The scourge of the tsetse

by E. D. Offori*

There are 22 species of tsetse fly (*Glossina*) a blood-sucking insect which occurs only in Africa. The fly is distributed across the continent between latitudes 15°N and 21°S, equivalent to approximately 10 million km^2 of land surface.

Its importance lies in the fact that it bites both humans and livestock, and in the process transmits the parasitic protozoan *Trypanosoma* which causes sleeping sickness in humans, and nagana in livestock. The disease, also known by the general name of trypanosomiasis, often kills or, at the least, produces morbidity in its victims which results in low productivity. Affected cattle quickly lose appetite, become noticeably emaciated, and succumb within a few weeks.

It is estimated that over 70% of the infested area in Africa constitutes potential agricultural land which, when developed, could increase the existing cattle population by an additional 100–110 million head. Surely the scourge of the tsetse in Africa is real, and T.A.M. Nash aptly summarized the relevance of the problem in his recent book *Africa's Bane, the tsetse fly.*

For many a decade, colonial governments and their successors in the affected countries in Africa have battled to reduce the menace of trypanosomiasis by attacking its vector, the tsetse fly. The strategies in this combat included such direct methods as capturing the adults by hand nets, on adhesive surfaces, or by traps; locating, collecting, and removing the immature stages (puparia) from the soil; and applying insecticides to kill the adult fly. Indirect methods included altering the fly's habitat and removing its natural source of food, namely, wild animals.

As a practical approach to exterminating tsetse, bush clearing was undertaken with the objective of destroying vegetation that constitutes the resting-haunt of the adult fly. Secondly, vegetation clearing often creates "barrier" zones that restrict, and in some cases, prevent the migration of adult tsetse from one area to another. Game destruction was aimed at depriving the fly of its main source of nutrition, thus resulting in starvation and eventual elimination of the fly. Some game animals serve as the "reservoir" for the parasite that causes the disease in man and his domestic animals; thus, by destroying game, the parasite is also eliminated.

These two methods – bush clearing and game destruction – together with the use of insecticides held sway for many years. Indeed, the use of insecticides alone – especially DDT, dieldrin and endosulfan – either as aerosols sprayed directly onto the fly or as residual deposits on vegetation or traps, or livestock attacked by the fly, has been largely responsible for the enormous strides made during the past 30 years to reduce the menace of the fly in many areas of Africa.

Unfortunately, these traditional methods have serious disadvantages which, therefore, require that their continued use be reviewed. For example, apart from its obvious destructive effect on the fauna of any locality, killing game deprives the native human populations of their main source of animal protein. Indiscriminate clearing of vegetation not only depletes the African forests of precious timber and wood for fuel, but also leads to soil erosion and its attendant dangers to agriculture. Finally, few insecticides are species-specific. Thus, their use almost invariably poses the problem of killing other organisms as well. Considerable evidence has accrued over the years to indicate that many of the insecticides used for tsetse control create other environmental problems, such as pollution. In any case, with the increasing cost of insecticides, it is doubtful if the financial resources of some of the affected African countries can continue to sustain an expensive operation which is often not entirely cost-effective.

The sterile insect technique: alternative or supplement?

In the recent past, several alternatives to the traditional methods of tsetse control have been suggested, including the use of parasites and pathogens affecting the immature and adult stages of the fly, the use of predators, pheromones, and juvenile hormones. One of the most promising and practical of the approaches so far investigated is the Sterile Insect Technique (SIT). Essentially, the technique consists of releasing large numbers of laboratory-bred irradiated males into the natural population, so that when these sterile males mate with sexually normal wild females, the latter fail to produce offspring. Sterility is induced in the male by exposing puparia or young adults to a source of gamma radiation such that the sterilizing dose does not adversely affect their mating and inseminating ability.

The SIT as applied to tsetse avoids some of the disadvantages of the other methods described above. It is environmentally acceptable and is readily adaptable to area-wide control schemes against low-density populations. Furthermore, it is species-specific and can be used in special circumstances as a quarantine procedure to prevent re-establishment in tsetse-fly-cleared areas. It should be kept in mind that application of insecticides is

* Member of the Agency's Insect and Pest Control Section, Joint FAO/IAEA Division.

