Conditions for the Possible Spread of the New World Screwworm Fly to Sudan and Contingency Plans

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INTRODUCTION

The New World screwworm fly, Cochliomyia hominivorax (Coquerel), is still limited to a 20,000 square km area around Tripoli, Libya. The Food and Agriculture Organization (FAO) of the United Nations has enlisted the U.S. Department of Agriculture to develop a screwworm eradication plan using sterile male screwworm release (SMSR) technology that was successfully implemented in the U.S. and Mexico. A donor conference on May 18, 1990, at FAO/Rome has been scheduled to solicit funds for the projected two-year eradication program that will cost approximately $85 million. Details on the status, implications, and eradication of the New World screwworm in North Africa are provided in Appendix A. If the screwworm spreads beyond its present range in Libya, the chances of its eradication will become increasingly remote. An infestation of Sudan will likely be permanent, with dire economic and ecological consequences.

CONDITIONS IN SUDAN

Sudan is the largest country in Africa, and is bordered by Libya, Egypt, Ethiopia, Kenya, Uganda, Zaire, the Central African Republic, and Chad. Saudi Arabia is about 210 km across the Red Sea. Most of Sudan is composed of vast and inaccessible scrubland and desert with little or no infrastructure; the Sudan/Libya border is particularly desolate. The borders between Sudan and its eight neighbors are largely uncontrolled. The southern districts (Southern Darfur, Southern Kordofan, Blue Nile, Upper Nile, Bahr El-Ghazal, El Buheyrat, Junglei, and Western and Eastern Equatoria) are beseiged by war, and the western and northwestern districts are under strict military control with Libyan troops occupying areas of Northern Darfur. Under the present government, travel for foreign nationals outside of Khartoum and Omdurman is granted by permit only (which authorizes such travel for a period of one month); the permit may take up to two weeks to acquire. Overland travel is difficult at best; a trip from Khartoum to El-Fasher, (about 300 km) may take more than three days of hard driving in a 4X4 vehicle. Survey in such conditions, especially with the assistance of foreign screwworm experts, therefore, will be encumbered by a complex of logistical impediments.

Although the Sahara Desert provides a barrier of sorts to the spread of C. hominivorax, Tripoli is about 1,600 km from the Sudan border, and it is reported that livestock does not commonly enter from Libya, it should be remembered that only one screwworm-infested animal is sufficient to cause considerable

concern. The Sudan border is transected by two dirt tracks, and there are no settlements in the vicinity. Smuggling and nomadic movement undoubtedly occurs on occasion, which, in the absence of any survey activities there, may not be detected. The Libyan troops may also bring in their own livestock for food, although this has not been proven. Free-ranging wildlife (e.g., gazelle, oryx, and jackals) cannot be inspected and are thus another potential mode by which the screwworm could enter Sudan. The imminent open border agreement between Libya and Sudan may increase the chances of screwworm introduction, but this is speculative.

Egypt has ceased to import livestock from known screwworm-infested areas including Libya, and intensive survey assisted to some degree by military personnel is underway. Should the screwworm become established in Egypt, however, the Nile Valley would be a likely route of entry in Sudan. Sudan does not import livestock from Egypt, but there is occasional camel herding across the border. The camels, then may be herded south along their migration routes into Sudan's interior (Fig. 1).

In northern Chad, the Tibesti area would offer a favorable habitat for screwworm, should it arrive there. Transhumance and wildlife movement commonly occurs from Chad to Sudan, especially camel- and cattle-herding nomads that come to Northern and Southern Darfur.

Most Sudani livestock is kept by nomads that herd roughly 21 million cattle, 17 million sheep, two million camels, one million equines, and millions more goats. Nomadic cattle migration routes (Fig. 1) are generally concentrated between latitudes 12 - 9 degrees N and move eastward toward Ethiopia and southward toward Bahr EL-Ghazal, El-Buheyrat, Upper Nile, and Junglei districts. This situation would facilitate the spread of screwworm into the Central African Republic, Zaire, Uganda, Kenya, and Ethiopia. Camel herding is mainly between latitudes 18 - 11 degrees N, and movement is southward to central Sudan (Fig. 1). Transhumant tribes commonly mix during the rainy season, which would further exacerbate the chances of screwworm dispersal.

