies before and after each flight.

Based at Tripoli airport, the centre

27. A herd of sheep is sprayed with coumaphos as a prophylactic measure



Summary of data from all 11 fixed quarantine stations, 1991

28. Unloading the boxed sterile flies from a German Cargo aircraft on arrival at Tripoli airport

Figure 15. Animals entering and leaving control areas through quarantine posts

was equipped with six refrigerated trailers for the storage of the sterile insects as well as with the equipment necessary to transfer the boxed insects from the planes to the trailers and vice versa.

Standard air freight equipment was used to unload the shipment from the German Cargo planes. The pupae had been boxed at the Tuxtla Gutierrez plant and then transported in wire baskets, especially designed for the SECNA programme, with each basket containing 24 boxes. The wire baskets were loaded on to standard air freight pallets for the journey from Mexico to Tripoli.

Once unloaded from the aircraft, the wire baskets were placed in wheeled dollies, stacked two baskets wide and six high and then wheeled into the appropriate temperature-controlled trailer (see Photos 28, 29 and 30).

It was crucial that the flies were placed in the centre's various storage facilities promptly and maintained at the correct temperature to ensure both quality and correct times of emergence (to coincide with release days). The entire unloading and storage procedure

29. The boxed flies were loaded on to wheeled dollies and placed in the appropriate temperature-controlled trailer at the distribution centre therefore had to be completed in approximately one-and-a-half hours.

During the period when shipments arrived twice weekly, from February 3 to April 28, the centre received 10.5 million insects every Wednesday evening and 17.5 million every Sunday evening. The pupae were then placed in trailers with emergence temperatures calculated for dispersal either 32 or 54 hours after arrival.

Following the introduction of direct charter flights and the increase to 40 million sterile flies delivered once a week, the emergence rate of the adult flies had to be adjusted to correspond to the scheduled days of dispersal (flies were released four days per week).

The pupae were held in the temperature-controlled trailers at 10°C, 20°C or 26°C, depending on the intended day of dispersal. Since the pupae had been reared and irradiated by consecutive production shifts at Tuxtla Gutierrez, the Tripoli distribution centre correspondingly divided the pupae for release according to their shift (or age). Those that had been irradiated and packaged first, and were therefore the oldest, were kept at emergence temperature for release the next day, and so on.

30. The temperature-controlled trailers in which NWS pupae were stored until required for dispersal over the infested zone

Round-the-clock checks on the storage facilities were made to ensure that the required temperatures and humidity were maintained. It was also essential that there was a constant supply of fresh air into the trailers, which meant that they had to be opened on a regular basis to allow for ventilation. The trailers were equipped with provisions to drain condensed water, a temperature-control system and a cooling unit with sufficient overcapacity to compensate for the heat produced by the flies.

When 80 percent of the flies had emerged, the insects were ready to be dispersed. However, storage of the insects required careful management and flexibility. Bad weather, aircraft maintenance problems, military manoeuvres in release sectors and other problems frequently required the rescheduling of release flights, which in turn required adjustments in the management of the stored insects.

Liaison with aviation unit

Based on the data and instructions received from the field and epidemiology units, the distribution centre prepared fly dispersal grids and instructions on the number of flies to be dispersed per square kilometre. These grids were used by the aviation unit to calculate the number of boxes to be released per square kilometre and for the preparation of flight plans, which detailed the aircraft speed, altitude and the number of boxes to be released during the flight and per minute.

There were four systems on which the distribution centre could base grids for fly dispersal:

- the regular system of flight grids, four days per week, which was used for the duration of the programme;
- a specific system, which allowed for the release of a greater number of flies in heavily infested areas;
- hotspot treatment, which was used following the discovery of an isolated case and involved the distribution of an additional 500 boxes of sterile flies, released in a circle around the area where the case was discovered;
- river treatment, which was designed for use along river valleys (not used during the Libyan programme because of the absence of rivers in the infested area).

Dispersal

The flies were dispersed by the Libyan Aeroclub (see box on pp. 108-109), which had been contracted by FAO. The Aeroclub provided 10 experienced pilots and four (later increased to five) Twin-Otter aircraft, each with the capacity to carry up to 2 000 boxes of flies. The planes were fitted with specially designed dispersal chutes for fly release.

The dispersal schedule involved 18 flights per week, starting on Sunday and ending on Wednesday. On two alternate days pilots were required to make five flights, and on the other days four flights, for a total of about 65 flying hours per week.

It was essential, particularly during the hotter months, that flies be dispersed very early in the morning, since temperatures could reach 40°C by 10 AM. Flights were therefore scheduled to depart between 6:46 AM and 7:15 AM.

The aircraft travelled at an average of 277 km per hour, at an altitude of approximately 460 m. They flew prescribed parallel flight lanes, 4 km apart,

The Libyan Aeroclub

The Aeroclub was founded in 1973 by a group of Libyan pilots, with the aim of training people to fly planes. It expanded its activities in 1980, with the introduction of a commercial division, offering Twin-Otter, De Havilland (DHC-6) planes for both scheduled and charter flights. With much of its work involving the transport of experts and goods to and from Libyan oil fields, the Aeroclub's pilots are experts in desert operations, including flying at low altitudes, and its planes are equipped to land on desert airstrips.

In 1991 the Aeroclub was partially privatized and renamed the Light Air Transport and Technical Services Co. As well as taking over responsibility for all private, executive and commercial and training operations of the former Aeroclub, the new company also provides maintenance services and technical assistance to other light aircraft operators in Libya and runs search and rescue missions.

Its main fleet includes two Merlin IIIB SA 226s, 14 De Havilland Twin-Otter aircraft, three Cessna 402s and seven Cessna 310s.

The contract to fly for the SECNA programme represented not only one of the Aeroclub's major contracts for 1990-1991, but was also seen by pilots as an important opportunity to do something for their country.

However, while the type of work was new, interesting and challenging for the Aeroclub pilots, it also had its drawbacks.

Captain Ibrahim Azzabi (now chief pilot for the Light Air Transport Co) was one of the pilots working on the SECNA project. His recollections give some insight into the sometimes difficult conditions under which the pilots worked — and also into how useful it was to have a sense of humour.

One of Capt. Azzabi's strongest memories was of the smell which emanated from the boxes of sterile flies (probably from their food).

"It was horrible, really unpleasant," he said. "But you got used to it in time. Although it was very bad during the month of Ramadan, because when you are fasting, your sense of smell is much stronger." (The pilots were exempted from fasting, because of the nature of their work, but many still decided to observe Ramadan.)

But, worse still, the pilots had to deal with fly "escapees" – those which managed to get out of the boxes during the flights.

"You know that when the flies were put on the plane they were virtually asleep because they had been kept at a low temperature, but after a while they would start to wake up and some would escape from the boxes," said Capt. Azzabi.

"By the time we finished some flights, there would be thousands of flies in the cockpit. And they are very sticky flies. Once one landed on your face, you couldn't get rid of it and we didn't want to kill them because they cost a lot of money.

"We used a shield between the cockpit and the cabin to try to prevent them coming in, but they would usually find a way to get in to us."

To deal with the invasion of NWS flies into the cockpit, the pilots devised methods to get rid of the insects without killing them.

"We used to vacuum them out of the cockpit," explained Capt. Azzabi. "You put one end of a garden hose out of the cockpit window and used the other like the nozzle of a vacuum — because of the difference in pressure between inside and outside the plane, the flies would be sucked out."

The pilots would also evacuate large numbers of flies from the cockpit by herding them toward the window and then opening the window. The resulting vacuum effect would suck them out en masse, however it would also have the effect of sucking more flies from the rear of the plane into the cockpit — and so the exercise would be repeated. As Capt. Azzabi recalled: "When you think back, we had fun with the flies."

The commitment of the Libyan Aeroclub to the dispersal operation contributed greatly to the success of the SIT campaign. SECNA would like to acknowledge the work of Mr M. Zaidan, Capt. M.M. Tumia, Capt. T. Sodik, Mr T. Tagiury, Capt. M. Fituri and Capt. A. Tawil.

adjusted to a separation of 3 km for the alternate release days.

Two pilots flew in each aircraft, and two people were employed as dispersers, who released the boxed sterile insects according to the prescribed release programme. The dispersers were also responsible for loading the boxes on to the planes (see Photos 31, 32 and 33).

Laboratory and quality control

SIT experts have noted that the quality of sterile flies is more important than the number of flies released. The success of SIT depends on the ability of the factory-reared sterile males to compete with wild males and mate with a sufficient percentage of the wild female population to break the wild pest's life cycle.

Quality control was therefore a key factor in the Libyan eradication programme. The monitoring of fly quality at all stages of the operation was important to identify problems promptly and take corrective action when necessary.

Quality control tests were conducted on every shipment at the production plant in Mexico, at the distribution centre in Tripoli and at the SECNA field programme laboratory.

At the production plant the tests included measuring larval and pupal weight during the production phase, followed by sterility tests to ensure proper radiation exposure. Samples of boxed pupae were taken from each batch before every shipment to conduct quality control tests in line with those conducted in Tripoli.

Quality control tests were developed to meet the specific needs of the eradication programme and were conducted at the Tripoli distribution centre both pre- and post-flight.

Overview

The quality control tests conducted in Tripoli during the SIT programme showed that consistently good-quality flies had been released. They also demonstrated that transport of the flies from Mexico to Libya and handling procedures on arrival did not cause any measurable negative effect.

Biological evaluation and identification

Biological evaluation of trapped flies was carried out; until June 1991, a colony of the North African NWS strain was maintained in a specially equipped quarantine unit for research purposes.

The identification of female flies trapped in the dispersal area has already been discussed. Up to 6 000 trapped flies per day were received at the laboratory at the height of the programme, and NWS flies had to be identified to obtain data on how efficiently they dispersed after release. A proportion of the female NWS were dissected to determine fertility (see box on page 113). Results of these examinations were useful in determining the ra-

31. The boxed flies being loaded on to a Libyan Aeroclub Twin-Otter aircraft tio of fertile to sterile female flies.

The laboratory staff also examined all samples collected from myiasis cases from the field to identify them as NWS or caused by other species.

Laboratory tests

Tests were conducted in a stable environment to achieve general base-line data on flies originating from the different production shifts.

Pupal weight. This test is used to indicate the size and energy reserves of the emerged flies. In general, it was considered that the bigger the fly, the better it was expected to perform in terms of mating, agility and longevity. In Mexico, however, it had been found that flies reared on the newly introduced gelled diet were smaller than those previously reared on a liquid diet, while their quality appeared unchanged.

The pupae arriving in Tripoli had an average weight of approximately 40 mg. Because the pupae were weighed in Mexico and Tripoli at different stages of their development, no comparisons were made between test results at both locations.

32. One of the Libyan Aeroclub's Twin-Otter aircraft, used during the SIT operation for fly dispersal

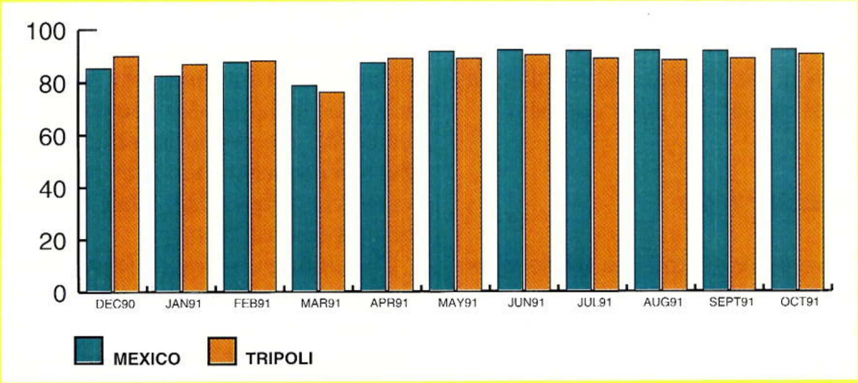


Figure 16. Percentage of adult fly emergence

33. A box of sterile flies is dispersed from the aircraft

At the SECNA laboratory

On a good day in the SECNA Tripoli laboratory, Dr Samira Ashur Oumar sometimes dissected 1 000 flies. For a newly graduated veterinary doctor it was hard work. But, as Dr Ashur Oumar said: "Only the first fly was difficult."

Dr Ashur Oumar was one of the women veterinary doctors who worked as laboratory assistants at the SECNA field programme's Tripoli headquarters. Their work involved quality control testing but, during the main eradication programme, their time was taken up mainly with identification of flies caught in traps and identification of larva samples.

According to the head of the laboratory unit, Dr René García, up to 6 000 flies per day were received at the laboratory during the main eradication programme. Only female NWS flies were dissected, to determine whether or not they were sterile. A sterile female could be identified by her atrophied ovaries — the result of irradiation.

Dr Ashur Oumar started work for SECNA immediately after graduating from Al-Fateh University in 1990. Women have been encouraged to attend university in Libya only in recent years, and Dr Ashur Oumar was the only woman in her year. She is now one of only a few hundred Libyan women veterinary doctors, although each year sees more women enrolling to study veterinary science. Dr Ashur Oumar will continue to work at the Tripoli central veterinary laboratories and plans to specialize in epidemiology.

SECNA FP laboratory assistant Dr Samira Ashur Oumar dissecting female screwworm flies

Emergence. The percentage of adult emergence was useful as an additional indicator of fly vigour. Eighty percent adult emergence was considered to indicate that the flies were of good quality. Emergence in Libya was consistently around 88-90 percent throughout the SIT programme (compared to around 90 percent emergence in Mexico) (see Figure 16).

Malformed pupae/adults. The tests on pupae were used to determine the impact of handling on boxed pupae. A malformed pupa was defined as one that was cracked. Tests showed an average of below 2 percent cracked pupae throughout the programme, which was not considered to be a significant loss. No malformed adult flies were detected by laboratory tests.

Sex ratio. Tests found that the sex ratio ranged between 35 and 65 percent males, with an overall average of 50 percent.

Longevity without food and water. This test measures the initial energy reserves of newly emerged flies. For practical purposes, it provided information on the life expectancy of flies released under unfavourable conditions.

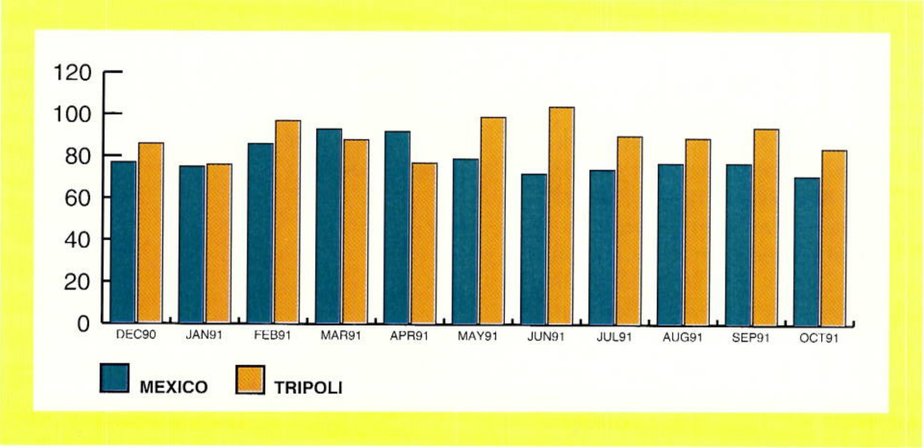
Test results showed that the average longevity of flies was higher in Libya than in Mexico for eight out of the 11 months during which tests were conducted, although overall results showed there was no difference in quality of flies before and after transport from Mexico (see Figure 17).

Longevity with food and water. Results showed that flies survived longer in Mexico than in Libya. It was believed that the most likely cause of this variation was related to the different conditions under which the tests were made.

In Tripoli, the tests were conducted under continuous light, while in Mexico they were conducted in 14 hours of light and 10 hours of darkness. The flies tested in Tripoli were therefore active for 24 hours a day. Insects live longer if they get daily rest.

Sterility. Trapped female flies were dissected to confirm that they were

Figure 17. Total hours of longevity without food and water



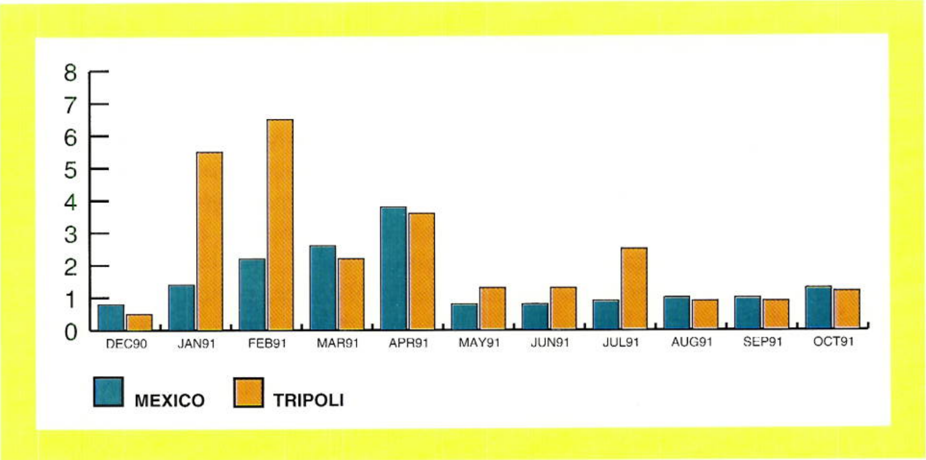


Figure 18. Percentage of mortality

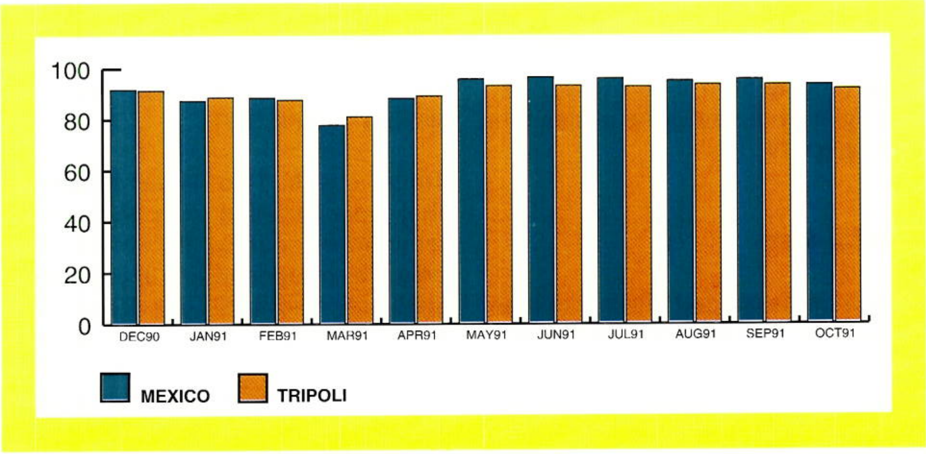
sterile. As anticipated, results showed 100 percent sterility in sampled flies.

Tripoli longevity. This test was developed and conducted only in Libya, since it was felt there was a need for data that reflected the estimated longevity of flies after emergence and just prior to release. These tests were conducted without food and water in standard quality control cages. Average longevity was 2.5 days.

