Tsetse flies are bloodsucking flies of the genus *Glossina*. They occur only in tropical Africa and are important as vectors of African trypanosomiasis in both humans and animals. Sleeping sickness, as it is commonly called, is generally fatal in humans if left untreated. Sleeping sickness occurs in scattered foci throughout Africa south of the Sahara. In 1996, it was estimated that between 20,000 and 25,000 people die from the disease annually; however, the risk of severe epidemics continues to exist.

**Biology**

Tsetse flies are robust, 6–15 mm in length, and can be distinguished from other biting flies by their forward-pointing mouthparts (proboscis) and characteristic wing venation (Fig. 2.1). There are about 30 known species and subspecies of tsetse flies belonging to the genus *Glossina*. They can be divided into three distinct groups or subgenera: *Austenia* (*G. fusca* group), *Nemorhina* (*G. palpalis* group) and *Glossina* (*G. morsitans* group). Only nine species and subspecies, belonging to either the *G. palpalis* or the *G. morsitans* group, are known to transmit sleeping sickness (Table 2.1).

**Life cycle**

The female tsetse fly does not lay eggs but produces larvae, one at a time. The larva develops in the uterus over a period of 10 days and is then deposited fully grown on moist soil or sand in shaded places, usually under bushes, fallen logs, large stones and buttress roots. It buries itself immediately and turns into a pupa. The fly emerges 22–60 days later, depending on the temperature. Females mate only once in their life and, with optimum availability of food and breeding habitats, can produce a larva every 10 days.

**Resting places**

The flies pass most of their time at rest in shaded places in forested areas. The preferred sites are the lower woody parts of vegetation; many tsetse flies hide in holes in the trunks of trees and between roots (Fig. 2.2). They search for food only for very short periods during the day. The flies often rest near to food sources. Common risk areas where people are likely to be bitten by tsetse flies are:

- on forest trails;
- near water collection points in forests;
- in vegetation close to bathing and water collection sites along the banks of rivers;
Fig. 2.1
Tsetse fly; this shows a feeding fly with a swollen abdomen (by courtesy of the Natural History Museum, London).

Table 2.1
Species and subspecies of *Glossina* known to transmit sleeping sickness

<table>
<thead>
<tr>
<th>G. palpalis group</th>
<th>G. morsitans group</th>
</tr>
</thead>
<tbody>
<tr>
<td>(subgenus <em>Nemorhina</em>)</td>
<td>(subgenus <em>Glossina</em>)</td>
</tr>
<tr>
<td>palpalis gambiense</td>
<td>morsitans centralis</td>
</tr>
<tr>
<td>palpalis palpalis</td>
<td>morsitans morsitans</td>
</tr>
<tr>
<td>tachinoides</td>
<td>pallidipes</td>
</tr>
<tr>
<td>fuscipes fuscipes</td>
<td></td>
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<tr>
<td>fuscipes quanzensis</td>
<td></td>
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<tr>
<td>fuscipes martinii</td>
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</tbody>
</table>

Fig. 2.2
In forested areas, tsetse flies typically rest on twigs and woody parts of vegetation close to the ground.
— in vegetation surrounding villages;
— sacred forests or forests on cemeteries;
— forest edges surrounding plantations (e.g. of coffee or cacao);
— savanna habitats (*morsitans* group).

These areas often form a boundary between two different habitats or vegetation types of which at least one is wooded. Such a combination offers the flies both safe resting places and a good view of their feeding grounds.

**Food**

All tsetse flies, males as well as females, feed on blood, but the species differ in their preferences for the source of blood. Most tsetse flies feed preferentially on animals and only accidentally on humans. The most dangerous species are those that are flexible in their choice and feed on any blood source that is easily available, including humans. While searching for food they are attracted by large moving objects, by strikingly blue objects (1), and by carbon dioxide.

**Public health importance**

Tsetse flies cause painful bites and, during the day, can be a nuisance where they occur in large densities.

**Sleeping sickness**

Two different types of human sleeping sickness are caused by different subspecies of trypanosome parasites (Fig. 2.3):

— gambiense sleeping sickness (caused by *Trypanosoma brucei gambiense*) is generally considered to be a chronic disease and is found mostly in West and Central Africa;
— rhodesiense sleeping sickness (caused by *Trypanosoma brucei rhodesiense*) is an acute disease that occurs mainly in East Africa.