Other myiasis-causing flies occur in Sudan, including Chrysomya bezziana, Lucilia spp., Calliphora spp., and Fannia spp., but they exist as a relatively chronic, low-level problem. The destructive potential of C. hominivorax in Sudan is likely to far exceed the threat of indigenous myiasis-producing species due to its lack of natural enemies, a largely favorable habitat, and its deep-burrowing habit. A screwworm invasion of Sudan would probably result in catastrophic consequences to livestock and those who depend upon it, and the national economy (Sudan is an exporter of livestock to countries such as Saudi Arabia which would probably impose quarantines). The already beleaguered wildlife of Sudan (Table 1) would suffer immense, and in some cases, irreparable losses.

Table 1. A representative list of wildlife that would be vulnerable to New World screwworm attack in Sudan. All can be considered already endangered.

Nubian ibex
Scimitar-horned oryx
Tiang
Waterbuck
Bushbuck
Boehr reedbuck
Salt's dik-dik
Addax
White eared cobb
Nile lechwe
Rhim gazelle
Dama gazelle
Red fronted gazelle
Soemmering's gazelle
Dorcas gazelle
Roan antelope

Giraffe
Elephant
White Rhinoceros (only 30 left in the world)
Sudan water buffalo
Nubian ass
Barbary sheep
Warthog

