

Eradication of the Screwworm

From Libya

Using the Sterile Insect Technique

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SUMMARY

The introduction in 1988 of the New World screwworm into Libya 1988, presented a serious threat to the livestock and wild life sectors of the African continent and the mediterranean region. In this article, Moises Vargas-Terán, Brian Hursey and Edward Cunningham describe the action taken to determine the extent of the problem, to prevent the spread of the infestation and to eradicate the fly from the region using the sterile insect technique.

New World screwworm myiasis is caused by the larval stage of the fly, Cochliomyia hominivorax (Coquerel), infesting the tissues of living animals. It is an obligate parasite and the female may oviposit in any wound or abrasion in mammals, including humans. Its natural distribution extends from the state of Minnesota, USA, (before eradication) southwards as far as Buenos Aires, Argentina, and includes the Caribbean region.

The Problem

The Libyan Emergency began when the fly was first detected in March 1988 10 km south of Tripoli¹. It was probably introduced through the importation of infested livestock from an endemic area in Latin America. This created an international alarm because of the risk presented to the whole of North Africa, and the possibility that the disease could spread to other areas of suitable habitat in Africa, the Middle East and southern Europe².

The infested area (25 000 km²) was located in the northwest region of Libya defined by the Mediterranean sea to the north and east, the Sahara desert to the south and the coastal area of Tunisia to the west. The area is well irrigated all year round and the crops produced are mainly cereals, fruits and vegetables. The wild flora is predominantly small flowering trees, especially mimosa, tamaris and acacia, which, in Texas and Mexico, were a source of nectar for the flies.

The climate is mediterranean (summer 24 C0 to 28 C0), with a rainy season in the winter months (December - February, 13 C0 to 15 C0) . The soil is sandy and there are no rivers or high mountains. Fifty percent of the country's human population is concentrated in the infested zone, mainly in Tripoli. Land, air and sea communications are excellent, with international airport and port facilities situated in the centre of the infested zone.

The domestic animal population in the area is estimated at 2.7 million, comprising sheep (77.5%), goats (18.7 %), cattle (2.1%), and camels (1.7%). There are a few wild species such as gazelles, rabbits, wild dogs, red fox (Vulpus vulpus) and golden jackal (Canis aureus)³.

Surveys indicate that the prevalence of myiasis was low in winter and increased during the spring, reaching a peak in the summer months.

Each animal with either one or more infestations was recorded as a single case. From January 1989 to December 1992, out of 15 883 myiasis cases examined 88% (14 011) were identified as New World screwworm myiasis. The following species were most commonly affected: sheep (74.3%), cattle (16.5%), goats (4.2%), camels (2.3%), horse (0.9%) and others (1.8%). The remaining 12% were identified as being caused by the following fly species: Lucillia cuprina, Lucillia cericata, Chryzomyia

rufifacias, Chryzomia microphagon, Musca domestica, Sarcophaga spp. and Wohlfahrtia spp.⁴.

Fifteen human cases were officially confirmed.⁵ However, during 1988 more than 200 unspecified human myiasis cases were reported at Tripoli General Hospital⁶.

Several cases were found in captive animals at the zoological garden in Tripoli. However, no cases were found in other free-roaming wildlife outside the zoo.

To prevent the further spread of the disease, 13 quarantine stations, operational for 24 hours a day, were immediately established at strategic internal and border points. Inside the infested area, transported livestock were inspected and sprayed with larvicide before being allowed to leave the area. Suspect animals were quarantined. More than one million animals were inspected from December 1990 to December 1992. Fewer than 5% of the animals were put in quarantine, but none for New World screwworm infestation. At the same time, a special operation of surveillance and animal quarantine was implemented in the neighbouring countries of Algeria, Chad, Egypt, Morocco, Niger and Tunisia.

Simultaneous action was taken to reduce the number of wounds in potential host animals and, through prophylactic treatment, minimize the

screwworm threat and suppress the natural population. More than 200 livestock inspectors were needed to implement these activities and to gather information on screwworm distribution and abundance, as well as to secure the participation of the agricultural community in the implementation of control measures (8-4).

