PD-AA2-272

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Success of tsetse
sterility

Summary of Tsetse Fly Sterility Program

1963 - 1980

Conducted under Participating Agency Service Agreement between the Agency for International Development and the Agricultural Research Service, USDA.

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December 1981

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Summary

The concept of control of insect pests by the sterile insect technique (SIT) was generated by Dr. E. F. Knipling of the Agricultural Research Service (ARS), USDA. In the early 1950's insect production and radiation sterilization studies in the U.S. led to practical demonstrations of the technique by the elimination of screwworm flies from large areas of infestation. The low biotic potential of the tsetse fly, in the view of U.S. and British scientists, made it an ideal target for SIT experimentation. As vectors of both animal trypanosomiasis and human sleeping sickness in almost 10 million square kilometers in Africa, tsetse flies impact heavily on the economy and health of inhabitants of the region.

Under a Participating Agency Service Agreement (PASA) with ARS, Agency for International Development (AID) support for an SIT investigation in Africa led to the establishment in 1964 of a team of ARS and Agricultural Research Council of Central Africa (ARC) researchers in Southern Rhodesia for a pilot project on SIT with tsetse flies. The locale and the association of ARS and ARC scientists, and subsequently scientists of the University College of Rhodesia, were ideal for research but the restrictive situation that developed as a result of trade sanctions implemented by the United Nations in 1965 made the continuation of the research to fruition impossible. However, the progress made in Rhodesia from 1964 to 1969 on chemosterilization and radiation sterilization methodology and the promising results obtained in field release trials revealed the efficacy of the SIT and demonstrated the need to continue the research by relocation of the activity to another country in East or Central Africa.

After intensive survey of potential sites and nearly two years of negotiations with Zambia, Tanzania and the United Nations Development Program, AID entered into a bilateral agreement with Tanzania. ARS scientists arrived in Tanzania in late 1971 and, after an initial period beset by administrative difficulties, were settled in Tanga in mid-1972. The research team, jointly staffed by personnel of the Tanzania Ministry of Agriculture and ARS, overcame a myriad of severe transport and supply problems and established a research facility. Construction of the laboratory complex at Tanga for the rearing and sterilization of the tsetse fly did not come easily because it was necessary for the project staff to design and build each of the structures, including insectaries, animal quarantine buildings, barns, garages, offices and associated buildings.

Technical progress in Tanzania included the development of the world's largest colony of tsetse flies, which was maintained on live host animals, the selection and assessment of a 195 sq. km test site area, and ultimately the sequential release of sterile flies and a successful research demonstration of the SIT. Concurrently, membrane feeding technology was developed and successfully field-tested as part of a research program conducted by the International Atomic Energy Agency and supported by PASA funds provided through an ARS/IAEA Cooperative Research Agreement.

With this AID-supported research on the SIT successfully accomplished, the project achievements should serve as the basis for future activities leading to practical fly control operations integrating the SIT and conventional control technology. A project proposal was submitted

in 1978 by ARS/AID to meet this objective, but extensive revision by the USAID program office made the proposal unacceptable. Thus, after successfully completing the research program in 1979, ARS was forced to withdraw its staff because future funding had not been committed.

The program, currently (1981) supported by regular Tanzanian funds and limited bridging funds from AID, still awaits a formal project plan and design for renewal of activity. The longer the program languishes, the greater is the probability that the production capability and the local expertise developed by the research activity will be lost. A long term, meaningful commitment is required to revitalize the Tanga program.

Internationally, the impact of this research program has helped to stimulate similar investigations in other areas in Africa and in Europe. Two SIT research programs are currently active in West Africa. The extent of the applicability of the SIT to trypanosomiasis control will be revealed as the technology developed by these three and subsequent SIT research programs are incorporated into actual tsetse control operations.

The most notable benefits of the SIT are that it is target-specific, has negligible adverse effect on the environment, and promises to reduce the need for the use of dangerous and costly chemicals. The probability of large-scale practical usage of both the SIT and other tsetse fly control systems will depend to a great extent on the level of support for the training of African scientists and technicians, an area at present vastly neglected.

Because the tsetse fly/trypanosomiasis problem in Africa is one of immense proportion, it may be essential to integrate the use of conventional control procedures and new alternative technology, such as SIT, to cope with the various situations. This will require bilateral and international support. Numerous reviews and evaluations have resulted in a series of strategy statements for bilateral and international programs to control or eradicate tsetse fly populations. The consensus is that achievement in fly control will require costly coordinated efforts. AID, with the collaboration of international and other donors, could support programs that would lead to the practical utilization of integrated SIT and conventional technology for tsetse fly control in major areas of Africa.

Genesis of the Program

In the mid-1950's the Agricultural Research Service (ARS) of the United States Department of Agriculture (USDA) developed a system of insect control based on control of the reproductive capacity of indigenous insect populations. Under the guidance of E. F. Knipling, the screwworm fly *Cochliomyia hominivorax* (Cqrl) was eradicated from the island of Curacao and then from the entire southeastern United States by releasing sterile insects that demonstrated for the first time the potential of the sterile insect technique (SIT). Following publication of the Curacao results, workers in eastern and southern Africa inquired about the possibilities of controlling tsetse flies (*Glossina* spp.) using the SIT and received encouragement and information from ARS.

W. H. Potts conducted studies in England on the effects of gamma radiation on *Glossina morsitans* using pupae collected in East Africa. The results, although preliminary in nature, were encouraging and H. R. Simpson published theoretical calculations on the effect of sterilized males on natural tsetse fly populations. The likelihood of using the SIT for *Glossina* control posed several challenges. Several species (22) exist, many of which were recognized as significant vectors of trypanosomiasis. Furthermore, techniques for rearing *Glossina* were sorely inadequate at that time. Without a satisfactory rearing capability, implementation of the SIT seemed unlikely even though promising results had been achieved with chemical sterilants, which at that time were considered as possible agents for treating indigenous insect populations *in situ*.

Sharing a mutual interest in assessing the SIT for *Glossina*, AID and ARS developed a proposal for determining the feasibility of such an approach. Recognizing the need to contribute to improvement of methodology for control of trypanosomiasis, AID sought a program leading to more effective means of vector control. Knipling, with ARS' recent SIT successes with screwworm flies, understood well the inherent advantages of the SIT methodology, especially for the control of insects with low biotic potential like tsetse flies. He considered a multifaceted research program that would include studies on the SIT. Knipling envisioned the SIT as a powerful tool for eliminating *Glossina* populations of low density and as an adjunct to conventional methods that were capable of reducing high density populations to low densities. The sterile insect can be used most economically at low densities, while insecticides are most economical when used in high density populations; by combining these principles Knipling felt that control might be achieved more cheaply than by using either technique alone and also that the resulting reduction in the amount of insecticide required for large-scale control operation would be significant.

In 1962 Knipling traveled to Africa for AID. In Conakry he attended the Commission for Technical Co-operation in Africa South of the Sahara meeting of experts on tsetse and trypanosomiasis control. He also visited several countries where tsetse control had been practiced on a large scale. Following his return and armed with the concepts gleaned

from experienced tsetse field workers, Knipling fostered a proposal by ARS and AID to study the feasibility of using the SIT for tsetse fly control. The proposal envisaged an evaluation of chemosterilants and irradiation as sterilizing techniques, studies on attractants that might be used to bring indigenous fly populations to a source of sterilant, and research on production of tsetse flies for release purposes. Since only limited success had been achieved in the previous several decades of experimentation with indoor colonization, Knipling opted to attempt to produce flies outdoors in large cages or in the uncaged environment.

During the 1962 trip to Africa, Knipling had tentatively identified Southern Rhodesia as the optimum location for the proposed project. Here were located an experienced group of tsetse workers, ample field populations of tsetse flies, a willing cooperating institution and, perhaps equally important, trained collectors capable of providing adequate numbers of fly pupae from field collections throughout the year for biological study.

In June 1963 a Participating Agency Service Agreement (PASA) was initiated between ARS and AID and in the following months ARS signed a Cooperative Agreement with the Agricultural Research Council of Rhodesia and Nyasaland (ARC, subsequently changed to the Agricultural Research Council of Central Africa). By the end of 1963 ARS personnel were on site in Southern Rhodesia and in early 1964 investigations were initiated on sterilization of tsetse flies and construction of a field station was initiated in the Zambezi River Valley.

Administrative Development of the Rhodesia Project

Working in cooperation with ARC, ARS established a research program based in Salisbury, Southern Rhodesia (now Zimbabwe). A formal cooperative agreement between the 2 groups provided for reimbursement of expenses incurred by ARC for recruitment of personnel, staff salaries and benefits, equipment, supplies, travel, and research activities commensurate with the goals of the program. The ARS team had a separate fund for its activities, administered from the U.S. and supplemented with the support activities of the U.S. Consul General in Salisbury (the nearest USAID offices in Zambia and Malawi were too distant for effective administrative assistance).

During 1964 the ARC research team was recruited, a laboratory was constructed at the Ministry of Agriculture's Veterinary Research Station, and a field station was established in the Zambezi River Valley ca. 15 km downstream from Chirundu. Laboratory studies were initiated in Salisbury on reproductive biology and sterilization of tsetse flies. Outdoor rearing studies were initiated at Chirundu in large cages and in the natural environment. Studies on the population dynamics of tsetse flies were initiated near Kariba, at one of ARC's tsetse field stations. These activities gradually gained momentum in 1964 and 1965 with the acquisition of equipment, vehicles, personnel and a functional organizational structure.

In November 1965 the government of Southern Rhodesia unilaterally declared its independence from Britain, setting in motion a series of political events that would eventually force the project to relocate in another African country. Within a few months the United Nations instituted mandatory trade sanctions against Rhodesia and several international research organizations pulled out of the country. However, Zambia and Malawi, the other ARC member countries, continued their support thereby assuring the continued funding for ARC from U.K. The United States continued to support the ARS/ARC research program even though there were considerable pressures to abandon or relocate the program for political reasons.