Sand fox
Fennec
Cheetah
Leopard
Lion
Striped hyena

Green vervet monkey
Madrass monkey
Olive baboon

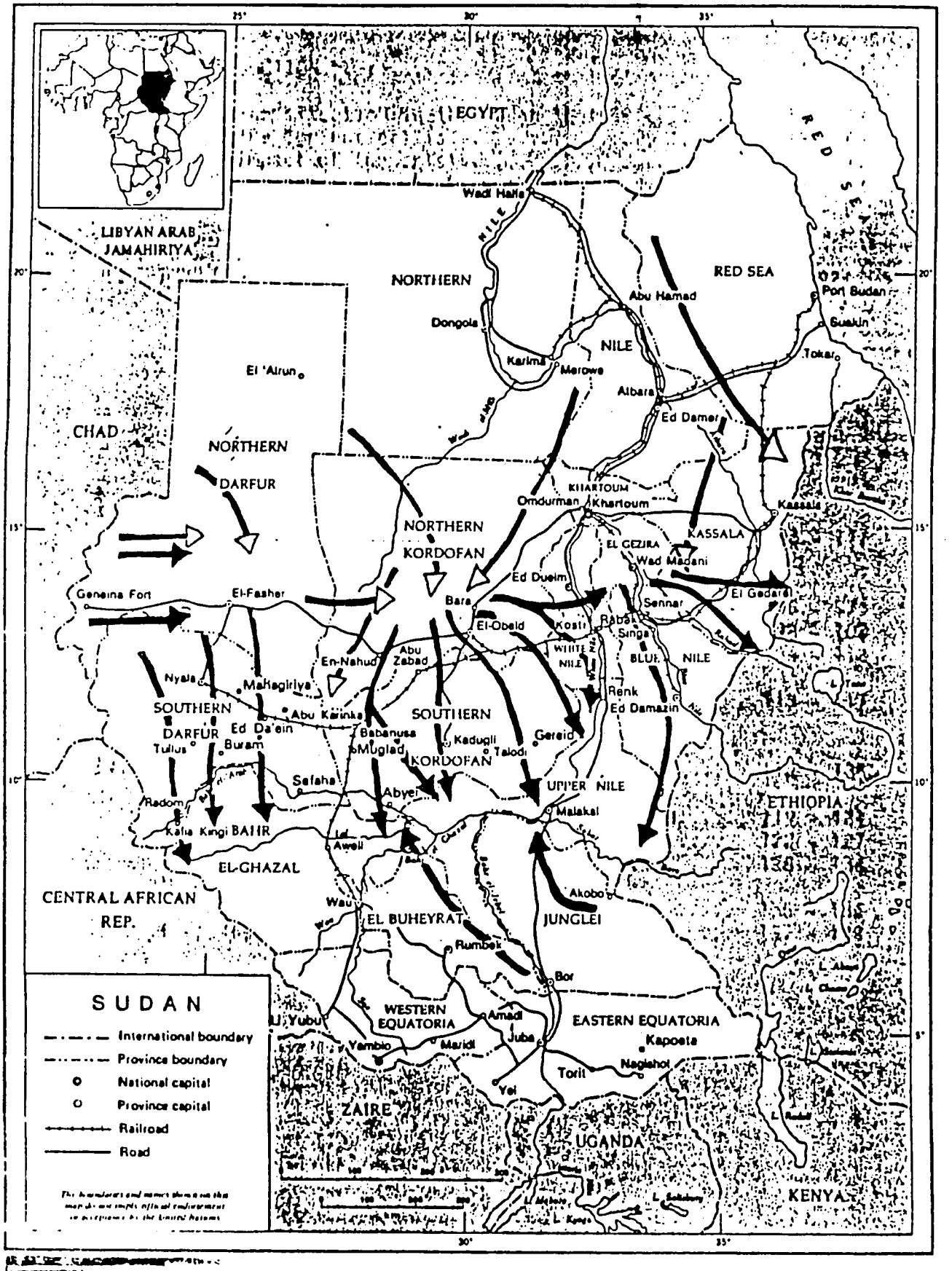
Ostrich
Other large bird species

Figure 1.

CATTLE AND CAMEL MIGRATION ROUTES

Cattle ⟶

Camels ⟶



Information gathered from the Sudan Ministry of Animal Resources.

In view of the relatively large number of New World myiasis cases among humans in the Tripoli area (Appendix A), the population of Sudan would be at least as vulnerable. Herders commonly sleep in close proximity to their livestock, and the health infrastructure in Sudan is weak. Human myiasis, its diagnosis and remedy are described in Appendix B.

CONTINGENCY PLANS IN SUDAN

The GOS was notified of the screwworm infestation in Libya in 1989 first by USAID. Discussions were subsequently held in Sudan, and information was disseminated to the veterinarians. The veterinary faculty at Shambatt University in Khartoum indicated that FAO was not keeping them informed at all. Most Sudanese who know of the infestation in Tripoli think that the screwworm was introduced from the U.S., as indicated by a Ministry of Animal Resources (MAR) progress report.

In 1989, a scientist from Sudan's Veterinary Research Administration attended a one-week training course in Libya on the biology, identification, and control of C. hominivorax. Two FAO-sponsored screwworm experts, T.R. Donald and D.B. Thomas, visited Sudan in late 1989. Their trip reports were not made available to USAID, MAR, and the veterinary faculty at Shambatt University. FAO has, however, provided coumaphos insecticide, alcohol, sample collection test tubes, posters, and two dissecting microscopes, but this material will be held in Khartoum until survey vehicles are provided. FAO/Khartoum has a screwworm officer, Mr. Ben Yaha, recently arrived from the Yemen Arab Republic.

The MAR has appointed a screwworm officer and has developed a plan of work for screwworm monitoring composed of three general components as outlined below. The enactment of each component is contingent, to a large extent, upon donor assistance.