At the distribution centre

Tests were conducted at the distribution centre to detect any impact on fly quality attributable to transport, handling and temperature manipulations during storage in the temperature-controlled trailers. The tests were done on dispersal days, both before the flight and post-flight, on boxed flies which had been carried on the aircraft.

Figure 19. Results of flight agility tests (percent)



Emergence. The data were used to clarify that fly quality was not affected by temperature manipulations and to ensure that the required number of adults had emerged by the programmed dispersal day. Results corresponded to those produced by laboratory tests.

Mortality. This important test produced results that generally showed negligible differences between fly mortality in Libya and Mexico. During January, February and July, brief periods of significant fly mortality were detected in Libya. Temperature-controlled trailers malfunctioned in January and February; in July, extended holding periods attributable to delayed dispersal flights, combined with extremely hot weather, contributed to fly mortality (see Figure 18).

Malformation. Tests found a low occurrence of malformed flies throughout the programme, ranging from 0.3 to 0.8 percent. Each release box contained 1 600 pupae, which was not considered to cause overcrowding after fly emergence.

Flight agility. This empirical test was considered very important, since it tested the boxed flies' ability to fly on the day of release. Tests were conducted outdoors, and results showed an average ranging from 87.6 to 93.5 percent agility throughout the programme (see Figure 19).

Special tests

Tests were developed in Libya to meet the special requirements of the programme. Their results provided the programme with valuable information, since the tests had been motivated, planned and conducted specifically to meet the defined needs of the programme.

Bioassay. All facilities, equipment and diet to be used during the SIT programme in Libya were tested to ensure that no insecticides or other toxicants were present. This involved exposing sterile NWS or, preferably, Mediterranean fruit-flies (because they are more sensitive to insecticides and toxicants) to surfaces, cages and food to be used in the eradication programme. No problems were encountered with either insecticides or toxicants.

Biological base-line data. A Libyan NWS colony, known as TA-90, was maintained at the SECNA FP laboratory to obtain biological base-line data before shipment of sterile NWS flies began. Ranges in the data obtained were wide because the strain was not colonized long enough to become laboratory-adapted.

The strain originated from egg masses collected in November 1990 and was reared on the gelled diet used in Mexico. Pupae were transferred to the USDA laboratory at Fargo, North Dakota for studies to ensure that the strain was sexually compatible with a new strain being considered for mass-rearing at the Mexican facility, known as Costa Rica-91. The colony was destroyed in June 1991.

Trailer check. Two release boxes per shift were sampled from each of the temperature-controlled trailers. The boxes were opened and the emerged adults allowed to fly out. Rough estimates were then made of emergence and mortality rates, which later corresponded well with the results from standard flight agility tests.

Emergence upon arrival. A quick test (30 minutes) was developed to determine the emergence of flies for each of the production shifts on arrival in Tripoli. Data collected from this test were used to determine the weekly strategies for holding temperatures in the temperature-controlled trailers to ensure that adequate numbers of flies emerged for each of the four release days. The test involved sampling four boxes of flies per shift at random, as the transport plane was being unloaded. The boxes were placed in a microwave oven set at high energy level for two minutes to kill the emerged flies.

The percentage of emergence was rapidly calculated by counting the dead flies. A rate of 10 percent emergence upon arrival would mean that 24 hours at 25-27°C was required to reach 85-90 percent emergence for release the following day.

Temperature strategies. Alternative strategies were needed to meet the programme's requirements for properly emerged, good-quality flies on each dispersal day.

Investigations were carried out to determine if quality was affected when flies were subjected to an accelerated emergence in high temperatures (27°C for 36 hours) as opposed to recommended temperature (21°C for 60 hours). No differences in fly quality were detected between the two strategies, and it was concluded that accelerated emergence was not hazardous to the flies.

Bag test. Preliminary tests showed that ordinary paper bags might be used to replace emergence/dispersal boxes. However, more testing would be required to confirm this finding.

Chilling of emerged flies. When planned dispersal flights were delayed, emerging flies had to be inactivated by lowering holding temperatures. If active flies were kept for longer than 36-48 hours, they consumed food and were subjected to overcrowding and stress, lowering fly quality. Tests on maintaining the emerging flies at low temperatures for prolonged periods were conducted. Results indicated that chilling the emerging boxed flies at 10°C for 24 and 48 hours did not affect fly quality.

Prolonged chilling of boxed pupae. It was found that pupae could be chilled for up to 72 hours without any significant loss of quality. Tests to determine the actual time limit for chilling boxed pupae without quality loss were conducted in Mexico. Preliminary results indicated that the upper threshold was 110-120 hours at 10°C, although one series of tests showed that a chilling period of 180 hours did not affect fly quality.

Heat stress: boxed pupae/flies. The Libyan climate and the possibility of breakdowns in cooling systems necessitated tests to determine the flies' heat tolerance. Preliminary test results showed that pupae could be held at 30°C for 48 hours. After 72 hours the mortality rate increased, and flight agility declined.

Tests done on emerged flies showed that there was a high mortality rate after 24 hours at 32-35°C, which was caused solely by heat stress. Complementary tests were conducted in Mexico.

Hypoxia. Consideration has been given to the prospect of long-distance transport of sterile NWS flies under hypoxia (reduced oxygen to delay emergence).

The pupae would then be shipped in bulk, rather than in boxes.

Studies were therefore done at the SECNA laboratory and by the Mexico-US Commission on emerged flies that had been transported under hypoxia as pupae. Quality was measured using the standard laboratory quality control tests; emerged flies originating from pupae that had been shipped normally were used as controls.

Preliminary results indicated increased mortality among flies which had emerged from pupae held under hypoxia. However, other quality control tests on surviving flies showed satisfactory emergence, longevity and flight agility in flies emerged from pupae which had been held for 24 hours under hypoxia. After 48 hours under hypoxia, results showed variable and slightly poor emergence, longevity and flight agility.

Release/capture study

A special release/capture study was conducted to determine dispersal and longevity of sterile NWS flies. Ground releases were made of sterile flies marked with a fluorescent dye, and standard traps baited with swormlure-4 were set up to capture them.

The study was conducted in the Tarhuna area, from August to the end of the SIT programme. Under the study, 100 000 marked flies were released twice a week, using a different colour dye for each release batch. Twenty-eight baited wind-oriented traps were installed. Seven traps were placed in each of the cardinal directions, at distances of 0.5, 1, 1.5, 2, 3, 4 and 5 km from the release point.

The traps were sampled daily, and quality control tests were conducted to measure fly quality. Results showed that the average field longevity was three to four days and that flies spread rapidly in all directions up to 5 km.

The epidemiology unit

This unit played a significant, central role in the SECNA field programme. Its role was to collate and analyse all programme data. The unit analysed all field, laboratory and dispersal data on a weekly basis and also made observations on plans and measures for the execution of the programme, taking into account other experiences in NWS and animal disease eradication programmes.

The unit advised the programme directors on programme strategy and had the latitude to develop and present any information that could assist in the determination and modification of the strategy.

Based on the data from other units, the epidemiology unit prepared plans for the distribution of flies, including the number of flies to be released in a given area. It conducted studies on the impact of weather on SIT effectiveness and analysed available data to determine the role the cold winter of 1990-1991 had played in the significant reduction in the wild NWS population.

Data analysis

Detailed data analysis by the epidemiology unit was carried out after the completion of SIT. It used two major computer software packages for this purpose: dBASE IV for data management and ILWIS GIS (Geographical Information System) for spatial analysis. It also used Lotus 1-2-3 for numerical

A phenological analysis of screwworm in Libya

Dr Krafsur's study of the relationship between weather and screwworm survival and reproduction was important in clarifying the effect that temperatures during the unusually cold winter of 1990-1991 had on the rapid success of the SIT programme.

The report in fact concluded that the accumulated evidence supported the view that the elimination of the NWS population from January to June 1991 was attributed to the release of sterile flies.

Data in the report indicated that the winter climatic conditions on the coastal plain of Libya were very similar to those of southern Texas and the Rio Grande Valley, where the screwworm readily overwintered until it was eradicated by means of the sterile insect technique.

Dr Krafsur's analysis of data, mainly from Texas, established that the parasite could overwinter successfully, as long as the mean temperature for three consecutive months was not below 9.7°C. He reported that successful overwintering of NWS was highly probable in the coastal plain of Libya during 1990-1991, but unlikely in the interior highlands.

The mean temperatures (from December to February) for Sorman and Zawia (on the coastal plain west of Tripoli) were above the overwintering threshold (9.7°C) for three consecutive winters from 1988 to 1991. The data showed that temperatures in both areas were not as severe during the winter of 1990-1991 as they had been in 1988-1989. However, the screwworm had survived the earlier winter.

At Gharyan, 40 km south of Tripoli, with an elevation of 600-800 m, the mean winter temperature for 1990-1991 was 8.6°C, which was lower than the threshold and would not permit overwintering by NWS.

Other main points of Dr Krafsur's report are as follows:

- The high rate of animal inspections suggested a strong probability of detecting breeding screwworm populations wherever and whenever they occurred.
- Generation times and life expectancies among adult flies were estimated. From these data, based on historical experience in Libya from 1989 to 1990 and in Texas from 1962 to 1983, predictions of NWS population growth in Libya in 1991 were made. Case reports for January to June 1991 were consistently less than these estimates, confirming the effectiveness of the eradication campaign.
- Phenological simulations of sterile mating among feral screwworms supported the contention that sterile fly dispersions were related to the case incidence in the Zawia and Zuwarah districts from late January to July.

analysis and the creation of graphs and charts as well as Harvard Graphics.

NWS and weather

Two comparative studies by the epidemiology unit produced results that had enabled SECNA to conclude that, while low winter temperatures slowed NWS activity, climatic conditions did not account for the early suppression of the population. The NWS had survived three winters in Libya, indicating that it was well adapted to local conditions and that weather alone was not enough to eradicate the pest.

Having survived the winter, the population would normally have expanded in March and April. However sterile flies were already being dispersed over the entire infested zone by early

34. Libyan people, including children, were encouraged to assist with fly dispersal by opening any boxes of sterile flies that failed to open automatically after dispersal from the aircraft

February. These flies would therefore have been available for mating with newly emerged indigenous flies.

In 1991, 35 wild females were captured in wind-oriented traps. Using standard population estimation methods (the Lincoln Index) this indicated that in excess of 100 000 wild females were present in Libya during March and early April. The last wild fly was captured on April 27, indicating that substantial numbers of adults emerged from pupae that had overwintered in Libya.

Many cases of myiasis caused by species other than screwworm were discovered in 1991, which suggested that the screwworm population had been selectively eliminated. Only six NWS cases were found in 1991.

The relationship of weather to screwworm survival and reproduction was reviewed by Dr E.S. Krafsur of the department of entomology of Iowa State University, in a report commissioned by FAO, *A Phenological Analysis of Screwworm in Libya* (see box on page 119).

Communication and information

The cooperation of the public, in particular livestock owners, is another essential factor in a successful SIT programme and, in Libya, a carefully planned multimedia communications campaign ensured that Libyan people were extremely well informed about the screwworm and the use of the sterile insect technique.

A wide range of information materials were prepared and distributed to livestock owners throughout the country, concentrating on the infested zone, to gain their cooperation in surveillance, treatment, quarantine and animal movement control activities.

The public was kept informed about the programme through radio, television and face-to-face meetings, as well as through the broad distribution of printed materials. During the SIT operation the public was also encouraged to assist the campaign by opening any boxes that had failed to open during dispersal (see Photo 34). The communication and information campaign is detailed in Chapter seven.

SIT coordination in Mexico

To streamline the process of transporting the sterile flies from Mexico to Tripoli, and to ensure the consistent communication and coordination with MACES and the Tuxtla Gutierrez production plant, SECNA posted representatives in Mexico. A site coordinator was based in Mexico City, and a programme representative was based at the production plant. These positions were merged during the programme, and the coordinator/representative was stationed at the production plant.

The FAO/SECNA coordinator/representative was for the most part required to liaise with MACES and German Cargo Services during the programme, handling administration and reporting and compiling data for presentation to SECNA headquarters and the field programme.

During the preparation of each shipment, the coordinator/representative was required to verify that the flies were sterile and to confirm the quality of the flies. Reports were then made to SECNA on the results. SECNA was also notified of the departure times of each flight and the estimated time of arrival in Tripoli.

Technical evaluation

Independent technical evaluation of the programme was carried out by a Technical Advisory Committee (TAC), which was made up of three experts who visited Libya twice during the programme, in May and September. The committee was required to review the programme and recommend specific actions (see box on this page). Following the visits to Libya, the TAC produced two reports which provided a valuable overview of the programme's progress.

The Technical Advisory Committee

The TAC's responsibilities were specified in the Action Plan for the eradication programme. The experts were to:

- review the technical operations of the screwworm eradication programme in Libya and surrounding countries;
- review physical facilities available to the SECNA field programme;
- evaluate results of the eradication programme to the date of reporting;
- recommend a specific programme of action to be followed after the eradication of the screwworm.

Ongoing activities

Although the SIT campaign ended in October 1991, the SECNA programme did not stop. To ensure that the country was in fact screwworm-free, surveillance, treatment, animal movement control and quarantine activities had to be maintained for at least eight to nine NWS life cycles.

Emergency restart plan

These activities continued at an intensive pace throughout 1991 and into 1992. An emergency SIT restart plan was prepared, which would enable the resumption of sterile fly releases within four days of any positive identification of NWS infestations.

Within 24 hours of any positive identification of screwworm larvae, the case was to be reported to SECNA in Rome, samples sent to the FAO reference laboratory in London, and a request made to the Mexico-US Commission for the supply of flies (3.5 million initially together with an order for 14 million flies per week for 14 weeks).

On the same day, surveillance and trapping activities would be initiated, and all animals in the immediate area of the screwworm case treated as a preventive measure.

Backed up by intensified ground activities, flies would be released using hotspot treatment. The emergency SIT operation would then continue for at least 84 days if no further cases were detected.

SECNA therefore continued its activities in North Africa until the official declaration that the region was screwworm free on June 22, 1992, when responsibility for the maintenance of the preventive programme, the final phase of the eradication campaign, was handed over to Libyan veterinary authorities.

Chapter five

Managing the campaign

35. The distribution centre and aviation unit team

There had never been any doubt that the presence of NWS in North Africa represented an emergency and that the only way to prevent this devastating insect pest from spreading throughout the Eastern Hemisphere was through immediate and decisive action.

Prompt action by the Libyan authorities in the early stages of the crisis had been crucial in containing the NWS. Close liaison was maintained by FAO with the Libyan government, the governments of neighbouring countries, and the relevant international organizations; within months of receiving notification of the NWS presence in the Libyan Arab Jamahiriya, FAO had approved and financed technical cooperation projects worth more than US$2 million for Libya and other threatened North African countries.

The Libyan government took prompt action to set up the appropriate management structures to deal with the screwworm problem, establishing a National Screwworm Committee under the direction of the Secretary of Agriculture in May 1989.

In June 1990, as work in North Africa moved toward the implementation of a formal eradication programme, FAO's Director-General formed the Screwworm Emergency Centre for North Africa (SECNA) with wide-ranging authority to handle all of FAO's responsibilities and activities in response to the emergency situation.

Initial phase

Responsibility for the programme during the initial phase had been taken by FAO's Agriculture Department, headed at the time by Assistant Director-General, Dr Bonte-Friedman. All activities were coordinated by the department's Animal Production and Health Division, headed at the time by Director Dr Jasiorowski. Within that division, the animal health service and its veterinary services group were largely responsible for planning and development work in the early stages of the emergency.

The animal health service worked in close cooperation with the Agricultural Operations Division, specifically its regional operations service.

Numerous other FAO divisions and services were involved in the complex process of planning and development, approval of finances and contracts throughout the programme.

The Action Group

The FAO Screwworm Action Group (later the FAO/IAEA/IFAD/UNDP Action Group) was formed on April 27, 1989 to act as a coordinating body in the North African screwworm campaign.

Original members of the group included representatives of the FAO Animal Production and Health Division, the Agricultural Operations Division, the Information Division and the Joint FAO/IAEA Division.

IFAD, which had also received a request for assistance from the Libyan government, joined the action group on July 31, 1989; UNDP joined on November 16, 1989.

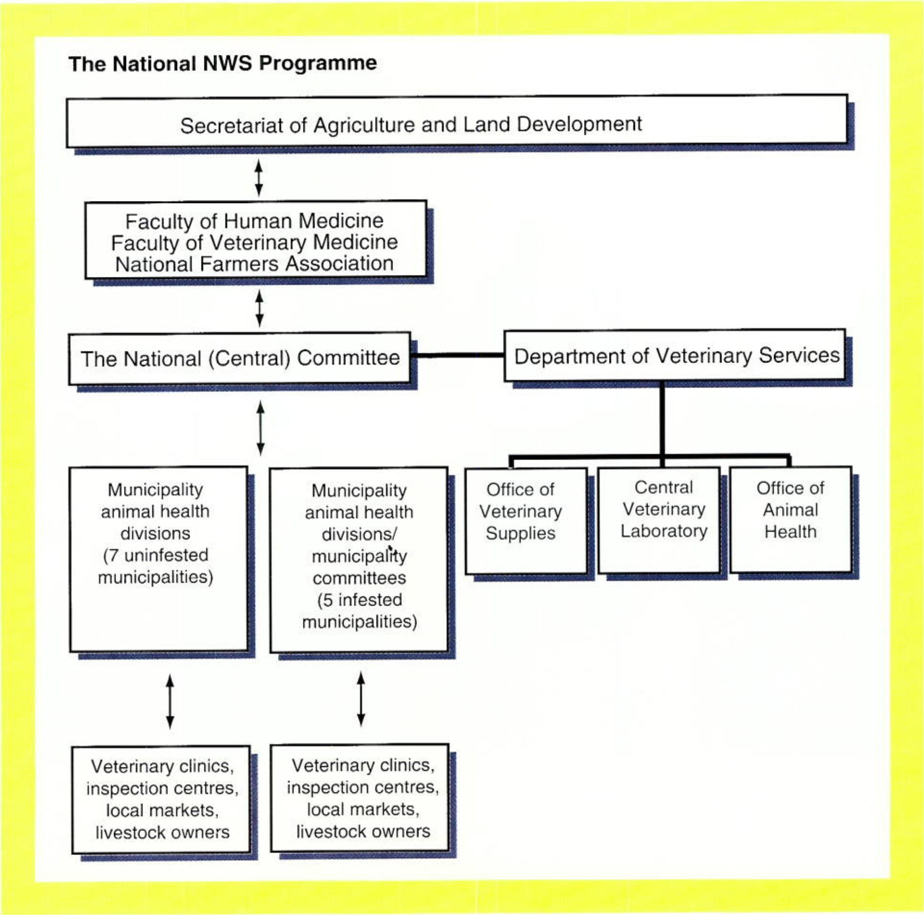
The main role of the action group was to act as the central coordinating body during the early stages of the screwworm programme. It functioned in this capacity until the formation of SECNA in June 1990, and its weekly meetings were attended by representatives of the various FAO divisions and other organizations involved in the programme.

The Libyan national NWS infrastructure

In the early stages of the crisis, the Libyan government had established the infrastructure for surveillance, control and prevention activities, based on its vast network of veterinary facilities spread throughout the country. There were 104 clinics in the infested area alone, operating within a government structure headed by the Secretariat of Agriculture and coordinated by the Department of Veterinary Services.

