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R. E. Reichard, M. Vargas-Terán, & M. Abu Sowa

Myiasis: the battle continues against screwworm infestation

The New World screwworm fly (*Cochliomyia hominivorax*) caused myiasis extensively among livestock in Mexico and the southern third of the USA until eradication was achieved by repeatedly releasing sterile males of the species on a massive scale. The pest appeared in Libya in 1988, the first time it had become established outside the western hemisphere. Because of the threat of myiasis in animals and people, not only in Libya but also elsewhere in Africa and beyond, a concerted campaign of sterile male releases was mounted with strong international support, and the outbreak has been eliminated. Action is continuing against the pest in Central America.

The New World screwworm (*Cochliomyia hominivorax*) was originally found infesting people in the penal colony of Devil's Island in French Guiana in 1858. Today, in tropical America, it causes significant human morbidity and, where medical services are poor, even mortality. Dramatic effects on mammalian wildlife have also been observed. In both North and South America it is well known as one of the most important insect pests of livestock.

Previous to its establishment in Libya in 1988 it occurred only in the western hemisphere, where it still causes large losses in certain economies that depend heavily on livestock. Its eradication from Mexico and the USA by means of the sterile insect technique cost US$ 750 000 000.

Predictions were made in 1988 that the spread of the screwworm from Libya to the rest of Africa, the Middle East and the Mediterranean Basin would result in massive and continuing losses in animal production and cause severe damage to wildlife and humans.

Had there not been an eradication programme in Libya, the screwworm would inevitably have spread to an area where the use of the sterile insect technique would

Dr Reichard is Field Programme Epidemiologist, Screwworm Emergency Centre for North Africa, Gorji Road, PO Box 83252, Tripoli, Libyan Arab Jamahiriya; Dr Vargas-Terán is Technical Officer, Screwworm Emergency Centre for North Africa, Food and Agriculture Organization, Via delle Terme di Caracalla, Rome 00100, Italy; Dr Abu Sowa is Chief of Veterinary Services, Libyan Arab Jamahiriya.
have been impracticable. When in 1989 the
decision was taken to initiate the eradication
programme in Libya the only existing sterile
fly production plant, located in Mexico, was
not operating at full capacity. Production
was increased to supply all the required
sterile screwworm flies.

Prior to the launching of the full-scale
programme in February 1991, more than a
year and a half of intensive preparatory
activities had been undertaken, not only by
Libya but also by Algeria, Chad, Egypt,
Niger, Sudan and Tunisia, with the
assistance of several United Nations
agencies. The infestation was confined to an
area in which eradication was feasible.

Human myiasis

There have been several hundred
documented cases of screwworm infestation
of humans in tropical South America,
including many deaths. One published list (1)
of screwworm diagnoses in humans in the
western hemisphere contains 391 cases, 11
of which were fatal; the nasal sinuses were
affected in 24 cases, a concealed and
particularly dangerous location, especially in
severely debilitated individuals or those with
sinus cancer.

Between 1969 and 1988, 39 cases were
reported in humans in the USA and Mexico.
In both countries during this period the
parasite was subjected to prevention or
eradication procedures to some degree.
There was also considerable public
awareness of the pest, relatively low levels
of infestation occurring in animals because
of control activities. However, the total of
officially diagnosed cases in livestock
approached half a million. The parasite was
eradicatied from the USA in 1982 and from
Mexico in 1991.

In Libya the first human cases occurred in
1988 before the parasite became notifiable,
almost simultaneously with and in the same
area as the first cases in livestock. At least
four cases of myiasis in livestock were
taxonomically identified and a total of
15 cases were confirmed in humans. The
Food and Agriculture Organization (FAO)
quickly alerted the countries of the
Mediterranean Basin, Africa and the Middle
East of the immediate risk and of the
importance of surveillance, not only in
livestock but also in humans, who, being
more mobile than livestock, possibly acted as
sources of fresh outbreaks.

In tropical areas of North and South
America the people are familiar with the
parasite and take necessary precautions.
However, if the New World screwworm had
spread to sub-Saharan Africa or the tropical
Middle East, especially where rural
inhabitants live close to their animals, there
might have been significant human
morbidity, and mortality where health
services were poor.

Myiasis is caused when a wound becomes
infested by dipterous larvae. If, as with the
New World screwworm or the Old World
screwworm (*Chrysomya bezziana*), they feed on

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living tissue, the wound deepens and
extends dramatically. It may attract
secondary infestations of other flies. Until
the advent of the New World screwworm in
Libya, myiasis in livestock was not notifiable
in most countries. An increase in human
myiasis was brought to the attention of the public health authorities in Libya in 1988.