1). General Survey

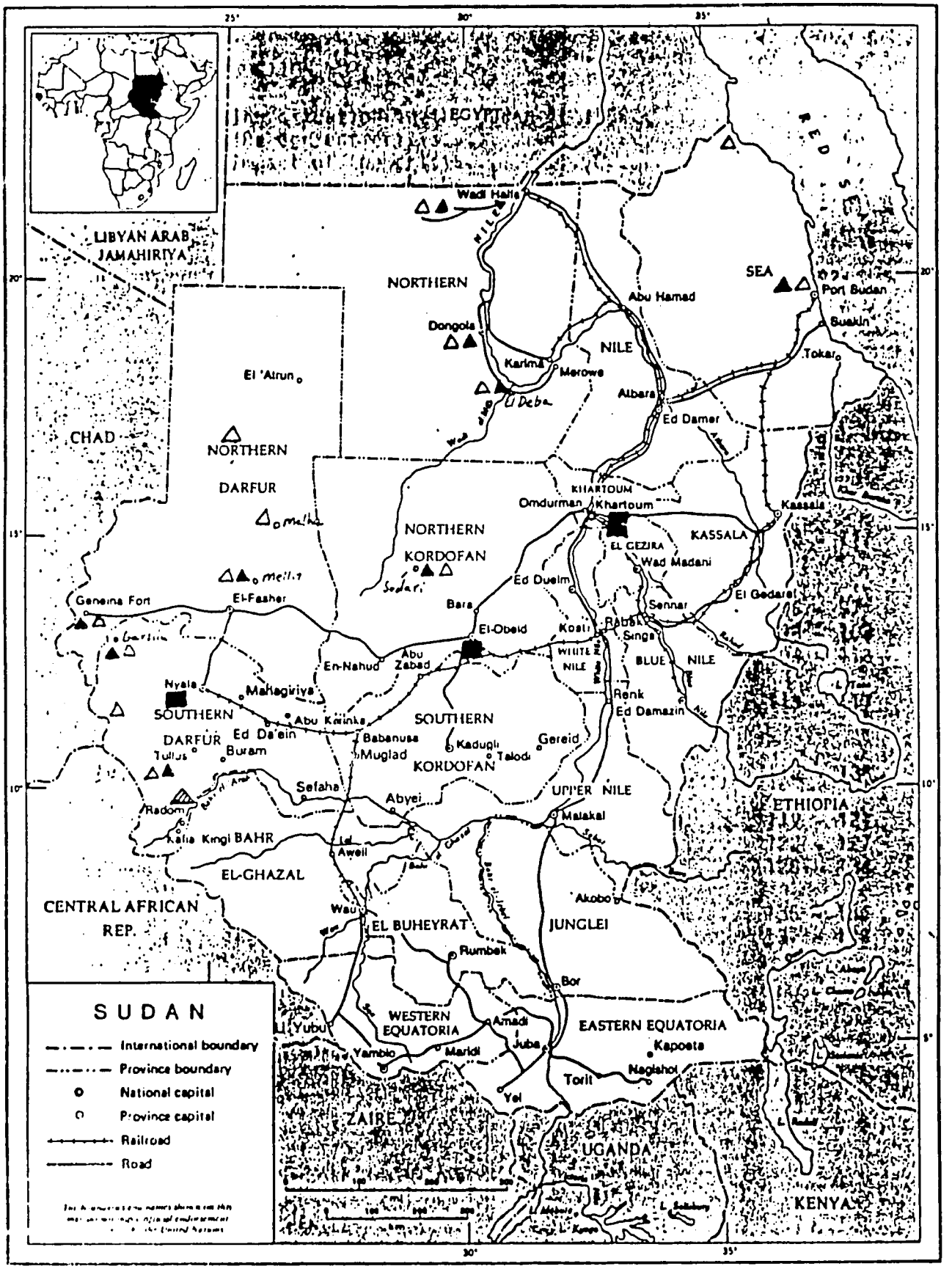
Animals in border settlements near Libya, Chad, and Egypt, and nomad herds arriving from these countries should be inspected. Survey should operate along five "legs" to cover areas in western, eastern, and northern Sudan (Fig. 2) that are likely to become infested first. The "legs" are:

i) Sodiri - Wadi El Malik - Malha Wadi Hawar (N. Darfur and N. Kordofan),
ii) Mellit - El Geneina - Forobarunga - Wadi Salih (N. Darfur),
iii) Umdafog - Rahad El Birdi - Umballot (S. Darfur),
iv) Wadi Halfa - Dongola (Northern Sudan), and
v) Halaib - Mohamed Gol (Red Sea).

Figure 2. Screwworm monitoring stations and survey sites proposed by the Ministry of Animal Resources.

△ = mobile survey unit ▲ = monitoring station

■ = training/diagnosis center ◬ = ecology station



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2) Monitoring Stations: Selected locations along the animal migration routes (Fig. 1), border settlements, and Khartoum airprt should be provided with trained staff to monitor resident and migratory livestock. They should be provided with traps (e.g., adult traps and sentinel animals), dissecting kits, and sample preservation material. The veterinary clinics at Sidary, Mellit, El Jineaena, Rihaid El Birdi, Wadi Salih Halfa, and Port Sudan were suggested (Fig. 2).

