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AFRICAN TRYPANOSOMIASIS

by

David H. Molyneux, Ph.D.

September 1991

VBC Tropical Disease Paper No. 7

Other papers in the VBC series include:

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Life cycle illustration: Taina Litwak
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The blue square shows a trypanosome, the parasite that causes sleeping sickness. The other symbols depict essential components of vector-borne disease control: the environment, communities and research.

Author

David H. Molyneux, Ph.D., is Director of Research at the Liverpool School of Tropical Medicine. He has been a member of several national and international committees on African trypnosomiasis research and control.

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Executive Summary

African sleeping sickness is endemic in 36 countries where the vector, the tsetse fly (*Glossina*), is found. Recent estimates suggest that some 50 million people are at risk of acquiring the disease and at least 25,000 new cases occur every year.

Two forms of the disease are recognized. An acute infection caused by the more virulent *Trypanosoma brucei rhodesiense*, rhodesian sleeping sickness is found in east and south-central Africa. The chronic *T. b. gambiense*, or gambian sleeping sickness, is found in west and central Africa. A third form, *T. b. brucei*, causes "nagana," an immensely important disease of livestock.

Major epidemics with high mortality have occurred several times in this century. Half a million deaths were reported in Zaire from 1896 to 1906. Another epidemic along Lake Victoria killed approximately 250,000 people. Outbreaks of both forms of sleeping sickness continue to occur in areas of Uganda, Rwanda, Kenya, Zaire and Sudan.

Gambian sleeping sickness is largely dependent on transmission between humans and tsetse flies, but a peridomestic cycle including pigs, dogs and cattle is also possible. Antelopes and other game serve as reservoirs of rhodesian sleeping sickness in the wild, and cattle are domestic reservoirs.

Both forms of the disease are almost invariably fatal if untreated. Symptoms in the disease's early stages include intermittent fevers, headaches, swollen glands, intense itching and general malaise. When the central nervous system is invaded, the predominant symptoms reflect pathological changes in the brain, often leading to drowsiness, somnolence and eventually a comatose state.

Early-stage sleeping sickness is easier and less hazardous to treat than late-stage disease. Suramin is used for treating *T. b. rhodesiense*. Suramin or pentamidine can be used for treatment of early stages of *T. b. gambiense*.

Late-stage sleeping sickness has been treated with melarsoprol, but the drug's side effects can lead to death and many cases are refractory to treatment. Over 90 percent of more than 600 patients with late-stage gambian sleeping sickness who had not responded to treatment with melarsoprol have been cured with a new drug, eflornithine. Both melarsoprol and eflornithine are expensive (about $140 per patient) and require several weeks of hospitalization. Unlike melarsoprol, eflornithine is not effective against *T. b. rhodesiense*.

Human trypanosomiasis is focal because tsetse fly distribution is restricted to specific vegetational habitats, including riverine forests, savannah and scrub. Early control measures based on destruction of game and tsetse habitats were effective, but have been largely abandoned for conservation purposes.

Recently traps have proved an effective tool for tsetse control. Scent-baited traps impregnated with pyrethroid insecticides are very efficient in reducing local populations of vectors in both West and East Africa. A pyramid-shaped trap that does not require insecticides has also shown great promise. Traps are inexpensive and, with appropriate training, can be maintained by community members.

1. Introduction

African human trypanosomiasis, or sleeping sickness, is caused by a protozoan parasite of the genus *Trypanosoma*. Humans acquire infection from the bite of an infective tsetse fly of the genus *Glossina*. Two forms of the disease are recognized: an acute infection caused by the more virulent *T. brucei rhodesiense*, which is found in eastern and south-central Africa, and the chronic *T. b. gambiense*, found in west and central Africa.

a. Symptoms

Both types of sleeping sickness are almost invariably fatal if left untreated. In *T. b. rhodesiense*, the first symptom is a lesion, or chancre, at the site of the bite where trypanosomes begin to divide. Chancres are rarely seen in *T. b. gambiense*, but this may be because of its long incubation period. With *T. b. gambiense*, symptoms do not appear for months or even years after infection, compared to *T. b. rhodesiense*, which has an incubation period of only a few weeks.

The symptoms in the early stages of the disease, when parasites are confined to blood and body tissues, are not specific. They may include fever, headaches, general malaise, weight loss, intense itching, anemia, amenorrhea in women and impotence in men. Swollen glands in the back of the neck are an early symptom of gambian sleeping sickness known as Winterbottom's sign.

During the late stage, when parasites invade the central nervous system (CNS), the predominant symptoms reflect pathological changes in the brain. Sleeping sickness patients are drowsy during the day and cannot sleep at night. Other late-stage symptoms include blank stares, mood changes, convulsions and slurred speech. Patients are unable to coordinate body movements and may suffer partial or total paralysis. They become uninterested in their surroundings and unable to concentrate or even to eat because their sleepiness becomes overpowering. Eventually, they fall into a coma and die.

Symptoms can vary greatly from one patient to the next. Early-stage symptoms can also occur during the late stage of the disease.

b. Biogeography

Human trypanosomiasis occurs only where the tsetse fly is found, in Sub-Saharan Africa north of the Kalahari desert. The distribution of the two forms is shown in Map 1. Human trypanosomiasis is generally focal because tsetse fly distribution is restricted to specific vegetational habitats, including riverine forests, savannah and scrub. Some 100 sleeping sickness foci are recognized throughout the endemic region.

Thirty-six countries in sub-Saharan Africa are known to be within the endemic area.