In 1967 both Zambia and Malawi decided to withdraw from ARC. This forced the withdrawal of U.K. support for the Rhodesian phases of ARC and the organization was disbanded in September 1967. In order to retain a viable research entity, ARS negotiated a cooperative agreement with the University College of Rhodesia (UCR) where several of the ARC tsetse workers and their laboratories were housed. Under the new arrangement UCR assumed the administrative responsibilities for the tsetse staff and stations previously controlled by ARC, and the ARS Project Leader assumed overall direction of the program. Without the considerable political assistance of the U. S. Consul General in Salisbury, the State Department's Office of Science and Technology and the Washington-based ARS and AID staff the first phase of this research program could not have been completed. However, with their continued support, the Rhodesian phase of the program was completed in December 1969.

Technical Progress in Rhodesia

Glossina morsitans morsitans was chosen as the primary test species because it is the most important and widespread vector of trypanosomiasis among the 22 species of *Glossina* found in Africa. Therefore, it was felt that success achieved with this species would encourage similar attempts with other important vectors which, because of behavioral and ecological characteristics, might prove to be even more suitable targets for the SIT.

The field station at Chirundu was established in a relatively undisturbed segment of the natural habitat along the southern bank of the Zambezi River. Many attempts were made to rear *G. m. morsitans* in screen cages covering as much as 930 m^2 of suitable habitat and in smaller cages that were specially designed to take advantage of behavioral traits of the species. Both types of cages were stocked with pupae collected in the field, with flies that had emerged from such pupae, or with adult flies captured in the nearby bush, but regardless of season, cage design, or experimental variations, the survival of the introduced flies was inadequate, and breeding on a self-sustaining basis was unsuccessful. However, the flies held in small (20 X 20 X 25 cm) cages within the larger cages invariably survived and reproduced, while their semi-confined counterparts, which were allowed to roam freely in the larger cages and feed at

will on their natural hosts (introduced cattle and bushpig) failed to survive and to reproduce efficiently. Attempts to concentrate natural fly populations by increasing the host density (cattle) in suitable habitats were also unsuccessful, and the density of the fly populations remained similar to those in the control areas over the 2 years of testing. After more than 3 years of thorough study the field rearing investigations were discontinued.

Meanwhile, workers at the Tsetse Research Laboratory (TRL) at the University of Bristol, U.K., had developed methods of rearing *Glossina austeni* in the laboratory that were singularly effective, so much so that the flies had a reproductive capacity which undoubtedly exceeded that found in nature. ARS therefore solicited their assistance in 1967 and within 1 year after being provided two shipments of field-collected pupae TRL succeeded in attaining a high reproductive efficiency with *G. m. morsitans*. Subsequent studies on the degree of selection and adaptation in the establishment of the colony revealed no differences between native and Bristol colony males. When males of the Bristol colony were released back into their original field habitat in Rhodesia 2 years after colonization, they survived and dispersed as well as the native flies.

The major source of flies for the routine investigations was the collection of live pupae in the bush near the Kariba field station. When conditions were optimum, as many as 30,000 pupae were gathered weekly by 15 searchers; but during the rainy seasons the searching teams were hard-pressed to provide 1,500-2,000 pupae, numbers just barely sufficient to conduct meaningful laboratory research.

Males radiosterilized as older pupae or adults were found to be sexually competitive with untreated laboratory-emerged males in small cages in the laboratory and in large field cages in the natural habitat. The studies also showed that the chemosterilants tepa and metepa caused permanent male sterility without affecting mating competitiveness. Furthermore, behavioral studies indicated that multiple mating by female flies would not seriously affect control operations in the field.

Information about the seasonal fluctuations of indigenous tsetse fly populations in feeding, dispersal, mating behavior, reproductive status, birth and death rates, and length of life and about the interaction of these and other factors with population density is particularly important when sterilization is to be used for control. The field studies conducted in the Zambezi valley near the Kariba field station demonstrated fluctuations in density and reproductive viability of the natural fly population throughout the year and revealed the probable effect of environmental stresses on the viability of the released sterile males.

The completion of the population studies set the stage for sterile fly releases, which were conducted on islands in Lake Kariba from 1967-1969. These

trials revealed that chemosterilized *G. m. morsitans* males were effective in the natural habitat against indigenous populations. One isolated island population was completely eliminated by releases of sterile adult flies, although the competitiveness of the released adults was only 20%. In contrast, released pupae were found to be fully competitive and, when used following aerial applications of insecticide designed to suppress the density of the indigenous population, greater than 98% overall control was achieved. Unfortunately, this series of field trials was interrupted by political events which forced the termination of the project. The study was subsequently resumed in Tanzania.

The details of these and other findings and achievements of the Rhodesian phase of this program can be found in the reports and publications cited in the project documentation section of this report (p. 23).

Political Problems Related to Continuation in Rhodesia

From 1965 to 1968 political pressures to relocate the program gradually increased as a result of the Rhodesian Government's unilateral declaration of independence from the United Kingdom. The trade sanctions that were imposed by the United Nations (UN) were supported by the U.S. Government. The sanctions and related policies made it difficult to support the research activity and prevented visitation to the project by expert consultants and AID and ARS program managers. Nevertheless, it should be noted that the working relationship and collaboration between Rhodesian and U.S. scientists and technicians were excellent and highly productive throughout the duration of this project, which began in 1964. However, by 1968 it was obvious that the political problems and U.S. Government policies would ultimately require the closure of the program. A decision to terminate in 1968 was temporarily rescinded because of pressing research needs. The project was subsequently terminated in December 1969.

Preparation for Relocation

In anticipation of the ultimate political decision to relocate, AID/ARS made an administrative decision to seek a location for continuation of the program and early in 1968 established a Task Force charged with finding an alternate site.

The objective of the survey team was to: (1) identify cooperating institutions that could provide laboratory space, technical personnel, and other personnel support; (2) identify suitable locations for an extensive field trial operation, preferably 100 - 300 square miles of isolated tsetse fly population or approximately 500 - 1,000 square miles of non-isolated but manageable fly population, or alternatively, smaller areas for replicated plots; (3) determine to the extent possible the host country level of personnel support for field operations; and (4) indicate to the extent possible the degree of USAID Mission support to the project.

After identifying apparently isolated or semi-isolated tsetse fly areas in five countries of East Africa (Zambia, Malawi, Tanzania, Uganda, and Kenya), a survey was conducted in September and October 1968. Uganda and Zambia, both apparently receptive, were ranked highest on the basis of fly populations, personnel, and facilities. However, Uganda subsequently reversed its decision and was withdrawn from consideration. Initially, Zambia enthusiastically sought the project but the plans were eventually scuttled by the excessive demands of the Director of the Zambian National Research Council, to the dismay of the Ministry of Agriculture and the Tsetse Fly Control personnel. Kenya was interested and had excellent facilities and personnel, but was ruled out partly by USAID reluctance to have more AID projects and partly because the project would have to shift to a new species of fly. Malawi had no *G. m. morsitans* and limited research facilities or personnel.

Of Tanzania the team concluded: adequate field populations of *G. m. morsitans* were available; laboratory facilities were generally adequate, but laboratory availability remained problematical because of possible conflict with the needs of the East African Community. Expertise on tsetse research was virtually nonexistent at that time and there was an apparent lack of specific information on field populations of *G. m. morsitans*. While field populations and laboratories existed in Tanzania, the team felt that the shortage of experienced senior tsetse staff would make the field work difficult and prolonged but the program could be conducted in this country.

Establishment of Tanzania Project

Following a subsequent joint AID/UN Food and Agriculture Organization (FAO) Mission in Tsetse Fly Control to East Africa in February 1969, attempts to involve the United Nations Development Program (UNDP), even with FAO requests, met with unbelievable delays. AID eventually responded to strong requests from USAID in Tanzania. The decision to locate in Tanzania was made in part because of the enthusiasm on the part of the Tanzanian Government and its Tsetse Control Unit. From the 1969 request by the Government of Tanzania to the arrival of the two ARS technicians in September 1971 took almost two years.

After eight months of frustratingly slow preparatory work and with construction already initiated at Morogoro, the team was ordered by the Ministry of Agriculture and Cooperatives to relocate to a 20-acre plot adjacent to the government livestock station at Tanga, over 200 km away. The building of the first unit at Tanga was scheduled for July 1. To the tribute of the research team, which did the construction work, the first goat house was operable on August 30, 1972, and a tsetse rearing complex partially stocked by September 15. This achievement in the face of serious obstacles was made possible by the diligence of the USAID Mission in encouraging and bolstering the support of the Ministry.

The forced change in location was not achieved without its toll, however. The delays, reversals, and frustrations ultimately resulted in the departure of the entire expatriate staff (the ARS Project Manager and an ARS entomologist and the Ministry's Project Co-Manager). In May 1973 the ARS Technical Advisor was called from Florida to assume temporary

direction of the research. A temporary Ministry entomologist was assigned to Tanga to assume charge of the station. ARS recruitment processes were accelerated and by July an ARS scientist had arrived; in November the ARS Project Manager was on site in Tanga.

From 1971 through 1973 was a most difficult period, one in which the program came close to foundering. However, after these prolonged growing pains, the program stabilized and gradually resumed its previous stature as a sound research endeavor.

Administrative Development of Tanzania Project

The work in Tanzania was conducted under the auspices and joint funding from the Technical Assistance Bureau (TAB) of AID and the Republic of Tanzania. ARS combined with the Division of Livestock (DL) of the Tanzanian Ministry of Agriculture (Kilimo) to create the facilities at Tanga, provide the staff, and conduct the research. Through the PASA, ARS was reimbursed for expenses incurred for the staff, equipment, travel, etc., administered from the U.S.; a separate allocation was transferred to Dar es Salaam, where the USAID mission provided fiscal support staff to manage the bookkeeping on local expenditures for animals, feed, medication, vehicles, etc. The Ministry of Agriculture provided about 70 permanent employees with funding for operation of the station at Tanga. The ARS Project Manager shared the administrative direction of the program with the DL Project Co-Manager, and the daily management of the research aspects was directed by the ARS Project Manager.