3) Ecological Studies: The prevalence, biology, and seasonal abundances of the different myiasis-causing flies should be studied. The ecology station near Radom was suggested (Fig. 2).

The MAR further indicated that the survey program should be managed from Khartoum Central Laboratories, with the Nyala and El Obeid regional laboratories to be additional training and diagnosis centers (Fig. 2). Requirements were listed as follows:

1) Staff
- 15 research officers
- 14 veterinarians
- 3 entomologists
- 10 technicians
- 5 drivers
- 5 mechanics

2) Vehicles
- 5 diesel pickup landrovers
- 1 truck
- 6 motorcycles
- ? spare parts

3) Living Accomodations
- 4 tents (6-person capacity each)
- 4 tents (2-person capacity each)
- 20 safari beds
- 4 portable tables
- 8 portable chairs
- 2 sets of cooking gear
- Nyala and El Obeid regional labs to be renovated to include lab space, and office, and a bathroom in each

4) Preserving Material
- alcohol
- glycerol
- insect mounting media

5) Laboratory Equipment
- 4 dissecting microscopes
- 4 field microscopes
- 3 portable generators
- 10 dissecting kits

6) Trapping Material
25 meters of mosquito netting
100 yards of blue and black terlin material
100 meters of 1/2-inch diameter metal tubing

7) Experimental Animals
20 goats
20 head of cattle
? small laboratory animals

8) Fuel
20 drums (? capacity) diesel
1 drum (? capacity) engine oil
50 liters brake oil
20 tins (? capacity) lubricant oil

9) Training
assistant researcher to obtain M.S. or Ph.D. in entomology with emphasis on myiasis
3 researchers (entomologists and/or parasitologists) to receive training (3-6 months) in the U.S. or Mexico
3 lab technicians to be trained in handling fly traps, and screwworm rearing in the U.S. or Mexico

The FAO TCP/RAB/8955(E) project has agreed to fund:
5 m/m screwworm surveillance,
2 m/m training,
insecticide packets,
sampling kits, and
a one-week training course for 15 participants
all at a cost of about $55,000. Of all the countries that border Libya, Sudan is receiving the least assistance from FAO.

RECOMMENDATIONS

Every effort should be made to encourage and support FAO's plan to eradicate the screwworm from Libya before it spreads to the rest of North Africa, southern Europe subSaharan and southern Africa, the Middle East, and/or Asia.

USAID/Khartoum should continue its diligent efforts to keeping abreast of screwworm developments in North Africa to inform the GOS, and the progress of the GOS's contingency planning.

AID/AFR/TR's AELGA Project now includes screwworm control. AFR/TR should consult with AID/GC to examine the stipulations set out under Section 513 of the Foreign Assistance Act (now in effect in Sudan) to exempt and include Sudan under the AELGA umbrella to prepare not only for screwworm, but locust and grasshopper outbreaks as well. USAID/Khartoum should be consulted immediately with regard to this recommendation.

AID/AFR/TR should be prepared to conduct an environmental assessment in Sudan in the event that USG assistance with pesticide-related control measures is to be provided.

The misperception in the MAR that the screwworm was imported to Libya from the U.S. should be dispelled. The U.S. does not export livestock to Libya, and the screwworm was eradicated from the U.S. in 1982. The probable origin of the Libyan screwworm strain is South America.

Technical assistance should be provided to Sudan to review and revise the MAR's survey and training plan, identify sources of assistance, and cost estimates to prepare Sudan in the most timely, practicable, effective, and cost-efficient way possible.

FAO should be reminded to send its "screwworm information" newsletter to Sudan's MAR, the veterinary faculty at Shambatt University, the Institute of Environmental Studies, and all donors active in livestock development, including USAID/Khartoum. Emphasis, too, whould be placed upon the potentially devastating effects of screwworm infestations.

FAO should be encouraged to supply the GOS with the balance of items on its TCP grant to Sudan that it has not yet delivered to facilitate speedy initiation of survey.

Technical assistance, in the form of screwworm expers (U.S. or Mexican), should be provided to Sudan to further assess and train GOS personnel (in the MAR, Shambatt University, and the Extension Service) on screwworm biology, survey, and control.