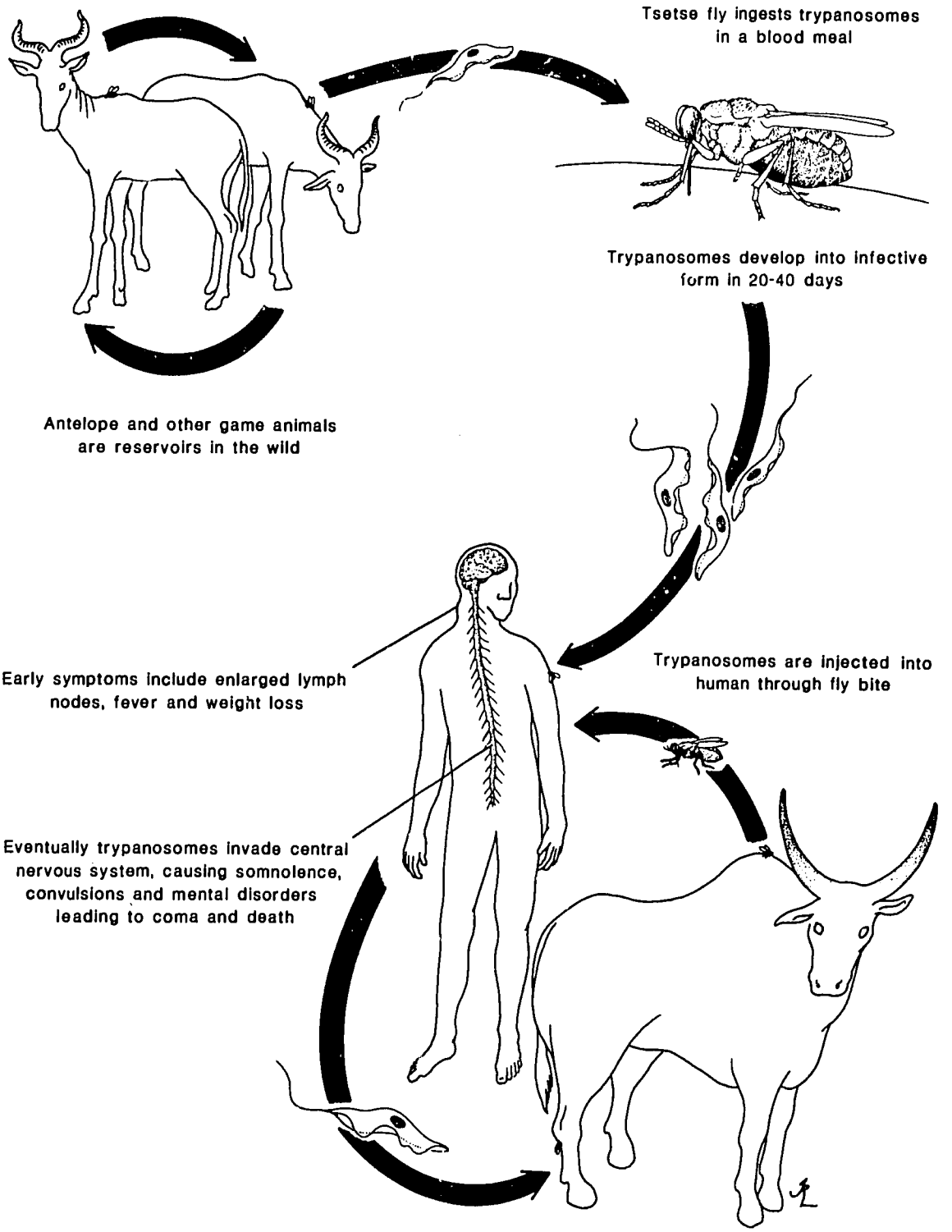
c. Agents

The genus *Trypanosoma* is parasitic in the blood of many vertebrates and is transmitted by a variety of bloodsucking vectors. The trypanosomes that cause disease in animals and humans in Africa are all transmitted by the bite of the fly *Glossina*. They develop to infective forms in the salivary glands and mouthparts of the fly (see life cycle, p. 5).