The National Screwworm Committee, formed to oversee all surveillance, quarantine and control activities, was first chaired by Dr Ali Guma, the national coordinator for FAO projects in Libya. After one month, the chair was transferred to the director of veterinary services, Dr Masood Abusowa. The committee comprised the chairmen of the animal health divisions in the five municipalities in the infested zone; representatives of the Veterinary Ser-

Figure 20. The National Screwworm Committee



vices Department, the Faculties of Human and Veterinary Medicine of Al-Fateh University and the National Farmers Association (see Figure 20).

The national committee reported directly to the Secretary of Agriculture and Land Development. It received weekly reports from the municipal committees, which in turn received daily reports from the inspection teams working in the infested areas. The chief veterinary officers in the seven NWS-free municipalities were also required to undertake surveillance activities and report to the committee.

This structure was supported by the Department of Veterinary Services, which provided the required veterinarians and technicians. The service employed approximately 300 veterinarians and 1 200 technicians and veterinary assistants, who worked at the central animal health and veterinary laboratories in Tripoli and in the network of veterinary clinics distributed throughout the country. They all combined their normal work with screwworm campaign activities.

The central committee formed inspection teams to undertake prevention, control and surveillance work in the infested municipalities. There were

36. The late Mr Bashir Said El-Mabrouk, former Libyan ambassador to FAO (far left), chairing a screwworm action group meeting

94 teams operating by August 1989 under the supervision of the municipal committees and working from the veterinary clinics.

In Rome, the Libyan ambassador to FAO, the late H.E. Mr Bashir Said El-Mabrouk, was instrumental in coordinating his government's effort with the activities of FAO and donors. He took several initiatives which contributed to the success of the preliminary stages of the campaign. Mr Bashir Said died in a car accident in Libya, on November 12, 1990, after chairing one of the most critical action group meetings of the programme (see Photo 36).

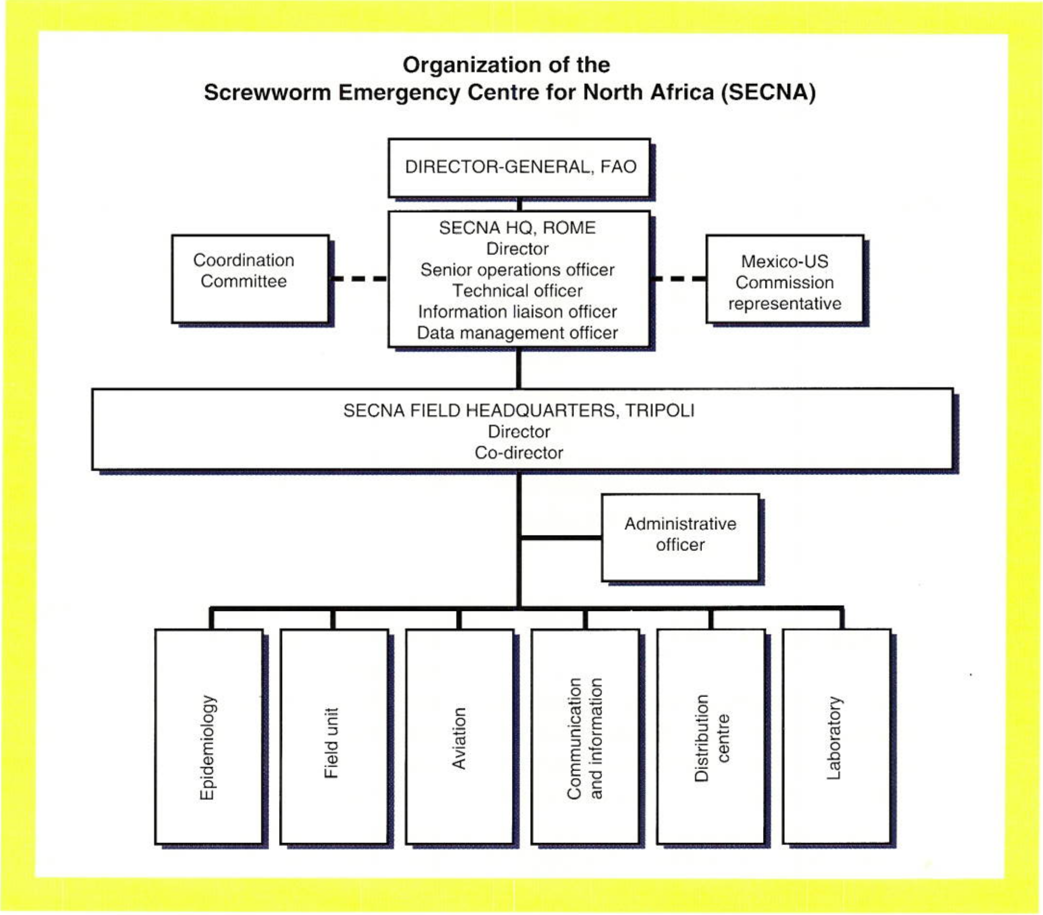
SECNA

The FAO Director-General formed the Screwworm Emergency Centre for North Africa (SECNA) on June 15, 1990, instructing all FAO departments, divisions, regional and field officers to give the highest priority to any requests by the centre for support.

SECNA structure and functions

In line with the emergency nature of the screwworm situation in North Africa,

Figure 21. Organization of the Screwworm Emergency Centre for North Africa (SECNA)



FAO created SECNA with special authority, designed to avoid any delays in implementing the eradication programme.

The centre operated under the instructions of FAO's Director-General and dealt directly with donors, countries at risk of NWS infestation and other relevant organizations.

Its director was given extensive delegated authority to permit fast decisions and to expedite operations for the programme, including the procurement of supplies.

SECNA's structure — management headquarters in Rome and a field programme in Libya (see Figure 21) — was designed to facilitate a rapid flow of command and action. It was complemented by two committees:

- an independent Technical Advisory Committee, which undertook two missions to Libya to monitor and evaluate the technical aspects of the eradication programme;
- a Coordination Committee, comprising representatives of all involved UN agencies (FAO, IFAD, UNDP and IAEA), donors and the affected countries. The committee was responsible for the coordination of all activities and for reviewing the progress of the programme, overviewing policy, endorsing any major changes to the programme and advising on administrative and financial considerations.

Staffing of SECNA

Initially, SECNA was placed under the direction of Dr Lucas Brader, then director of the FAO Plant Production and Protection Division; he was considered the most appropriate person to head the new body since it was modelled on FAO's Emergency Centre for Locust Operations (ECLO), which he had directed with considerable success. On November 1, 1991, after Dr Brader left FAO to take up the position of director-general of the International Institute for Tropical Agriculture (IITA), SECNA was transferred to the FAO Animal Production and Health Division, and the division's new director, Dr E.P. Cunningham, was appointed SECNA director. The immediate priorities for the new director were to continue the complex negotiations to finalize a contract with the Mexico-United States Commission and maintain efforts to ensure funding for the eradication programme.

Headquarters

SECNA headquarters in Rome comprised the director and two full-time specialists, senior operations officer Dr A.E. Sidahmed and technical officer Dr M. Vargas-Terán. Later, the team was joined by a computer data management officer, an information officer and a part-time media liaison officer (see box on page 133).

The headquarters team was responsible for coordination of the technical and managerial aspects of the programme, including all financial matters, liaison with other FAO divisions and units, the recruitment of consultants and coordination with donors and the countries at risk of infestation.

It was also responsible for meetings of the Coordination Committee and the Technical Advisory Committee and for the preparation of detailed progress reports on the eradication programme.

Management meetings, chaired by the SECNA director and attended by the senior operations officer, the technical officer and the field programme director and co-director, together with other senior staff as appropriate, were held every two to three months throughout the programme. They were held both in Tripoli and in Rome and were designed to streamline decision-making on programme activities (see Photos 37 and 38).

Mexico site coordinator

A SECNA representative was appointed to the Mexico-US Commission, based at Tuxtla Gutierrez, Mexico, to assist in the coordination of the SIT component of the eradication programme (see box on page 133).

Initially two SECNA staff members were posted in Mexico, one as a special programme representative at the sterile fly production plant in Tuxtla Gutierrez and another as site coordinator, based in Mexico City. The two positions were merged during the programme into the role of site coordinator, based at Tuxtla Gutierrez, responsible for general supervision and coordination of the weekly sterile NWS shipments to Libya and for the link between MACES and SECNA during the eradication programme. The site coor-

37. A SECNA management meeting. From right, field programme director Dr D.A. Lindquist; SECNA director Dr E.P. Cunningham; field programme co-director Dr M. Abusowa; counterpart laboratory chief Dr K. Mughadmi; communication and information officer Dr M. Husni; aviation officer Capt. L. Messick; and quality control chief, Dr J. Chirico

dinator was also required to verify the sexual sterilization of the NWS flies sent to Libya and to confirm the quality of the flies.

The field programme

The SECNA field programme was established in Libya in August 1990, and a director, Dr D.A. Lindquist, appointed on August 17. Dr M. Abusowa was appointed co-director of the field programme in September.

In Libya, the SECNA field programme staff of international experts was ostensibly in place by the end of 1990 (see box opposite).

As is normal practice in United Nations field programmes, all senior international staff worked with local counterparts who were funded by the Libyan government.

The field programme structure

The field programme director reported directly to the SECNA director at FAO headquarters and was responsible for all field activities, including management of all resources, programme

38. During the same management meeting, from left, administrative officer Mr F. Salvatori; SECNA director Dr E.P. Cunningham; field programme director Dr D.A. Lindquist; senior operations officer Dr A. Sidahmed; technical officer Dr M. Vargas-Terán; surveillance chief Dr L. Liera; senior epidemiology officer Dr R. Reichard

SECNA professional staff

SECNA headquarters, Rome

Dr E.P. CUNNINGHAM, Director AGA/SECNA (Ireland)
Dr A.E. SIDAHMED, Senior Operations Officer (Sudan)
Dr M. VARGAS-TERAN, Technical Officer (Mexico)
Mr S. BARNES, Information Officer (Australia)
Ms M. KASSA, Computer Data Management Officer (Ethiopia)
Mr P. McCORMICK, Media Liaison (United Kingdom)

Field programme

Director's office

Dr D.A. LINDQUIST, Director (USA)
Dr M. ABUSOWA, Co-Dir. (Libya)

Administration

Mr Fernando SALVATORI (Italy)

Aviation

Capt. Larry MESSICK (USA)
Mohammed EL-SHAWSH (Libya)

Communication and information

Dr Mohammed HUSNI (Libya)
Mr Fourat DRIDI (Tunisia)

Distribution centre

Dr Eduardo RIOS (Mexico)
Dr Omar EL-RAIS (Libya)
Dr Miguel Arturo CRUZ (Mexico)

Epidemiology

Dr Robert E. REICHARD (USA)
Dr Mohammed ABU-DIAH (Libya)
Dr Lennart SJOELAND (Sweden)
Mr Harry LAME (Netherlands)
Dr F.A. POUDEVIGNE (France)
Dr Adele BENGERE (Libya)

Field

Dr Luis F. LIERA (Mexico)
Dr Abubaker BELAZI (Libya)
Dr Arturo MARTINEZ (Mexico)
Dr Musadek AMARA (Libya)
Dr Juma HALOUN (Libya)
Dr Lutfi TUNISI (Libya)
Dr D. BRUZZONE (Italy)
Mr Saydil-Moukhtar TOURE (Senegal)

Laboratory

Dr René GARCIA (Mexico)
Dr Khalifa MUGHADMI (Libya)
Dr Jan CHIRICO (Sweden)
Mr Mamdouh TAHER (Jordan)

Mexico

Dr Salem EL-AYAN, Special Representative to Commission (Libya)
Mr Fabio RODRIGUES-TORRES, FAO/SECNA Site Coordinator (Colombia)

strategy and its implementation. He also maintained close contact with the Libyan government on all matters related to the eradication programme.

The co-director (who was also chairman of the Libyan National Screwworm Eradication Committee), was jointly responsible for supervising the field activities and for ensuring the availability and coordination of Libyan government inputs to the eradication programme.

The co-director also helped to streamline activities in Libya, by advising on matters involving Libyan authorities and ensuring that effective and continuous communication was maintained with the Libyan government at the highest levels.

The field programme team

The SECNA field programme operated from a base in the central veterinary laboratories in Tripoli, with facilities including a diagnostic laboratory, a laboratory for quality control and a research and development department.

As detailed in Chapter four, the field programme was divided into seven units, each headed by an international expert and his or her Libyan counterpart. A number of Libyan professional staff also worked in the units (see box on page 133).

The staffing of the units was as follows:

- *Field unit*: staffed by a senior surveillance officer, a trapping and collection officer and two quality control experts;
- *Laboratory*: headed by a senior laboratory research and development officer and staffed by a quality control chief and a quality control laboratory development expert;
- *Epidemiology*: headed by a senior epidemiologist and staffed by an epidemiologist and two associate professional officers — an agricultural engineer and a junior epidemiologist;
- *Distribution centre*: based at Tripoli airport and headed by a senior officer and various staff including dispersers (see Photo 35, the chapter opener);
- *Aviation*: headed by an aviation officer, who was responsible for coordinating the aerial dispersal operations;
- *Communication and information*: headed by a Libyan communications officer;
- *Administration*: headed by an administrative officer.

The Coordination Committee

This committee was established, as stipulated in the plan of operation for the screwworm eradication programme, to coordinate all activities of the programme, overview policy, endorse any major changes to the programme and advise on administrative and financial matters.

The committee's meetings were chaired by Assistant Director-General (Agriculture) Dr H. de Haen, and the SECNA director Dr E.P. Cunningham, with the SECNA senior operations officer Dr A. Sidahmed acting as secretary. It comprised representatives of all involved UN agencies, donors and affected countries (see Annex 3 for a full list of representatives). The committee met four times during the programme — on June 11 and October 15, 1991 and on February 12 and June 25, 1992.

Reports documenting the progress of the eradication programme in detail and providing up-to-date information on the programme's budget and funding status were presented to participants at each meeting.

These reports in fact form an important chronological summary of the eradication programme, detailing all activities relating to the distribution of sterile flies, surveillance, control and quarantine activities, research and development work, the information and communication campaign and activities in neighbouring countries.

The progress report detailing the period from February 1 to May 31, 1991 was accompanied by a Technical Advisory Committee report and a special report on surveillance and prevention activities in neighbouring countries. The progress report for the period June 1 to August 31, 1991 was accompanied by the second report of the Technical Advisory Committee. Participants were also given executive summaries of three special studies on specific matters relating to the programme: *A Phenological Analysis of Screwworm in Libya; Computerization and Analysis of SECNA Technical Data*; and *Economic Impact of NWS Eradication from North Africa.*

Apart from the printed reports, members of the committee were given verbal presentations on the progress of the programme and were given the opportunity to ask questions and discuss any relevant matters.

In this respect the meetings were an important opportunity to clear up any concerns held by the representatives of donor countries and organizations about the programme.

The Technical Advisory Committee (TAC)

This committee acted as an independent body to monitor and evaluate the progress of the eradication programme in Libya. It conducted two missions to Libya and prepared reports for presentation to the coordination committee.

The members of the Technical Advisory Committee were:

Dr N. Pineda Vargas, former director, Screwworm Eradication Programme in Mexico; Dr W. Takken, department of entomology, Wageningen Agricultural University, the Netherlands; and Dr D.W. Anderson, former MACES general subdirector, Mexico.

The committee's first mission to Libya was from May 5 to 10 and the second from August 31 to September 6, 1991.

Following its first mission the TAC commented that SECNA, working in collaboration with the Libyan government, had done an excellent job in establishing an effective management structure in a short time and in implementing the many technical tasks necessary for the programme. The TAC recommended that the fly release programme be maintained at least until October of that year and that a full surveillance and quarantine programme should continue until at least May 1992. Based on observations of the field programme's operations the TAC made various recommendations on how its activities could be strengthened.

After the second mission, based on the excellent progress made in the eradication programme, the team concluded that evidence was sufficient to justify ending sterile fly releases in October of that year.

Data analysis

The emergency nature of the SECNA programme meant that comprehensive data analysis was retrospective, since time was insufficient during the actual campaign to conduct anything more than basic and essential work in this area. A vast data base was accumulated during the programme, ranging from census and environmental data through precise records of all surveillance, quarantine and laboratory activities.

As both hardware and software became available, computers were used for data analysis relating to the preparation of weekly and monthly reports by the field programme.

Staff

In Tripoli, the epidemiology unit had two experts working on computer data analysis and, in Rome, the computer data management officer was responsible for compiling data for inclusion in reports.

Software

The SECNA programme used three main software packages for data analysis: Lotus 1-2-3 and dBASE IV for numerical analysis and creation of graphs and charts; and ILWIS GIS (Integrated Land and Water Management Information System Geographical Information System) for spatial analysis.

To avoid the necessity of re-entering data for every single analysis, master data bases were created using dBASE IV, which enabled the transport of data to other software packages, using custom-written applications or standard software.

Additional software used by SECNA included AutoCAD, to make high-quality output maps possible; Harvard Graphics, to enhance the quality of Lotus 1-2-3 graphs; and WordPerfect, for report writing. Custom software was written to handle such tasks as the classification of data and the transfer of real-world coordinates to ILWIS coordinates.

Data

Data were gathered for inclusion in dBASE IV in late 1991 from the SECNA programme (case, trapping and quarantine data, for example) and from external sources including the Libyan Ministries of Planning and Agriculture, regional development plans and agricultural census reports for 1987 as well as from satellite images and various topographical and navigational maps.

Staff were confronted with a major problem in the area of spatial analysis because of the lack of a consistent nomenclature in the information available on geographical and administrative units in Libya.

They found that, in Libya, there was no common denominator for the different administrative subdivisions, apart from areas called "branches" (the largest sub-unit of each municipality); a single branch could cover an area of several hundred square kilometres and stretch from coastline into the desert. Staff at the SECNA field programme, however, managed to adapt the branch system to create a series of maps that detailed the number of NWS myiasis cases by animal species per year, using ILWIS GIS.

Using GIS, maps were also produced which combined data on the location and number of NWS myiasis cases with data on the status of the land.

Reporting system

Technical information, compiled on a weekly basis, was crucial to the effective planning, management and implementation of the SECNA field programme operations. Data were produced by the field programme's individual units and submitted to the epidemiology unit for analysis; a final, weekly summary was sent to SECNA headquarters in Rome for tabulation, analysis and preparation of reports.

Based on these reports, monthly summaries were prepared, which then provided the basis for the preparation of the main progress reports on the programme, produced every four months for submission to the Coordination Committee.

The type of data produced on a weekly basis by the field programme is summarized as follows:

Field unit

- number of animals inspected weekly in the surveillance areas, by species and municipality;
- number of larva samples submitted by inspection teams for laboratory identification (whether positive or negative for screwworm) by species and municipality;
- date, host species and location (using municipality and map coordinates) of positive and negative larva samples (done monthly);
- all details on quarantine activities, including the number of animals entering and leaving the control areas, by species and inspection post, the number of animals sprayed, the number of wounds detected and treated;
- reports on fly catches, including data on the total number of male and female screwworm flies, number of traps operating and data on temperature and rainfall.