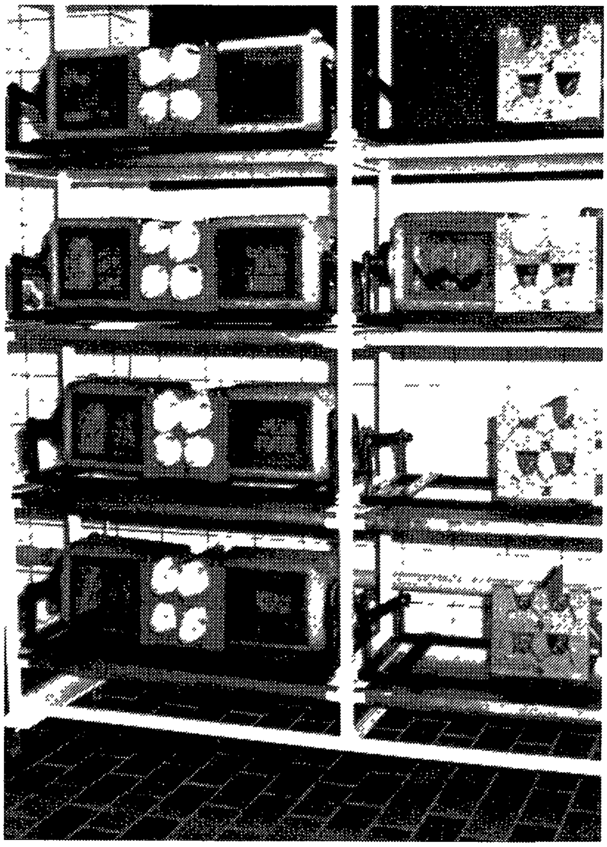

Figure 1. Feeding of *Glossina palpalis palpalis* on guinea pigs.

effective in areas with high tsetse fly density, but is not cost-effective where populations are low. The SIT, on the other hand, is most cost-effective when the population is low.

One of the main pre-requisites for the successful application of the SIT for tsetse control and eradication is the ability to rear the fly in large numbers. Owing to the very low rate of reproduction in tsetse, this requirement was difficult to realize in the past. However, considerable progress has been achieved during the last decade, and colonies of up to 60 000 have been reared in support of field programmes.

That the SIT can be used to suppress or control tsetse populations has now been amply demonstrated through major field programmes concluded in 1979 in Tanzania and Upper Volta. Another large-scale programme was recently initiated in Nigeria.

The point must be stressed that tsetse occurs naturally at relatively low population densities; therefore, it is an ideal candidate for the application of the SIT. The efficiency of the method is enhanced if the natural population in any given area is reduced even further by using other environmentally safe methods prior to the release of sterile males. The SIT should, therefore, be viewed as a supplement rather than an alternative to other methods of tsetse control, indeed, an ideal component of an integrated control operation.

Mass-rearing of tsetse

The responsibility for developing and promoting the application of the Sterile Insect Technique for the control of tsetse and other pests belongs to the Joint FAO/IAEA Division, which very soon after its establishment 17 years ago recognized the advantages of utilizing radiation and radioisotope techniques in the study and management of insect pests. In 1967, the first step was taken to provide facilities at the Agency's Seibersdorf Laboratory to rear tsetse flies. The objective was to develop methodologies for the application of the new technique in the fight against tsetse. During the succeeding 14 years, activities have been concentrated in three main areas.

Tsetse research at the Seibersdorf Entomology Laboratory has emphasized the development and improvement of rearing techniques suitable for the mass-production of economically important species of tsetse. The laboratory's efforts in this direction include the improvement of *in vivo* feeding of mass-reared flies and the development and perfection of an *in vitro* feeding system whereby blood is offered to flies via a membrane. *Glossina morsitans*, *G. tachinoides* and *G. palpalis* have been investigated in depth, and animal hosts, notably rabbits and guinea pigs, have been evaluated. A mass-rearing system has recently been developed for *Glossina palpalis palpalis* using guinea pigs as host (Fig.1) and the colony contained over 20 000 females at peak production, thus enabling the laboratory to supply puparia to support a field project currently underway in Nigeria.

Recent development in the rearing technique has involved the use of freeze-dried bovine blood, which has the advantage of being easily packaged, stored, and reconstituted for use. The reconstituted blood is offered to flies on an electrically warmed plate overlaid by a silicone membrane, which serves as an artificial skin for the flies to pierce through (Fig.2). The development of a rearing technique without recourse to live animals has been a major achievement of the tsetse research programme at Seibersdorf. Efforts are currently being made to develop a mass-rearing system using *in vitro* feeding. The laboratory is also engaged in quality-control studies of mass-produced flies, as well as investigations to determine the doses of gamma radiation required to sterilize various species of tsetse without loss of viability or sexual performance, parameters that are essential for the successful application of the Sterile Insect Technique.

One of the most active areas of operation of the Joint FAO/IAEA Division has been to involve researchers in Africa and other parts of the world in the programmes aimed at promoting the application of the SIT for tsetse control. This is accomplished partly through encouragement and financial support for research in suitable institutions and partly through seminars, research co-ordination meetings, expert group panels, and publication of significant developments. Between 1967 and 1980, seven research contracts were

Figure 2. Feeding of *G. palpalis palpalis* via silicone membrane.

awarded to scientists in Africa and other countries to undertake investigations in support of the Division's SIT programme for tsetse control. During the same period, cost-free research co-operation agreements were concluded with five institutions in Europe and North America, and in 1978 and 1979 technical contracts were awarded to five scientists to investigate specific aspects of tsetse biology relevant to the application of the SIT.

Through these research contracts and agreements and periodic meetings to review and programme for future action, the Division's tsetse programme benefits continuously from the advice and information of distinguished researchers in the field.