The facility at Tanga was built entirely by the project staff. Thus, in addition to evolving a research organization with both laboratory and field responsibilities, a major portion of the commitment from 1972-1977 involved construction activities (office building, 3 large insectary and animal holding complexes, irradiation building, animal quarantine, stores and garage facilities, and one residence).

Commodities and local services such as communication, transportation, facilities, and trained counterpart personnel were often unavailable and routinely had to be procured by alternative routes. Systems were devised to utilize as far as possible local resources, anticipate even minor requirements months in advance, and adapt project plans and operations to the local situation in order to maintain laboratory and field operational programs with minimum interruption.

Paramount among the logistical problems was the proper maintenance of vehicles. The routine laboratory operations of mass rearing tsetse flies required extensive vehicular travel for animal procurement and fly collection, transportation of personnel and supplies and materials, administrative duties, field surveys, and transportation of sterilized pupae to the field release site from the laboratory. The project had a

garage but lacked adequately trained mechanics or even one who could train and supervise locally-hired workers. Some 10% of the local USAID budget was spent to maintain vehicles, but the results were less than satisfactory and it was a constant struggle to keep vehicles in operating condition. The problem arose not only from the conditions under which the vehicles were used, but also because of the prevailing relatively high accident rate. Early in the project the average life of vehicles was ca. 6 months. Through the efforts of the AID Program Manager and ARS Project Manager an arrangement was worked out to allow ARS personnel to operate the vehicles themselves, which extended the vehicle life span to 1 to 2 years. This was not a trivial matter because research of this nature cannot be accomplished without sufficient reliable means of transportation.

Other locally-encountered operating problems included periodic and unannounced shortages or interruptions in building materials (e.g., nails, cement, paint), animal feed (concentrates and forage), electricity, and water supplies. During the construction of the laboratory facilities these shortages varied in severity and in the length of delay, but eventually systems were developed that reduced the impact of the hazards to the mass rearing program caused by these shortages. Standby generators, which were automatically activated when power failures occurred, helped protect against loss of climatic control in the rearing units. Water catchments were constructed to collect rain water, which was piped to humidifiers and used as needed to water the host animals. Station property was plowed and planted in hay grasses and other crops palatable to the goats and rabbits to supply the needs during shortages and reduce hay purchases.

Specialized equipment (e.g., humidifiers, air conditioners, special cage netting, and nontoxic glues) and scientific equipment often had to be procured outside the country from non-U.S. sources. The support received from the International Atomic Energy Agency (IAEA) and TRL in obtaining equipment and supplies available only in Europe played a major role in the success of this project. The minimum safe margin for ordering commodities from the U.S. was six months lead time. These needs were not always possible to predict and often the USAID mission could not give assistance in the specialized requirements; therefore it was largely due to the interest of these cooperating agencies that lack of supplies did not interupt the project.

Technical Progress in Tanzania

Three goals were sought in the Tanzanian program: (1) to establish and maintain a thriving colony of the tsetse fly *G. m. moraitana* in Africa; (2) to produce sufficient excess tsetse flies to conduct sterilization, release, and ecological studies, and to supply field test operations; and (3) to suppress or eradicate the indigenous *G. m. moraitana* in a large experimental area.

The program achieved each of these objectives by (1) establishment of the world's largest, self-sustaining colony of tsetse flies (*G. m. moraitana*) with an offtake of flies available for release, (2) development

of irradiation and handling techniques to allow the successful release of high quality sterile insects, and (3) control of the fly in the field by sequential releases following a temporary suppression of the natural fly population with a non-persistent insecticide. If it had been possible to totally isolate the experimental area from the effect of immigrating fertile flies, eradication might have been achieved. The high level of competitiveness of the released sterile flies and the level of population control achieved with this integrated program demonstrated that the SIT merits a role in trypanosomiasis control in Africa.

The *in vivo* rearing system developed at TRL was adopted at Tanga. To conduct large-scale rearing of the flies, it was first necessary to develop systems for housing and managing up to 600 goats and over 100 rabbits under tropical conditions. Indigenous goats and goats imported from Kenya were acquired and evaluated as tsetse hosts; unsuitable animals were culled from the herd and a selective breeding program was conducted with the remainder. A similar process was followed with rabbits, which were imported from Kenya and Europe. Disease prevention and control among the animals was a major concern as they were continuously maintained in groups indoors. The provision of an initial quarantine period, spacious well-ventilated housing, careful animal husbandry, and daily veterinary surveillance all contributed to the maintenance of a healthy and thrifty animal herd.

The fly colony was made up of ca. 50,000-55,000 females and 10,000-15,000 males. These stocks were maintained in three separate insectaries, each with its own animals, feeding rooms, and fly-holding rooms. The flies were fed daily on animals that were rested for 2 days between feeding days to prevent skin reactions. Strict precautions were taken to prevent insecticidal contamination of the colony area; these included changing clothes and washing prior to beginning work and routinely assaying animal foods for pesticide residues. Temperature, humidity, and photoperiod in the fly-rearing areas were strictly controlled. The fecundity of the Tanga strain of *G. m. moreitana* was somewhat lower than that of strains from other areas in Africa because of genetic factors; nevertheless, the female flies produced an average of 5-6 pupae with the highly acceptable mean weight of 29 mg. Of the male pupae, produced at a cost of $220/thousand, 28% were returned to the colony and 64% were actually released in the field.

The excess mature pupae from the rearing facilities were irradiated in a nitrogen gas atmosphere, which suppressed the emergence of flies during irradiation and reduced radiation damage in the somatic tissues of the fly. The pupae were separated by sex according to a system based on the differential developmental rates of males and females during the pupal stage, so most of the irradiated insects were males. Sterilization was achieved by exposure of pupae to 11.8 krads of gamma radiation in a cesium-137 irradiator. The irradiated pupae were chilled and transported by road to the field and placed under sand in special containers at each release site. Within just a few minutes the pupae warmed and the adults emerged synchronously and were automatically marked as they crawled up through the sand, which contained fluorescent powder.

The field site at Amboni Estate Ltd.'s Mkwaja Ranch was located near the coast of the Indian Ocean 95 km south of Tanga. In order to partially protect the experimental area from fly migration a 1-km-wide strip was cleared around the 70-km perimeter. During the experimental period the barrier was reinforced along the perimeter with residual applications of DDT on tree trunks to reduce the impact of immigrating flies. Surveillance of the 195 sq. km site revealed ca. 1300 *G. m. morsitans* and 600 *G. pallidipes* per sq. km and localized minor populations of *G. brevipalpis*. The distribution and dynamics of the population were determined with the assistance of computer program analyses of the data from the 200 km of flyrounds traversed weekly for 14 months in the experimental and control areas.

The field trial was initiated in November 1977 by first suppressing the tsetse population with 2 aerial sprays of endosulfan applied at 20 g/ha with a 28-day interval between sprays. Each application of this nonresidual aerosol gave virtually complete control of the adult tsetse, leaving females that subsequently emerged from pupae in the soil to be the target of sterile male releases.

The releases were made twice weekly at a monthly rate of 135 sterile males per sq. km by placement of irradiated pupae at each of 120 release sites. The pupae were distributed in a density pattern closely resembling the distribution of the indigenous fly population; each release site was visited once each 14 days. Approximately 27,000 sterile males were liberated monthly.

The released sterile males were highly effective and as a result the *G. m. morsitans* population was reduced to ca. 15% of its normal density and held at that level throughout the last 12 months of the release study. Extensive studies were conducted with marked flies released outside the barrier to determine the origin of the residual 15%. Calculations based on the observed number of marked flies that crossed the barrier revealed that the residual population was being maintained by immigrant flies and their progeny. The *G. pallidipes* population, which suffered the same degree of suppression from the aerial sprays but which was not under stress by sterile males, returned to its normal prespray density within a few months. During the release program the incidence of trypanosomiasis in cattle fell to only 16% when the vector population was low shortly after the aerial spray program, but returned to 36% when the check species, *G. pallidipes*, was again at normal strength.

Record-breaking rains fell during the experimental period and were in part responsible for the influx of flies from the surrounding habitat into the experimental area . They not only encouraged rapid grass and bush growth, which enhanced fly movement across the barrier, but they also reduced the effectiveness of the DDT deposits along the perimeter of the barrier. The DDT deposits were designed to provide a second line of defense against fly penetration because 1 km was a minimal clearing for suppressing fly movement, since game animals had unrestricted movement throughout the experimental and surrounding areas; the costs of creating a wider barrier for the research were prohibitive ($250,000 was expended upgrading and extending the previously existing barrier around Mkwaja Ranch).

In a practical situation, fly control would be conducted in an area large enough to include natural boundaries of tsetse populations and thus preclude migration as a factor.

The competitiveness of the released males was extremely high. When present at an average ratio of only 1 sterile male for each indigenous male, they held the indigenous population at 85-95% control. Had the barrier been fully effective, rather than only partially so, it is likely that complete control would have been achieved.

The objectives of rearing high quality flies and assessing the sterility method were met, but realistic estimates of costs for the practical use of the technique were not revealed. However, half of the rearing costs went to maintenance of the host animals. Reduction of these expenses would be very significant. *In vitro* rearing would accomplish such reductions. During the release trial a back-up colony of 10,000 *G. m. morsitans* (which never had to be used) was maintained *in vitro* by IAEA at its Seibersdorf Laboratory near Vienna, Austria. These flies performed as well as *in vivo*-reared flies when field-tested in Tanzania in 1979. Thus, significant reductions in rearing costs can be anticipated.