The GOS should intensify its public awareness campaign to include rural villagers and nomads. Nomads, in particular, should be encouraged to have their livestock inspected regularly.

The GOS should begin survey of its borders with Libya, Chad, and Egypt as soon as possible. The GOS should facilitate maximum survey team mobility despite the military presence in western and northern Sudan.

Despite the imminent open border agreement between Libya and Sudan, the GOS should be encouraged to scrupulously monitor all animal movement into its territory.

The GOS should be prepared to impose quarantines on livestock imports and migration from any neighboring nations found to be infested with the New World screwworm.

The GOS should be encouraged to request that Libyan troops in Sudan not be accompanied by livestock animals that originated in Libya.

The Ministry of Health should be made fully aware of the impacts that the screwworm can have on humans, and be given instructions on how to prevent and treat myiasis in humans.

Appendix A

The New World Screwworm Fly in North Africa: Implications and Eradication Plans

by

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Just as the desert locust, Schistocerca gregaria (Forskal), plague of 1986-1989 was ending in Africa (Showler and Potter 1990, Appleby et al. 1989), the New World screwworm fly, Cochliomyia hominivorax Coquerel (Calliphoridae: Diptera), made a debut appearance outside the Western Hemisphere (El-Azazy 1989, Gabaj and Beesley 1989). The screwworm fly is purported to have arrived in Libya sometime in 1987 and was formally identified in April 1989 (FAO 1990c). The U.S. Department of Agriculture (USDA) indicated that the Libyan screwworm strain probably originated in South America and was accidentally introduced to North Africa on livestock shipments (Gabaj et al. 1989). The fly has since become established in about 20,000 km2 around Tripoli from 60 km east of the Tunisian border to 225 km east, and 80 km inland from the Mediterranean coast (FAO 1990a). The area includes five of Libya's 13 municipalities, and about 1.2 million head of livestock (FAO 1989c).

THE PROBLEM

The New World screwworm fly is indigenous to the Americas and is an obligate parasite of warm-blooded animals (James and Harwood 1969). The gravid female is attracted to wounds that can be as small as a tick bite (FAO 1989a), the eggs are deposited there in batches of 10-390 eggs; as many as 2,800 eggs can be produced by each female (James and Harwood 1969). The eggs hatch within 24 hours, and the larvae burrow into the wound, through flesh, bone and other tissues for 5-7 days until

they emerge, drop to the ground, and pupate in the soil (Gabaj et al. 1989). Pupae eclose in about seven days. An entire life cycle takes about 24 days (James and Harwood 1969).

Screwworm myiasis can result in traumatic injury, secondary infections, and is often fatal. In the Americas, 20% of infested animals die (McGourty 1989); fully grown cattle can be killed within 10 days (Gabaj et al. 1989). At best, an infected animal suffers debilitated health, reduced lactation, and a low rate of weight gain (FAO 1990a, James and Harwood 1969). Newborn animals are most vulnerable to attack (FAO 1989a). Hides can be rendered unmarketable, and practices such as dehorning and castration of livestock must be modified to mitigate the risk of infection (James and Harwood 1969). The screwworm is the most important insect pest of livestock in the Western Hemisphere with annual economic losses estimated at hundreds of millions of dollars (FAO 1990a). Thousands of Libyan livestock animals (mainly sheep, goats, camels, and equines) have been infected. 1,938 cases were found in 1989, mostly in Zawia, Tripoli, and Al Murcab municipalities. From September-December, 1989, there were 82, 400, 726, and 607 cases each month, respectively (FAO 1990b, Thomas 1989), but many others were probably not detected. In 1935 in Texas alone, 1,200 livestock and 55 human screwworm myiasis cases were recorded (James 1948). Thirty confirmed, and up to 300 unconfirmed, human cases were reported from Libya in 1988 (Showler 1989a). The screwworm can invade open wounds, and oral, ocular, and aural routes of entry, but human infection

most commonly occurs in the nasopharyngeal passages; if not removed, the larvae can eventually enter the brain (Hunter et al. 1966). The only certain remedy for nasopharyngeal myiasis is surgery (Showler 1989a). In African conditions, where human health is notoriously poor, external lesions frequently go untreated, and people commonly cohabitate with or live in close proximity to their livestock animals. Such conditions serve to exacerbate the risk posed to humans (Showler 1989a).