Control of screwworm myiasis by chemical means, supported by the required specific animal husbandry practices, is expensive, short term and not always effective. It involves repeatedly treating the wounds of infested animals with selected insecticides. Infested animals may not be found, or by the time they are found they may already have severe and often fatal infestations. Total avoidance of wounding is unattainable in most animals. The sterile insect technique, first proposed by Knipling in 1985, requires the mass rearing of the insect pest to produce large numbers of progeny that are then sterilized by radiation and sequentially released over the infested area⁸. The radioactively induced dominant lethal mutations ensure that when sterile males mate with wild females they prevent the production of viable offspring. For the sterile males to be effective, they must pass seminal fluid to the wild females, which will otherwise mate again. Thus there must be no interference with the mating and insemination process. Sterile females also contribute to the suppression and elimination of the wild population since fertile males that mate with sterile females are, in effect, partially removed from the reproductive population. The sexually active irradiated

flies must be released in sufficient numbers to ensure the progressive decline of the wild population.

Before implementation of the sterile insect technique could be confidently initiated, the following information was required: (1) Confirmation of the genetic compatibility between the fly strain "Orange Walk 1987 (OW-87)", collected from Belize and used in the mass breeding plant in Mexico, and the wild strain in Libya. Test results from mitochondrial DNA analyses indicated that the wild strain in North Africa was reproductively compatible with that being mass produced in Mexico. (2) An assessment of the density of the wild population, so as to estimate the release rate of sterile insects and the continuous monitoring of both wild and sterile population densities in order to check on the progress of the operations. These adult fly surveys involved the use of 80 specifically designed wind oriented traps baited with the olfactory attractant "Swormlure-4", made up of ten strongly aromatic organic acids and alcohols. At the same time, electrified targets, as originally developed for tsetse control, were field tested and then used to augment the survey effort. These tests confirmed the attractive efficiency of "Swormlure-4" and agreed with the finding that targets fitted with black material attracted twice as many flies as did red ones¹⁰. (3) Confirmation that seasonal climatic factors influenced the population densities of wild adults and to what extent. This information was essential to the decision as to when the large-scale sequential releases of sterile insects should commence so as to achieve an

optimum effect. Adult fly surveys and monthly figures on the incidence of myiasis confirmed that low winter temperatures significantly suppressed population growth and adult fly activity. (4) Confirmation of the sexual competitiveness and survival of sterile flies under field conditions in Libya. In realisation that the capture of adult flies during stressful winter conditions, this assessment was based on the strategic placement of 28 sentinel and surgically wounded groups of sheep within the infested area. (5) Confirmation of the limits of the infested zone and the pattern of fly distribution within the area. This would help in determining the best geographic pattern for aerial releases of sterile males and on the amount of overlap required at the apparent limits of infestation.

The Action Taken

To identify an effective means of transporting the sterile insects from Mexico, the Mexican-US screwworm breeding plant, which produces between 3.5 and 40 flies per week, sterilized five and a half day old pupae using Caesium-137^(Ref.11). Since this was the first time that transatlantic transportation of the New World screwworm was carried out, several tests were made on the effects of various combinations of temperatures and relative humidity and of different packaging systems, on fly survival and fitness. Two systems of boxed-fly transport were developed. The first, based on available scheduled flights, involved

24-hour transport by truck, from the rearing plant to the airport in Mexico, an eight-hour transatlantic flight from Mexico to Frankfurt, followed by a three-hour charter flight to Tripoli: a total transit time of 35 hours. This system had limitations in that only 28 million insects could be transported weekly, at 10 C0. and 27% relative humidity. A second system was therefore tested and adopted. This involved the use of privately chartered direct flight from Mexico to Tripoli, taking a total of 14 hours. By this means it became possible to increase the weekly consignment to 40 million insects and to maintain them under the more favourable conditions of 20 C0 and 27% relative humidity.

Between December 1990 and October 1992, 1300 million insects were transported in weekly shipments without interruption. Quality tests carried out in Mexico and Libya showed no evidence of poor biological quality. These tests included daily entomological monitoring and determination of fly emergence, flight agility and longevity without food and water.