The results demonstrate that the use of sterile tsetse flies in operational programs to supplement pesticides can be realistically anticipated. How extensively the method will be used is dependent upon how effectively it complements program activities and meets fiscal and environmental requirements. In areas with multiple vectors, it may be necessary to release more than one species to eliminate trypanosome transmission. Although this will certainly increase the cost of the control operation relative to the release of a single species, such increases may be acceptable when compared with the rising cost of conventional control methods.

Technical Progress by Subcontractor (IAEA)

Outside research to complement that conducted in Tanga was considered a necessary adjunct to the long-range progress of the program. A major grant was awarded to IAEA in Vienna, Austria, to conduct research that could not be conducted at Tanga without tapping resources dedicated to the more direct goals.

IAEA research developed a method of *in vitro* feeding in which flies are fed on preserved blood covered by a silicone membrane. The method was improved by utilization of blood preserved by refrigeration after separating plasma from red blood cells and holding each fraction separately. A technique was developed to store blood for extended periods; plasma and red blood cell fractions, quick-frozen and dried under vacumn conditions, were stored at room temperature for over 90 days and then reconstituted and used for *in vitro* feeding. Effective methods were developed for colonizing and maintaining *G. pallidipes* on artificial membranes thereby revealing the feasibility of using SIT with this important East Africa species. A technique was devised for assessing the development of the egg in the ovary and the larva in the uterus of field-collected flies to determine the incidence of sterile matings that occur in the field, and assess sterile male competitiveness.

To provide a safeguard in the event of the loss of one or more *G. m. morsitans* insectaries at Tanga that might have resulted from the breakdown of rearing facilities, insecticidal contamination, etc., a backup colony of the Tanga strain was maintained in Vienna for two years to assure the ability to reestablish the field colony at Tanga during the release program. The standby colony of 10,000 females was reared and maintained by membrane feeding of refrigerated horse blood. In a field study conducted at Mkwaja Ranch the effectiveness of these membrane-fed tsetse flies was compared to that of the flies reared on live animals at the Tanga laboratory; no differences were observed in the longevity and dispersal between these two strains.

Cooperative Endeavors

From the onset of the program in 1964 the project management recognized the need for outside consultation and linkages with other institutions with expertise in the field of tsetse fly rearing and ecology.

A 4-year cooperative program was funded (1966-1969) with the Institute of Tropical Medicine in Lisbon, Portugal. The studies were primarily directed toward assessing the degree of behavioral change that occurs in tsetse flies as a result of adaptation to laboratory conditions and the colonization process.

An unfunded 3-year cooperative program with TRL was conducted to observe the level of adaptation of colonized *G. m. morsitans*. These studies culminated in the release in the original Rhodesian habitat of flies bred in the laboratory in England and the demonstration of their ability to survive and disperse as well as the flies in the indigenous population. This cooperative effort was initiated in 1967 and after its successful completion in 1969 the cooperation continued on a variety of topics (genetics, membrane feeding, training of project staff, consultancies, and a field trial of pheromones in Tanzania by TRL and ARS staff). In 1979 a special TRL study was funded through the PASA for an assessment of the visual selectivity of tsetse flies. This investigation, conducted with monochromator equipment supplied by ARS, has provided precise information on the specific wavelengths of light that are attractive to tsetse flies. The results in this study (to be completed in 1981) have revealed evidence sufficient to warrant field studies, which may eventually lead to significant improvements in the ability to monitor tsetse fly populations and also new methods for control of indigenous fly populations.

In 1972 subcontract arrangements were completed to fund a Cooperative Agreement between ARS and IAEA to support relevant research at the IAEA Seibersdorf Laboratory and to provide experts, service, and specialized materials not commercially available. This activity was instrumental in the development of practical membrane feeding techniques that otherwise may not have been successfully achieved. Studies on the effects of tsetse sterilization were also conducted as were other evaluations of rearing methodology. Approximately $250,000 was directed over a period of 8 years primarily to the membrane feeding technique and an assessment of its potential for operational use both in the European laboratory and in the field under African conditions. Because of this investment, the membrane feeding technique is now available for practical use in the proposed continuation of the program in Tanzania, and IAEA has initiated its own SIT research program with membrane-fed flies in Nigeria. During the SIT field trial, operated from the Tanga facility, IAEA maintained a 10,000 fly back-up colony at Seibersdorf (for

additional details see p. 14). This contract also provided the administration mechanism for funding the studies on spectral response of tsetse at TRL (cited above).

Training

A serious effort was made to include funds in the PASA for training but this was not approved. It was only through generous efforts of the USAID Director that the project was able to send three individuals to the U.S. for academic training; other individuals received short-term training in the U.K. at TRL. There was also an in-house training program at the technician level for individuals with particular capabilities.

The importance of training at all levels was recognized as a factor of major importance at the inception of the Tanzanian phase of the project. Despite this recognition, the process for implementing training was one of the more difficult and frustrating elements in the entire project. This was partly due to AID administrative restrictions on funding undergraduate and graduate training for research programs and partly due to limited availability of suitable candidates.

Tanzanian members of the staff had opportunities to take advantage of diploma and certificate-level training at Tanzanian insitutions even though such training was not available in the field of tsetse fly control. Therefore, participants in this training were subject to subsequent relocation because it made them eligible for more rewarding employment in other fields. In a sense this was good for Tanzania and beneficial for the individual, but it was detrimental to the research program, which lost trained personnel as a result, and emphasized the need to create a pool of well-trained technical people in order to retain the numbers of skilled people required to operate the technical and scientific programs.

Through a manpower development activity, initiated near the end of the project, AID was provided training grants for academic studies for as many Tanzanians as were qualified for undergraduate and postgraduate training in the United States. Here too, the training in some instances made these personnel available for employment in fields other than tsetse fly work. Thus, in order to increase the pool of capable individuals, there is a distinct need to accelerate the processes of preparing Tanzanians for academic training in Tanzania, and in other African institutions and European and American universities.

On-the-job and on-site training of junior staff, from laborers through several levels of technicians, was conducted with diligence by the expatriate and Tanzanian specialists. Higher level technicians were trained at TRL; these trainees were extremely valuable in the fly rearing operations at Tanga.

With the progress and success of this tsetse fly research the demand for additional people in this field may accelerate as Tanzania expands its scope of operation. Such expansion will require that experienced people have an incentive to remain with the program and that those completing their training have a formal commitment and an obligation to serve the Project for a specific period of time.

Association with Other International Organizations and Bilaterally Interested Governments

The contract with IAEA (see p. 13) provided a research program on membrane feeding of tsetse flies as well as a source of materials and equipment for Tanga. In 1964-65 IAEA partially funded ARC research activities in Rhodesia on irradiation of tsetse flies. In addition, the Agency administered the secondment of 2 staff members in Tanzania: the Project Co-Manager from 1972-1973, and a specialist in tsetse fly rearing from 1974-1980. An IAEA entomologist was seconded to Tanga to support the research program for two six-week periods. IAEA has had a prolonged and steadfast association with the PASA program. Also, FAO participated with AID in 1969 in the administrative arrangements for relocation of the program.

From 1974 through 1980, the project participated in the IAEA Program on Coordinated Research on the use of sterility for tsetse fly control. Meetings convened at 18-24 month intervals brought together research groups and provided a formal means of continued dialogue. This activity was exceptionally effective as a medium for discussion of research progress between Tanga scientists and those from West Africa and Europe.

The Overseas Development Ministry (ODM: U.K.) also had considerable input through the provision of consultants and the continued close association between both the Rhodesian and Tanzanian phases of the project with TRL. Cooperative studies on rearing and genetics were conducted and staff from the 2 laboratories exchanged visits on multiple occasions to conduct laboratory and field work. Formal training in tsetse fly rearing was conducted at TRL for both junior and senior staff members from Tanga; the training played a significant role in the establishment of proper colony management in Tanga. ODM provided a consultant from TRL on 3 separate occasions to assist in the establishment of proper colony procedures at Tanga. Another consultant (Center for Overseas Pest Research) provided technical assistance in the aerial application of insecticides to suppress the indigenous tsetse populations in conjunction with the release program at Mkwaja Ranch.

The World Health Organization (WHO) maintained a continued interest in the conduct of these investigations. One member of the ARS staff has served on the WHO Expert Committee on Parasitic Diseases (Trypanosomiasis) since 1968 as a result of the international interest in the SIT. Several WHO staff members visited Salisbury and Tanga and reviewed the research progress between 1964 and 1979.

Two internationally-supported institutions, based in Kenya, maintained an active interest in the SIT project at Tanga because of their involvement in tsetse and trypanosomiasis research. Staff of the International Center for Insect Physiology and Ecology (ICIPE) exchanged visits with the Tanga staff. The Tanga facility for a number of years regularly provided ICIPE with tsetse flies for research purposes. The International Laboratory for Research on Animal Diseases (ILRAD) exchanged visits of staff members with the Tanga staff.

Environmental Assessment

The Tsetse Fly Research Project was the first AID research activity required to prepare an Environmental Assessment Statement, which was completed in April 1977. The President's Council on Environmental Quality laid down the requirements including the selection and the professional qualifications of team members, which it approved. This Assessment might serve as a guideline for assessment of future AID research programs. Since the Assessment required preliminary study by the team in the U.S. and subsequently an on-site evaluation of several days, it was an expensive operation ($100,000) - a warning for the future preparation of budgets for projects requiring environmental assessments.

The following is the Summary Statement that concluded the lengthy, documented report:

> "The Environmental Assessment Team has concluded that the Tsetse Research Project, Tanga, Tanzania, will have negligible detrimental effects on the environment of the Project Laboratory at Tanga and the field test site at the Mkwaja Ranch. As a result, given the successful conclusion of the Sterile Male Insect Release Method, future tsetse fly eradication projects may be undertaken with 40 to 50% reduced dependence upon insecticide applications."