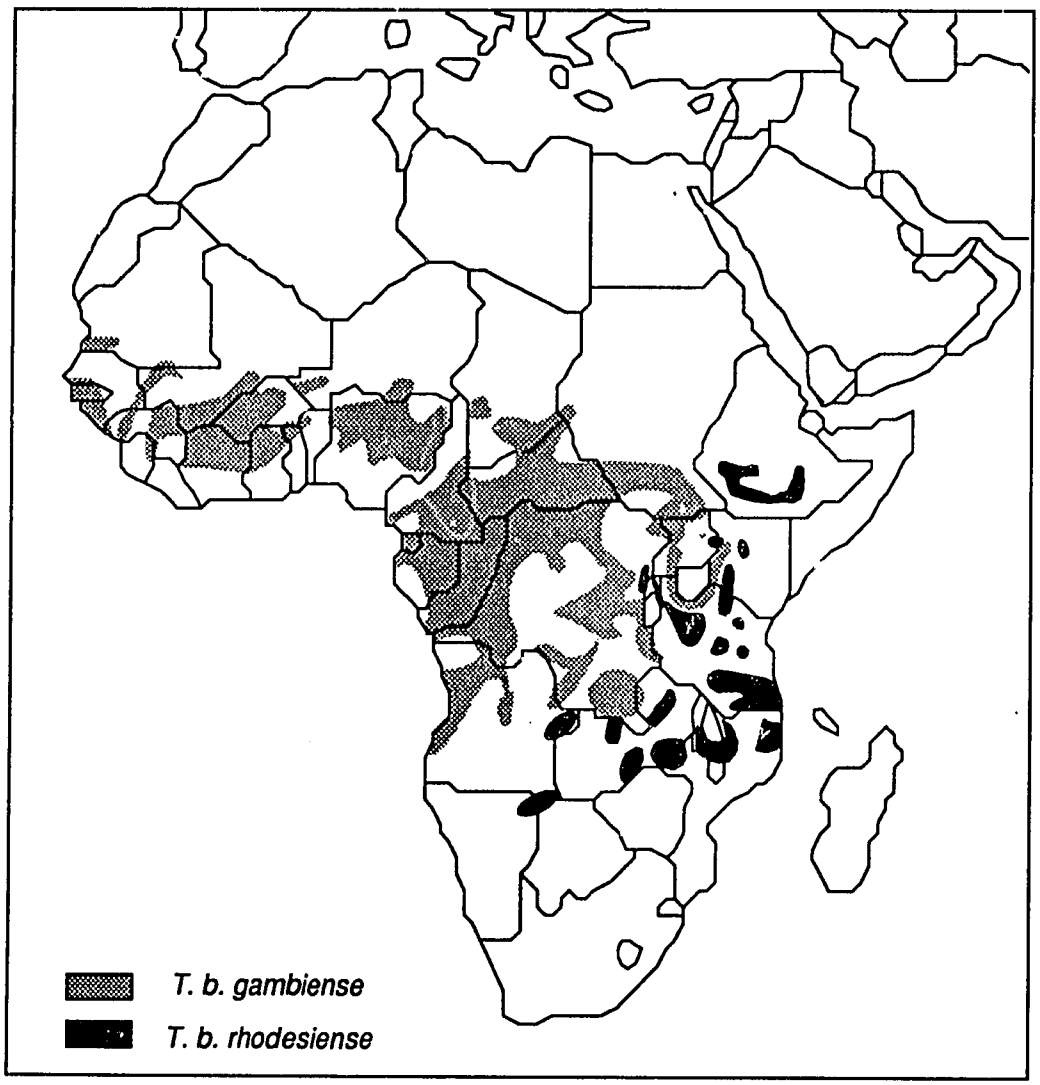
The relationship between the *T. brucei* subspecies *T. b. brucei*, which by definition is not infective to humans, and *T. b. rhodesiense* and *T. b. gambiense* has been the subject of considerable research. During the past decade, studies have progressed from using serological methods to more precise enzyme profiles and DNA characterization methods to identify different species and subspecies of the parasites. These research techniques have provided a better understanding of the epidemiology of the disease.

For example, it was assumed that trypanosomes that caused infection in human volunteers could be defined as *T. b. rhodesiense*. Those that did not produce infection when inoculated into volunteers were defined as *T. brucei*. However, more recent studies indicate that the distinction may not be quite so simple. Some variants of *T. brucei* have proved infective to humans in laboratory studies of parasite clones, and it appears that the infectivity of the parasite is changeable. On the other hand, isoenzyme analysis and DNA probe studies have demonstrated that some isolates of *T. b. rhodesiense* from people and animals can be distinguished as human infective strains.

Life Cycle of Trypanosoma brucei rhodesiense



Map 1. Distribution of African Trypanosomiasis



Prepared by the Vector Biology and Control Project
Source: Hunter's Tropical Medicine, seventh edition. G. T. Strickland, ed. Philadelphia: W.B. Saunders, 1991

Humans were believed to be the only reservoir of gambian sleeping sickness because of the long incubation period of the disease, but a range of domestic and wild animals can be experimentally infected with *T. b. gambiense* from humans. Studies of parasite isolates from domestic and wild animals have shown that they are biochemically indistinguishable from those isolated from humans in sleeping sickness foci. However, the importance of these animals as reservoirs has yet to be fully evaluated.

d. Vectors

Only tsetse flies of the genus *Glossina* transmit the human trypanosomes. The life cycle in a tsetse fly is the same for all subspecies of *T. brucei*. It is a complicated cycle of development, which lasts 15 to 32 days after trypanosomes are taken up by a fly. It culminates in production of infective trypanosomes, which are inoculated into humans in saliva when the fly bites.

Theoretically, all species of *Glossina* can act as vectors of human trypanosomes, but in practice the *G. fusca* group of tsetse fly plays no role in transmitting human trypanosomiasis. Generally, *T. b. rhodesiense* is transmitted by the *G. morsitans* group species when the infection is endemic and only sporadic infections occur. *G. fuscipes* is the vector of epidemic *T. b. rhodesiense* in Uganda and Kenya when transmission between humans and flies, a characteristic of the epidemic cycle, occurs.

Human infection with acute rhodesian sleeping sickness is the result of the bite of a savannah tsetse, whose predominant sources of blood meals are game animals or, if available, domestic bovids. The disease is also associated with occupations that expose humans to tsetse fly bites in areas with abundant game animal populations.

T. b. gambiense is transmitted by the riverine *G. palpalis* group of flies and their subspecies. These flies are restricted to humid habitats, such as vegetation fringing lakes or rivers, isolated areas of dense vegetation in savannahs, which are often considered "sacred forests," and the more humid forested areas of west and central Africa.

2. Distribution and Severity

Sleeping sickness is endemic in 36 countries of sub-Saharan Africa, where some 50 million people are at risk of acquiring it. It is primarily a rural disease. An estimated 25,000 new cases occur every year. Approximately 17,000 new cases are caused by *T. b. rhodesiense* and 8,000 are caused by *T. b. gambiense* annually.

The most recent systematic compilation of data on the prevalence of both forms of African sleeping sickness is shown in Annex 1. These numbers represent reported cases, and underreporting is common.