The diagnosis of New World screwworm requires the identification of larvae obtained from myiasis specimens. Samples should be taken from the deepest part of the wound so as to avoid secondary blowfly larvae that feed on already necrotic tissue nearer the surface. Several samples of larvae should be taken from each wound. Samples for identification should be preserved in either 70% alcohol or 10% formalin.

The success of the recent large and costly eradication programme in Libya depended on the quality of surveillance. It was imperative that both medical and veterinary officials of countries at risk were provided with information and larval samples relating to any human myiasis cases. Animal health officials of countries at immediate risk underwent FAO training courses on surveillance, identification and prevention, and samples were diagnosed by trained laboratory technicians. Confirmation of infestation by New World screwworm was given by the FAO reference centre for screwworm; other myiasis identification was made at the British Museum of Natural History, London.

**Clinical features**

Human myiasis occurs most frequently during the season when the screwworm population is high and outbreaks occur in domestic or wild animals (2). In Mexico, infestation occurred most often in wounded adults and children suffering from mental problems, alcohol abuse or obesity.

The common sites of infestation in humans are the nose, eyes and skin. The symptoms and clinical manifestations depend on the anatomical region affected and are usually characterized by local pain, intense pruritus, non-migratory cutaneous nodules, restlessness, and larvae emerging from wounds or cavities. Respiratory difficulty and headache occur in nasal myiasis. Infestation involves more than one larva per wound. Nasal myiasis sometimes goes undetected for long periods. However, a local swelling may occur and with adequate illumination the larvae may be seen. The larval mouthparts are deeply embedded in the host’s tissues and the posterior end containing the respiratory apparatus is left free to ensure a supply of air. If an infestation is not remedied, death may result.

**Treatment and prevention**

The treatment of cutaneous myiasis caused by New World screwworm involves attempts to asphyxiate, paralyse and/or physically remove the larvae. Specific treatment is required depending on the affected anatomical region. Heavy oils have been used to occlude infested wounds. Following this, the posterior ends of the larvae project into the air. Embedded larvae are difficult to withdraw because their spines allow them to resist removal. The larvae should not be punctured or fragmented as their body fluids are reportedly toxic.

The best approach is to remove the larvae as soon as possible by surgery under local anaesthesia. The complete maggots and
surrounding necrotic tissue should be removed and the cavity explored to ensure the removal of all insect matter. The wound should be irrigated and left open to heal. Tetanus prophylaxis should be administered and antibiotics may be indicated.

In untreated dermal myiasis, deterioration continues until the mature larvae back out of the lesion, drop to the ground and pupate in the soil. In some cases, larvae may be found on the host’s bed or on the floor. Untreated cases suffer extensive and traumatic tissue damage and the wound odour attracts more gravid female flies, with the result that multiple infestation develops.

In order to deal with nasopharyngeal myiasis the following procedure should be adopted.

- Anaesthetize the larvae and mucous membrane by applying benzol, ether or chloroform with an atomizer or cotton pledget. Block the nostrils with dry cotton wool for two to three minutes. Anaesthesia can also be induced by irrigating with 20% chloroform in sweet milk or 15% chloroform in light mineral or vegetable oil. In the case of extensive infestation, two or three applications of anaesthetic may be necessary.

- Remove the larvae with forceps and ask the patient to blow his or her nose. Special care should be taken to avoid rupturing blood vessels. Surgery may be required, during which the larvae should not be punctured or fragmented.

- Following removal of the larvae, aftercare should be provided as indicated.

The following measures to prevent the occurrence of New World screwworm myiasis in humans should be taken in areas where infestation occurs in animals.

- Persons with bleeding problems, perhaps associated with skin or sinus cancer, vulvitis, dermatitis, chicken pox or other wounds, should avoid sleeping outdoors.

- Frequent use should be made of fly repellents.

- Environmental sanitation should be practised to prevent contact with the screwworm fly. This includes the separation of animal and human living quarters, and wound and skin hygiene.

- Sleeping quarters should be protected with screens or bed nets, especially where people have wounds or active nasal or ocular discharges.

- The screening of hospital windows and doors is essential.

**The spread of New World screwworm**

At the larval stage the New World screwworm is an obligatory parasite on living mammalian flesh. Gravid female flies lay batches of several hundred eggs in wounds of animals. The larvae emerge approximately 12 hours later and burrow into and enlarge the wounds, growing as they consume the living tissue. Five to seven days later the mature larvae, about 1.5 cm in length, leave the wound, drop to the ground, burrow into the soil and pupate beneath the surface. Only the larval stage causes damage.

All wounds, no matter how small, attract the fly. The characteristic odour of
screwworm infestation attracts more gravid females, which lay more eggs, and the wounds are enlarged even further. Physical damage to the host is compounded by reduced resistance to secondary infections.