Aid Strategies

The Rockefeller Foundation and the Inter-African Bureau of Animal Resources (IBAR) convened a group of experts in 1978-79 to prepare a paper on Tsetse and Trypanosomiasis Control: A Strategy for the Future in Africa at the request of AID. This document deals with all aspects of the subject and includes a recommendation to assess the potential of the SIT for use in integrated control programs as soon as possible.

It was AID's original strategy to follow the pilot research, if it proved successful, with a large scale field operation program using the SIT. However, after the conclusion of the research only a small amount of bridging money was provided while discussions were being made on the exact nature of the next program and the proper sources of funding. During the course of the research phase it was also expected that the Development and Support Bureau (DSB) would support future programs with consultant services, participate in future meetings, and maintain liaison with programs in other African countries.

Plans were also developed to expand fly production at Tanga through the ad-addition of other fly species and by conversion to the membrane feeding technique to reduce the cost of production and eliminate the need for the maintenance of goats for feeding flies. If the expected production level were reached, it would then be possible to supply flies for field programs in Tanzania and perhaps in other East African countries as well.

It was envisaged that ARS staff at Tanga would be made available to other countries in the region to assist in setting up SIT programs until African scientific personnel were trained in sufficient numbers to fulfill such activities.

Recommendations were made in AID to support studies that might provide fly suppression methodology that would reduce the use of persistent insecticides, e.g., the use of microencapsulated pyrethrum, pheromones, and attractants. In preliminary laboratory or field trials at the Hebrew University of Jerusalem, ARS, ICIPE, and TRL, these approaches have shown promise as complementary measures. The development of these tactics should be pursued in future field trials as adjuncts to systems of suppressing fly populations to assure the effective application of SIT.

A further strategy was to maintain a strong linkage with TRL, IAEA, FAO, WHO, and the organizations and institutions in Africa interested in tsetse fly and trypanosomiasis control. Plans were also delivered to governments to encourage and sponsor attendance by qualified scientists and technicians to appropriate international meetings in entomology and particularly tsetse fly and trypanosomiasis conferences. Finally, a strategy was developed to encourage funding for SIT programs in other countries of Africa from UNDP, the World Bank, and other donors.

Project Reviews

In addition to the mandatory Research Advisory Committee (RAC) program reviews that were held regularly from 1964 through 1979, groups of international experts on tsetse flies and trypanosomiasis were formally convened in Tanga in 1974, 1975, and 1977 to inspect and review the program and to make recommendations. In 1979 the group met in Washington, D.C. to conduct a terminal review of the results of the completed program.

Although no on-site reviews were conducted between 1964 and 1969 due to political restrictions during the Rhodesian phase of the program, several special teams were funded to review the program from 1974 - 1980. In 1974 the American Technical Assistance Corporation reviewed the program and reported on considerations in the design of a field trial for tsetse fly control. A RAC-sponsored team in 1978 reviewed the progress of the research program in Tanga. In 1979, just prior to the repatriation of the ARS team, a review was conducted in Tanga and Dar-es-Salaam by a joint team of AID consultants and Tanzanian officials.

Host Government and Other In-Country Participation

During the Rhodesian phase of the program the Governments of Southern Rhodesia and of Rhodesia cooperated extensively with the research program, but the official project linkage was with ARC and UCR. Several field studies were conducted cooperatively with scientists of the Tsetse and Trypanosomiasis Control group of the Rhodesia Ministry of Agriculture. Also, one of the several project laboratories was built on the grounds of the Ministry of Agriculture's Veterinary Research Station in Salisbury. Without the full cooperation of the Government of Rhodesia, this work could not have been conducted, especially from 1966 to 1969 when the United Nations' mandated sanctions were being applied.

In Tanzania the formal linkage was with the Tanzania Ministry of Agriculture. Space was allocated for the project, first at Morogoro and then at Tanga, and a permanent staff of about 70 was assigned to duty at Tanga. Construction of the research facility at Tanga was done by the Tanzanian and ARS staff using funds provided from both U.S. and Tanzanian allocations. After the work was relocated at Tanga there was a continuous cooperative dialogue between the project and both funding organizations. Although there were some delays on occasion on the part of both Cooperators in fulfilling commitments, the desire to maintain progress usually resulted in the resolution of funding, personnel, equipment, and political problems. For example, in 1975 the Project Manager in his semi-annual report noted that the project was fortunate in receiving supplementary funds from the Ministry of Agriculture and that the increase in Officer strength was valuable to the advancement of the research effort. Furthermore, in spite of extreme shortage of housing in Tanga, the Government provided housing for most of the expatriate staff. To help offset the housing problems, AID purchased one residence in Tanga and provided materials for completion of a residence on the research station.

Amboni Estates Ltd. provided over 300 sq. km of Mkwaja Ranch for the field trials, which were conducted in concert with the Ranch's maintenance of over 12,000 head of cattle. In addition to providing this expansive test site, and housing and laboratory facilities for the team from Tanga, the Ranch Manager supervised a crew of over 200 laborers for the 2 years of bush clearing activities required to create a partial fly barrier around the experimental area. The Ranch Manager expressed great regret at the plan to phase the project out and when it was extended (temporarily) the Amboni management wrote a congratulatory letter to AID.

Although not formally linked to the program, the Government of Kenya provided short-term training for two ARS entomologists in pupal collection and field survey techniques, and sent observers to Tanga during the early stages of the investigations when the common international border was still open.

Proposed Extensions of Project

In 1973-74 considerations were given to the extension of the project beyond the field test at Mkwaja. At that time a tsetse fly control scheme was being developed in the West Lake Region by the Ministry of Agriculture's Tsetse Control Department. The USAID Mission and the Tsetse Control Department expressed interest in incorporating the SIT in this and another project, located at the National Livestock Ranch at Mzeri Hill Ranch. However, the timing was inappropriate since SIT was still in the research phase.

The first apparently serious proposal was generated in Zanzibar in September 1975. At the request of the Zanzibar Ministry of Agriculture and the U.S. Ambassador a team of ARS/AID/TRL experts associated with the Tanga project visited Zanzibar to investigate the feasibility of conducting a tsetse fly program on the island, using the SIT as the main component of the control effort. The consensus was that the characteristics of the island and the fly population made it an ideal location for a reasonably large scale field trial site. The team recommended that a formal fly survey be conducted under a separate AID contract as a prelude to consideration of a major program; unfortunately, the survey was not carried out.

In 1977 the USAID Mission requested future funding for continuing the work after completion of the 1978-1979 release trials at Mkwaja Ranch. In 1978, ARS submitted a tentative outline of work that invisaged conversion of the Tanga facility to a membrane rearing plant and developing the capability of rearing *G. pallidipes*; for the period required to complete these developments, a program for releasing sterile *G. austeni* on Zanzibar was proposed as an interim demonstration and training program. This led to a project proposal (PP) which was submitted to the Africa Bureau, where it was massaged first by the Program Office AID/W and later by the Program Office USAID/Dar es Salaam; these actions resulted in an unacceptable document, which was rejected when subsequently reviewed in Washington.

Since that time several temporary extensions have been funded in order to provide time for development of an acceptable proposal. However, in spite of initial strong support by DSB, the U.S. Ambassador in Dar-es-Salaam and ARS, there was no consensus within AID on the merits of the proposal.

In September 1979 ARS withdrew its staff from Tanzania, leaving one caretaker officer, because the PASA work had been completed and no commitment had been made by AID for future support. In October 1980 the caretaker officer was repatriated, leaving the Tanga facility without expatriate staff. Thus the extension of the project past the period of bridge funding remains in limbo. It would, indeed, be in AID's best interest to revive the PP and convene a group of technical personnel to put it into an acceptable condition.

There can be no doubt that the initial phase of this research successfully achieved its objective. At the present time other donor institutions and agencies are in the process of developing field programs

using the techniques developed in this program. If AID does not continue the program to fruition, credit for a major breakthrough may be defaulted to others in the eyes of the African countries that the United States is seeking to assist. Currently, many African scientists and administrators incorrectly assume that the results at Tanga were unsatisfactory, based solely on the fact that the ARS team was withdrawn.

In addition to Tanzania and Zanzibar there are other areas in Africa that are eligible for integrated fly control programs, e.g., Somalia. However, extension of the work in East Africa may require an adaptation of the rearing technique to other fly species, the most important of which is *G. pallidipes*. Studies funded by this project and conducted by IAEA in 1978-80 have revealed that *G. pallidipes* can be effectively reared on artificial membranes. Studies conducted earlier in Rhodesia demonstrated that this species can be sterilized with radiation in the same manner as with *G. m. morsitans*.

The Future for SIT

If AID wishes to capitalize directly on the accomplishments of this $6 million research activity, an opportunity through continuation of the project exists. However, each month that passes without a meaningful long range commitment increases the probability that the rearing capacity and expertise developed during the research at Tanga will be lost. Stop-gap, bridge funding is inappropriate for the preservation of program momentum at Tanga because qualified scientific staff cannot be procured in the absence of long-range goals. At this time, two years after the departure of the expatriate technicians, only a long-term, meaningful fiscal commitment could re-establish the positive momentum of the Tanga program.

The obvious goal would be to utilize SIT in operational programs designed to control trypanosomiasis in areas where the ecomomic return would merit the investment required. Conducting a training and demonstration program, for example on Zanzibar as suggested in the PP, would pave the way for effective operational programs. Now that membrane techniques are available for rearing both *G. m. morsitans* and *G. pallidipes*, the Tanga facility could be upgraded for this purpose, as outlined in the PP. After properly training the cadre by conducting a useful demonstration program on Zanzibar against *G. austeni* or elsewhere against *G. morsitans* and/or *G. pallidipes*, the Tanga facility could become an international center for training SIT cadre while at the same time conducting operational programs for trypanosomiasis control.