Because the screwworm is the most serious pest of livestock in the Western Hemisphere, a concerted U.S./Mexican eradication effort using sterile male screwworm release (SMSR) technology has been implemented in the Americas (FAO 1990a). Prior to its eradication from the U.S. in 1982, the screwworm infested the southern U.S. (Bushland 1985, Meadows 1985); during summer months it has been found as far north as Canada (Gabaj et al. 1989). Screwworm-related losses in Texas, 1976, were estimated at $300 million (Gabaj et al. 1989). Wildlife was also severely affected; U.S. deer populations rapidly increased after the screwworm was eradicated (FAO 1990a). Over $500 million was needed to eliminate the screwworm from the U.S. and Mexico, but the cost/benefit ratio was better than 1:10 (FAO 1990a).

MOBILIZATION

The Food and Agriculture Organization (FAO) of the United Nations, in cooperation with the International Atomic Energy Agency (IAEA), is taking the lead in dealing with the screwworm

in North Africa (FAO 1989b, McGourty 1989), and has helped to fund, supply insecticide packets and sampling materials, and provide technical assistance for survey and maintenance control (application of coumaphos to livestock wounds) (FAO 1989c,d) in Libya, Algeria, Tunisia, Egypt, the Sudan, Chad, and Niger (FAO 1989b), and "second line" countries that include Burkina Faso, Cameroon, Djibouti, Ethiopia, Mali, Mauritania, Morocco, Nigeria, Senegal, and Somalia (FAO 1990a,b). FAO has also sent information letters, accompanied by a New World screwworm identification key, to chief veterinary officers worldwide, and a manual for screwworm control has been developed in French and Arabic (FAO 1989d). At the 25th Session of the FAO Conference in Rome, November 1989, the FAO Work and Budget Program for 1990/1991 stated: "The recent appearance in North Africa of the American screwworm fly requires determined action for the control and eventual eradication of this devastating pest.... Immediate steps for control need to be taken" (FAO 1989e). International meetings that have addressed the screwworm problem in North Africa, other than those mentioned elsewhere in this paper, include those convened by the United Nations Development Program (UNDP), The Arab Organization for Agricultural Development, FAO/IAEA, and The International Fund for Agricultural Development (IFAD) (FAO 1990b).

The Libyan National Animal Health Service has created 90 mobile teams, with participation from over 200 Libyan veterinary clinics, to systematically monitor the infested area (feral dogs

are eliminated as part of the program) which report weekly to the National Screwworm Committee (FAO 1989c, 1990b, Thomas 1989). Despite such efforts, the screwworm can spread beyond Libya by flying (up to 300 km in a lifetime) (FAO 1989a) or by movement of infected livestock and wildlife across national boundaries (James and Harwood 1969). Tunisia imports about 15,000 head of livestock per month from Libya; the animals are inspected and drenched with diazinon at the Ras Adjir border station (more quarantine posts are planned). Egypt is a major importer of livestock but has halted all imports from infested areas, and an animal inspection program is underway (FAO 1989c, Thomas 1989).

The screwworm threat exists for southern Europe, all of Africa, the Middle East, and parts of Asia (FAO 1990a). Although the Sahara is a natural barrier to dispersal (Thomas 1989), the mediterranean climate and ecology of the North African coast would permit the fly to spread west to Morocco, and the Nile Valley of Egypt and the longitudinal oases lines in Algeria provide avenues to Sudano-Sahelian Africa and beyond (FAO 1990a, Gabaj et al. 1989, Appleby et al. 1989). Located in the Sahara Desert, the Tibesti (Chad) and Air (Niger) Mountains offer favorable habitats for the screwworm; in Niger, 90% of all Nigerian herders gather in the Air area during the summer (Thomas 1989). Nomadic herders (i.e., Bedouin and Tuareg tribes) frequently cross national borders undetected in the remote desert, and migrating wildlife cannot be practically

inspected for screwworm infection. In many Sahelian countries, survey infrastructure (e.g., roads) lacks (Thomas 1989). FAO estimates that there are 70 million livestock animals at risk in North Africa alone, which could result in $250 million worth of livestock damage each year (FAO 1990a). Mortality among newborn livestock animals in the Sahel my be as high as 80% if the screwworm crosses the Sahara (FAO/IAEA 1990). In the already famine-stricken Sahel, the result of screwworm-related livestock losses would be catastrophic (Gabaj et al. 1989). The injury that may be incurred against African wildlife, including already endangered species, is incalculable (FAO 1990b).