Laboratory

- results of quality control tests on fly emergence, sex ratio, malformed adults, longevity tests (with and without food and water), sterility and total longevity by shift (meaning the shift of workers handling the flies in Mexico);
- results of pre- and post-release mortality and mobility tests by date, shift, release area and flight time;
- transportation data, including pupation date, irradiation date, packaging date, number of boxes and pupae, date of transportation, duration of transportation, maximum and minimum temperature during transportation (all by shift);
- graphs of temperature against time during transportation, by pallet position in aircraft;
- numbers of positive and negative egg masses collected;
- numbers of sterile and fertile female flies dissected;
- numbers of negative and positive larvae identified;
- results of research and development activities.

Aviation and distribution

- map of distribution grids showing densities of sterile flies dispersed;
- detailed data on distribution flights, including kilometres flown, time of flight, altitude, boxes dispersed and frequency of dispersal by grid.

Epidemiology

These weekly reports consisted basically of additional analyses of data provided by the other units and the production of relevant maps and charts, including:

- maps and charts of animal census data;
- maps showing surveillance areas and distribution of surveillance teams, fly traps and control posts;
- maps showing geographical

distribution of screwworm and non-screwworm myiasis cases by time period;

- maps of trap catches of fertile and infertile NWS flies by time period;
- maps showing dispersal grids and densities of flies dispersed;
- analysis of myiasis cases by species and municipality;
- analysis of the relationship between climate and screwworm cases;
- analysis of ratios of sterile and wild female flies captured by trap group.

The unit was also involved in:

- analysis of data from quarantine posts to give more precise information on the sources and destinations of animals moving into and out of the control area;
- revision and review of reporting formats;
- preparation of contingency operational control plans under different outbreak scenarios within and outside the control area, and under different degrees of operational difficulty.

Following the end of the main eradication programme, the unit undertook a comprehensive analysis of all data generated during the programme.

Contracts

Following the decision to eradicate the NWS in North Africa using the sterile insect technique, it was necessary to determine which aspects of the eradication programme could be performed by FAO and which needed to be subcontracted to outside bodies.

It had become clear that three major components of the programme should be undertaken by contractors: the production of sterile flies; the transport of the flies to Libya; the dispersal of the flies over the infested area in Libya. The preparation of contracts for these activities was handled by the contracts branch of FAO's Administrative Services Division. The branch was headed at the time by Mr Anton Doeve.

The Mexico-US Commission agreement

The Commission's sterile fly production plant at Tuxtla Gutierrez, Mexico, was the only place in the world which produced sterile flies. At the time the Mexico-United States agreement was signed, in 1972, the NWS had never been found outside its natural range in the Americas, thus it stipulated that sterile flies could not be sold or sent outside the Americas.

FAO had made an initial approach to the US government in November 1989, requesting the provision of sterile flies from the plant for use in a North African eradication programme. Consequently, in March 1990, US President George Bush signed legislation permitting the sale of the flies anywhere in the world.

The achievement of a contract which was suitable to both FAO and the joint Mexico-US Commission was a time-consuming process, involving complicated and protracted contractual negotiations from July to November 1990. It was necessary to have the agreement of not only the two organizations, but also of the US State Department, the US Department of Agriculture (USDA) and the US Treasury, as well as the equivalent bodies in Mexico.

Since the Commission was jointly funded by the United States and Mexican governments, it was necessary to determine how it would deal with funds being provided by a third source (FAO) before a final agreement could be reached.

A contract was originally drawn up by FAO's contracts branch and submitted to the Commission. After considering this draft, the Commission drew up another contract, which, after several months of negotiations and modifications, became the final agreement between the two bodies.

Under the agreement, the Mexico-US Commission agreed to provide the maximum number of sterile NWS flies required for the eradication programme per week, at cost price. Formulae for the calculation of this cost price were agreed on.

The Tuxtla Gutierrez plant was also responsible for packaging the flies and performing predeparture quality control tests. Records were to be provided to FAO on production, sterilization, quality control, packaging and transportation of the flies.

FAO agreed to fund the necessary remodelling of the Tuxtla Gutierrez plant and the purchase of equipment, to enable it to increase sterile fly production to the required level.

Complex negotiations

As contractual negotiations continued into November, the need to finalize and sign the agreement became urgent, and the situation took on an air of high drama. The pilot release of sterile flies in Libya had originally been scheduled to begin in November 1990 to take advantage of the naturally low screwworm population during the cooler months of the year.

Screwworm cases had been very high from July to November, peaking in September at 2 932 confirmed infestations; SECNA staff were extremely worried about the impact on the programme's effectiveness if the commencement date for the pilot programme was further delayed.

In November, a final version of the agreement was presented to FAO by the Mexico-US Commission, with the proviso that no further alterations could be made. However, the contract contained a clause in which MACES specifically disclaimed liability in the event that a screwworm fly was not sterilized, thus resulting in the release of a fertile screwworm fly in Libya.

The issue of liability posed a significant obstacle to achieving a final agreement as all three parties — MACES, FAO and the Libyan government — in effect refused to accept legal responsibility for the release of a fertile fly.

Concerned at the prospect of vexatious litigation by a country with which it had no legal or diplomatic relations, the United States government had ensured that the liability disclaimer was inserted into the contract.

The Libyan authorities, concerned that there may not be 100 percent sterility, also stood firm on the issue and refused to accept liability. This created significant problems for FAO, which normally operated projects with indemnities by national governments against legal claims and therefore could not accept liability under the MACES contract.

Confronted with the reality that urgent action needed to be taken in Libya, FAO's Director-General instructed that the contract be finalized, despite the serious concerns about the liability issue. He stipulated, however, that there had to be an agreement with the Libyan government on the matter.

Agreement reached

Following two days of intensive discussion in Tripoli between SECNA and Libyan authorities, including the late Libyan ambassador to FAO, Mr Bashir Said El-Mabrouk, the liability issue was resolved on November 12, 1990 to the extent that an agreement could be reached.

In a major show of diplomacy, Mr Bashir Said suggested that the programme should go ahead on the basis of the contract document as it stood, which meant in effect that the Libyan government accepted liability. Mr Bashir Said was killed in a car accident following the meeting. His contribution was later described by the SECNA director as "a victory for common sense".

Problems continue

The problems were not yet over, as FAO discovered when the signatures of the relevant authorities in the United States and Mexico were required.

FAO had already set the date for the first shipment of sterile flies to leave Mexico on December 1, 1990, and all arrangements were in place for their transport from Tuxtla Gutierrez to Tripoli. Following the agreement with the Libyan authorities on November 12, the contract went back to the United States, where it remained for some weeks in Washington, D.C., waiting for signatures from the US State Department and the USDA.

It was then sent to Mexico for signatures from the Ministries of Agriculture and Foreign Affairs. FAO's representative in Mexico obtained the final signature on November 30, one day before the first shipment of flies was to leave Tuxtla Gutierrez by truck for Mexico City airport. The only further requirement was that the fully signed document be registered with the appropriate officer at the United States Embassy in Mexico City.

A major, last-minute hitch occurred when it was discovered that the officer had left the city and could not be contacted. At this stage the truck carrying the first shipment, which was half-way between Tuxtla Gutierrez and Mexico City, was called back to the production plant and the shipment cancelled because the agreement had not been finalized.

The action was greeted with incredulity at FAO in Rome. Frustrated by the delay to the start of the eradication programme, FAO ensured that the shipment could be transported to Tripoli the following week.

Two days after all bureaucratic obstacles were finally overcome, on December 12, 1991, the first shipment of flies left the Mexico plant, arriving in Libya on December 14.

German Cargo Services

The massive and complex task of transporting the sterile flies to Libya was put to international tender by FAO. A major consideration in awarding the contract was that the successful tender submitted the right specifications for transport of the flies.

Two tenders were called, one for the pilot project of the preparatory phase and another for the main eradication programme. For the first contract, three firms submitted bids, and for the second 22 firms from 14 countries. German Cargo Services was eventually awarded both contracts to transport the sterile flies to Libya.

Contract details

To ensure the quality of the flies arriving in Tripoli, their transportation according to exact specifications was critical. The contract therefore outlined requirements regarding loading and unloading time, the manner in which the flies were loaded on to and stored in the aircraft, the temperature within the aircraft, the duration of the flight and other considerations.

Under the contract, the contractor was also required to provide details to FAO on the conditions under which each flight took place — information which would be useful in determining the causes of any reduction in the quality of the flies.

Transport arrangements

During the pilot phase and the first months of the main eradication programme, German Cargo Services was responsible for the charter transport of the sterile flies only from Frankfurt to Tripoli, the first leg of the journey being by regular scheduled air freight. From May 3, it was responsible for their transportation directly from the plant at Tuxtla Gutierrez, Mexico to Tripoli airport.

The Libyan Aeroclub

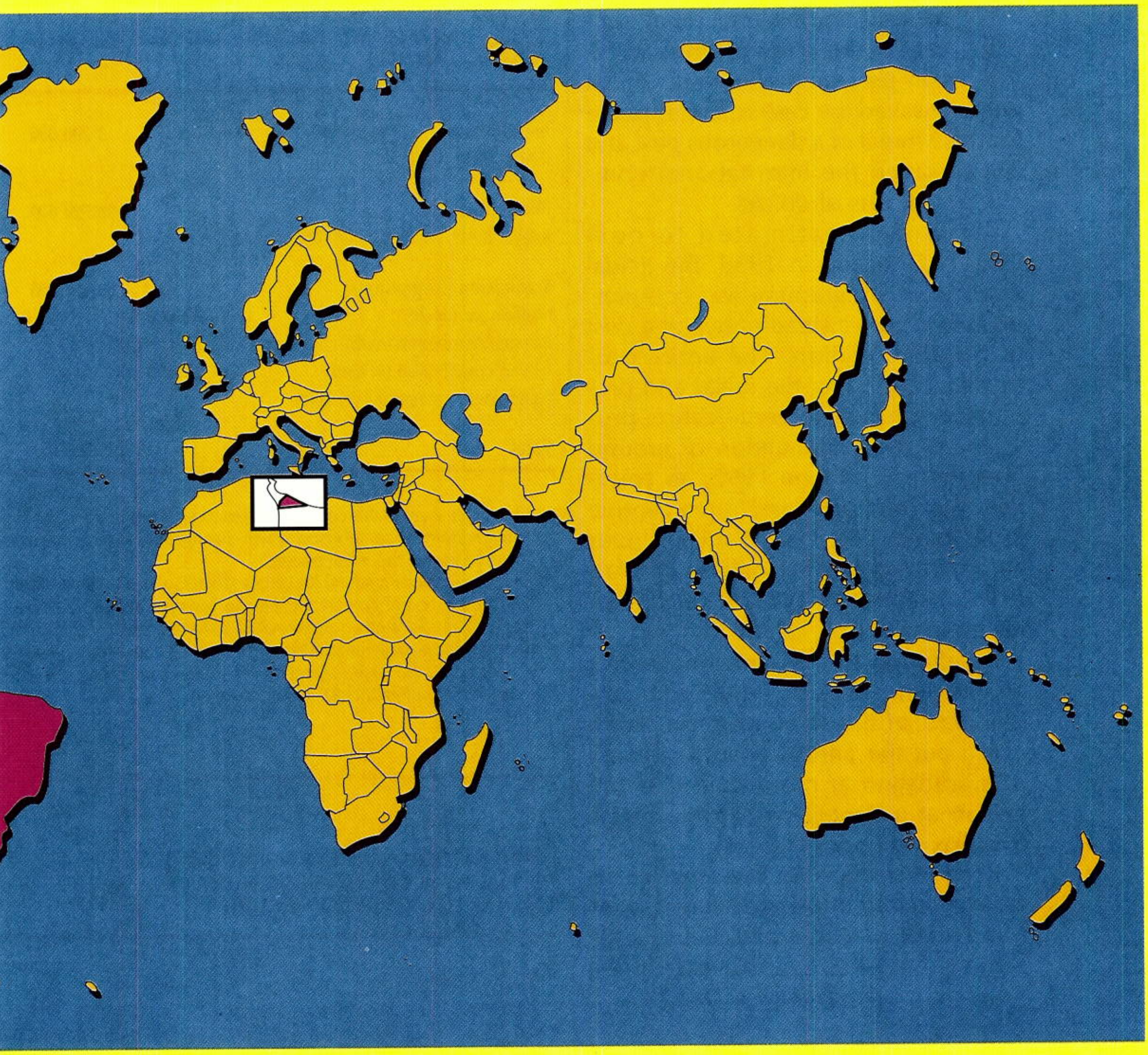
The Aeroclub was awarded the contract for the aerial dispersal of the sterile flies in Libya after responding to the call for international tenders with the lowest bid.

Contract details

The contract outlined exact specifications for the actual aircraft, the qualifications of the crew, the conditions of dispersal (including handling of the boxed flies and the method of dispersal), the frequency of flights, the necessity of maintaining detailed flight records and modifications to the aircraft to accommodate the dispersal chutes.

Chapter six

Money matters



The outstanding and rapid success of the screwworm eradication programme in North Africa not only saved the Eastern Hemisphere from the threat of a dangerous pest, but it also saved the international community millions of dollars.

Originally estimated to cost US$117.5 million in 1990, the actual eradication programme was completed in one year instead of two at a cost of US$66.6 million. The entire programme, including the initial and preparatory phases, the eradication programme, the continuation of ground operations until June 1992, an emergency restart plan and a preventive programme, cost US$75 million (plus an additional US$5.1 million in bilateral donations to Libya and neighbouring countries) (see Table 7).

In addition to these major savings, an independent study on the economic impact of the screwworm in North Africa put the annual regional benefit of eradication at more than US$300 million at a benefit/cost ratio of 50:1 (see box on opposite page).

Revised budgets for the programme were prepared in planned stages, with summaries of expenditure and estimates presented to donors at each meeting of the Coordination Committee.

Funding arrangements

Funding sources for the programme were divided into three main groups: multidonor (including governments and institutions), United Nations agencies and the Libyan government, which contributed both in cash and in kind to each phase of the programme. Neighbouring countries contributed in kind for their own surveillance and control programmes.

TABLE 7: NEW PROGRAMME BREAKDOWN OF OVERALL FUNDING SOURCES (in US$)

Initial phase (FAO, Libya, UNDP)		3 700 000
Pilot phase* (Libya, IFAD, AfDB, UNDP, IAEA, FAO)		10 700 000
Eradication programme		60 600 000
Multidonor funds**	32 600 000	
Libyan contribution (cash)	11 400 000	
Libyan contribution (in kind)	14 600 000	
Neighbouring countries (in kind)	2 000 000	
Total		75 000 000

* The major share of this cost (equivalent to $7.5 million) was the Libyan government contribution which also included some expenses incurred during the initial phase.

** Does not include bilateral donations: The EC allocated an additional $1.1 million to Egypt, $1.1 million to Tunisia and $438 000 to Algeria; IsDB allocated an additional $1 million to Libya and $1.5 million divided equally among the neighbouring countries — Algeria, Chad, Egypt, the Niger, Morocco, the Sudan and Tunisia; the USA allocated an additional $1 million to Egypt.

TABLE 8: TECHNICAL COOPERATION PROGRAMME PROJECTS FOR NWS CONTROL/ERADICATION (in US$)

First-line countries	
Algeria	250 000
Chad	305 000
Egypt	250 000
Libya	345 000
Niger	250 000
Sudan	150 000
Tunisia	250 000
Regional project	400 000
Second-line countries Burkina Faso, Cameroon, Djibouti, Ethiopia, Mali, Mauritania, Morocco, Nigeria, Senegal, Somalia	225 000
Total	2 425 000

Economic impact

NWS eradication from North Africa resulted in an annual benefit of US$300 million for the region, according to a special study commissioned by SECNA and completed in September 1991.

The study, *The Economic Impact of NWS Eradication from North Africa,* by Mr John Grindle of Rural Development International, showed a benefit/cost ratio for the region of 50:1.

Assessments were also made for the infested area alone and for Libya. In the infested area, the saving was estimated at US$9.3 million annually, with a benefit/cost ratio of 1.5:1. For Libya as a whole, the saving was US$18.9 million annually, with a benefit/cost ratio of 3:1.

On the basis of these figures, the study concluded that the eradication programme was clearly justified on the basis of the benefits to Libya alone.

"For the region as a whole the returns depend on the risk of spread and the rate of spread. Even a 50 percent chance of its spread over a period of ten years would suggest a benefit/cost ratio of around 10:1," the study concluded.

The study noted that the high returns were not surprising, since the costs related to a small area within Libya, while the benefits accrued to the entire region and beyond.

The figures presented in the study were calculated by comparing the savings made by avoiding the costs of ongoing treatment and production losses with the actual cost of the programme and a continuing annual cost for surveillance and control.

Estimates of the cost of treatment and production losses were based on a decline in production of 4 percent and an annual treatment/surveillance cost of US$1.10 per head of livestock.

To reflect values more accurately in international terms, the dollar figures were calculated at a "parallel" exchange rate rather than at the official direct exchange rate. In addition, international prices rather than local prices were used.

The benefit/cost ratios were more favourable when accounted in Libyan prices. They were 5:1 for the infested zone and 10:1 for the whole of Libya.

TABLE 9: SOURCES AND ALLOCATION OF FUNDS FOR THE PREPARATORY PHASE (in US$)

Sources of funds	Personnel	Equipment and supplies	Purchase of flies	Transport of flies	Dispersal of flies	GOE and DOR*	Total
IFAD		361 168	157 843	286 610	138 600	105 779	1 050 000
AfDB		839 750		378 064		32 186	800 000
UNDP	205 000	325 000					530 000
IAEA							507 000
FAO	200 000	30 000					230 000
Libya							7 500 000
Total	405 000	1 105 918	157 843	664 674	138 600	137 965	10 617 000

* General operating expenses and direct operating expenses.

The US$3.7 million initial phase was funded by FAO through Technical Cooperation Projects (US$2.5 million) (see Table 8) and the joint Libyan government/UNDP US$1.25 million cost-sharing project, to which the Libyan government contributed US$1 million and UNDP contributed US$250 000.

The US$10.6 million preparatory phase (including the pilot release of sterile flies) was funded by the Libyan government (US$7.5 million), IFAD (US$1.05 million), the African Development Bank (AfDB) (US$800 000), UNDP (US$530 000) and IAEA (US$507 000) as well as FAO (US$230 000) (see Table 9). Further funds were provided by UNDP, AfDB and IFAD for activities in neighbouring countries. UNDP provided US$108 333 each to Tunisia and Egypt; IFAD provided US$105 875; and the AfDB provided US$71 250 to each of Algeria, the Sudan and Morocco and a further US$32 186 for the programme.

In total, the multidonor component of the main eradication programme amounted to US$35.1 million (US$2.5 million were pledged but not received

TABLE 10: NWS ERADICATION PROGRAMME, SOURCES OF MULTIDONOR FUNDS (in US$)

Sources of funds	Payments
Governments	
Australia	232 558
Austria	755 487
Belgium	1 000 000
Finland	761 853
France	2 000 000
Germany	3 639 000
Ireland	200 000
Italy	894 784
Luxembourg	143 300
Netherlands	2 045 824
Spain	160 000
Sweden	2 287 082
United Kingdom	1 884 550
United States*	6 000 000
Institutions	
AfDB	4 000 000
EC**	2 466 583
IFAD	4 000 000
IsDB***	2 458 109
OPEC fund	200 000
WWF	10 000
Total	35 139 130

* Additional $1 million allocated for activities in Egypt.