T. b. rhodesiense is endemic in the following countries: Angola, Botswana, Ethiopia, Kenya, Malawi, Mozambique, Namibia (no recent case reports), Rwanda, Sudan, Swaziland (no recent case reports), Tanzania, Uganda, Zaire, Zambia and Zimbabwe. Little information is available about this acute form of the disease in Angola, Sudan and Zaire, where *T. b. gambiense* is the major sleeping sickness problem.

T. b. gambiense is endemic in Angola, Benin, Burkina Faso, Burundi (no recent case reports), Cameroon, Central African Republic, Chad, Congo, Côte d'Ivoire, Equatorial Guinea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Mali, Niger (no recent cases reports), Nigeria, Senegal, Sierra Leone, Sudan, Togo, Uganda and Zaire. The shores of Lake Victoria in Uganda and Kenya have been endemic for *T. b. gambiense* disease in the past, but rhodesian sleeping sickness is now the major problem in the areas around the lake.

a. Child survival

Trypanosomiasis does not usually affect children because they have less risk of exposure than most adults. Adults who farm or hunt are more likely to be infected because these activities expose them to tsetse fly bites. When children do become infected, the onset of sleeping sickness is extremely sudden and severe, with early CNS problems.

b. Economic Impact

Large areas of Africa cannot be settled or used for livestock because of trypanosomiasis. The World Bank reports that "nagana," the form of trypanosomiasis that attacks domestic cattle and horses,

makes livestock production impossible on some 10 million square kilometers in higher rainfall areas, or 45 percent of all land in sub-Saharan Africa.

African human trypanosomiasis also affects economic productivity because it usually strikes working-age adults. The World Health Organization (WHO) Expert Committee on Trypanosomiasis estimated that the average rural inhabitant would lose 10 years of income, or $615 (1986 U.S. dollars), because of premature death caused by sleeping sickness.

3. Control Measures

The strategy for controlling human trypanosomiasis is based on active or passive surveillance, treatment and, if appropriate, vector control. During the past decade, substantial progress has been made in research to provide more effective control methods.

a. Surveillance

Sleeping sickness control, particularly *T. b. gambiense* control, has depended on searching for infected individuals through active or passive surveillance. The most common early symptom, intermittent fever, is common in rural African populations, so patients are not likely to seek treatment during such fevers, when parasites would be easier to find.

The surveillance strategy is to reduce the human reservoir of infection, make treatment less hazardous through early detection, and limit human suffering from the disease by detecting and removing as many infected individuals from the community as possible. In 1986, WHO's Expert Committee on Trypanosomiasis estimated that average testing costs were US $1.00 per person. Cheaper, reliable serological techniques would reduce this cost and facilitate identification and treatment of early-stage cases.

Rhodesian sleeping sickness is usually diagnosed through passive detection at fixed health centers. Blood film examination is the method of choice because *T. b. rhodesiense* parasites are more easily detected in the blood of patients than *T. b. gambiense*. Serological tests have not been used regularly for surveillance of *T. b. rhodesiense* disease. During epidemics, such as the one in Uganda during the 1980s, active surveillance by mobile teams is necessary for control.

Epidemic *T. b. gambiense* was controlled during the early decades of this century by intensive surveillance of infected populations. Mobile teams equipped with microscopists systematically surveyed populations by assembling everyone and examining their cervical lymph nodes. All palpable lymph nodes were needle-biopsied and examined microscopically for living parasites. These teams also examined thick blood films for parasites.

More recently, serological surveillance techniques have been used to detect suspected cases in a few countries. Of these, the Card Agglutination Test (CATT) has the advantage of an on-the-spot result, allowing immediate, detailed parasitological examinations of suspected cases. The introduction of microhematocrit centrifugation techniques and cellulose column filtration procedures (mini anion exchange centrifugation technique, or MAECT) has significantly increased the sensitivity of parasitological diagnosis, but their use is usually confined to fixed medical facilities.

b. Chemotherapy

Early-stage sleeping sickness is easier and less hazardous to treat than late-stage disease. Suramin is used for treatment of early-stage *T. b. rhodesiense*. Five injections of a dose of 20 mg/kg of body weight are administered with an interval of five to seven days between injections. The same dose of suramin can be used to treat early stage *T. b. gambiense*. The side effects of suramin treatment are fever, joint pain, skin rash and scaling.

Pentamidine also can be used for treatment of early-stage *T. b. gambiense*. Pentamidine is administered at a dose of 4 mg pentamidine base per kg of body weight with seven to 10 injections, either daily or on alternate days. Suramin costs US $8 and pentamidine US $35 per patient.

Pentamidine injections may be painful. Their side-effects include vomiting, abdominal pain, hypotension, fainting and hypoglycemia. Treated patients should remain prone for one hour after receiving an injection to reduce the risk of hypotension. Pentamidine should not be used to treat *T. b. rhodesiense*.

Until recently, late-stage sleeping sickness has been treated with melarsoprol, the only drug that could pass the blood-brain barrier and destroy parasites in the central nervous system. Melarsoprol, which is administered in a series of intravenous injections, is highly toxic and its side effects are fatal in up to five percent of patients.

An alternative treatment for late-stage gambian sleeping sickness, eflornithine, has proved safe and highly effective in clinical trials conducted by the UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (TDR). Over 90 percent of more than 600 patients with

late-stage gambian sleeping sickness who had not responded to treatment with melarsoprol were cured with eflornithine. Some investigators conducting early trials of eflornithine dubbed it "the resurrection drug" because it aroused comatose sleeping sickness patients so quickly. The drug inhibits an enzyme, ornithine decarboxylase, essential for trypanosomes' growth and multiplication. It is not effective against the more virulent *T. b. rhodesiense.*

Like melarsoprol, eflornithine is administered intravenously, so patients must be hospitalized to receive treatment. Intravenous doses of 100 mg/kg every six hours a day for two weeks are recommended. Oral administration is not recommended because it results in a significant number of relapses and causes diarrhea, nausea and vomiting.