In 1996 it was estimated that some 50 million people in 36 countries are at risk of acquiring sleeping sickness. However, only about 20,000 new cases are reported annually. Between 2% and 3% of them die as a consequence of resistance to the drugs and secondary effects of the drugs. It is believed that many cases go unreported.

Other trypanosome species can cause diseases in wild and domestic animals, including cattle, pigs and horses.

**Transmission**

Tsetse flies can acquire trypanosome parasites by feeding on infected people and large domestic and wild animals. When an infected tsetse fly bites it injects the parasites into the blood. The parasites multiply and invade the body fluids and tissues.
Fig. 2.3 Geographical distribution of foci of gambiense and rhodesiense sleeping sickness, 1996 (© WHO).
Fig. 2.4
Transmission of gambiense sleeping sickness occurs most frequently along rivers and lakes.

Infection usually takes place where humans enter the natural habitat of the tsetse flies.

Gambiense sleeping sickness is mainly transmitted by tsetse flies belonging to the *G. palpalis* group. These flies attack people at places along rivers such as river crossings, lakeside villages, and bathing and washing places, and also near water holes, plantations and along roads bordered by vegetation (Figs. 2.4 and 2.5).

Rhodesiense sleeping sickness is transmitted by savanna species belonging to the *G. morsitans* group. These species normally feed on wild animals that inhabit savannas and woodlands, such as the bushbuck, or on domestic animals, such as cattle and goats. They also attack people who live in or enter these areas, for instance farmers, herdsmen, fishermen, hunters, travellers and collectors of honey. In some epidemic areas (e.g. near Lake Victoria) rhodesiense sleeping sickness is transmitted in the peridomestic environment from person to person or from domestic animals to humans by *G. f. fuscipes* of the *G. palpalis* group (Fig. 2.6).

**Clinical symptoms**

Among the first symptoms and signs of sleeping sickness are headache, irregular fevers, swollen tissues and joint pains (Fig. 2.7). At a later stage the parasites invade the brain, which usually leads to mental disorders, coma and death. There is often a latent period before any obvious symptoms or signs appear, which may last for months or years in gambiense sleeping sickness. This latent period does not exist or is short in rhodesiense sleeping sickness. Gambiense infections usually progress slowly while rhodesiense infections are acute. If untreated, both gambiense and rhodesiense infections are fatal.
Fig. 2.5
Transmission cycle of gambiense sleeping sickness.

Fig. 2.6
Transmission cycle of rhodesiense sleeping sickness.
Tsetse Flies

Fig. 2.7
African sleeping sickness usually starts with headaches, irregular fevers, swollen tissues and joint pains. At a later stage the brain becomes affected, which results in mental deterioration, coma (the sleeping stage) and death.

Treatment

Infection cannot be prevented through chemotherapy. In the past, pentamidine was used but it is no longer believed to be effective.

In the early stages of the disease, when the central nervous system is not yet involved, treatment is possible: suramin sodium is used for rhodesiense infections and is administered intravenously; pentamidine, used for gambiense infections, is usually administered intramuscularly, although slow intravenous infusions have been shown to be equally effective. Both drugs have side-effects.

In the late stage, when the central nervous system is involved, the chances of achieving a cure are diminished. Until recently, melarsoprol was the only available drug for treatment of the late stages of both gambiense and rhodesiense sleeping sickness. The drug carries a risk of serious side-effects, which may be fatal, and must be administered under strict medical supervision. It is not recommended for use in the early stages of the disease.

In 1994, a new drug, eflornithine, was used successfully for the treatment of all stages of gambiense sleeping sickness. However, the production of this drug ceased at the end of 1995.

Prevention and control

The current strategy for sleeping sickness control is based on active and passive case detection (surveillance), treatment of infected people, and, when appropriate, tsetse control. In recent years, community participation in national programmes has been sought to ensure the sustainability of control activities.

Surveillance aims to reduce the human reservoir of infection and to make treatment less hazardous through early detection. It also provides early warning of
any increase in the prevalence of infections. As the symptoms are generally mild in gambiense sleeping sickness, surveillance involves screening programmes conducted by mobile teams. In areas with rhodesiense sleeping sickness, surveillance relies mainly on individual patients coming to rural health facilities.