** Additional $1 million allocated for activities in Egypt, 1 million for Tunisia and 438 000 for Algeria.

*** Additional $1.042 million contributed directly to Libya and $1.5 million disbursed equally among the neighbouring countries: Algeria, Chad, Egypt, the Niger, Morocco, the Sudan and Tunisia.

as of May 1992) (see Table 10). The Libyan government contributed US$11.4 million in cash and US$14.6 million in kind (see Tables 11 and 12). A further US$2 million was contributed in kind by neighbouring countries in support of their own programmes.

The funds provided from these sources were also used for the continuation of ground operations, at a cost of just under US$4 million, from the end of the main eradication programme in October 1991 to the declaration that Libya was screwworm-free in June 1992; they were also put toward the US$2.5 million preventive programme, designed to complete the eradication programme by securing the gains made and to minimize the possibility of any further outbreaks in the region (see Table 13).

Donors

The first donors pledging conference, held in July 1990 at IFAD headquarters, was organized jointly by IFAD and FAO. It had been preceded by two donor consultations, held in January and May 1990 (the first convened by IFAD and the second by FAO). The purpose of the consultations had been to advise potential donors of the screwworm situation in North Africa and to outline proposals for an eradication programme.

In June 1990, FAO had led a technical formulation mission to Libya (with the participation of IFAD, UNDP and IAEA) which resulted in the preparation of a programme for the eradication of the NWS from Libya using SIT.

The members of this important mission were: Dr A. Sidahmed, Dr D.A. Lindquist, Dr M. Vargas-Terán, Dr M. Abusowa and technical officer Mr G. Panayoti, IFAD representative

TABLE 11: LIBYAN CONTRIBUTION IN CASH (in US$)

Description	Amount
Personnel (national incentives)	8 842 868
General operating expenses	2 536 235
Total	11 379 103

TABLE 12: LIBYAN CONTRIBUTION IN KIND

Description	Libyan dinars*
Personnel (national counterparts) supporting field staff, administrative support	2 152 800
Duty travel	986 500
Supplies	100 000
Premises	660 000
Training	10 000
Total	3 909 300
Total in US$	$14 641 573

* 1990 US$1 = 0.267 Libyan dinars.

TABLE 13: PREVENTIVE PROGRAMME BUDGET (in US$)

North Africa risk reduction	1 340 000
Risk reduction in endemic areas	250 000
Research contracts	520 000
Travel	150 000
General operating expenses	120 000
Direct operating expenses	91 000
Total	2 471 000

Dr M. Shagroun and UNDP representative Mr E. Murat.

The resulting document outlined in detail both a plan of operation and the financial requirements of the proposed US$117.5 million two-year programme, covering the cost of the purchase of sterile flies and their transportation to Libya, staffing, logistic support, training and equipment. At that point the Libyan government was expected to contribute US$26 million while US$91 million was required from donors. (Since the activities funded by the Libyan government contribution were largely connected with monitoring, surveillance and quarantine, its final contribution remained the same).

The document was presented to donor representatives at the pledging conference as the basis on which they would then make their funding commitments.

The conference yielded US$30.2 million in funding pledges from 13 countries and six agencies, of which US$5 million was made available immediately. These funds enabled the recruitment of international experts and the ordering of US$3.2 million worth of equipment for the main eradication programme in 1990.

A second donors conference, called jointly by FAO and IFAD and held at IFAD headquarters, took place on February 12, 1991, as the programme's pilot phase was being completed and the main eradication was getting under way. A revised eradication programme project document was presented to the donors. The conference resulted in a further US$8.6 million being pledged, with another US$9 million indicated as a possibility, bringing the total amount to be provided for the programme to US$46 million.

Budget revisions

Responsibility for the preparation and review of budgets was held by the SECNA senior operations officer.

In line with the agreed financial management of the programme, budget reviews were conducted in regular intervals throughout the eradication programme. Apart from the original budget estimates of July 1990 and the revised version of January 1991, five major revisions were made.

The first revision was presented to the Coordination Committee meeting on June 11, 1991. Based on the rapid success of the sterile fly dispersal operation during the early months of 1991, the actual project was revised. Plans to continue the use of SIT in 1992 were suspended, and it was decided to reduce the maximum deliveries of sterile flies in 1991 to 40 million per week. The consequent budgetary changes meant that the multidonor funds required were scaled down from the original US$91 million to US$45 million.

In July, following three months of freedom from screwworm cases and no further evidence of wild NWS flies in the infested zone from trapping data, it was decided to end the SIT operation on October 15, 1991 (provided no further cases occurred). The second budget revision, therefore, further reduced multidonor fund requirements to US$34 million for 1991; a third revision in September reduced it again to US$31 million.

However, at the same time, plans were formulated to secure the gains of the eradication programme by undertaking appropriate preventive action. Plans for this final phase of the programme were presented at the October 15 Coordination Committee meeting.

Apart from provisions for the orderly

run-down of the programme, including the maintenance of ground operations to the end of June 1992, a US$2.2 million emergency restart programme to cope with any further outbreaks and a US$3 million preventive programme for the region were proposed, at a total cost of US$7 million, bringing the total requirement for multidonor funds to just over US$38 million.

At this point (the end of September 1991), it was estimated that the cost of the entire project, incorporating all phases, would be US$81.7 million.

Final budget arrangements

The continued success of the eradication programme enabled a further reduction in the budget in February 1992. The revised estimates were discussed at the third Coordination Committee meeting on February 12, 1992.

Revised estimates for the preventive programme were reduced to US$2.5 million and the total requirement for multidonor funds was reduced to US$35.7 million, bringing the total cost of the programme to US$78.2 million (as previously outlined).

The preventive programme is detailed in the Conclusion.

A further revision was discussed at the SECNA management meeting, held in Tunis on April 29 and 30, 1992. This revision reflected a reduction in the total programme requirement (including the preventive phase) to US$32.6 million. Most of the savings were under the equipment component and reflected the closing figures of the accounts for 1991.

Institutional arrangements

Project agreements for the pilot programme and the main eradication programme provided the necessary financial and legal support.

A tripartite agreement was signed by the Libyan government, FAO and IFAD for the pilot project in June 1990.

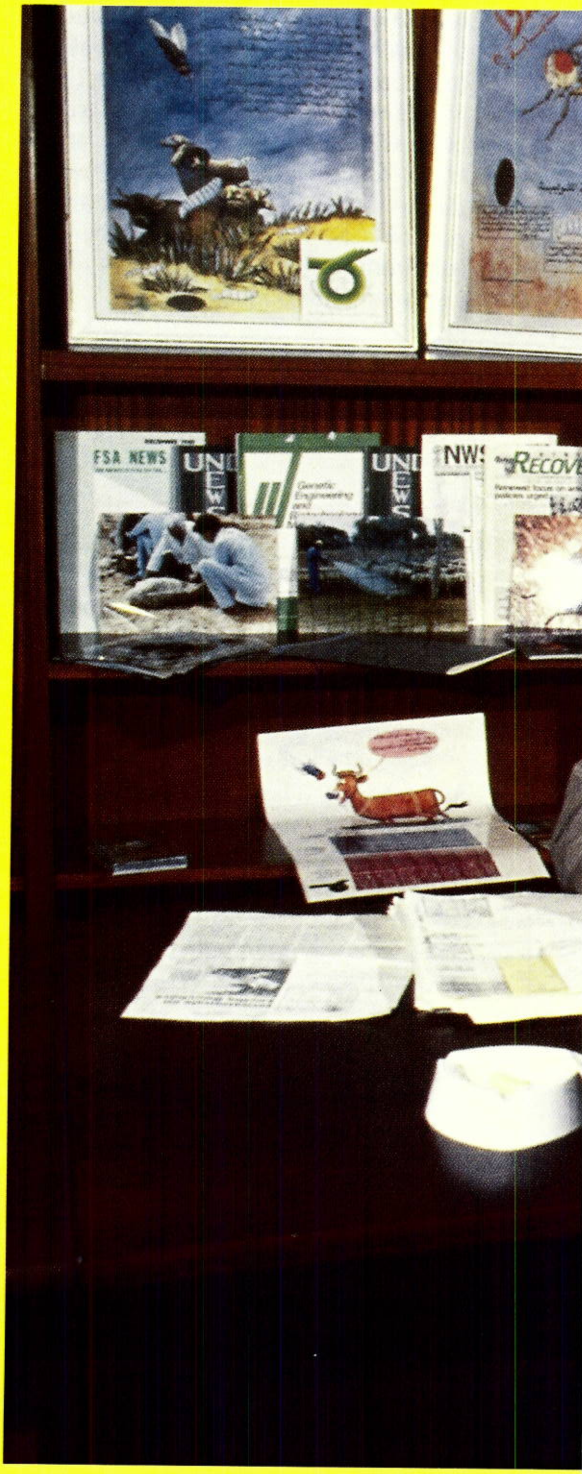
In February 1991, FAO, IFAD and the governments of Libya, Algeria, Chad, Egypt, the Niger, the Sudan and Tunisia signed the agreement for the main eradication programme.

The internationally funded components of the main programme were financed from a single trust fund, established by FAO in Rome. Another trust fund was established by FAO in Tripoli for the deposits of the Libyan government cash contribution.

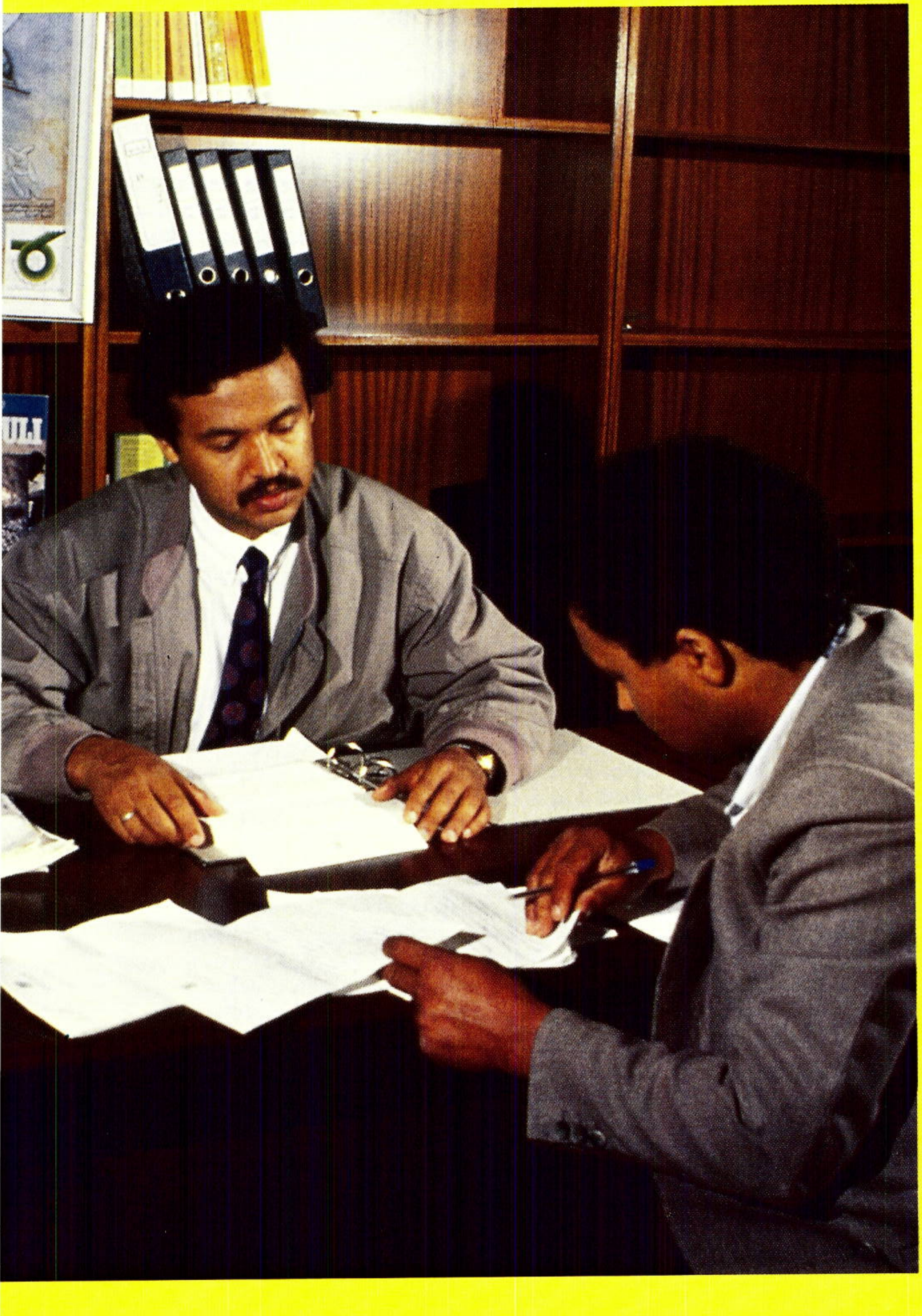
While SECNA headquarters was responsible for all financial matters during the campaign, the field programme was given authority to disburse US dollars and local currency through UNDP and a local bank account respectively.

Chapter seven

Involving the public



39. A successful communication campaign was implemented in Libya by a team led by veterinarian Dr Mohammed Husni



Communication and information activities were more than a support to the resolution of the screwworm problem in North Africa — they were part of the solution.

An intensive campaign to inform the general public and livestock owners in the Libyan Arab Jamahiriya of all stages of the control and eradication programme and enlist their support and participation in the NWS activities, combined with similar activities in neighbouring countries and a well-coordinated international publicity campaign, ensured that the NWS had an extremely high profile for the duration of the programme.

In Libya, a dynamic multimedia communication and information campaign kept public attention focused on the NWS at all stages of the programme. Even young children knew about the pest and the danger it posed both to animals and themselves. Meanwhile, the obvious news potential of the North African emergency ensured that the international media was keen to pick up the story. The Italian press dubbed the NWS the "*mosca assassina*" and the English described it as a type of "flying piranha": evocative phrases which quickly drew public attention to the dangerous insect.

The communication and information component of the screwworm eradication programme was divided into two main areas:

- Communication activities in the field, mainly addressing livestock owners, were initially developed and coordinated by the development support communication branch (under the direction of Ms S. Balit) of the FAO Information Division. A strategy was further developed by an FAO expert in consultation with the SECNA field programme communication and information unit. The strategy was then implemented by the unit, under the direction of Libyan veterinarian, Dr Mohammed Husni, whose considerable skills and communication flair resulted in a highly successful local campaign.
- International public information and publicity had the support of the FAO Information Division, coordinated by the director, Mr R. Lydiker.

SECNA headquarters' information activities were further strengthened by the employment of a part-time, Rome-based information officer, who was responsible for the preparation of a monthly NWS newsletter which provided constant updates on the eradication programme. For a number of months SECNA also employed a media liaison officer to coordinate contacts with the media.

FAO activities

In July 1989, the development support communication branch became involved in the Screwworm Action Group to assist with the development of a communication strategy and action plan to support the screwworm programme.

A communication consultant was sent to Libya in July to act as a resource person for the regional training workshop held in Tripoli. Later in the year another consultant, a graphic artist, was employed to prepare a communication and information strategy for the screwworm campaign. He visited Egypt and also collected and reviewed visual material that had been used in the Mexican screwworm eradication campaign.

The consultants were employed under FAO Technical Cooperation Programme projects, already approved for the North African region, Egypt, Algeria, Chad and the Niger. They were graphic artist Mr S. Willby and communications experts Mr M. Agamia and Mr L. Boukchina.

Mr Willby was required to identify the necessary communication activities in the North African region, identify and create initial messages and prepare a draft communication strategy. The two other consultants were required to provide back-up support, to test the visual materials produced and to assess national resources in the region to implement a communication strategy.

Two sets of four posters and six information cards were produced: one set for use in Libya, Tunisia and Algeria, where livestock owners generally wear trousers (see Photos 40 and 41) and another for use in Egypt, the Sudan and parts of Chad, where livestock owners generally dress in a long white garment called a *galabia*. The material was field-tested in Egypt with good

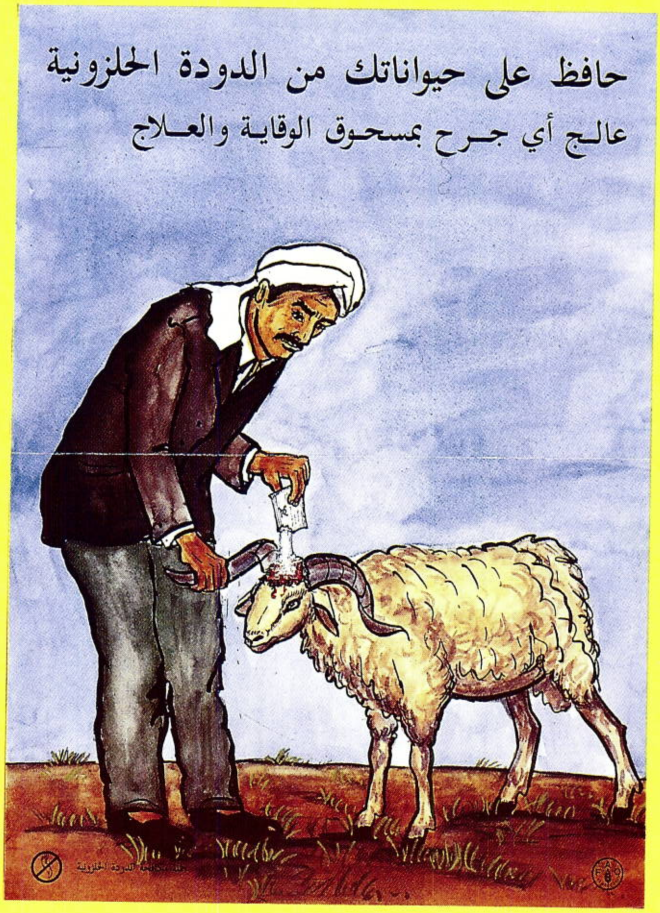
40. Examples of the printed material produced for the eradication programme

results and was printed in Arabic, English and French and distributed in Libya and surrounding countries.

All posters carried the simple message "Protect your animals against screwworm", supported by particular messages relating to the activity depicted on each poster such as "Treat all wounds with the preventive and curative powder", "Take samples of larvae from deep in the wound and report to the veterinary or agricultural official" and "Do not transport animals with wounds or larvae infestation".

The set of six cards depicted a skull and crossbones with the message "Screwworms can attack all your animals"; on the reverse side, they carried illustrations and messages on the need for inspection and treatment of animals, reporting of myiasis and how to use the larva sampling and treatment kit.

Slide sets showing cases of screwworm myiasis were compiled for use in the regional training programmes and local training activities. A video programme on the Mexican eradication programme was translated into Arabic and French for use in information and



41. Messages related to the activity depicted on the poster

training in the affected North African countries. It was also shown on television in countries throughout the region, including Libya.

Communication strategy

Following the decision to use the sterile insect technique to eradicate the New World screwworm in North Africa, a communication strategy was prepared for the programme in March 1990. Its main objective was to assist the governments of Libya and neighbouring countries to develop their own communication campaigns.