If AID extends further its 3-year debate on the decision of how to proceed from this point, the Tanga operation will fade away by default. However, ARS and AID administrators have reason to be proud of the research accomplishments of this program. SIT research operations in two other countries (Upper Volta and Nigeria) have been initiated as a direct result of the AID/ARS research investment. The attitude of international agencies has been changed from cautious doubt and skepticism to optimistic support for SIT as a tool that can help in the battle against trypanosomiasis. The pioneering research conducted in this program has induced strong international impetus and increasingly rapid progress in effective fly production technology.

Regardless of whether AID plays a future role in improving methods of controlling tsetse flies, it has already provided the support that was required by ARC, UCR, Kilimo and ARS to reveal the potential that SIT offers for trypanosomiasis control. Without further refinement, which is inevitable and desirable, SIT technology should now be within the reach of those African nations that are willing to commit adequate numbers of trained cadre. Where tsetse control is conducted, integrated programs utilizing SIT will require reduced amounts of pesticides and may be more economical than in the past.

Project Documentation

I. Project Publications and Manuscripts.

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II. Methods of sterilization, transportation and release of sterilized males. Williamson, D. L., H. Baumgartner, A. G. Mtuya, D. B. Gates, P. E. Cobb, and D. A. Dame.

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IV. Application of endosulfan as an aerosol prior to release of sterile males. Williamson, D. L., D. A. Dame, C. W. Lee, D. B. Gates, and P. E. Cobb.

V. The impact of sequential releases of sterile tsetse flies. Williamson, D. L., D. A. Dame, D. B. Gates, P. E. Cobb, B. Bakuli, and P. V. Warner.

An assessment of the suitability of the indigenous East African goat and hybrid goats as hosts for rearing *Glossina morsitans morsitans* Westwood. Warner, P. V., D. Mung'ong'o, H. Baumgartner, D. L. Williamson.

A three-year summary of morbidity, mortality, and reproduction in goats used as hosts for the tsetse fly *Glossina morsitans morsitans* Westwood in Tanzania. Warner, P. V., D. Mung'ong'o, E. Mrisho, and D. L. Williamson.

Tsetse fly feeding preferences as determined by a mobile electric grid trap in Tanzania. Gates, D. B. and D. L. Williamson.

C. Manuscripts in Preparation

In vivo rearing of *Glossina morsitans morsitans* Westw. in Tanzania (Diptera:Glossinidae)

I. Acquisition and development of host animals. Warner, P. V., D. L. Williamson, D. J. Gregory, A. Isangya, and E. Karosi.

II. Acquisition and development of the tsetse fly colony. Gates, D. B., D. L. Williamson, S. R. Mbise, H. M. S. Nkungu, and H. Baumgartner.

III. Design of a rearing and host animal facility. Williamson, D. L., P. V. Warner, S. R. Mbise, and H. Baumgartner.

D. Publications by Cooperators Resulting from Direct Support or Cooperative Activities

Bauer, B. and H. Wetzel. Effect of bacteria on tsetse flies fed through membranes. Proc. Symposium Sterility Principle for Insect Insect Control, IAEA/FAO, Innsbruck: 495-499. 1974.

Bauer, B. and H. Wetzel. A new membrane for feeding *Glossina morsitans* Westw. (Diptera:Glossinidae). Bull. Ent. Res. 65: 563-565. 1976.

Jaenson, T. G. T. and W. Takken. Rearing of *Glossina pallidipes* using membrane-feeding technology. Ent. exp. & appl. 27:102-104. 1980.

Jordan, A. M., M. A. Trewern, D. I. Southern, P. E. Pell, and E. D. G. Davies. Differences in laboratory performance between strains of *Glossina morsitans morsitans* Westwood from Rhodesia and Tanzania and associated chromosome diversity. Bull. Ent. Res. 67: 35-48. 1977.

Langley, P. A., P. M. Huyton, D. A. Carlson, and M. Schwarz. Effects of *Glossina morsitans morsitans* Westwood (Diptera: Glossinidae) sex pheromone on behaviour of males in field and laboratory. Bull Ent. Res. 71: 57-63. 1981.

Weiss, M. and W. Takken. Field studies with irradiated *Glossina morsitans morsitans* Westwood (Diptera:Glossinidae) from a colony maintained on a membrane feeding regimen. Bull. Ent. Res. 70: 221-227. 1980.

Wetzel, H. Rearing of *Glossina palpalis palpalis* Robineau-Devoidy on freeze-dried blood. Proc. IAEA Symposium on Isotopes and Radiation Research on Animal Diseases and their Vectors, Vienna: 439. 1980.

Wetzel, H. and B. Bauer. Influence of antibiotics on *Glossina morsitans* Westwood. Proc. Symposium Sterility Principle for Insect Control. IAEA/FAO, Innsbruck: 501-505. 1974.

Wetzel, H. and D. Luger. *In vitro* feeding in the rearing of tsetse flies (*Glossina m. morsitans* and *G. p. palpalis* Diptera: Glossinidae). Tropenmed. Parasit. 29: 239-251. 1978.

II. Reports

A. Insects Affecting Man and Animals Research Branch, ARS, USDA and Agricultural Research Council of Central Africa (Salisbury, Rhodesia)

1. Tsetse Fly Investigations, 1964 (1); Jan-Jun: 9 pp
Tsetse Fly Investigations, 1964 (2); Jul-Dec: 44 pp
Tsetse Breeding Project, 1964 (1); Jan-Jun: 12 pp
Tsetse Breeding Project, 1964 (2); Jul-Dec: 29 pp
Tsetse Fly Investigations, 1965 (1); Jan-Jun: 20 pp
Tsetse Fly Investigations, 1965 (2); Jul-Dec: 46 pp
Tsetse Fly Investigations, 1966 (1); Jan-Jun: 32 pp
Tsetse Fly Investigations, 1966 (2); Jul-Dec: 63 pp
Tsetse Fly Investigations, 1967 (1); Jan-Jun: 66 pp
Tsetse Fly Investigations, 1967 (2); Jul-Dec: 54 pp

2. 1964 Annual Report, Agricultural Research Council of Central Africa: 44-53
1965 Annual Report, Agricultural Research Council of Central Africa: 63-68
1966 Annual Report, Agricultural Research Council of Central Africa: 76-77, 90-97
1967 Annual Report, Agricultural Research Council of Central Africa: 41-46, 49-65

B. Insects Affecting Man and Animals Research Branch, ARS, USDA and University College of Rhodesia (Salisbury, Rhodesia)

1. Tsetse Fly Investigations, 1968 (1); Jan-Jun: 30 pp
Tsetse Fly Investigations, 1968 (2), 1969 (1); Jul-Jul: 60 pp
Tsetse Fly Investigations, 1969 (2); Jul-Dec: 12 pp

C. Agricultural Research Service, USDA and Division of Livestock, Tanzania Ministry of Agriculture (Tanga, Tanzania)

1. Research on Sterility Methods of Tsetse Fly Control, Sep 1971-Sep 1972: 2 pp
Research on Sterility Methods of Tsetse Fly Control, Sep-Dec 1972: 5 pp
Research on Sterility Methods of Tsetse Fly Control, Sep 1972-Feb 1973: 17 pp
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Tsetse Research Project, Jun 1976-June 1978: 43 pp

2. Tsetse Research Project Monthly Reports, Jun 1973-Sept 1980

D. Tsetse Fly Research Review Panel

1. 1974 Tsetse Fly Project Review Committee, Tanga: 7 pp
   1975 Tsetse Fly Project Review Committee, Tanga: 12 pp
   1977 Tsetse Fly Project Review Committee, Tanga-Mkwaja: 40 pp
   1979 Tsetse Fly Project Review Committee, Washington: 13 pp

E. Cooperators

1. Institute of Tropical Medicine, National School of Public Health and and Tropical Medicine, Lisborn, Portugal.

   (a) The breeding in the laboratory of a Rhodesian colony of *Glossina morsitans* (1967-1968):

      I. The first results of the colony evolution: 31 pp
      II. Evolution of the first to sixth generations: 20 pp

2. Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture, Vienna, Austria.

   (a) Entomology Quarterly Reports, Seibersdorf Laboratory, 1972-1981.

F. Consultants, External Review Teams, and Special Missions

1. Tsetse Fly Survey Team (East and Central Africa) Sep-Oct, 1968: 23 pp. D. A. Dame, N. Konnerup, J. G. Matthysee, and C. H. Schmidt.

2. Joint AID/FAO Mission of Tsetse Fly Control to East Africa, Feb, 1969: 41 pp. E. J. Buyckx, D. A. Dame, N. Konnerup.

3. Report of Tsetse Research Project Co-manager (IAEA Contract Termination), May 1973: 4 pp. D. C. Robertson.

4. Progress in Tsetse Rearing Aspects of the Tanzanian Government/U.S. Department of Agriculture Tsetse Research Project, Tanga,

   (a) Feb. 1973: 8 pp A. M. Jordan
   (b) Nov. 1973: 10 pp A. M. Jordan
   (c) May, 1974: 7 pp A. M. Jordan

5. Observations on the Tanga (Internal) colony of *Glossina morsitans* with suggestions for future work, Jun, 1973: 10 pp. E. D. Offori.

6. Considerations in the design of a field trial for tsetse fly control, Dec, 1974: 81 pp. H. C. Olson, R. A. Ward, E. W. Kehrberg.

7. Comments on and suggestions for the field programme of the Tsetse Research Project, Aug, 1975: 4 pp. J. M. B. Harley.

8. Status of the sterile insect release - tsetse fly. Apr, 1976: 26 pp. R. Wesselman.

9. The Tsetse Research Project - an environmental assessment, Apr, 1977: 28 pp. R. Adams et al.

10. Aerial spraying technique prior to sterile male release for tsetse control at Mkwaja Ranch, Tanzania, Nov, 1977: 22 pp. C. W. Lee.