Marion Merrell Dow, the U.S. pharmaceutical company marketing the drug under the name "Ornidyl," has agreed to supply eflornithine to countries with endemic trypanosomiasis for four years at a below-cost price. A total adult dose will cost about U.S.$140, compared to a per patient cost of $133 for melarsoprol.

c. Vector control

Traps are the most promising and environmentally acceptable method of tsetse fly control. Tsetse fly traps were used successfully for control in early studies and improved models have renewed interest in this method. The biconical Challier/Lavissiere traps impregnated with deltamethrin were used to control *G. palpalis* group flies in western and central Africa. Several models based on this design are being evaluated.

Insecticide-impregnated screens have also been used as lethal targets for tsetse flies. Though less effective than traps, screens are cheaper to manufacture and easier to transport. Traps baited with synthetic odors based on ox breath and targets impregnated with deltamethrin provide similar low-technology methods for control where sleeping sickness is transmitted in epidemics by savannah flies.

Impregnated biconical traps, the more recently developed Gouteux/Lancien pyramid trap that does not require insecticide, and odor-baited traps are the most appropriate vector control tools for trypanosomiasis. Traps use little or no insecticide, reducing both the environmental effects of insecticides and the

reducing both the environmental effects of insecticides and the drain on foreign exchange reserves. They also can provide a source of local employment for trap manufacturing and help involve communities in vector control.

Before the advent of insecticides, vector control in west and central Africa, particularly in Anglophone countries, was based on destroying fly habitats to reduce contact between people and tsetse flies. Extensive areas of bush were cleared in eastern Africa and game was destroyed in some countries to remove *Glossina* food sources. These activities were directed primarily toward controlling savannah tsetse flies to allow livestock raising, but they probably also reduced endemic *T. b. rhodesiense*.

Applying residual insecticides to the known resting sites of flies became the method of choice from the early 1920s to late 1940s. These techniques were used more widely against riverine flies to control localized transmission of *T. b. gambiense* vectors.

Ground spray programs are best conducted during the dry season to ensure that the insecticide remains active as long as possible. The effectiveness of insecticides rapidly declines with the onset of the rainy season. Large-scale *Glossina* control activities against animal trypanosomiases in Nigeria have eradicated tsetse flies from several sleeping-sickness foci.

Aerial application of insecticides by either fixed-wing aircraft or helicopters has been used to control animal disease vectors and could be deployed for human disease control during emergencies. Extensive aerial spraying in Botswana, Zimbabwe and Zambia has successfully controlled savannah vectors and reduced the incidence of human disease in recent years.

Releasing sterile male flies is not considered a cost-effective method of human sleeping sickness control. Because of the high capital and operating costs of such genetic control efforts, sterile male release is likely to be more feasible for animal trypanosomiasis control.

d. Vaccination

Vaccination to protect people from sleeping sickness is not considered feasible because the variety of antigens produced by various species of trypanosomes prevents development of suitable universally protective antigens.

e. Chemoprophylaxis

Muscular inoculation with pentamidine 4 mg/kg every six months has protected populations at high risk in areas of *T. b. gambiense*. Chemoprophylaxis is no longer recommended because prophylactic doses may mask undetected infections and can provoke drug resistance.

f. Constraints to control

Technical

Currently available diagnostic techniques would increase diagnostic efficiency considerably, but they are not widely used in the field. Microhematocrit centrifugation and MAECT require electrical power supplies not likely to be available in rural areas. Hand- and battery-operated centrifuges may be effective alternatives.

Refinement of serology, particularly further development of the CATT test and development of a field kit for antigen detection, should allow for more widespread seroepidemiology conducted on the spot by relatively unskilled personnel. Improved surveillance would make it possible to treat more cases at earlier stages of the disease. Early treatment provides a more optimistic prognosis and is much cheaper and more suitable for mass treatment efforts. Both drugs available for treatment of late-stage disease are expensive and require weeks of hospitalization. Eflornithine is only effective against gambian sleeping sickness, and melarsoprol can cause severe, sometimes fatal, side effects.

Vector control by ground spraying of residual insecticides is reliable, but application of chlorinated hydrocarbons can have serious environmental consequences. This technique depends on good logistical support and availability of insecticide. The experienced personnel necessary for rapid deployment of ground spray teams in emergencies often are not readily available. Using sequential aerial applications limits harmful environment effects, but residual helicopter operations have significant effects on non-target organisms. Air spray control methods requires skilled personnel, efficient organization, and foreign exchange to buy insecticides.

Human resources

Limited numbers of skilled personnel are available to undertake control measures. More recently developed tools, however, including CATT and *Glossina* traps, can be deployed by relatively unskilled personnel.

The supply of trained personnel for evaluation and research is also limited, despite significant investment in research and training. Most field-based studies on trapping, diagnosis and epidemiology have been conducted by expatriate scientists. Few trainees have remained in trypanosomiasis control long enough for their national programs to benefit from their training.

Economic

Financial support provided by TDR has enabled researchers to provide valuable new tools for African trypanosomiasis control. Deployment of these tools on a wider scale, however, will depend on increased commitments from national governments and control programs.