The strategy proposed a multimedia campaign, including the use of posters, leaflets, radio and television spots, videos, slide sets and film strips, as well as face-to-face communication with the public, specifically livestock owners.

The aim of the communication campaign was to create an awareness among livestock owners and the general public of the screwworm control and eradication programme to gain both their support and participation in the programme.

A Regional Information Committee for North Africa was formed by IFAD, with representatives from Libya and the neighbouring countries to ensure a coordinated approach to the communication campaign.

A communications officer was employed by SECNA in September 1990 to work in Libya to assist in planning and implementing a communication programme. After his departure, the national team took full responsibility for communication and information activities (see Photo 39, the chapter opener).

Communication and public information in Libya

When the Libyan government formed its National Screwworm Committee in May 1989, the director of the Tripoli Zoo veterinary hospital (Dr Husni), was appointed to head a communication and information unit with the aim of informing and educating the public, particularly livestock owners, about the NWS.

The campaign drew on local knowledge of the social and cultural characteristics of Libyan livestock owners.

Since the pest had never before been found outside its natural range in the Americas, it represented a completely new threat in Libya. Farmers and veterinarians alike had not seen the screwworm larvae before and were understandably shocked by the destruction and suffering they caused.

An action plan was developed to alert farmers and the general public to the screwworm threat and to support the work of the inspection teams by advising and encouraging livestock owners to inspect their animals regularly, to treat all wounds and to report all cases of myiasis to the local veterinary clinic or the inspection teams.

Using FAO communication strategy as a guide, the unit implemented a campaign that was without doubt a major success.

The campaign was divided into three main phases:

- an initial phase to inform and educate the public and livestock owners about the danger of the screwworm and to encourage them to treat all animal wounds, report cases of myiasis and cooperate with local veterinary staff, livestock inspection teams and quarantine stations;
- the eradication phase, involving

an intensive communication drive to inform the public and livestock owners about the sterile insect technique and the distribution of sterile flies. During this phase the basic education and information campaign was strengthened.

- the follow-up to the eradication programme, which aimed to ensure that people understood that, while it had been announced that the pest had been eradicated, it was extremely important to remain vigilant. Livestock owners were urged to continue treating wounds, to report all cases of myiasis and to continue to support the work of inspection teams and local veterinary staff.

The campaign used posters and leaflets, radio and television. It also concentrated on face-to-face meetings with livestock owners and the general public.

The target audience was divided into three main groups — livestock owners, the general public and veterinary staff and technicians.

Assessing needs

Livestock owners in the infested area were surveyed to determine literacy levels, reading habits, whether or not they watched television and listened to the radio and whether they preferred to receive information in their own local language or in formal Arabic. They were also questioned on their daily activities to determine the most appropriate times to broadcast information on radio and television.

On the basis of the survey, a series of posters and leaflets were developed, and television spots showing the screwworm fly and larvae and the NWS life cycle were produced and broadcast. Other television spots gave information about the use of chemicals to treat wounds and warned about the need to protect children from the flies.

Television and radio

Radio was used extensively, because it was the best medium for reaching animal herders, who generally worked in isolated conditions. During the eradication programme, regular radio and television programmes were broadcast, including interviews, talk shows and up-to-date bulletins on the progress of the programme such as details of the numbers of flies released and whether any screwworm cases had been confirmed and where. The communication unit also participated in a weekly agricultural programme on the radio.

A 20-minute special television programme, outlining the screwworm campaign in detail, was also produced.

Television and radio programmes were generally produced in cooperation with the Agricultural Information Service of the Libyan Secretariat of Agriculture.

As required, news bulletins were released for television and radio broadcast and for publication in Arabic-language newspapers.

Several videos were produced for television broadcasts and for use at meetings with farmers and the public. One short animated video depicted what happened when a sterile male NWS mated with a wild female. Another was produced to explain, in storytelling style, about the sterile flies and their production in Mexico.

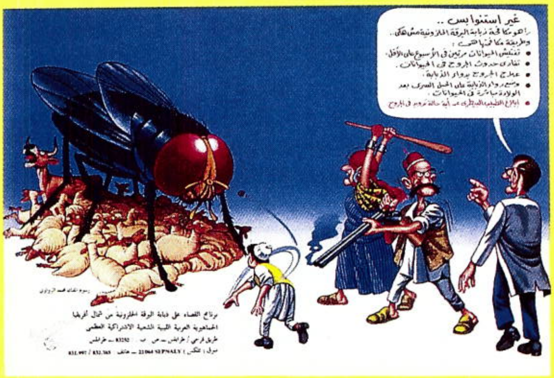
In collaboration with the Agricultural Information Service of the Secretariat of Agriculture, a film for television and several radio dramas were produced about the screwworm; in collaboration with Egypt and Tunisia a light drama was filmed about how one family dealt with their screwworm-infested cow and dog.

Posters and printed materials

A popular and able Libyan cartoonist, Mr Mohammed El-Zawawi, was commissioned to design posters for the campaign, using his popular caricature style.

The emphasis in the posters was on strong visual images, with one portraying a giant fly standing over a herd of frightened sheep and another showing an NWS fly buzzing around a cow looking for a wound in which it could lay its eggs. The cow, however, happily informed the fly that it had no wounds because of the vigilance and care of its owner. The written messages were simple and concise, stressing the need to inspect animals and treat all wounds (see Photo 42).

A series of brochures was produced to coincide with the launch of the SIT programme. Four brochures, printed in Arabic, were designed to strengthen communication and information ac-



42. A popular Libyan cartoonist was commissioned to design posters and other printed material for the campaign

tivities and conveyed messages on animal quarantine, precaution measures, treatment of wounds, protection measures for humans and on the SIT itself (see Photo 43).

A screwworm campaign logo was designed specifically for use in Libya, to draw public attention to the programme (see Photo 44).

Face-to-face meetings

With the launch of the main eradication programme, the emphasis shifted toward direct contact with livestock owners and the public. Regular meetings were organized through the network of farmers' cooperatives. The meetings were generally held in village community halls; slide and video programmes were shown and printed material distributed. Discussion and questions were encouraged, and the meetings were generally lively affairs.

From mid-1991, monthly meetings were also held in schools in the four infested municipalities. A documentary film on the NWS was shown, and students who gave the best answers to questions about the eradication programme were given gifts at the end of the meetings.

Other activities

An exhibit promoting the screwworm eradication programme was prepared for the Tripoli International Fair in March 1991. Apart from the use of posters, photographs and videos and the distribution of information material, the exhibit featured one live sterile screwworm fly housed in a large glass case, which succeeded in attracting much attention.

A highlight was certainly a visit by the Libyan leader, Colonel Moammar El Quadaffi, on July 28, 1991, to the SECNA field programme headquarters. Col. Quadaffi toured the facility, spoke with staff and was given an outline of the programme. The event was widely covered in the Libyan media.

The post-eradication programme

During the final phase of the strategy, livestock owners were encouraged to continue surveillance activities by inspecting their animals and treating all wounds in case of another outbreak.

For this final phase the field programme communication and information unit produced T-shirts, caps, ashtrays, key-rings, pens, pencils, calendars, cigarette lighters and other items. A new set of posters was designed and produced with the message that it was necessary to remain vigilant, even though eradication had been achieved. Billboards, featuring the drawings of Mr El-Zawawi, were also used during this phase.

Review

FAO headquarters communication officer for the programme, Mr A. Heidoub, travelled to Libya in October 1991 to review the screwworm communication and information campaign. His visit followed an earlier one by Ms Balit.

Observing that the campaign was highly successful — because of its intensive use of multimedia, the role of Dr Husni and the willingness of the public to cooperate — Mr Heidoub recommended that it should be documented and used as an example for emergency programmes in other countries.

During his visit to Libya, the communication officer was impressed by how well-informed local people were about the screwworm, about the need for surveillance and treatment and about the operation of the eradication programme itself.

While on a field trip in a village lying outside the infested area, he took the opportunity to question a group of schoolchildren, aged from seven to 12 years, about the screwworm programme. A dispersal plane happened to be flying overhead, dropping boxes of flies. He found that the children were well-informed and could answer all questions put to them about the pest, the purpose of dropping the flies and the details of the sterile insect technique itself.

Activities in the region

An FAO consultant visited Algeria, the Niger and Chad in October and November 1989 to explain the screwworm communication and information strategy and to advise governments on the development of their own strategies. Another mission was conducted in second-line countries in 1991.

Neighbouring countries were supplied with slide sets and the Mexican screwworm video as well as the poster and information card sets. Photographic and radio equipment and a slide projector were also supplied to Algeria, while radio equipment was supplied to Chad.

An FAO communication specialist also visited the ten second-line countries in 1991 to assist and advise in the implementation of communication and information campaigns.

Public information

The international publicity campaign was a key to the success of the programme, because the amount and type of media coverage given to the North African emergency could determine world opinion on the issue; it therefore had great impact on the sensitive area of donor funding of the eradication programme.

Since donor countries would be influenced not only by public opinion, but also by the potential for the screwworm to spread throughout the Eastern Hemisphere, it was crucial that international media coverage gave a clear picture of the screwworm threat and the various stages of the eradication programme.

The media campaign involved the Information Division's press section and the radio and television section. A media liaison officer was appointed to work specifically on the screwworm issue in June 1991. Attached to SECNA, the officer was responsible for writing press releases, in liaison with the press section chief, and for organizing press conferences. He accompanied a group of journalists on a field trip to Libya during the eradication programme.

FAO's media campaign was launched on April 18, 1990 when FAO called an international press conference at *Stampa estera* (the association for foreign correspondents) in Rome, to announce to the media the presence of the NWS in Libya and the threat to Africa, the Near East, southern Europe and Asia, as well as outlining FAO's plans to eradicate the pest using the sterile insect technique.

It was the first time FAO had organized a large-scale formal technical briefing at *Stampa estera*, and it was attended by more than 90 journalists representing the international press, radio and television — one of the highest attendance levels ever recorded at *Stampa estera*. Seven journalists from key media organizations in London and Paris, including the BBC and *Le Monde*, were specifically invited to the conference by the Information Division.

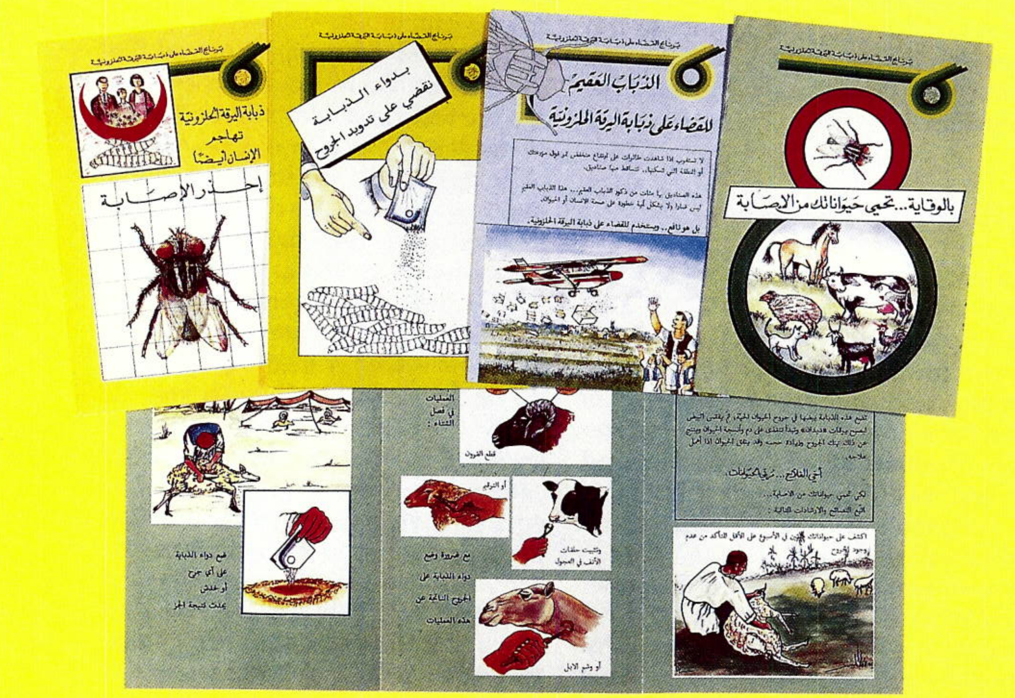
During the conference a six-minute video was shown to outline the problem. The London-based television news agency, Visnews, later sent by satellite a three-minute story based on the video to more than 60 outlets worldwide.

The story was given vast coverage around the world in major newspapers and by radio and television networks.

The press section

The press section issued a total of 12 press releases, coinciding with the various stages of the North African screwworm programme and culminating in the announcement in Washington on October 7, 1991 that the pest had been eradicated from Libya.

Apart from the initial press briefing at *Stampa estera*, a second major press



43. A set of brochures conveyed simple messages about animal inspection, treatment and quarantine to livestock owners and the general public

conference was held at FAO in conjunction with the first donors conference in May 1990; a third was held in Washington when eradication was announced.

Two major field trips to Libya were organized for journalists during the eradication programme, one of them partially funded by Lufthansa, the parent company of German Cargo Services, which was contracted to transport the sterile flies from Mexico to Tripoli. IFAD also organized media visits to Libya, including one major group visit and several individual field trips.

The radio and television section

This section assisted a team from the Libyan Secretariat of Agriculture in the production of three hours of footage on the pest. It also distributed footage from this video to television stations and produced the six-minute video press release, which was shown during the first FAO press conference at *Stampa estera* and to delegates at the first donors consultation. The video was produced in Arabic, English, French, Italian and Spanish, and was distributed worldwide. It was given

44. The Libyan NWS logo

significant airing on European and African television stations.

An edited version, sent by satellite to more than 60 television stations by the television news agency, Visnews, was seen by more than 50 million viewers.

Other activities by the section included translation of a Mexican film on NWS eradication into Arabic, English and French, which was then distributed to interested countries. Several radio information programmes on the NWS project, including interviews with FAO specialists and staff of the Libyan Secretariat of Agriculture were produced and broadcast throughout Europe and Africa.

The section has compiled an archive of video and radio programmes produced about the screwworm.

Information materials production

The Information Division's information materials production branch prepared an exhibit for the FAO donors consultation in May 1990 and was also responsible for preparing a screwworm information kit for distribution to delegates.

45. An NWS newsletter was produced and distributed by SECNA on a monthly basis during the eradication programme

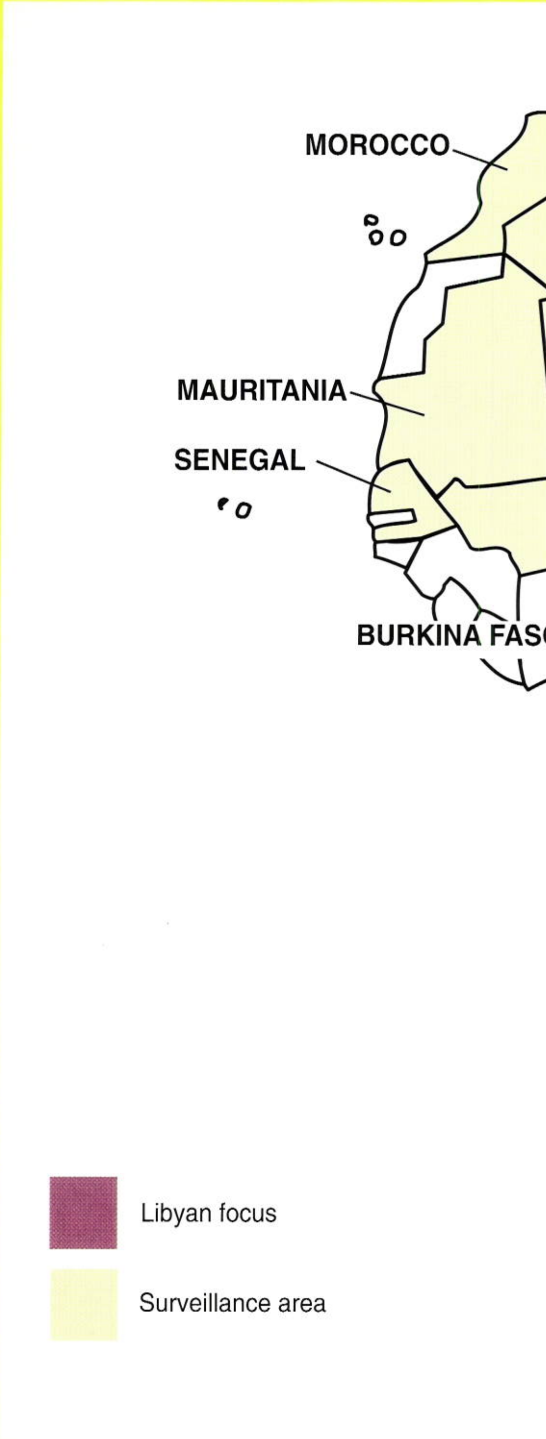
The SECNA information officer was employed jointly by this branch and by SECNA. He was responsible for the production of a monthly NWS newsletter, which was designed to publicize the eradication campaign and to keep donors and the international community informed of its progress (see Photo 45).

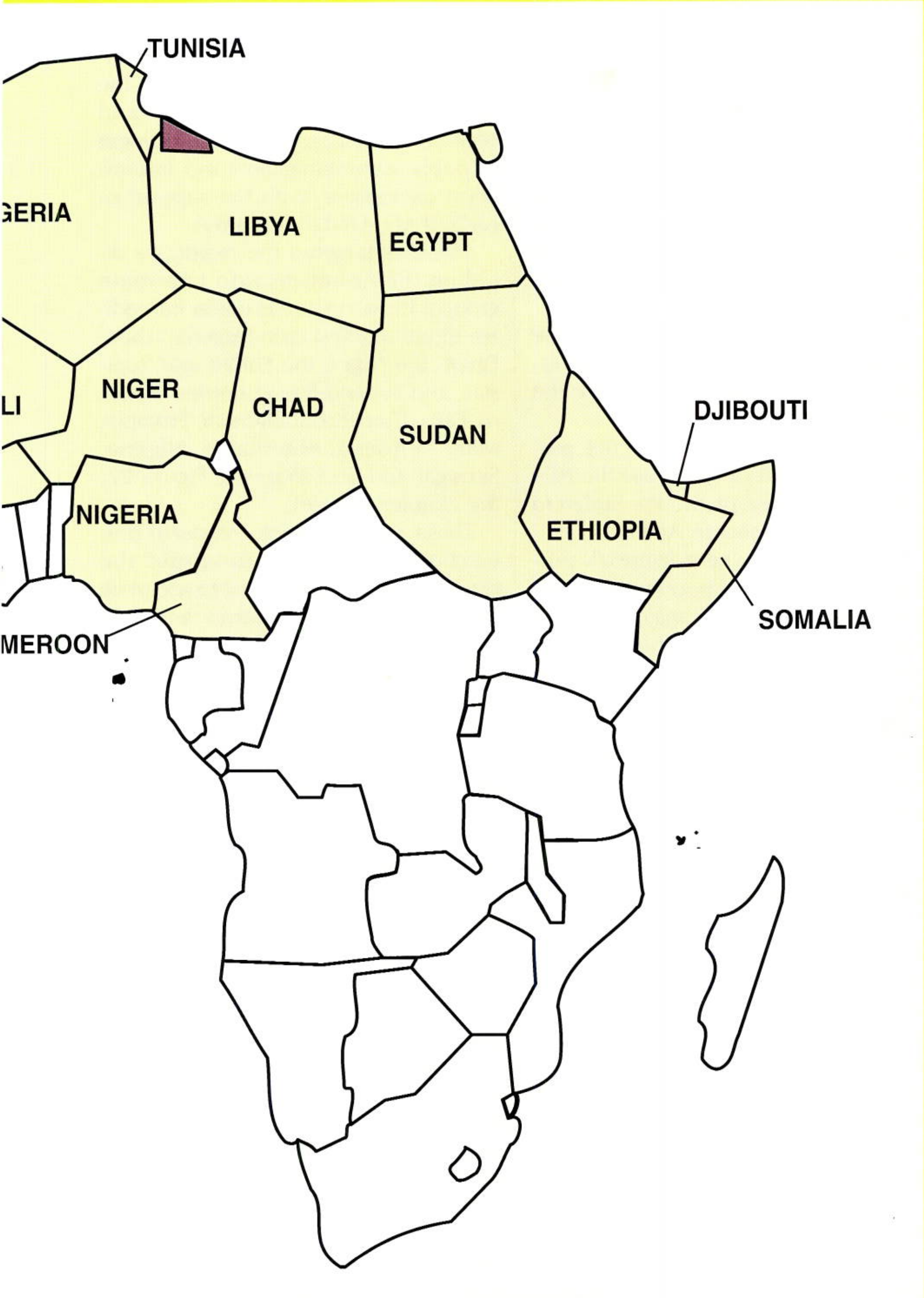
The officer researched, wrote and designed the newsletter. After the declaration that the NWS had been eradicated in Libya, he wrote and designed a 16-page booklet on the programme for general readership.