11. Review of the USAID tsetse fly project and possible future tsetse fly projects. Jul, 1978: 12 pp. J. H. Ehrenreich and R. A. Ward.

12. Sterility method for tsetse fly control (review of tsetse fly project), Aug. 1979: 18 pp. J. G. Matthysee, S. Kunz, R. Wright, L. L. Ilmolelian, and L. Machibya.

Project Scientific Personnel

I. Senior Staff

A. Rhodesia:

Dr. D. A. Dame	ARS Project Leader, Entomologist	1963-69
Mr. J. Ford	ARC Project Leader, Entomologist	1964-65
Dr. R. J. Phelps	ARC Project Leader, Entomologist	1965-67
Mr. G. J. W. Dean	ARC/UCR, Entomologist	1965-69
Dr. E. Hajdu	ARC, Entomologist	1965
Ms. R. C. Heaversedge	UCR, Entomologist	1967-69
Mr. H. R. Ford	ARS, Technician	1964-65
Mr. D. R. Birkenmeyer	ARS, Technician	1966-69
Mr. R. Borthwick	ARC, Experimental Officer	1965-66
Ms. S. A. Clements	UCR, Experimental Officer	1967-68
Mr. A. Douglas-Jones	UCR, Experimental Officer	1967-69
Mr. H. J. Kidner	UCR, Experimental Officer	1969
Ms. H. C. Mousley	ARC, Experimental Officer	1965-67
Mr. J. Paget	ARC, Experimental Officer	1966-67
Ms. W. Petrie	UCR, Experimental Officer	1968-69
Mr. K. Rhodes	ARC, Experimental Officer	1964-67
Ms. P. W. Salt	UCR, Experimental Officer	1968-69
Ms. A. L. C. Tingay	ARC, Experimental Officer	1964-66
Mr. B. R. Williamson	ARC/UCR, Experimental Officer	1966-67
Mr. F. Wilson	ARC, Experimental Officer	1964-66
Ms. S. Wortham	ARC, Experimental Officer	1965-66

B. Tanzania:

Dr. D. A. Dame	ARS, Technical Advisor, Entomologist (Gainesville, FL)	1972-80
Dr. B. G. Hightower	ARS, Project Manager, Entomologist	1971-73
Mr. D. C. Robertson	Kilimo Project Co-Manager, Biologist	1971-73
Dr. D. L. Williamson	ARS Project Manager, Entomologist	1973-79
Mr. S. R. Mbise[a/]	Kilimo Project Co-Manager, Field Officer	1974-75
	Project Co-manager, Entomologist	1979-80
Mr. A. M. Mwashala[a/]	Kilimo, Tsetse Officer	1971-73
	Project Co-Manager	1975-76
Mr. A. G. Mtuya	Kilimo, Research Officer	1975-76
	Project Co-Manager	1977-78
	Research Officer	1979-80
Mr. H. Baumgartner	IAEA, Rearing Specialist	1974-80
Mr. D. R. Birkenmeyer	ARS, Entomologist	1971-72
Mr. P. E. Cobb	ARS, Entomologist	1975-79
Dr. E. R. Easton	Kilimo, Entomologist	1973-74
Mr. D. B. Gates	ARS, Entomologist	1973-79
Dr. D. J. Gregory	AID, Veterinarian/Entomologist	1974-75
Ms. S. A. Tarimo[a/]	Kilimo, Biologist	1975-77
Dr. P. V. Warner	ARS, Veterinarian	1976-79
Mr. B. G. Bakuli	Kilimo, Asst. Field Officer	1975-80
Mr. O. S. Chalo	Kilimo, Asst. Field Officer	1972-80
Ms. A. Isangya	Kilimo, Asst. Field Officer	1973-80
Mr. E. M. Karosi	Kilimo, Asst. Field Officer	1974-79
Mr. G. Kithama	Kilimo, Asst. Field Officer	1976-79
Mr. R. C. A. Kweka	Kilimo, Field Officer	1976-78
Ms. J. Lubuva	Kilimo, Asst. Field Officer	1975-77
Ms. E. Mrisho	Kilimo, Asst. Field Officer	1973-80
Mr. J. P. Mtui	Kilimo, Asst. Field Officer	1977-80
Mr. D. Mung'ong'o	Kilimo, Asst. Field Officer	1977-80
Mr. E. A. Mwakyolo	Kilimo, Asst. Field Officer	1973-78
Mr. H. M. Nkungu	Kilimo, Asst. Field Officer	1971-78
Mr. P. Semwenda	Kilimo, Asst. Field Officer	1977-80

a/ Provided training in USA leading to B.Sc., M.Sc., or Ph.D.

II. Cooperators and Consultants

A. Rhodesia:

Prof. J. Fraga de Azevedo	Institute of Tropical Medicine, Portugal
Ms. M. Bolton	Ministry of Agriculture, Rhodesia
Prof. E. Bursell	Univ. College of Rhodesia, Rhodesia
Dr. R. de Costa Pinhao	Institute of Tropical Medicine, Portugal
Dr. A. M. Jordan	Tsetse Research Laboratory, U.K.
Mr. P. K. I. MacKenzie	Ministry of Agriculture, Rhodesia
Dr. T. A. M. Nash	Tsetse Research Laboratory, U.K.
Mr. R. D. Pilson	Ministry of Agriculture, Rhodesia

B. Tanzania:

Dr. B. Bauer	International Atomic Energy Agency, Austria
Dr. D. A. Carlson	Agricultural Research Service, USA
Dr. R. Galun	Hebrew University, Israel
Mr. M. K. Gao	Ministry of Agriculture, Tanzania
Dr. D. G. Haile	Agricultural Research Service, USA
Mr. J. M. B. Harley	Commonwealth Institute of Entomology, U.K.
Dr. L. L. Ilmolelian	Ministry of Agriculture, Tanzania
Dr. T. G. T. Jaenson	International Atomic Energy Agency, Austria
Dr. A. M. Jordan	Tsetse Research Laboratory (ODM) U.K.
Dr. K. R. Kern	Iowa State University, USA
Dr. N. Konnerup	Agency for International Development, USA
Dr. G. C. LaBrecque	International Atomic Energy Agency, Austria
Dr. P. A. Langley	International Atomic Energy Agency, Austria Tsetse Research Laboratory, U.K.
Dr. C. W. Lee	Centre for Overseas Pest Research, U.K.
Mr. J. G. LeRoux	Ministry of Agriculture, Kenya
Dr. D. A. Lindquist	International Atomic Energy Agency, Austria Agricultural Research Service, USDA, USA
Dr. A. R. Mews	International Atomic Energy Agency, Austria
Dr. T. A. M. Nash	Tsetse Research Laboratory, U.K.
Dr. C. H. Schmidt	Agricultural Research Service, USA
Dr. J. M. Skovlin	Forest Service, USDA, USA
Dr. W. Takken	International Atomic Energy Agency, Austria
Dr. P. Vail	International Atomic Energy Agency, Austria
Dr. A. N. V. van de Vloedt	International Atomic Energy Agency, Austria
Dr. M. Weiss	International Atomic Energy Agency, Austria
Dr. H. Wetzel	International Atomic Energy Agency, Austria

Visitors at Tanga

A partial list of visitors to the Tanga Laboratories and the project from 1975 through 1980 has been compiled. It should be noted that the number of visitors is extraordinarily large for a location in a rather remote area of Africa. The visitors include scientists, administrators, representatives of international institutions and industry, teachers, students, missionaries, and tourists. If one notes the many students from many American, African, and European countries including the USSR, it is obvious that the program has drawn the interest of the faculties of institutions in those areas. The program also attracted the news media and the film industry. An American and a German documentary film were produced and the project was featured in Nova's "The Tsetse Trap" (BBC), which was aired throughout the world.

No attempt has been made to include all the Tanzanian officials and students who have visited. Indeed, the list is far from complete and concentrates primarily on personnel from the scientific communities; many of this group have returned periodically in order to keep abreast of research developments.

Abdel-Razig, M. E.	FAO	Ghana
Adams, R.	University of Chicago	USA
Akatekwa, G.	Vet Services	Zambia
Alberolie,H.	Dept. Zoology	UK
Albers, U.	Amboni Ltd.	Switzerland
Albinns, B.	--	Denmark
Alford, P.	Gen. Air Services	Swaziland
Alsop, N.	Hoescht	Botswana
Amman, H. P.	Amboni Ltd.	Switzerland
Andrews, B.	London Sch. Trop. Med.	England
Armbrester, V.	West Virginia University	USA
Aronour, L.	American Embassy	Tanzania
Arvan, M.	Vet Services	Zambia
Baldry, D.	WHO	Switzerland
Balize, P.	World Bank	Tanzania
Bauer, B.	IAEA	Austria
Beck, E.	Parasitology Inst.	Germany
Beinhauer, W.	CVL	Tanzania
Bevins, R. J.	University of Missouri	USA
Bianco, T.	London Sch. Trop. Med.	England
Blaser, E.	Mkwaja Ranch	Tanzania
Bondet, C.	Pasture Res.	France
Bryan, J.	MRC Fajara	The Gambia
Burns, M.	USAID	Tanzania
Carlson, D.	USDA/ARS	USA
Carter, N.	Ciba-Ceigy	Kenya
Cavanah, H. E.	University of Missouri	USA
Chaudhury, M.	ICIPE	Kenya
Chernush, K.	AID/W	USA
Chizyuka, H.	Vet Services	Zambia