Technical assistance

During the past decade, five Member States in Africa have benefited from assistance offered by the Joint Division in connection with the application of the SIT in various aspects of tsetse control operations. Most of the assistance was in the form of training. Between 1969 and 1981, the Entomology Laboratory at Seibersdorf offered training on aspects of tsetse rearing and irradiation to 13 people, of whom 12 were from Africa. The training lasted between three months and two years. The Agency also provided financial support for trainees and scientific visitors to other laboratories and institutions involved in tsetse research and other activities related to the application of the SIT for pest control. Additionally, personnel from the Joint Division provided technical expertise and consultantships in support of SIT programmes in Tanzania and Nigeria.

Biological control of tsetse in Nigeria

The most recent large-scale tsetse eradication programme involving the SIT was started in Nigeria in 1979 through a co-operative agreement between the Government of the Federal Republic of Nigeria and the IAEA. The project, called Biological Control of Tsetse by the Sterile Insect Technique (BICOT), has its headquarters in Vom, Vom Plateau State, Nigeria, and is financed by the Federal Nigerian Government and donor countries including the United Kingdom, the Federal Republic of Germany, Belgium and Sweden. The objective is to demonstrate the economic feasibility and financial competitiveness with existing control measures of the SIT for eradication of the target species, *Glossina palpalis palpalis*, as well as to work out the protocol for its integration within an overall trypanosomiasis control programme.

The BICOT project is operationally divided into two phases:

the pre-eradication phase, to last for four years; and

the eradication phase, which is expected to last for two years.

BICOT became operational in January 1979, when essential facilities, including an insectary and office buildings, were completed and the rearing of the target species started. Since 1979, ecological studies have been in progress in several areas potentially suitable for the SIT programme.

The proposed project area lies within the 9 400 km^2 Lafia agricultural development project, which is a major Federal-, State- and World Bank-financed scheme with a substantial livestock development. Both *G.p. palpalis* and *G. tachinoides* occur in relatively low to high densities. Riverline habitats tend to be restricted and confined by extensive cultivation; high-intensity cultivation towards Lafia and Akwanga in the west, and increasing land-use intensity to the north, south and east, are considered significant isolating features.

Before and during the releases, an untreated area with essentially similar ecological characteristics and tsetse populations will be sampled periodically as an external control, to monitor natural variations in populations of the target species.

Initially, an area approximately 1500 km^2 will be involved and will encompass complete riverine systems. By selecting such a large area for treatment, it is expected that immigration of flies into the centre of the target area will be minimal. By this approach, the need for creating artificially-isolated tsetse populations would be eliminated.

At the completion of the BICOT project, it is anticipated that sufficient information will become available to apply the SIT on a practical basis to eradicate tsetse flies in other parts of Africa. The expectation, therefore, is that the project will result in the transfer of a modern technology to developing countries in Africa to assist in solving a problem that has defied permanent solution for many years. It will also provide needed information on the relative costs of such an operation when weighed against those of current tsetse control methods.

Economic benefits

Until comparatively recently, tsetse control operations aimed primarily at reducing the incidence of human trypanosomiasis. With the attainment of political independence by many African countries and implementation of policies aimed at self-sufficiency in food production, the need for agricultural land reclamation became pressing. Thus, for most countries of modern Africa, the primary economic reason for controlling tsetse flies is to make land available for development, including crop production and livestock improvement.

One of the main constraints to an effective development of several areas of Africa is the tsetse fly. In their efforts to remove this constraint, African countries will have to apply the most effective and least expensive methods available, and work out the most appropriate operational strategies to achieve their goal. The SIT is an efficient method to use against the tsetse, thanks to the very low rate of increase of tsetse populations in nature. The efficiency of the method can be further increased if the natural population in the target area is reduced even further using other methods before the release of sterile males. The initial costs can be high due to the need to provide adequate facilities for mass-rearing and irradiation of the fly and for maintenance of equipment and personnel engaged in field and laboratory operations.

As to actual operational strategies, several options are open for consideration by affected countries. Where the target species is distributed uninterruptedly within an ecological zone spanning two or more neighbouring countries, it would appear a reasonable strategy to plan and operate an SIT programme on a regional rather than on a national basis. The co-ordinating role of international organizations such as the FAO and the IAEA in such a venture cannot be over-emphasized.

Bibliography:

Africa's Bane, the tsetse fly **T.A.M. Nash** Collins, London (1969).

The role of trypanosomiasis in African ecology **J. Ford** Clarendon Press, Oxford, U.K. (1971).

The African trypanosomiases Ed. **H.W. Mulligan** George Allen and Unwin Ltd, London (1970).

The distribution and abundance of tsetse **J.P. Glasgow** Pergamon Press, Oxford, U.K. (1963).

Sterility principle for insect control or eradication, Proc. Joint FAO/IAEA Symp. Athens, Greece, 14–18 Sept 1970, IAEA, Vienna (1971).

Sterility principle for insect control 1974, Proc. Joint FAO/IAEA Symp Innsbruck, Austria, 22–26 July, 1974, IAEA, Vienna (1975).

Isotope and radiation research on animal diseases and their vectors, Proc. Joint FAO/IAEA Symp. Vienna, Austria, 7–11 May, 1979. IAEA, Vienna (1980).

IDRC-077e *Tsetse the future for biological methods in integrated control,* Ed. **M. Laird**, Ottawa, Canada (1977)