ERADICATION

The only proven method for successfully eradicating the screwworm from infested areas is SMSR, developed by the U.S. and Mexico (FAO 1989a). Male pupae are irradiated with gamma rays and the emerged adults are infertile (FAO 1989a). FAO now has a screwworm eradication staff in Rome, and they plan to implement a USDA-drafted SMSR program in Libya (McGourty 1989). In 1989, a USDA/ARS screwworm laboratory in Fargo, North Dakota, demonstrated that the Mexican and Libyan screwworm strains are sexually compatible (Taylor 1989). The U.S. Congress passed USDA-authored legislation (H.R. 4010) to permit the transfer of SMSR technology from the Western Hemisphere (e.g., the sale of sterile male screwworm flies) (Congr. Rec. 1990) for FAO use in North Africa, and it was signed by President Bush on March 15,

1990 (Showler 1990b). The U.S./Mexico Joint Border Commission oversees screwworm eradication in the Americas (Thomas 1989); the Mexican commissioners have shown a willingness to provide the sterile male flies to FAO.

USDA has suggested that an SMSR program in Libya will involve the release of about 100 million sterile males per week (FAO 1990a). This will require a substantial production increase at the U.S./Mexico Joint Border Commission's sterile male screwworm production facility in Tuxtla Gutierrez, Mexico (production in 1989 was 250 million per week) (FAO 1989a). The production increase will require renovation of the production facility in terms of labor agreements and equipment (Showler 1990a). Nevertheless, the eradication program in Libya may commence soon, since the first stage of SMSR will use only about four million sterile males per week (Showler 1989b).

Because sterile male screwworms will be produced in Mexico, they must be air shipped to Libya and released within four days of production. Chartered aircraft will most likely be the only reliable, albeit expensive, option available to transport 100 million sterile male pupae (packed in ice chests) per week for two years (Thomas 1989). Once the flies arrive in Libya, they may have to be packaged for aerial or terrestrial release in cardboard boxes. The SMSR program will be augmented by an intensive animal inspection and control (animal drenches, dips, and wound treatment) effort, a survey system that includes fly traps and sentinel animals, the possible use of a screwworm

adult suppression system (SWASS) which involves dichlorvos treated bait pellets, and a public awareness campaign (FAO 1989a,b, Thomas 1989).

A two year SMSR program in Libya, excluding sterile male production facility renovation costs, will entail the commitment of at least $60 million (Economist 1990). IFAD and UNDP earlier committed about $3 million, which is clearly insufficient to cover the total costs of eradication (FAO 1990c). At the Twentieth Regional Conference for the Near East in Tunis (March 1990), it was suggested that advanced donor commitment of at least $25 million annually should be made for two years (FAO 1990c). FAO convened a donor conference in Rome on May 3, 1990.

It is imperative that funds be gathered as soon as possible to facilitate FAO's SMSR program. If the New World screwworm fly spreads beyond its present range in Libya, the chances of eliminating it will become increasingly remote (FAO 1990a), especially in the vast and often inaccessible African terrain where livestock and wildlife are not systematically regulated. Screwworm dispersal outside of Libya poses the threat of creating a new and probably permanent ecomomic and ecological scourge (FAO 1990c) in southern Europe, the Middle East, the Indian sub-continent, the Far East, and an already economically beleaguered Africa.

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Appendix C

Persons Contacted in Sudan

Dr. Amir, Veterinary Faculty, Shambatt University, Khartoum
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Mr. Ron Libby, USAID/OFDA/Khartoum
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Appendix D

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Appendix B

Screwworm Myiasis in Humans

by

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