Historia Medicinae Veterinariae, 2004, 29, 2 : 43-53

History of the screwworm (*Cochliomyia hominivorax*) eradication in the Eastern Hemisphere

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Introduction

American screwworm, now called New World Screwworm (NWS), caused by *Cochliomyia hominivorax* (Coquerel) belongs among dipteran flies and is distributed throughout the Western Hemisphere (Central and South America and certain Caribbean Islands). This horrible myiasis attacking warm-blooded animals and man spread in 1988, for the first time in the history, outside of enzootic territories of American continent. It was introduced through trade in North Africa, i.e. in the Eastern Hemisphere. This fly is an invader of fresh skin wounds where they lay their eggs. The larvae hatch, crawl into the wound and borrow into the flesh feeding on wounds fluids and live tissue. The wound can become greatly enlarged due to multiple infestation and, if left untreated, the victims die. The paper is based on historical documents of the Food and Agriculture Organization of the United Nations (FAO), literature sources (6,7,8,9) and personal experience. The first FAO document on this subject was the Report of the FAO mission (15-22 April 1989), led by the author of this paper as the Chief, Animal Health Service (responsible for United Nations animal health policy), sent to investigate, confirm the presence of the NWS and identify limits of invaded territory (4). Majority of the NWS documents were produced by the FAO Screwworm Emergency Centre for North Africa (SECNA) as ad hoc organization with special staff and financing to deal with NWS (3) established by Dr E. Saouma, Director General, FAO on 15 June 1990. Among other sources belong the protocols of the FAO Screwworm Campaign Action Group, FAO/IFAD Screwworm Campaign Action Group and FAO Animal Health Service Screwworm Task Force, all chaired by the author (2,5). National statistical data on the results of epizootiological analyses, inspections of animals and laboratory investigations were of particular importance.

Situation

First international mission together with Libyan specialists carried out a fact-finding survey to determine the reality of screwworm infestation. It was found the evidence that the rapidly spreading myiases were prevalent in domestic livestock, mainly in sheep, with the Tripoli area as the epicenter. Entomological investigation by the mission reconfirmed the findings by local specialists (1) that the causing agent was *Cochliomyia hominivorax*. Maggots collected from animals were identified by the Faculty of Veterinary Medicine and maggots from humans (e.g., from head, neck, hand and scrotum wounds) by the Faculty of Medicine. Later control and eradication programmes were supported by entomological investigations at Central Veterinary Diagnostic Laboratory. Intensive follow-up national and international special diagnostic programme, surveillance and reporting systems facilitated to identify screwworm occurrence and to monitor territories at risk in Africa, Southern Europe and Near East. Following countries were identified as being at high risk: Tunisia, Algeria, Chad, Egypt, Niger and Sudan where FAO initiated special programme of surveillance, monitoring and training. Extensive surveillance and supporting communication activities were also undertaken in other countries at risk: Burkina Faso, Cameroon, Djibuti, Ethiopia, Mali, Mauritania, Morocco,

Nigeria, Senegal and Somalia. Similar surveillance was implemented in Spain, France, Italy, Greece, Turkey, Jordan and Israel. NWS invaded during several months a territory of 25000 km^2 between Mediterranean Sea and parallel 32°10' (Sahara desert) and between meridians 11°45' and 15°15' with more than 2.7 million domestic animals. It was anticipated that without immediate control and eradication, the fly would spread widely and cause incalculable losses in livestock production and sanitary consequences. If the screwworm left uncontrolled, it would inevitably spread to neighbouring countries and eventually into sub-Sahara Africa, Mediterranean Europe and the Near East.

Emergency and containment programme

Immediately after the confirmation of the NWS occurrence, FAO declared global emergency, started special surveillance, preventive and control activities and began preparation for the application of the sterile insect technique (STI). NWS was made notifiable to be reported as other danger diseases of international importance. First control phase consisted mainly in: establishing specific diagnostic system to detect and monitor NWS in the North Africa region and other territories at risk and controlling animal populations and their movement (individually examined for wounds and screwworm larvae) to prevent introduction of NWS to territories free of the pest. It was arranged for production of coumaphos (5%) powder for treatment of wounds and prophylactic spraying (0.25%). Millions of sampling/treatment kits which consisted of insecticide powder and larval collection tubes were routinely provided to livestock owners. The fly's mobility made containment extremely difficult. Adult flies can travel up to 200 km and, where conditions are favourable, the size and range of the population can expand rapidly. The screwworm presence in North Africa, therefore, was a concern of international significance: unless quickly eradicated, it would inevitably spread. It could easily migrate around North- and West African coasts and down the Nile valley. Such as infestation would be virtually impossible

to eradicate and the countries affected would be saddled with the on-going expense of treatment and control programmes and with enormous consequences. The only way to prevent this devastating insect pest from spreading throughout the Eastern Hemisphere was by immediate eradication ("now or never !").