In tropical climate or during warm seasons the life-cycle of the New World screwworm can take as little as 19 days. When cooler weather prevails, pupal development and the maturation of the adults are slowed down and the life-cycle may last over two months. Freezing weather kills all stages of the insect and determines the limits of its overwintering areas. Flies have been reported to travel up to 200 km but this is exceptional.

If there are sufficient wounds and if other environmental conditions are favourable, explosive outbreaks may occur.

In a county in North Carolina some 10,000 livestock cases were diagnosed during a particularly severe outbreak. In an infested area of 25,000 square kilometres around Tripoli, Libya, nearly 3000 cases were diagnosed in September 1990. Neither of these locations is in the tropics, where conditions are generally considered to be optimal for the New World screwworm.

Infestations can spread rapidly as a result of the transportation of animals over long distances. Outbreaks may occur wherever larvae drop to the ground to pupate, provided the appropriate conditions exist.

When the pest was enzootic in the southern USA, seasonal outbreaks occurred sporadically in the central and northern states during warm weather. In the USA and Mexico, when infested livestock were transported through intensive barriers of sterile flies, outbreaks occurred repeatedly in areas where eradication had otherwise been achieved.

Several reintroductions of screwworms have taken place in the USA since eradication but none has yet caused significant outbreaks. As of mid-1991, the last detected imported case in the USA involved a wounded soldier returning from Panama in 1990. In Mexico, infested animals from Central America have recently been detected and in France a dog was found to be infested on arrival from South America.

The most likely source of the outbreak in Libya was livestock imported from tropical America. The pest overwintered in Libya for at least three years, during which it spread approximately 200 km in each direction along the coast from Tripoli.

**Economic impact**

The importance of screwworm to the keeper of livestock derives primarily from the expense and effort involved in regularly examining animals and treating wounds to prevent sickness and death. Livestock management in the USA and Mexico was frequently scheduled to avoid calving, branding and castration during the main periods of fly activity. In the USA, screwworm infestation was seasonal and covered approximately the southern third of the country, where labour costs of screwworm prevention and treatment made livestock production expensive and, in some cases, uneconomic. However, the eradication of the pest in the southwest of the USA was
one of the principal causes of unemployment among cowboys, who had previously been required to "ride the range" and so reduce losses caused by screwworms.

Studies of the economic effects of screwworm infestation in North and South America have largely been limited to countries considering or effecting eradication programmes. It was recently estimated that reinfestation of the USA would cost some $ 453 million a year and that eradication had spared Mexico annual losses of $ 156 million.

Had the insect spread to sub-Saharan Africa, the Middle East and the Mediterranean Basin, similar or perhaps even greater losses to livestock economies could have occurred. Although the Old World screwworm, found in Africa and Asia, is also a primary flesh-eating parasite, losses of the magnitude of those caused in the western hemisphere by the New World screwworm have not been documented. A conservative estimate of $ 4 a year per head of livestock for the control of the New World screwworm in North Africa suggests that the total bill would have been $ 280 million a year for the region's estimated 70 million animals.

**Screwworm and wildlife**

The susceptibility of wildlife to the New World screwworm has been thoroughly documented. The population of North America's major ungulate, the deer, increased dramatically following eradication of the parasite.

The large herds of wild ungulates with seasonal breeding, such as those which occur in the savannas of sub-Saharan Africa, constituted an enormous potential target. The simultaneous availability of umbilical and vaginal wounds could have provided conditions for explosive outbreaks. The International Union for the Conservation of Nature urged speedy donor support for the eradication of the New World screwworm because of the effects the parasite could have had on Africa's fauna.

**Eradication of New World screwworm**

The programmes in North and South America combined the traditional procedures of surveillance, treatment and movement control for the eradication of animal disease with the first use of the sterile insect technique. This technique, described as autocidal control or the suppression of a pest population by genetically altering a stage of its life-cycle, was envisaged by Knipling in 1937 (3). It requires the rearing, sterilization and release of large quantities of an insect species in an infested area. The sterile males mate with fertile females, which consequently produce no offspring. As sterile males continue to be released, fewer fertile matings occur in each generation until the population ceases to exist.

The severe damage caused by the screwworm to the livestock industry of the USA led Knipling to test the technique against this insect on a small island off Florida, and the subsequent eradication of the pest on the Caribbean island of Curaçao proved its effectiveness. A control programme begun in 1957 led to the eradication of screwworm by 1959 in the enzootic area of semitropical southern Florida, from which the pest had spread annually during warm weather to other parts of the southeast of the USA.

After the success in Florida, livestock producers in the southwestern USA persuaded the Texan and Federal authorities
to participate in the funding of an eradication programme. Sterile flies were first produced in 1962 in a plant converted from an aircraft hangar on the Mexico-USA border. Populations of the pest were quickly suppressed and an attempt was made to establish a sterile-fly barrier along both sides of the 3000-km border.