Continued investment in active sleeping sickness surveillance, which is a prerequisite for applying the most effective control strategies, is not considered a priority by many governments, except during epidemics. The high cost of surveillance, diagnostic kits, and drugs to treat sleeping sickness is also a drain on foreign exchange. There is a continuing need to draw governments' attention to the potential damage that sleeping sickness can inflict on rural populations if basic surveillance activities are not maintained.

4. Current Research

a. Diagnosis

Evaluations conducted by WHO in collaboration with African and European laboratories in several African countries have confirmed the value of CATT as a sensitive diagnostic tool applicable in field situations. A serological method of *T. b. rhodesiense* diagnosis based on antigen detection is being developed that would fulfill the criteria for field tests: ease of use, rapid results, high specificity and long shelf life.

Little research is dedicated to improving parasitological methods of diagnosing sleeping sickness because it is unlikely that the sensitivity of MAECT can be improved. Research to enhance the efficiency of parasite detection methods and improve diagnosis should be directed toward developing methods appropriate for use in the field.

b. Chemotherapy

Now that field trials have demonstrated that eflornithine is an effective treatment for late-stage gambian sleeping sickness, studies are underway to determine whether the dosage and duration of treatment can be reduced without loss of efficacy. Because eflornithine is not effective against *T. b. rhodesiense*, researchers are testing the effectiveness of drug combination therapy to treat late-stage rhodesian sleeping sickness.

Other compounds that have indicated promise are triacetylbenzentrisguanyl-hydrazone (TBG) and bromoacetylcarnitine (BAC). Scientists are conducting laboratory research on the basic mechanisms of cell and molecular biology of trypanosomes, upon which much of rational chemotherapy is based. Several research groups are studying unique trypanosome metabolic pathways likely to be the most relevant to future chemotherapeutic targets.

c. Epidemiology

In the laboratory, more precise biochemical typing procedures have been developed that have led to a better understanding of the epidemiology of sleeping sickness. Results of isoenzyme analyses and

DNA probes are used to identify species and subspecies of trypanosomes. These results and studies of animal reservoirs in West and Central Africa are providing a more complete picture of the epidemiology of African trypanosomiasis, which is essential for control. There is a continuing need to assess the importance of animal reservoir hosts, particularly of *T. b. gambiense*.

Recent studies have shown that data from weather satellites can be used to predict the mortality rates and abundance of tsetse flies over large areas of Africa. Data from satellite channels that monitor the amount of red and infrared light reflected by the planet's surface are used to produce an index of the level of photosynthetic activity, which also indicates the amount of vegetation cover. Researchers found that this index was significantly correlated with the mortality rates of tsetse flies from sites in West and East Africa and with the abundance of two species of tsetse over the northern half of Côte d'Ivoire. Their findings suggest that remote sensing data can be used to produce maps of high-risk areas for sleeping sickness transmission, which would help target control efforts.

d. Vector biology

Extensive laboratory and field investigations of various aspects of *Glossina* biology have been conducted in recent years. Laboratory and field studies of *Glossina* sex pheromones and different attractants have contributed to our understanding of the biology of tsetse flies and led to improved trapping techniques.

e. Vector control

Most tsetse control research is being conducted on trapping and odor baits. The effectiveness of traps is being evaluated in a number of pilot projects.

Evaluations have demonstrated that traps and screens can rapidly reduce fly populations by more than 95 percent over long distances of riverine habitat. Studies of colors for traps and odors for attracting the *G. palpalis* group are needed to improve trapping efficiency.

Pilot trials of traps have shown promise in reducing exposure to disease and antibody levels in human and animal populations. In one study in the Republic of Congo, community-maintained pyramid traps reduced vector density by 90 percent or more in 44 of 55 villages. In nine of the villages, the density of *G. palpalis* collected from the traps

dropped to zero. Screening surveys also showed a reduction in the prevalence of infection after tsetse flies had been eliminated. By the end of the study, however, villagers in 41 communities had stopped maintaining the traps. Investigators concluded that more research was needed on the sociocultural implications of tsetse trapping.

Improvement of trap design, odor baits and olfactory stimulants continue to be promising avenues for research on controlling *G. morsitans* group flies. Ecological and behavioral studies that define the optimal distribution of traps, number per unit area and cost-effectiveness compared with other techniques of control are closely integrated components of such research. However, this research is mainly relevant to animal trypanosomiasis control. *G. morsitans* control to control endemic human *T. b. rhodesiense* is not likely to be cost-effective.

5. Trypanosomiasis from the A.I.D. Perspective

African trypanosomiasis, in both its domestic animal and human forms, is a major deterrent to economic development in parts of Africa. Although the numbers of cases reported today are not comparable to the massive epidemics that occurred earlier in this century, local outbreaks continue in many A.I.D.-assisted countries.

TDR, which A.I.D. supports, has targeted African sleeping sickness and is providing support for certain basic research elements. Other groups, such as the International Laboratory for Research in Animal Disease in Nairobi (ILRAD), are conducting basic research on the *T. brucei* group and related cattle parasites.

a. The Horizon

During the next 10 years, continued research on tsetse fly traps will produce more effective traps for local control and a better understanding of how to motivate community members to maintain them. Geographical information systems that use remote sensing data to map areas of high risk for sleeping sickness may make it possible to target tsetse fly control efforts. Wider use of recently developed serological and parasitological diagnostic techniques in the field will make early detection and treatment more common.

b. Priorities for future action

- Ecological studies that define the optimal distribution of traps, number per unit area and cost-effectiveness compared with other control methods.

- Behavioral studies on community participation in tsetse fly trapping.