Use of sterile insect technique (SIT).

SIT was developed by R.C. Bushland and E.F. Knipling in 1938 and proved to be effective in USA and Mexico. Initial study confirmed that North African strain of NWS was compatible with the strain used for the production of sterile insect at Tuxtla Gutierrez factory in Mexico (only in world). The technology relied on the regular sequential release of factory bred and sexually sterilized flies. The success of SIT depended 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. The screwworm flies were reared artificially and exposed to irradiation by caesium 137 shortly before they emerge from the pupae. Male flies were sterile but able to mate. The female mates only once, and when mated with a sterile male, lays eggs that do not hatch. Field application of this method in North Africa required demanding preparation and solving immense problems of biological, technological, managerial, financial, social, legal, political and language character. After not easy legislation process, on March 15, 1990, United States President Bush signed law exceptionally permitting the sale of sterile NWS produced under US and Mexican governments to be used in Libya. Sterile flies production capacity of the Mexican facility was significantly increased to be able to meet additional requirements for eradication

programme in North Africa. Necessary support in terms of staff, funds, organization, management, equipment, transport, facilities, logistic, communication, extension, etc. was ensured. SIT was supported by NWS population suppression through animal inspection, wound treatment and preventive spraying of herds/flocks at risk, efficient diagnosis, recording and reporting of screwworm cases, communication campaigns and control of animal movement.

It was necessary to identify programme phases and key moments for STI application in time and space. Scientifically based monitoring system and epizootiological analyses were complemented by more detailed mapping, including use of satellites photographs to identify ecological conditions and their dynamics for corrections of STI targets and timing. During pilot phase it was necessary to develop the infrastructure and test the feasibility of transferring the proven technology, i.e. to test the logistic support necessary to apply SIT successfully in North Africa. New laboratory facilities were established for identification of NWS and quality control. The tests involved analyzing emergence, mortality, flight agility and longevity and were conducted both in Libya and Mexico.

Initially, it was necessary to study: sterile screwworm surviving in the best possible conditions from the factory up to final dispersion and mating in target zones in a very distant territory; transcontinental transport of sterile flies and their storing under North African conditions up to reach the optimal stage for release and mating; effective system of aerial dispersion of sterile flies in terms of frequency, intervals, size and location paths; etc. It was established a continuous control from production factory up to effectiveness of STI practical application and continuous surveillance in invaded and threatened zones and countries. The sterile NWS is a living insect requiring particular conditions with regard to temperature, packaging, shipping, storage, handling and

must be transported within a limited period. In order to ensure good quality flies, a decision was taken to transport the insect in the pupal stage by packing 1600 pupae into small biodegradable cardboard dispersal boxes. Each box contained a small cup of special gelled diet for the emerged flies. The temperature during ground and aerial transportation of the pupae must remain at 10^{o} C. Afterward, the sterile flies were stored in chambers at a temperature of 25^{o} C to 27^{o} C for a minimum of 48 hours until 80 % of the pupae emerged. Then the boxes were loaded on twin-engine aircraft, each fitted with a specially designed chute through which the boxes were released at a predetermined rate. The boxes were designed to open during their fall from the aircraft, or on impact with the ground, thus releasing the flies. Pilot dispersion started in December 1990 with more than 5 million of sterile flies and continued in January 1991 into eradication phase without interruption.

Eradication phase

The main activity consisted in intensive dispersion of sterile flies over infested area of about 25000 km^2 and protective barrier of 15000 km^2 including 2500 km^2 in north-eastern Tunisia. From January to 15 October 1991 a total 1257 million sterile flies were dispersed. Usual weekly dispersion of 40 million flies was carried out using five twins' engine aircraft belonging to Libyan Aeroclub. The dispersal aircraft flew along predetermined paths, 4 km apart, and boxes were dispersed at a rate of 3 to 10 per minute as the plan flew at 240 km/hour at an altitude of 500 m. On each dispersal day an area of approximately 6400 km^2 was covered, with an average distribution of 800 flies per km^2. An extensive communication campaign ensured that people in the affected regions were fully informed on the programme (using radio, TV, leaflets, posters, etc.). The population was informed why low-flying airplanes were dropping cardboxes full of flies

of American origin over large territory. Because no further evidence of NWS in the six months following detection of the last case in April 1991, SIT was terminated. From July 1989 were reported 14111 cases. Tens of human cases were reported as well. The continuous compilation of NWS negative results of surveillance throughout the country confirmed the evidence that NWS no longer existed in North Africa. A resume of data from field activities since beginning of May 1991, the first month with no NWS detected, through to the end of the year showed that nearly 180000 trapped females NWS flies were dissected, with no fertile flies found. The number of inspections of animals exceeded 22 million, with 700 samples of other larvae collected from wounds, but no NWS found. Almost 3/4 million animals were inspected at quarantine stations, with the same results. Continuous surveillance in following years has confirmed NWS eradication in North Africa and thus in the whole Eastern Hemisphere .