However, in years when conditions were favourable to the parasite this barrier was penetrated by flies from enzootic areas to the south. In 1972, livestock producers in northern Mexico collaborated with their counterparts in the USA to convince the governments of both countries to establish a Mexico-USA screwworm eradication commission similar to the one that had worked on the eradication of foot-and-mouth disease in Mexico.

In 1976 a large plant in southern Mexico began producing sterile screwworm flies and by 1981 its output was such that a plant in Texas could be closed. In 1982, 500 million flies were produced every week in the Mexican facility. This operation required more than 100 tonnes of dried blood, milk and eggs every week. Sterile pupae were shipped in bulk in refrigerated trailers to regional packaging centres in Mexico, from which they were dispatched in boxes containing 1600 pupae. The boxes were transported in temperature-controlled trailers to several airfield distribution centres for dispersal over infested areas. A variety of fly dispersal patterns was employed in response to information received from a ground force of up to 600 inspectors, and a series of animal inspection and quarantine stations controlled the movement of livestock from infested areas to ones from which the pest had been eradicated.

Up to 60 aircraft flew daily to disperse the sterile flies and as many as 2800 employees worked in the campaign. The programme has now moved to the south and, since 1988, sterile flies are being released in Guatemala and Belize. The present objective is to eradicate the screwworm from Central America and to establish a sterile fly barrier at the Isthmus of Panama (see figure).

Immediately after official confirmation in 1989 of the presence of New World screwworm in Libya a series of governmental and United Nations activities were begun. The veterinary service of Libya provided 90 teams who were responsible for containing the outbreak by periodic inspections of all animals in and around the infested area. Wounds were prophylactically treated and the movement of livestock was controlled. FAO, IAEA, IFAD and UNDP assisted with consultancies, training and the provision of equipment and insecticides. FAO’s Screwworm Emergency Centre for North Africa managed and coordinated the programme.

Prevention programmes in all neighbouring countries concentrated on surveillance, public information and the control of animal movements. Libya hosted FAO-sponsored training courses on the prevention of screwworm attack for veterinarians and technicians from countries in the region.

The huge costs of the campaign were promptly supported by 14 countries and six international organizations. In July 1990, $28.6 million were pledged to initiate the programme.

The Screwworm Emergency Centre for North Africa was established at FAO headquarters in Rome and its field programme headquarters were set up in Tripoli. Containment activities were successful. The infested area around Tripoli had expanded only from approximately 18 000 to 25 000 square kilometres by the time field eradication activities commenced,
and no foci developed elsewhere in the region as a consequence of animal movements. However, infestation had become much more severe within the affected area, and more than 10,000 cases were recorded in the second half of 1990, compared to under 2000 in the same period of 1989.

In December 1990, 3.5–7.0 million pupae were transported from Mexico to Tripoli every week and the emerging sterile flies were dispersed over an area near Tripoli. Subsequently, with ground surveillance and the control of animal movements firmly in place, the numbers of sterile flies dispersed were increased, releases being made twice weekly. Commencing in February 1991, 28 million were dispersed weekly; in May 1991, 40 million flies were dispersed two days per week over the entire infested area and the surrounding protection zone. During the first seven months of 1991 only six outbreaks of New World screwworm were detected in samples from more than 800 animals with wound myiases.

Surveillance and animal movement control continued undiminished for several months after eradication had apparently been achieved and the release of sterile flies had ceased. Information activities, however, aimed at eliciting reports of myiasis from livestock owners, have been intensified. The
Emergency Centre will continue its coordinating role until mid-1992 and the infrastructure required for a new campaign of sterile fly releases will remain in place and personnel will be ready to respond, should the need arise.

The overwintering of New World screwworms for at least three years on the southern shore of the Mediterranean was unprecedented, as was the use of the sterile insect technique on a large scale in Africa. For approximately three years, before eradication was officially declared in October 1991, the pest presented a potential threat of enormous proportions to the livestock, wildlife and human populations of a large part of the eastern hemisphere.

References


The risk approach

Over the past few years, the epidemiological concepts of relative and attributable risk have been adapted and applied to the priority problems of primary health care. This approach seeks to quantify various health or social conditions that are associated with an increased risk of disease and death. “Attributable risk” is the increased risk of disease presented by a particular condition or problem. In other words, some of the risk of malnutrition is attributable to measles or other infections, some to poor kinds of food, some to cooking habits, some to absence of a parent, etc. Obviously some attributable risks are more significant than others. The early identification of mothers or children with a high risk profile permits corrective measures to be implemented more efficiently and effectively. This increased emphasis on helping people in whom difficulty is anticipated has been described as “something for all, but more for those in need—in proportion to that need”.