Christie, J.	Vassar College	USA
Clark, N. T.	World Bank	Kenya
Collins, W.	C.D.C.	USA
Craig, G. B.	University of Notre Dame	USA
Crouch, E.	May & Baker Ltd.	England
Cuisance, D.	IEMVET	Upper Volta
Curtis, C.F.	London School of Hygiene	England
Dadialo, L.	--	Italy
Danjo, H.	Technical AID	Germany
Davenport, C.	AID/W	USA
Dawson, B.	New Zealand Tech. Assistance	Tanzania
Deep, R.	USAID	Tanzania
Dieck, W.	German TV	Kenya
Dohan, T.	EAVRO	Kenya
Duffield, P.	IITA	Tanzania
Duke, B.	WHO	Switzerland
Eagle, S.	Masai Project	Tanzania
Ehrenreich, J.	University of Idaho	USA
Ekern, A.	Agr. University	Norway
Eng, R.	AID/W	USA
Eny, L.	Dairies Laboratory	Australia
Fedenco, G.	--	Italy
Ferguson, D.	AID/W	USA
Field, D.	Tourist	Botswana
Finelle, P.	FAO	Italy
Fisher, J.	Masai Project	Tanzania
French, C.	S.B.S.	Tanzania
Friedericks, K.	Parasitology Inst.	Germany
Galun, R.	Hebrew Univ. of Jerusalem	Israel
Galvin, T.	Texas A & M University	USA
Gleeson, P. A.	Agric. Institute	Ireland
Goldwyn, E.	B.B.C.	England
Gonzalues, A.	Vet. Institute	Mozambique
Goodwin, J.	Texas A & M University	Mali
Griene, D.	Hoechst.	Kenya
Gremwood, J.	Tanga Harbour	Tanzania
Hagan, A.	University of Missouri	USA
Haile, D.	USDA/ARS	USA
Hansen, E.	Road Betterment Unit	Tanzania
Hamon, J.	WHO	Switzerland
Halbakken, D.	USAID	Tanzania
Hedges, S.	B.B.C. World Serv.	England
Helle, W.	University of Amsterdam	Holland
Henning, C.	--	Germany
Henson, J.	ILRAD	Kenya
Hewett, R.	Consultant	USA
Higby, A. G.	--	Kenya
Hilland, R.	Gen. Air Services	Swaziland
Hitchcock, J.	WHO Filariasis Project	Tanzania
Hohne, H.	West Berlin University	Germany
Horchnor, F.	Parasitology Inst.	Germany
Houston, J.	Colby College of Agriculture	Malawi
Howe, W.	New Zealand Tech. Assistance	Tanzania

Huyton, P.	Tsetse Research Laboratory	England
James, W.	AID/W	USA
Jegour, J.	Tourist	Tanzania
Johns, V.	USAID	Tanzania
Jordan, A. M.	Tsetse Research Laboratory	England
Jorgensen, K.	Olf Stadsing Ltd.	Denmark
Juma, O.	Chief Vet. Officer	Zanzibar
Kaiser, W.	EAVRO	Kenya
Kalhammer, F.	USAID	Kenya
Katondo, K. M.	OAU	Kenya
Kern, R.	Iowa State University	USA
Kessy, S.	Hoechst	Tanzania
Khanbhai, M.	Amboni Ltd.	Tanzania
Khovri, R.	World Bank	Kenya
Kilborne, M.	Pilot	Swaziland
Kovatch, B.	Walter Reed Hospital	Kenya
Kozak, A.	Amboni Ltd.	Switzerland
Kreitz, D.	Tourist	USA
Kruse, G.	German TV	Kenya
Kunkel, H.	Texas A & M University	USA
Kunz, S.	USDA/ARS	USA
LaChance, L.	USDA/ARS	USA
Ladenheim, H.	AID/W	USA
Langley, P.	Tsetse Research Laboratory	England
Laurens, I.	FAO	Tanzania
Laurent, L.	USDA	USA
Lawrence, L.	West Virginia University	USA
Lee, C. W.	COPR	England
Lemon, P.	Consultant	USA
LeRoux, J.	Ministry Agriculture	Kenya
Lindquist, D.	USDA/ARS	Austria
Lindstrom, U. B.	Dept. An. Agr. Research	Finland
Lofthouse, E.	AID/W	USA
Logan, L.	Texas A & M University	Mali
Lonnfors, M.	Finnish An. Breeding Assoc.	Finland
Lorimer, N.	ICIPE	Tanzania
Lou, F.	Technical AID	Germany
Lounibos, L. P.	ICIPE	Tanzania
Lyimo, S.	Student	USSR
MacDougal, H.	American Embassy	Tanzania
Maiga, S.	Cent. Vet. Laboratory	Mali
Matlhatlhedi, F.	Egerton College	Kenya
Matthysse, J. G.	Entomologist	USA
Maxwell, R.	Kilimo	Tanzania
McGreevy, P.	London Sch. Hyg.& Trop. Med.	England
McIntyre, I.	Glasgow University	England
Mekuria, Y.	Cent. Lab & Res. Inst.	Ethiopia
Meyerhoff, K. H.	--	Germany
Miller, C.	May & Baker Ltd.	Kenya
Moloo, D.	ILRAD	Kenya
Mrema, A.	Tanzania Nat. Sc. Res. Council	Tanzania
Msangi, A.	University of Nairobi	Kenya
Mtete, W.	Egerton College	Kenya
Nassor, S.	Kilimo	Zanzibar
Nikundiwe, A. M.	Univ. of Dar es Salaam	Tanzania

Nogge, G.	IAEA	Austria
O'Farrell, K.	Agric. Institute	Ireland
Offori, E.	IAEA	Austria
O'Keefe, T.	AID/W	USA
Otieno, R.	ICIPE	Kenya
Patterson, R.	USDA/ARS	USA
Paulsen, D.	EAVRO	Kenya
Petch, H. G.	--	England
Peters, N.	Liverpool School Trop. Med.	England
Petersen, J.	ICIPE	Tanzania
Philip, T.	Nabo Engineering Works	Tanzania
Pitts, S.	USAID	Tanzania
Politzar, H.	DSTZ	Upper Volta
Purcell, C.	AID/W	USA
Reish, R.	Technical AID	Germany
Robertson, D.	Ciba-Geigy	Saudi Arabia
Rodgers, W.	Univ. of Dar-es-Salaam	Tanzania
Rossiter, I.	World Bank	Tanzania
Rusha, C.	World Bank	Tanzania
Schoeller, W.	Amboni Ltd.	Switzerland
Schmidt, C.	USDA/ARS	USA
Seorneby, M.	--	Sweden
Shaffer, M.	ISM	Tanzania
Shermen, R.	Ciba-Geigy	Tanzania
Shoo, T.	WHO Filariasis Project	Tanzania
Shyler, V.	--	USA
Simnonson, S.	SLP	Tanzania
Singh, M.	Ranchi University	India
Skolvin, J.	USDA/FS	USA
Smiley, K.	Missionary	Ireland
Sooboda, A.	German TV	Kenya
Sousa, L.	Min. Agric.	Mozambique
Southerland, D.	World Bank	USA
Starnes, O.	Rockefeller Foundation	Kenya
Stelzer, E.	--	Austria
Steverson, H.	USAID	Tanzania
Stoops, D.	World Bank	USA
Storlokeken, K.	--	Tanzania
Strangeways Dixon, J.	ICIPE	Kenya
Stternstedt, R.	--	Zambia
Suchovsky, P.	Amboni Ltd.	Switzerland
Sukumba, B.	World Bank	Tanzania
Tanberg, F.	USAID	Tanzania
Taze, Y. R. R.	Tsetse Research/Training	Zambia
Ternu, S. E.	Malaria Institute	Tanzania
Thomas, C.	FAO	Tanzania
Thompson, P.	Tourist	USA
Todd, D.	Department of State	USA
Torriani, A.	Amboni Ltd.	Tanzania
Uilenberg, G.	Cent. Vet. Laboratory	Tanzania
Vail, P.	IAEA	Austria
Van der Vloedt, A.	IAEA	Austria
van Harn, A.	Harvard	USA
van Harn, C.	Children's Hospital	USA
Wachale, J.	Missionary	Ireland
Wagner, G.	USDA	Kenya
Walker, J.	AID/W	USA

Ward, R.	Walter Reed Army Inst. Res.	USA
Warren, M.	C. D. C.	USA
Watts, R.	Tourist	England
Weiss, M.	IAEA	Austria
Wettach, F.	Agava Trading Hs.	Switzerland
Wetzel, H.	IAEA	Austria
Wills, G. N.	Tourist	Zaire
Wilson, G.	Twiga Chemicals	Tanzania
White, G.	WHO Filariasis Project	Tanzania
Whittle, H.	A.B.U. Hospital	Nigeria
Wright, R. E.	Oklahoma University	USA
Wyers, D.	Med. Res. Center	Kenya
Zahar, A. R.	WHO	Geneva

Additional Information Sources

Biannual Reports of the AID Research Advisory Committee (1965-1979)

Application of Sterility Principles for Tsetse Fly Suppression

IAEA Report of Expert Planning Group. Atomic Energy Review 10: 101-130, 1972.

Tsetse and Trypanosomiasis Control: A Strategy for the Future in Africa (J. J. McKelvey, Task Force Chairman)

Interafrican Bureau for Animal Resources/Rockefeller Foundation, Nairobi/New York. 51 pp. 1979.

Programme for the Control of African Animal Trypanosomiasis and Related Development. FAO, Rome 1979.

A Report on African Animal Trypanosomiasis. (E. Wedman, AID Consultant) 1980.

The Environmental Impact of Tsetse Control Operations. J. H.Koeman, W. Takken, FAO. Annual Production and Health Paper No. 7. 44 pp. 1978.

The African Trypanosomiases. Report of a Joint WHO Expert Committee and FAO Expert Consultation. WHO Technical Report Series No. 635. 96 pp; also FAO Animal Production and Health Paper No. 14. 96 pp. 1979.

Tsetse: The Future for Biological Methods in Integrated Control (M. Laird, Editor). International Development Research Centre (Ottawa) Publication IDRC-077e. 220 pp. 1977.

Insecticides and Application Equipment for Tsetse Control. FAO Animal Production and Health Paper No. 3. 72 pp. 1977.