Management and support

Effective international technical and financial assistance together with strong national public veterinary services were considered the crucial pre-requisites for the success. The eradication was the outcome of the activities of many thousands of specialists, managers, farmers, supporting staff to cover extremely complex spectrum of all necessary tasks at local up to intercontinental levels. Particular role had specialists with experience from screwworm eradication in USA and Mexico. The intercontinental programme was supported, additionally to FAO, also by other United Nations agencies: International Atomic Energy Agency (IAEA), United Nations Development Programme (UNDP) and International Fund for Agriculture Development (IFAD). Support was provided also by 22 international donors and financial institutions. Local government provided a range of facilities, support staff and other assistance to the project. Department of Veterinary Service employed approximately 300 veterinarians and supporting staff of about 1200 persons. In total more than 50 million inspections were recorded (e.g., during eradication phase - every months the surveillance units were carrying out about 3 million inspections and treating nearly 20000 wounds). National authorities ensured also landing, take-off, parking, servicing, refuelling and repair facilities for project aircraft; facilities for storage and loading of boxed flies; support staff to assist with and implement air dispersal.

FAO Animal Health Service was in charge of the programme from the beginning up to June 1990; particular responsibility had Service Chief V. Kouba (Czechoslovakia) and Senior Officer R.E. Reichard (USA) assisted by B. Hursay (United Kingdom). Afterward, SECNA

took over the main responsibility. Its headquarters professional staff consisted from: E.P.Cunningham, Director (Ireland), A.E. Sidahmed, Senior Operation Officer (Sudan), M. Vargas-Teran, Technical Officer (Mexico), S. Barnes, Information Officer (Australia), M. Kassa, Computer Data Management Officer (Ethiopia) and P.McCormick, Media Liaison (United Kingdom). SECNA field programme (directorate in Tripoli) was implemented by following professional staff: D.A. Lindquist, Director (USA), M.Abusowa, Co-Director (Libya); Epidemiologists R.E. Reichard (USA), M. Abu-diah (Libya), L. Sjoeland (Sweden), H. Lame (Netherlands), F.A. Pouldevigne (France) and A. Bengere (Libya); field working specialists L.F. Liera (Mexico), A. Belazi (Libya), A. Martinez (Mexico), M. Amara (Libya), J. Haloun (Libya), L. Tunisi (Libya), D. Bruzzone (Italy) and S.M. Toure (Senegal); laboratory specialists R. Garcia (Mexico), K. Mughadmi (Libya), J. Chirico (Sweden) and M.Taher (Jordan).
SECNA staff included also aviation, communication and information specialists, distribution center and administrative workers.

Conclusion

The losses reached hundreds of millions US$. In case of spreading over Sahara the consequences would be irreparable and supposed future losses were estimated to be of many billions of US$. Only costs of on-going treatment and control were estimated to be of hundreds of millions US$. In addition to the economic impact, a continent-wide infestation would pose a major human health risk. In remote areas where medical facilities were limited or not existing at all, humans would fall easy victims - particularly children, the sick and the aged. For Africa's wildlife was the risk of significantly reducing natural populations and establishing a permanent "breeding pool" from which it could re-infest domestic herds. The eradication showed a clear economic return. Pre-eradication programme cost about 10 million US$ and the eradication about 80 million US$. An independent economic appraisal, considering also avoiding

future spreading, showed a very high benefit/cost ratio - 50:1. Eradication without recurrence was achieved in extremely short period before the parasite further spread and become enzootic in the Mediterranean Basin and eventually in other areas of the Eastern Hemisphere. Eradication itself took about six months, although it was preceded by 1.5 year of preparation and followed by one year of continuous surveillance and preventive actions. The hemisphere was saved from this very dangerous zoonosis and could be again declared as NWS free territory. The eradication of *Cochliomyia hominivorax* in the Eastern Hemisphere was the most successful large international animal health programme organized by the United Nations.

Tab. 1
Screwworm cases by months in North Africa during 1989-1992
(each case = laboratory-confirmed infestation of one animal)

Months	1989	1990	1991	1992
January	?	102	3	0
February	?	94	2	0
March	?	190	0	0
April	?	289	1	0
May	?	371	0	0
June	?	917	0	0
July	111	1 570	0	0
August	29	2 145	0	0
September	75	2 932	0	0
October	419	1 701	0	0
November	796	1566	0	0
December	607	191	0	0
Total	2 037	12 068	6	0

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Received July 2003

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