- Studies to improve trap efficiency, including identification of host odors that may be attractive to *G. palpalis* group flies and trials of traps using a range of attractant chemicals that enhance trap effectiveness to the *G. morsitans* group.

- Broader deployment of recently developed serological and parasitological diagnostic techniques and evaluation of their efficacy.

- Development of a serological test for *T. b. rhodesiense* that could be used over the range of this disease and deployed either in passive surveillance or for active case finding during epidemics.

- Studies on basic biochemistry that could lead to new treatments that would be easy to administer, effective against both stages of the disease, non-toxic and available to ambulatory patients without requiring hospitalization.

- The use of geographical information systems and remote sensing data to identify high-risk areas for sleeping sickness transmission and to target control efforts.

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Annex

Table 1. Number of New Cases of *T. b. rhodesiense* and *T. b. gambiense*

Country	Est. pop. at risk	1976	1978	1980	1982	1984	1986	1988	1989	1990
Angola	3 M	83	337	306	2,412	252	1,272	1,191	1,557	625*
Benin	.03 M	5	3	0	2	1	2	1	14	2*
Botswana	--	26	--	--	5	--	--	--	--	--
Burkina Faso	3 M	82	62	132	44	--	--	--	--	--
Burundi	.005M	--	--	--	0	--	--	--	--	--
Cameroon	.31 M	18	607	257	1,038	633	585	109	86	49
CAR	.12 M	117	130	73	459	473	67	154	308	197
Chad	.05 M	104	93	--	19	45	219	357	187	21
Congo	.5 M	184	235	626	252	436	391	567	642	320*
Cote d'Ivoire	4 M	269	391	378	253	--	235	--	--	125*
Eq. Guinea	.3 M	--	--	--	72	70	366	59	36	39
Ethiopia	.1 M	38	30	16	15	--	--	--	--	--
Gabon	.08 M	63	254	345	70	63	31	29	80	45
Gambia	.1 M	--	--	239	--	--	--	--	--	--

Source: World Health Organization, 1991

* partial count for the year
-- no data available

Table 1. New Cases of *T. b. rhodesiense* and *T. b. gambiense* (cont.)

Country	Est. pop. at risk	1976	1978	1980	1982	1984	1986	1988	1989	1990
Ghana	3.5 M	57	34	18	23	7	7	4	--	--
Guinea	2.5 M	--	--	192	184	168	--	--	--	--
Guinea-Bissau	0.3 M	4	27	4	16	2	--	--	--	174*
Kenya	0.7 M	7	13	--	--	--	--	--	--	90*
Liberia	0.2 M	0	0	0	--	--	--	--	--	--
Malawi	1.2 M	13	27	38	--	--	--	--	--	--
Mali	2.5 M	105	94	934	80	--	--	--	--	--
Mozambique	0.7 M	18	84	85	83	--	--	--	--	--
Namibia	1.4 M	--	--	--	--	--	--	--	--	--
Niger	0.5 M	0	0	0	0	--	--	--	--	--
Nigeria	30 M	467	604	80	--	--	--	--	--	--
Rwanda	.09 M	2	3	0	7	8	10	--	--	--
Senegal	--	5	0	--	--	--	--	--	--	--
Sierra Leone	0.4 M	--	--	20	--	--	--	--	--	--
Sudan	5.0M	431	1,500	1,163	1,074	200	58	56	63	--

Source: World Health Organization, 1991

* partial count for the year
-- no data available

Table 1. New Cases of *T. b. rhodesiense* and *T. b. gambiense* (cont.)

Country	Est. pop. at risk	1976	1978	1980	1982	1984	1986	1988	1989	1990
Swaziland	0.6 M	--	--	--	--	--	--	--	--	--
Tanzania	1.5 M	623	747	341	467	480	420	402	438	--
Togo	0.7 M	4	14	12	3	--	--	--	--	--
Uganda	6.0 M	52	6,266	8,648	1,560	2,198	4,746	3,645	2,052	2,581*
Zaire	10 M	3,818	5,790	4,817	5,703	7,150	10,665	9,588	7,515	8250*
Zambia	0.5 M	91	185	133	196	--	--	--	--	--
Zimbabwe	--	4	0	1	--	--	--	--	--	--

* partial count for the year
-- no data available

Source: World Health Organization, 1991

Table 2. Summary of African Trypanosomiasis, Surveillance and Control

Angola	Main trypanosomiasis foci in the northwest, some extending across the border into Zaire. Control activities have been hampered by civil disturbances, but with support from Sweden, the program has reinforced since 1982. An average of 200,000 people (approx. 10% of population at risk) are surveyed annually. The 1,557 new cases in 1989 are a substantial increase over other years in 1980s (except 1982-83, when all seropositive people were included in total of new cases).
Benin	Local transmission suspected to be low. Surveys using serology in the Atakora region near the Togolese border found few cases.
Botswana	Sporadic cases in the north. Sleeping sickness absent in other areas because of major tsetse control campaign for cattle raising.
Burkina Faso	Transmission persists in Banfora region and Bobo-Dioulasso. Major foci around Koudougou. Little known about northwestern and eastern regions. Long-term surveillance program in progress since 1984. Minor vector control project in the south for cattle raising.
Burundi	No information available. No systematic active surveillance.
Cameroon	After a serious outbreak in 1982-85, transmission persists in the Mbam (Bafia, Ombessa and Bokito) and Fontem/Mamfe areas. A spot serological survey in the Yokadouma area close to the flaring Central African Nola focus revealed no local transmission. Trypanosomiasis control program idling.
Central African Republic	Recrudescence in the Ouham region in the north with a major flare-up of the Batangafo focus. Serious outbreak of the Nola focus in the Sangha region. National control program uses serological diagnostic techniques in active foci and the Haut Mboumou (Obo, Zemio, Djema).