A series of photographs was taken of SIT activities in Mexico to document every stage of the fly rearing, sterilization and packaging processes and the eradication programme in Libya.

Chapter eight

Activities in neighbouring countries




TUNISIA
GERIA
LIBYA
EGYPT
NIGER
LI
CHAD
SUDAN
DJIBOUTI
NIGERIA
ETHIOPIA
SOMALIA
MEROON

It had been acknowledged from the outset that, left untreated, the New World screwworm would inevitably spread throughout the entire North African region and beyond.

In particular, the six countries bordering Libya were under constant threat of infestation by the NWS. It was estimated that the cost of controlling the pest without eradication would amount to more than US$280 million per year.

The combination of suitable climate and an abundance of hosts in the region provided ideal conditions for the NWS to become established.

Of particular concern was the prospect that the NWS could use the Nile Valley through Egypt and the Sudan to move into sub-Saharan Africa.

In this region, where livestock production is the most important income-earning activity for the majority of the people, the NWS would have caused immense losses. Already endangered wildlife in the region would have been significantly threatened, and the large migrating game herds would have provided a reservoir for the pest, making it impossible to control at any price.

Emergency action

When the NWS was first confirmed in Libya, the extent of its spread was unknown. Therefore, one of the first actions taken by FAO, after receiving notification of the NWS presence in Libya, was to contact all countries in the North African region requesting information. Following further confirmation by the first FAO mission to Libya in April 1989 that the pest was established in Libya, the Director-General of FAO met with the permanent representatives to the organization from Algeria, Egypt, the Niger, the Sudan, Tunisia and Libya to discuss the emergency.

Emergency measures were immediately initiated by these countries, in the areas of surveillance, treatment and control, as well as in the development of public communication and information campaigns, with the support of FAO, IFAD, UNDP and IAEA.

Activities targeted the region by dividing the countries into two main groups: those countries under immediate threat of infestation (Algeria, Chad, Egypt, the Niger, the Sudan and Tunisia), and second-line countries (Burkina Faso, Cameroon, Djibouti, Ethiopia, Mali, Morocco, Mauritania, Nigeria, Senegal and Somalia) (see Figure 22, the chapter opener).

These countries took extensive precautionary action throughout the screwworm campaign, first to ascertain the pest's possible presence and then to prevent its introduction.

The common activities undertaken by all countries, with the support of FAO, IFAD, UNDP and IAEA, included the training of personnel; the implementation of measures for screwworm prevention, surveillance and control; quarantine procedures; and public information and awareness campaigns.

These activities were conducted in strategic areas of each country (a total area of 15.6 million km^2) and involved the inspection of just under 14 million head of livestock. Rural populations, particularly those involved with livestock and in the areas bordering Libya, were alerted to the danger and instructed in the practical measures necessary to support national actions taken by their governments.

While the screwworm did not spread out of Libya, the actions taken were essential during the campaign. They also resulted in increasing the capability of national organizations in these countries to react to animal health emergencies.

Activities

Throughout 1989, FAO missions were conducted in the countries bordering Libya to determine whether the pest was present in these countries and to discuss and advise on actions necessary to prevent its spread.

Assistance under FAO's Technical Cooperation Programme was provided through:

- a US$400 000 regional project for Libya and the six neighbouring countries, which aimed to determine the spread of the pest, advise governments on screwworm treatment, control and eradication measures, and provide basic training on screwworm biology, identification, surveillance, prevention and control. The first training programme, conducted in Tripoli in July 1989, was funded under this project.
- projects approved for the individual first-line countries, to provide a total of US$1.8 million in assistance, including the provision of urgently needed insecticides and equipment. Visits by FAO consultants to the individual countries were also organized and funded under these projects. Algeria, Egypt, the Niger and Tunisia were each allocated US$250 000, Chad received US$316 000 and US$150 000 were allocated to the Sudan.
- a US$225 000 project approved for the ten second-line countries to advise governments on screwworm control measures and provide an emergency stock of insecticides and sampling kits for treatment. This project also funded a course, held in Tripoli in March 1990, to train veterinary officials from these countries in screwworm biology, identification, surveillance, prevention and control.

Surveillance activities

Algeria. Activities were concentrated along the Tunisian border. Thirty-five checkpoints were established and, in the course of surveillance activities in 1990, more than 580 000 animals were inspected and 1 741 of non-screwworm myiasis cases were treated with coumaphos. In 1991, more than 255 000 animals were inspected, 1 543 wounds were treated with coumaphos, and 18 cases of myiasis were detected, but none were caused by screwworm.

Chad. Priority surveillance areas were in the northern and northeastern provinces, bordering Libya. In 1990, almost 4.5 million animals were inspected, 4 535 wounds were treated, and 85 larva samples were collected, although none were identified as NWS. In 1991, 2.8 million animals were inspected, and 418 non-screwworm larva samples were collected.

Egypt. Surveillance, treatment and quarantine activities were concentrated in the Libyan border area, in the northeast of the country. During 1990, more than 830 000 animals were inspected, and 3.4 million animals were sprayed with coumaphos to prevent infestation. Eighty larva samples and 19 adult flies were identified as non-screwworm. In 1991, 432 000 animals were inspected, and 20 larva samples were tested and found to be non-screwworm. More than 2.6 million animals were sprayed.

The Niger. Surveillance activities were intensive in the four provinces near the Libyan border. During 1990, as part of the country's annual vaccination campaign, 2 453 wounded animals were inspected and treated, and 150 larva samples were collected, none of which was identified as NWS.

The Sudan. The country's border with Libya extends over 200 km. In this area during 1990, more than 1 million animals were inspected, and no cases of New World screwworm were reported. In 1991, more than 5 million animals were inspected with no NWS infestations found.

Tunisia. This was the country considered to be at greatest risk of infestation by NWS. In September 1990, NWS cases were reported in Libya within 20-40 km of the Tunisian border. More than 1.5 million animals were inspected in the border area of Tunisia in 1990; in other areas of the country more than 6 million animals were inspected as part of other zoosanitary activities. No NWS cases were detected.

In early May 1991 the eradication programme was expanded to encompass a 2 500 km^2 area of Tunisia, just inside its border with Libya. In 1991, more than 3 million animals were inspected in the border area, and 44 larva samples were identified as non-screwworm.

Second-line countries. Surveillance and public information activities were initiated in each of these countries and continued throughout the campaign. No cases of NWS were ever detected. Eighteen representatives of these countries attended the second training course in Tripoli, in March 1990, along with two representatives from Egypt and 23 from Libya.

As with the first course, participants attended lectures on screwworm biology, identification, surveillance, prevention, treatment and control methods, information, epizootology, eradication campaigns in Libya and Mexico, the economic significance of the parasite, field practice in the use of sentinel animals and guidelines for national and international reporting of the disease.

Practical field demonstrations included the use of sampling kits, field inspection, wound treatment, use of record sheets and public information activities. Also covered were the control of animal movement, inspection of domestic animals, dipping and spraying, the principles of SIT, production of sterile flies, packaging, storage, transport and aerial release, and the use of wind-oriented traps.

Following the second course, the attending professional officers implemented training programmes in their own countries.

Training manual

The *Manual for the Control of the Screwworm Fly,* Cochliomyia hominivorax (*Coquerel*), which had been published by FAO in late 1989, was distributed throughout all neighbouring and second-line countries. Containing information on biology, identification, myiasis, guidelines for control and economic considerations, the manual was intended as a training guide and a practical reference for veterinary staff. One thousand copies of the manual were produced in each of three languages — Arabic, English and French — and were distributed to chief veterinary officers of the countries involved.

Study tours

From July 1989 to November 1990, seven Tunisian professional officers visited Libya for training in surveillance and control activities. The visits also aimed to strengthen cooperation between the two countries to prevent infestation by NWS along the international border.

In the same period one Egyptian and eight Tunisian professional officers visited Mexico and Belize to study activities related to national and international control of animal movement and quarantine. They also toured the sterile fly production plant at Tuxtla Gutierrez to study the production and sexual sterilization of the NWS.

Communication and information

An FAO consultant visited all countries at risk, to assist in establishing communication and information programmes. As in Libya, the campaigns were designed to gain the cooperation of the public, specifically livestock owners, in surveillance, treatment and control. Information was disseminated via television, radio, pamphlets, newspaper articles, public gatherings and in schools.

IFAD sponsored a Regional Communication and Information Committee, involving Libya, Egypt, the Sudan and Tunisia and provided US$300 000 for development of public information campaigns in the region.

Chapter nine

Support organizations

FAO

FIAT PANIS

Apart from FAO, three other United Nations organizations were involved in the programme to eradicate the screwworm from North Africa: the International Fund for Agricultural Development (IFAD), the United Nations Development Programme (UNDP) and the International Atomic Energy Agency (IAEA).

IFAD raised funds for the programme as well as helping to develop and partially fund the pilot phase.

UNDP, the only UN agency with a resident representation in the Libyan Arab Jamahiriya, provided funding in 1989 for a project to develop and strengthen screwworm surveillance, treatment and control measures and helped fund the pilot release of sterile flies. UNDP also gave invaluable support to international experts working in Libya during the programme.

IAEA and FAO have a joint division (with laboratories at Seibersdorf, Austria) for the development of nuclear techniques for use in agriculture. IAEA has expertise in the sterile insect technique and several staff members with experience in dealing with NWS. Its full support was committed to FAO's activities in early 1989.

All three agencies were represented in the Screwworm Action Group.

The department of entomology of the British Museum (Natural History) was asked to act as FAO's reference laboratory for screwworm and animal myiases in October 1989.

IFAD

A multilateral financial institution within the UN system, IFAD is responsible for financing development initiatives in the agricultural sector. It has two main functions:

- providing loans to individual countries for development projects, which are then executed by national governments;
- providing funds for research, training and small-scale non-government organization projects through its Technical Assistance Grants (TAG) programme. This programme focuses on supporting agricultural research and emergency activities such as the NWS programme in North Africa.

IFAD played a leading role in the preparation of the pilot phase of the eradication programme, under the direction of Dr A. M. Kesseba, director of IFAD's Technical Advisory Division, and contributed funds in the form of a technical assistance grant.

IFAD worked with FAO to mobilize resources from donors for the main eradication programme. Two jointly sponsored donors pledging conferences were held at IFAD headquarters in Rome, which raised US$32.6 million in international funds.

IFAD became involved in the preparation of the pilot phase on May 3, 1989, following a request by the Libyan government for emergency assistance. IFAD sent a mission to Libya on May 21-26 to assess the screwworm situation and to make recommendations on possible IFAD action. Discussions were held with Libyan veterinary officials about the use of biological control measures against the screwworm (SIT).

Pilot project

Following the mission, IFAD recruited screwworm experts, who worked in conjunction with IFAD staff to prepare a project document for a pilot SIT programme. The resulting document, which took account of an earlier pilot programme's documents prepared by the Joint FAO/IAEA Division, was presented to IFAD's donor partners in late 1989 and then to its executive board in December 1989. The board approved the project and US$1.5 million in funds on December 4.

It had originally been proposed to start the project immediately. However, legal barriers to the sale of sterile NWS outside the Americas were not removed until March 1990, and protracted negotiations with MACES further delayed the start of the actual pilot phase until December 1990.

A preparatory phase, incorporating the pilot release of sterile flies got under way in July 1990.

Main programme

An IFAD consultant again travelled to Libya in June 1990 to work in conjunction with an FAO mission in the preparation of the project document for the main eradication programme. As a result, IFAD presented two "alternative scenario" budgets for the main programme, which was presented at the first donors pledging conference, in conjunction with the budget estimates prepared by FAO.

One of IFAD's alternative budgets was based on a two-year campaign with the release of a maximum of 50 million flies per week and the other on a maximum of 100 million per week; estimated total costs were US$62.7 million and US$81.6 million respectively.

FAO and IFAD entered into two Memoranda of Understanding, one for the pilot phase and another for the main programme, which outlined an agreement on the financial aspects and execution of the programme. Under the agreement, IFAD pledged an additional grant of US$4 million from its regular resources for the eradication programme, as part of the funds pledged at the first donors conference.

Donors

IFAD played a crucial role in lobbying for donors' funds for the eradication programme. The first donors pledging conference, in particular, resulted in pledges that were higher than anticipated; IFAD described the response of donors as demonstrating "an exceptional sense of international solidarity".

Communication and information

IFAD allocated US$300 000, as part of its funding for the pilot phase, to support communication and information activities in Libya and neighbouring countries.

It formed a Regional Communication and Information Committee, with representatives from Libya, Egypt, the Sudan, Tunisia and IFAD. The aim was to provide the support and funding to enable the individual countries to develop their own programmes.

IFAD produced an information video on the screwworm and funded other videos produced by individual countries, which were used to educate livestock owners and the general public about the screwworm. Funds were also provided for the joint production by Libya, Egypt and Tunisia of a light television drama about the screwworm. Brochures, posters and other information materials were prepared and distributed in Egypt, Tunisia and the Sudan.

IFAD coordinated its own media campaign about the screwworm programme, which included the distribution of press releases and the organization of media visits to Libya. IFAD also organized a special ceremony on January 8, 1991 to mark the pilot release project.

UNDP

The largest specialized agency of the UN system, UNDP is essentially a funding body. UNDP is the highest UN authority in all countries where the United Nations has a presence. The organization funds development projects through its Country Development Programme, which is funded by a large budget on the basis of five-year plans. UNDP is also responsible for providing administrative, financial and logistical support to the field projects of other UN agencies.

UNDP is the only UN agency with a permanent presence in Libya and is headed by resident representative Dr A. Al-Ani and deputy resident representative Mr E. Murat.

Activities

UNDP activities during the initial phase of the North African screwworm programme were crucial in supporting FAO action against the emergency. It provided funds in June 1989, in a cost-sharing arrangement with the Libyan government, for a project which assisted in establishing surveillance and treatment activities, as well as providing the essential support and equipment for consultants working in Libya under an FAO Technical Cooperation Programme project.

UNDP was also involved in ensuring that any problems related to administrative and financial matters were resolved promptly. Going beyond normal requirements, it provided a mechanism to enable the employment of local staff and the purchase of equipment during the initial months of the SECNA programme.

IAEA

IAEA had a major support role in the screwworm campaign: in planning for both the pilot and main eradication programmes; in research and development; and in the provision of staff, equipment and funding (see box opposite).

IAEA was involved through the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and also through its Department of Technical Cooperation. Funding for the Joint Division's activities was provided by IAEA and Swedish International Development Aid (SIDA) (a total of just over US$507 000), FAO (US$25 000) and USAID (US$20 000), which funded research to establish the sexual compatibility of the Libyan and Mexican NWS strains.

A further US$324 000 was provided by the Austrian government for the purchase of computer-enhanced satellite maps of northern Libya. On a scale of 1:50 000, the maps were created by combining Landsat and SPOT imagery and showed not only topographical features such as roads, but also the locations of green vegetation, which signified the presence of water — an important factor in being able to identify potential areas of New World screwworm infestation.

Planning

With expertise in the sterile insect technique, staff at the Joint Division provided invaluable assistance during the early stages of the programme. The head of the Joint Division's insect and pest control section was assigned to FAO headquarters in April 1989 to join FAO's Screwworm Action Group and prepare an action plan for the eradication of the NWS from North Africa.

IAEA staff who had an involvement in the screwworm programme were: Dr H. Blix, Director-General; Dr B. Sigurbjornsson, director of the Joint FAO/IAEA Division; Dr M. Zifferero, Deputy Director-General, Department of Research and Isotopes; Dr W. Klassen, head of the insect and pest control section (who replaced Dr D.A. Lindquist after his appointment as SECNA FP director); Dr André van der Vloedt, technical officer, Insect and Pest Control Division (see box on this page); Dr R.E. Gingrich, head of the entomology unit, Seibersdorf Laboratories.

The Joint Division also prepared a pilot test project proposal in July 1989, which, after several revisions, formed the basis of the project document for the IFAD-funded pilot phase.

In January 1990, an IAEA consultants' group prepared a key document that outlined a programme for the eradication of the NWS from North Africa. Published in April, the document was designed for use by the Joint Division as a guide in its support activities for the eradication programme. It formed the basis of the later FAO/IFAD project document and plan of action for the actual programme.

The consultants were Dr J. Novy, assistant chief, Policy and Programme Development, Animal and Plant Health Inspection Service, USDA; Dr

IAEA involvement

IAEA activities in support of the screwworm programme were:

- arranging for tests in Fargo, North Dakota, to study the sexual compatibility of the Mexican mass-reared and the North African strains of NWS;
- making available the facilities and staff of the IAEA laboratory at Seibersdorf, Austria;
- supporting research, including trial shipments of sterile NWS pupae from Mexico to study the effects of shipment on fly quality;
- providing modest equipment, supplies and training to the programme in Libya through an IAEA Technical Assistance Project;
- making available staff to assist in programme planning and implementation, both in Rome and in Libya.

Dr André van der Vloedt

On December 31, 1991, Dr André van der Vloedt died in Vienna of an undiagnosed illness contracted during a field mission.

A respected member of the Joint FAO/IAEA Division team, Dr van der Vloedt was well known for his enthusiasm, energy and commitment to his work in animal health. He was an early proponent of the SIT eradication programme adopted by SECNA, to which he made extensive contributions through early research and planning work.

L.F. Liera, area coordinator, MACES, Mexico; Dr J.W. Mackley, supervisory entomologist, Animal and Plant Health Inspection Service, USDA and MACES, Mexico.