A sterile fly distribution centre was established at Tripoli airport, central to the infested zone. Here, the sterilized pupae were stored in climatically controlled chambers at 10 C0 to 26 C., depending on the intended day of dispersal. When 90% of the pupae had emerged, they were loaded on to five Twin-Otter aircrafts, each with the capacity to carry 2000

boxes of flies and fitted with a special chute to facilitate release of the cartons.

The sterile males must outnumber native males and must also compete successfully with native males in mating with native females. Sterile fly releases were made over the infested area twice weekly; the flights were carried out in the early morning to minimize heat stress. Between 500 and 1200 flies (of both sexes) were released per km². These densities were calculated based on data indicating the incidence of New World screwworm myiasis and on the numbers of wild flies trapped. Distribution was along parallel lines set 4.0 km apart. These lines were offset by 2.0 km on the subsequent flight, thereby maximizing the chances of placing sterile males near breeding sites. Special grid releases were superimposed on the routine grid, and additional releases were made over areas where increased infestations were indicated.

The release of sterile insects began on the western edge of the infested zone in December 1990, over an area of 6000 km. This was increased, from January 1991, to include over 45% of the southwestern part of the infested area, a further increase was made in February 1990, resulting in ten million flies being released over an area of 10 520 km², and covering approximately 60% of the infested zone. In February 1991, weekly dispersals were begun over the entire infested area, using 28 million sterile insects. In May 1991, the treated area was expanded to include a protective

barrier around the infested area. This involved treating also some 2500 km² on the Tunisian side of the border, forming a total treatment area of 40 000 km² for the final stage of the campaign.⁴

All operations were supported by a well-organized communications campaign to ensure public cooperation.

The Result

Between 1990 and 1992, a total of 598 961 screwworm flies were captured, of which 62% were sterile (45% males, 55% females). More than 100 000 females were dissected and only 34 were found to be fertile; the last wild female was captured in April 1991. Of the other species of biting flies captured, 38 % were classified into the following families: Calliphoridae 52%, Muscidae 43%, Sarcophagidae 4%, Scimomyzidae 1% and Tachinidae 1%.

Due to the greater attractiveness of accidental wounds and the low density of the wild fly population, no fertile or sterile egg masses were collected. With regard to the effect of Libyan temperatures on the introduced populations, the New World screwworm survived three winters prior to the commencement of eradication measures, thus indicating that it was able to adapt to local conditions and that climate alone would not eradicate the pest.

As result of the implementation of the sterile insect technique, the New World screwworm was considered eliminated in April 1991 (Table 1), when the last myiasis case was reported and the last wild fly captured. Additional factors contributed to eradication, such as the geographical situation of the infested zone, the biological quality of the sterile flies and the effective support given by control activities. Eradication can now be confidently confirmed as no further evidence of the parasite has been recorded, up to July 1993, despite constant surveillance, albeit at a reduced level of intensity.

The cost of the eradication programme, in kind and cash, was approximately US\$75 million, with contributions from eight North African countries (37%), 22 donors (45%) and UN agencies (18%). When compared with the losses prevented and the costs avoided in the North African livestock sector alone, the programme showed a net return to investment of approximately 50:1^(Ref.12).

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Table 1. Myiasis due to New World screwworm¹ (and other Diptera)

	<u>1990</u>		<u>1991</u>		<u>1992</u>	
	NWS	Other diptera	NWS	Other diptera	NWS	Other diptera
Jan	102	15	3	17	0	11
Feb	94	28	2	17	0	6
March	190	73	0	128	0	56
April	289	50	1	221	0	94
May	371	42	0	191	0	76
June	917	65	0	158	0	27
July	1 570	53	0	105	0	8
Aug.	2 154	65	0	87	0	6
Sept.	2 932	45	0	61	0	2
Oct.	1 701	23	0	37	0	2
Nov.	1 566	25	0	41	0	7
Dec.	191	5	0	21	0	5
Total	12 068	489	6	1 084	0	299

¹ In 1989, a total of 1937 NWS myiasis cases were detected