Table 2. Summary of African Trypanosomiasis, Surveillance and Control, (cont.)

Chad	Surveys using serological techniques in the Moissala and Moundou areas have demonstrated active local transmission. Foci around Moundou (Tapol, Timbéri, Ranga) are highly endemic. National control program being implemented.
Congo	Serious outbreaks, particularly in the Bouenza area (estimated population at risk 150,000). Regions of the Couloir and Cuvette still active. Active surveillance using serology implemented only in the Bouenza area. Boko-Songho district and the urban and peri-urban Nayki focus most affected. Small-scale trials of tsetse trapping successful under specific circumstances.
Côte d'Ivoire	Transmission persists in the Daloa, Bouaké, Issia, Vavouvava, Zouenoula foci. Cases sporadically diagnosed around Abidjan. National program uses serology.
Equatorial Guinea	Major focus in Malabo island. Other foci are under control through active surveillance.
Ethiopia	Foci still active in the Gambella and Gila regions. Most cases found by passive surveillance. Population migration from northern area into active transmission regions of concern to health authorities. All foci generally considered *T. b. rhodesiense* but *T. b. gambiense* may have been imported recently. Surveillance program is being developed.
Gabon	Active transmission in the Estuaire and Port Gentil foci. Serodiagnostic surveillance employed, but surveillance limited.
Gambia	Little information available on surveillance. Occasional detection of isolated cases indicates persistence of low-level transmission.

Table 2. Summary of African Trypanosomiasis, Surveillance and Control (cont.)

Ghana	Between 1983 and 1988, all new cases identified originated from the Central region. Most cases found by passive surveillance.
Guinea	Little recent information available. Limited active surveillance. Recently reported cases (mostly from passive detection) indicate that transmission continues.
Guinea-Bissau	Occasional cases reported. Geographical distribution not well-known. Renewed interest in surveillance. National control program being prepared.
Kenya	Cases sporadically detected in the Lambwe Valley. Imported and autochthonous cases identified along the Uganda border; local transmission suspected. National control program reinforced to include population surveillance, treatment and vector control.
Liberia	Spot-check surveys seem to indicate some continued transmission. No systematic active surveillance.
Malawi	Majority of reported cases probably imported. Some local transmission in the locality of Kasungu and the Vwaza Game Reserves, which are near Zambia's Luangwa Valley. Renewed interest in surveillance. National control program in preparation.
Mali	No recent information available. Sporadic cases occur in Kayes, Koulikoro, Sikasso and Ségou. Occasional active surveillance. Population movement due to construction of Manatali and Seligue dams may have created new transmission sites. National control program has been planned, but not funded.
Mozambique	Most active foci are in Tete province. Increasing number of cases in Cumbo area. Other areas quiescent. National control program started in 1980 but has not been fully implemented.

Table 2. Summary of African Trypanosomiasis, Surveillance and Control (cont.)

Namibia	Little information available, no cases reported.
Niger	No cases reported.
Nigeria	Little information available. Gboko focus still active. No coordinated active surveillance. Vector control campaigns for cattle raising have also reduced human disease.
Rwanda	Two recognized active foci: Akagera-Nutara and Nasho-Mhanga. One national mobile team operational. Good coverage of the population at risk.
Senegal	Little information available. Endemic areas seem quiescent. Several cases reported recently in Casamance area, where epidemiological conditions are suitable for local transmission.
Sierra Leone	No recent information available. Cases reported occasionally.
Sudan	Cases reported from equatorial provinces. Epidemic proportions recognized since the late 1970s. Surveillance programs implemented in Li Rangu, Yambio, Source Yabu, Yei and south of Juba and Tambura abandoned due to difficult working conditions. Several NGOs have moved in to assist rural populations. No information available on disease along the Ethiopian border.
Swaziland	No cases recorded.
Tanzania	Persistence of transmission in most recognized foci. The most active areas are Arusha and Kigomai. Reinforcement of national program in view.
Togo	Only sporadic cases. All originate from the north: Tone and Oti regions. Recent surveys indicate a quiescent situation.

Table 2. Summary of African Trypanosomiasis, Surveillance and Control (cont.)

Uganda	Major *T. b. rhodesiense* outbreak in the southeast since 1978. Substantial reduction in the number of cases in the foci of the Busoga region on Lake Victoria's northern shore (Bugiri, Mamungalwe, Buwenge, Bulope, Namugongo) through reinforcement of control program and local community participation in vector control through trapping. However, epidemic has spread to Tororo and Mukono districts. Extension of control program in progress. *T. b. gambiense* reaching epidemic proportions in Northern and Northwestern regions. High local transmission along the White Nile and Sudan border.
Zaire	Devastating *T. b. gambiense* epidemics in vast areas of Zaire, where 60 percent of all reported cases in central Africa occur. An estimated 10 million people are at risk and 1.6 million at high risk of infection. National control system has collapsed after interruption of external assistance. Sleeping sickness foci in huge endemic zones: Bas-Zaire, Bandundu, Kasai, Maiema/Shaba, Equateur and Haut-Zaire. Several major foci extend across the borders of neighboring countries. Recent influx of Sudanese refugees in some endemic areas of the Haut-Zaire could extend epidemic outbreaks.
Zambia	Transmission persists in the north. *T. b. rhodesiense* of low virulence in evidence as well as suspected healthy carriers.
Zimbabwe	Sporadic cases in the northwest. Disease mostly contained through vector control measures initiated and maintained for cattle raising purposes.

Source: World Health Organization, 1990-91