The IAEA document outlined a work plan for the eradication programme and detailed the prerequisites for its implementation, as well as estimating the required donors' contribution at US$80 million, later revised by FAO in the preparation of financial estimates for the actual programme.

Field and training activities

The Joint Division sent several staff on missions to Libya, to assist in the regional training programmes, to provide technical backstopping during the programme and, most important, to gather live screwworm material for transport to the United States for vital tests, which would determine whether the wild Libyan NWS strain was sexually compatible with the mass-reared Mexican strain. After three unsuccessful attempts to gather live pupae, these tests proved positive.

After receiving the approval of the Austrian government in July 1989, the Seibersdorf laboratory received live NWS from the United States and Mexico to evaluate the effects of shipment on the quality of the flies.

Prior to the release of sterile flies in Libya, the Joint Division's Seibersdorf laboratory fabricated, or contracted construction of, the equipment for the eradication programme that was not commercially available, including fly traps.

IAEA also sponsored a one-month study tour to Mexico for three Libyan veterinarians in January 1990.

Research and development

Since the screwworm had been established in Libya for a short period, research on field ecology, population dynamics and population genetics was particularly important. The Joint Division was given responsibility for short-term research projects, including:

- quality control studies to determine the most appropriate packaging, transportation and short-term, pre-release storage conditions for NWS;
- studies of the relationship between screwworm activity and environmental and meteorological conditions;
- field and laboratory experiments to determine more specific details about the screwworm life cycle.

In February 1990, the Joint Division prepared a research and development proposal that outlined possible activities in support of the North African screwworm programme. It was submitted to SIDA as the basis of a request for funding. SIDA responded with a grant of just over US$390 000 for the research and development programme. It also provided two experts to work for the SECNA field programme for one year.

A screwworm research planning workshop, organized by the Joint Division and held at the IAEA headquarters in Vienna in December 1990, confirmed the agenda for research to support the SECNA programme.

British Museum (Natural History)

The British Museum accepted an FAO invitation in October 1989 to act as its reference laboratory for screwworm and animal myiases during the North African screwworm programme.

Through its department of entomology, the museum had three main functions as a support body to the North African screwworm programme. The museum staff associated with the reference laboratory were Dr M. Hall and Mr N. Wyatt.

The laboratory was required to:

- identify entomological specimens submitted by individual countries or by FAO, which were suspected to be *Cochliomyia hominivorax*;
- notify immediately FAO and the senior veterinary official of the country where a specimen had originated of any positive identifications;
- advise on animal myiasis biology, identification and control measures.

The reference laboratory received no samples of NWS for identification in 1990 and received only samples from the Zawia municipality in Libya during 1991. Scientists associated with the laboratory were involved in research and training activities related to the screwworm, provided information on the pest throughout the campaign and contributed to several papers on the NWS for publication.

Laboratory activities

To establish basic data on myiasis as an animal disease in Africa, the laboratory contacted chief veterinary officers in 46 African countries, requesting any information on wound myiasis, particularly in relation to the Old World screwworm, *Chrysomya bezziana*.

It participated in the second regional training programme in Libya and gave lectures and demonstrations to students in the United Kingdom. After several experiments with various processes, the laboratory developed a method to mount larvae and flies in a polyester resin.

The laboratory also acted as a point of reference for the international media, organizations and countries requiring information about wound myiasis and screwworm biology.

Research

Reference laboratory staff collaborated with the Natural Resources Institute and the Tsetse Research Laboratory, aiming to develop a system to suppress adult fly populations and improve monitoring systems (including traps and odour baits).

A mission was undertaken to Libya to assess the potential for the use of electric nets to improve monitoring and control of the New World screwworm (funded by the Joint FAO/IAEA Division). Tests in Mexico and Libya demonstrated that NWS flies could be attracted to baits by using a black cloth screen (impregnated with swormlure-4). The majority of flies remained on the cloth long enough to acquire a lethal dose of the insecticide. They found that in Mexico greater numbers of flies were attracted to the black cloth baits than were caught by wind-oriented traps.

Conclusion

Following the official declaration that North Africa was screwworm-free on June 22, 1992, responsibility for the Libyan component of the final phase of the eradication programme was handed over to the Libyan veterinary authorities, with FAO retaining responsibility for its implementation in the region.

The US$2.5 million preventive phase, which was to continue for at least one year, was conceived to secure Libya, the entire North African region and southern Europe against any further introduction of the NWS.

The three main objectives of the preventive phase were to:

- reduce the risk of future outbreaks of NWS or other exotic threats to the livestock sector in North African countries;
- reduce the risk of spread of NWS from enzootic areas;
- improve the technology of NWS eradication.

It was anticipated that, on the basis of these objectives, the preventive phase would result in:

- the establishment of diagnostic systems to detect and monitor myiasis in the North African region;
- a study to establish and implement strategy for controlling live animal movement to prevent introduction of NWS to countries free of the pest;
- a report on the worldwide situation of infested and NWS-free countries and on risks involved in international trade;
- the improvement of methods for rapid and economical deployment of the sterile insect technique.

In preparing this phase of the eradication programme, it was acknowledged that there would always be the threat that the region could be reinfested. Millions of live sheep and other animals are imported annually into countries in North Africa and the Near East and, in many cases, the development of control procedures necessary to protect the health of the domestic animal populations have not kept pace with the growing scale and speed of these international animal movements.

As a result, SECNA took into account the constant risk of the introduction of serious diseases into the region, as underlined by the screwworm emergency.

The Libyan campaign

The implementation of the preventive phase as the final phase of the eradication campaign provided the opportunity to increase security against the threat of further infestations as well as to consolidate the lessons of the whole programme.

While much valuable experience was gained from the United States and Mexican eradication programmes, the North African campaign presented a new set of technical problems that had to be resolved. Many of these concerned the logistics and biological considerations of long-distance transport and delivery of sterile flies. Since the transportation of flies accounted for half of the total cost of the North African programme, the efficiency of this operation in any future campaigns was considered critically important.

Technical challenges in the area of population suppression were also taken on by the SECNA programme. While some experience was gained in North Africa, the short duration of the campaign meant that further work was needed to develop the experience to provide clear guidelines on increasing the efficiency and reducing the cost of responses to any future outbreaks.

Activities

During the one-year phase, a range of activities was to be undertaken to achieve these objectives.

Diagnostic systems were to be established to detect and monitor myiasis in the region, including the upgrading of capabilities for collection and identification of myiasis samples and the preparation of national and regional NWS emergency plans. Recommendations were also to be developed for a cooperative agreement and legislation to avoid reintroduction of NWS.

A strategy to control animal movement to prevent introduction of NWS into NWS-free countries was to be established and implemented. The actual sources and routes of live animals entering into and crossing boundaries between North African countries had therefore to be determined. International quarantine stations were to be identified and guidelines prepared on technical and legal procedures.

Research

A method was to be developed for rapid, economical and biologically effective long-distance transportation of sterile insects and a manual prepared on the practical aspects of using SIT for NWS eradication.

The programme would also aim to increase the efficiency of monitoring release operations and would identify suitable and environmentally safe insecticides. The possibility of modifying the screwworm adult suppression system to make it environmentally safe for use in tropical and arid regions was also to be investigated.

Based on operational experience gained in Libya, the ILWIS GIS computer information management system was to be modified and upgraded, and a simple computerized system was to be developed for monitoring day-to-day worldwide geographical distribution of NWS and other exotic diseases under regular and outbreak conditions.

Several training courses for veterinary officials in the region were to be conducted, post-graduate fellowship and study tour programmes initiated and consultancy missions organized.

SECNA disbands

The final report on the Screwworm Emergency Centre for North Africa programme was presented to the last meeting of the Coordination Committee on June 25, 1992, three days after the formal declaration that North Africa was screwworm-free. SECNA was to continue for a further six months to finalize activities and was to be disbanded as of December 31, 1992.

Annex one

FAO chronology of events

1988
March
New World screwworm *Cochliomyia hominivorax* (Coquerel) discovered in the Libyan Arab Tamahiriya

1989
January 28
First published report of NWS in Libya in the *Veterinary Record* by Dr El-Azazy.

February 1
FAO receives CAB report on identification of NWS samples received from Libya in November/December 1988.

February 7
FAO sends Libya's NWS information to IAEA, APHIS, OIE and WHO.
FAO telexs to Libya, requesting confirmation of and details on NWS presence.
FAO telex to OAU/IBAR advising of NWS presence in Africa.

March 19
FAO telexes to Tunisia and Algeria requesting information.

April 22
IAEA receives *Note verbale* from the Libyan Permanent Mission requesting the agency's assistance.

April 15-22
FAO mission to Libya, which confirmed NWS presence.

April 24
FAO meeting with permanent representatives to FAO of North African countries (Algeria, Egypt, Libya, the Niger, the Sudan and Tunisia).

April 27
FAO Screwworm Action Group formed.
FAO Technical Cooperation Programme (TCP) project approved for emergency assistance to Libya (initially for US$182 000, later increased to US$345 000).

May 2
FAO Director-General telexes member countries concerning: risk of NWS.

May 9-13
FAO mission to Tunisia.

May 12
Meeting in Paris of directors of Veterinary Services of countries at risk in North Africa. The General Session of OIE agrees to include screwworm myiasis caused by *C. hominivorax* in List B of international notifiable animal diseases.

May 13-17
FAO mission to Egypt.

May 27-31
FAO/IAEA mission to Algeria.
First FAO *Screwworm Information Note* issued.
FAO employs a Mexican screwworm specialist as a four-month consultant.

May 27
Libya forms National Screwworm Committee.
Libya pledges to cover most of expenses for screwworm control programme.

May 30
Libyan National Screwworm Committee commences its monthly meetings.

June 4
Libya, UNDP and FAO approve US$1.25 million cost-sharing project, funded by Libya (US$1 million), UNDP (US$250 000) and executed by FAO.

June 5-6
FAO holds preparatory meeting in Rome on the formulation of a regional strategy for control and eradication of the screwworm in North Africa. Representatives of North African countries, Mexico and the United States attend.

June 6
FAO TCP project for the region approved, worth US$400 000 in technical support and training.

June 8
FAO TCP project for Tunisia approved, which was worth US$250 000.

June 14
Libya organizes 55 surveillance teams in infested area, gradually increased to 94.

June 18-22
FAO/IAEA mission to Libya.

June 21
FAO Director-General writes to Ministry of Agriculture, Mexico, regarding Mexican experts and provision of sterile flies.

June 27
FAO TCP project approved for Algeria, worth US$250 000.

July 2-13
IAEA mission to Libya collects NWS egg masses from sentinel sheep.

July 4
First FAO consultants arrive in Tripoli.

July 14
FAO TCP project approved for Egypt, worth US$250 000.

July 22-27
FAO-sponsored training course in Tripoli for North African countries at risk.

July 24
IAEA receives official Austrian government authorization to import sterile NWS from Mexico, for research work at Seibersdorf.

July 27
FAO TCP project approved for Chad, worth US$316 000.

July 28
FAO sends letters to all chief veterinary officers worldwide, notifying them of the screwworm threat in North Africa, with accompanying *Screwworm Information Notes.*

July 31
IFAD joins the FAO Screwworm Action Group.

FAO designates the British Museum (Natural History) as FAO reference laboratory for screwworm and animal myiasis identification.

August 4
FAO TCP project approved for the Niger, worth US$250 000.

September 25-26
Libyan National Screwworm Committee chairman visits IAEA, Vienna.

October 4
FAO Animal Health Service chief provides chief veterinary officers worldwide with an update on the screwworm situation and *An Abbreviated Guide to Identification of the Screwworm*, provided by the British Museum (Natural History).

October 23-27
FAO/IAEA mission to Libya for collection of NWS pupae, for transfer to Fargo, North Dakota for compatibility studies on Libyan and Mexican strains.

October 24
FAO holds second briefing session on the NWS in North Africa, attended by permanent representatives to FAO from Algeria, Egypt, Ethiopia, Libya, the Niger, the Sudan, Tunisia, Yemen and Yemen Arab Republic and representatives of IFAD.

November 5
Libya initiates strict control of stray animals.

November 7-12
Study tour of Libyan specialists in Mexico.

November 16
Conversion of FAO/IAEA/IFAD Action Group to FAO/IAEA/IFAD/UNDP Action Group.
FAO sends letter to Minister Counsellor of United States Permanent Representation, requesting provision of sterile flies and permission for US nationals to take part in the eradication campaign.

November 29
FAO mission to OIE to present NWS diagnosis prevention and eradication information to Commission on FMD and Other Epizootic Diseases.

December 14
FAO TCP project for second-line countries approved, worth US$250 000.
Sexual compatibility of Mexican and Libyan strains confirmed by USDA.

1990
January 8-19
Consultants' group meeting in Vienna to draft a project document for NWS eradication programme (experts from FAO, IAEA, United States and Mexico).

January 16
Three Libyan veterinarians undertake a one-month study tour in Mexico, sponsored by IAEA.

January 17
Meeting of representatives of the Arab Organization for Agricultural Development of countries under direct threat of spread of NWS.

January 28
FAO/IAEA mission to Libya for preparatory work related to experimental rearing of NWS for quality control.

February 12-17
FAO mission to Washington, D.C. to discuss provision of experts, sterile flies and materials.

March 15
US President George Bush signs legislation to permit the sale of sterile screwworm anywhere in the world.

March 17-22
Training course in Tripoli for representatives of second-line African countries.

March 30
Technical responsibility for screwworm assigned to Animal Production and Health

Division. Animal Health Service Task Force established.

April 12
Third letter to chief veterinary officers worldwide, updating screwworm situation and making recommendations of use of insecticides for screwworm prevention and control and emphasizing the need for immediate reporting of screwworm (as a notifiable disease).

April 18
FAO press conference on NWS, Rome.

May 18
FAO donors consultation, Rome.
FAO/IFAD Technical Assistance Execution Agreement signed for implementation of the preparatory phase.

May 26-June 1
Formulation mission to Libya to draft final project document for eradication programme.

June 1
First batch of sterile pupae from Mexico received at Seibersdorf for research and development work.

June 15
FAO Director-General establishes the Screwworm Emergency Centre for North Africa (SECNA), under the Plant Production and Protection Division. Action Group enlarged to include donors and other organizations.

June 19
FAO Director-General assigns FAO personnel to SECNA.

June 29
Joint FAO/IFAD press briefing, hosted by IAEA in Vienna.

July 1
Animal Health Service Task Force disbanded.

July 17
IFAD/FAO donor pledging conference held at IFAD, Rome, resulting in pledges for US$30.5 million.

July 23-August 1
FAO/IAEA mission to United States for negotiations on NWS programme and mission to Mexico to make arrangements for SIT programme.

August 17
SECNA field programme established in Libya and field programme director appointed.

September
OIE/FAO finalize proposal for NWS import/export control.

September 2
Libya assigns counterpart staff to SECNA field programme.

September 27
Libyan co-director assigned to SECNA field programme.
Just under 3 000 cases of NWS infestation recorded in Libya during September.

October 28
SECNA field programme starts Libyan NWS strain in laboratories.

October 29
FAO transfers SECNA to Animal Production and Health Division.

November 10-16
FAO/IAEA mission to Libya to discuss technical backstopping of NWS programme.

December 5
International Union for Conservation of Nature and Natural Resources urges funding support for NWS programme.

December 12
The contract under which MACES would provide sterile NWS finalized.

December 13-14
FAO/IAEA Research Planning Workshop on NWS at IAEA, Vienna.

December 15-18
SECNA field programme receives first shipment of sterile NWS (3.5 million) from Mexico for dispersal during the preparatory phase. SECNA begins case reporting by geographic coordinates.

1991
January 24
Donors consultation held at FAO, Rome.

February 1
Main eradication programme started. Sterile flies transported twice weekly from Mexico (28 million per week).

February 12
IFAD/FAO donors pledging conference held at IFAD, Rome. A further US$8.6 million pledged.

February 13
First dispersal of sterile NWS over entire known infested area (25 000 km^2).

February 25-March 2
FAO mission to Mexico to arrange expanded transport schedule for 40 million sterile flies per week.

March
First month in Libya with no NWS cases reported.

April 7
The last recorded case of NWS infestation in Libya.

April 27
Last fertile NWS fly trapped in Libya.

May 3
Direct charter flights from Tuxtla Gutierrez to Tripoli start, carrying 40 million sterile flies once a week.

May 5-10
SECNA Technical Advisory Committee holds first meetings in Tripoli and Rome.

May 5-6
Dispersal area is expanded to include a protective barrier around known infested area.

May 18
Sterile fly dispersal starts over a 2 500 km^2 area of Tunisia, near its border with Libya.
SECNA management meeting held in Tripoli.
Second month in Libya with no recorded cases of NWS infestation.
Number of animals inspected per month exceeds 2 million.
Number of inspection teams working outside the infested area is increased.

June 11
SECNA holds first Coordination Committee meeting in Rome.
A number of quarantine stations in Libya begin 24-hour control.

July
Number of fly traps increased.
NWS expert studies relationship of weather to NWS and concludes that use of SIT eliminated the NWS population.

July 15-16
SECNA management meeting held in Tripoli.
North African chief veterinary officers meet at SECNA field programme offices in Tripoli.

July 28
Libyan leader Col. Moammar El Quadaffi visits SECNA in Tripoli.
FAO Director-General and SECNA director address the second regular session of the Economic and Social Committee of the UN (ECOSOC) in Geneva on the NWS programme.

August
Number of animals inspected per month exceeds three million.

August 31-September 6
Second TAC mission visits Libya and SECNA headquarters, Rome.

September
Livestock economist commissioned to

study the economic impact of NWS eradication.

October 12
Last shipment of sterile flies leaves Mexico for Tripoli.

October 15
Final day of sterile fly dispersal in Libya.

October 21-23
SECNA management meeting held in Rome.
Second Coordination Committee meeting held at FAO, Rome.

November 5
Drs Knipling and Bushland presented with FAO awards for their pioneer work in developing SIT.

1992
January
NWS outbreak reported in Mexico.

February 12
Coordination Committee meeting at FAO, Rome.

April 8
SECNA management meeting, Rome.

April 29-30
SECNA management meeting, Tunis.

June 22
Formal declaration of Libya as screwworm-free and responsibility for Libyan component of the preventive phase handed over to the Libyan authorities.

June 25
Final meeting of the Coordination Committee and presentation of final reports on the eradication programme.

December 31
SECNA disbanded.

Annex two

SECNA documents

More than 100 documents were produced during the North African NWS eradication campaign, which detail all aspects and stages of the programme. They are available in the Animal Health and Production Division registry, FAO, Rome.

Project documents

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Progress Report for the Period February 1 to May 31, 1991. SECNA. June 1991.

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Report of a Second Mission to the SECNA Field Programme in Libya. August 31-September 6, 1991.

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A Phenological Analysis of Screwworm in Libya. E.S. Krafsur. August 1991.

Computerization and Analysis of SECNA Technical Data. S.N. Putt and A. McLeod. August 1991.

Economic Impact of NWS Eradication from North Africa. J. Grindle. September 1991.

The Potential Impact of the New World Screwworm on Wildlife in Africa, the Mediterranean Basin, the Near East and Asia. M.H. Woodford. March 1992.

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