Diagnosis is carried out by serological tests: the direct card agglutination test for trypanosomiasis (CATT) is used to identify patients with gambiense infections while the indirect immunofluorescent test (IFT) is used to detect rhodesiense infections. Seropositive cases are confirmed by the microscopic detection of parasites in blood or in lymphatic or spinal fluid.

Where recent epidemics have occurred, this was mostly due to a decline in surveillance activities and increased population movement. Control activities have also been hampered by a lack of suitable personnel and financial resources.

The main objective of vector control is to reduce contact between people and flies. The most promising and environmentally acceptable vector control methods currently available are those in which tsetse fly traps and insecticide-treated screens are used. Under epidemic conditions, when very quick action is needed, insecticides may be sprayed on to resting sites of tsetse flies in vegetation.

Control measures

A variety of methods can be used to control tsetse flies. Before suitable insecticides became available, control efforts mainly involved the removal of the woody vegetation forming the fly’s habitat. In areas of rhodesiense sleeping sickness, the primary food sources of the flies, wild game animals, were killed or removed. The tsetse flies then eventually disappeared because of food shortage. These methods have largely been abandoned and today insecticide spraying is used along with traps and insecticide-impregnated targets.

Traps and insecticide-impregnated screens

Traps and screens are an effective means of tsetse control. They are cheap, easy to transport, and completely safe for the user and the environment. Once a suitable trap or screen has been developed for a given area, no special expertise is needed in order to use it. This method is therefore ideally suited for anyone seeking to provide cheap and effective community protection.

Mode of action and design

For many years research workers have used specially designed traps to collect tsetse flies for study purposes. The flies search for blood-meals or resting places partly or wholly by sight, and are attracted by large objects that move or contrast with the landscape. Certain colours, especially blue, attract many tsetse flies (2). The blue screens of the trap are contrasted with black screens to make the flies settle. The flies subsequently move towards the upper part of the trap in the direction of the light. There they may become trapped in a specially designed bag.

An effective trap attracts all the flies from a distance of approximately 50 m, i.e. their range of vision. Migrating flies that pass nearby are also attracted. Thus a trap
can remove flies from an area much larger than the zone of immediate attraction. Flies that enter the trap may die because of exposure to an insecticide impregnated in the trap material or because they are exposed to the sun. Impregnated traps have the extra advantage that flies settling on the outside, but not entering, are also killed.

The basic design of traps and screens is applicable in all areas of Africa with tsetse flies but some modifications may be needed to make them more effective under local conditions. Attractive odours are available for the control of certain species that transmit animal trypanosomiasis (Glossina morsitans group).

The impregnated screen, a simplification of the impregnated trap, consists of a large piece of cloth of a colour attractive to tsetse flies. The impregnated insecticide kills the flies when they land on the screen. Impregnated screens are effective only as long as the insecticide lasts.

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**Use of traps by individuals or communities**

Since tsetse flies fly considerable distances, traps should be used on as large a scale as possible. This requires the participation of several members of a community and preferably of several communities or even districts. However, isolated communities in forested areas, for example in the Congo, have successfully implemented their own protection measures. Individual farmers can protect themselves in a forest environment by placing traps or screens on their plantations or camp sites.

**Models of traps and screens**

**The biconical trap**

The biconical trap was one of the earliest models to be designed (Fig. 2.8). Unlike the two later models it is not used in large-scale control operations because
of its relatively high price and complicated structure. However, it is still used to monitor the effectiveness of tsetse fly control activities.

The lower cone is made of electric-blue cotton or synthetic cloth. The inner part is divided into four compartments by four segments of black cloth. Four openings allow the flies to enter the blue cone. The upper cone is made of mosquito netting, and flies are caught in the top part, by a simple trapping device.

The Vavoua trap

This trap was designed in Vavoua, Côte d’Ivoire (Fig. 2.9) (4). It consists of a cone of mosquito netting attached to a circular piece of galvanized metal wire and placed above three screens joined together at angles of 120°. Each screen is two-thirds blue and one-third black, the black parts being joined together in the middle. The flies land on the black parts, fly upwards towards the light and are caught in the upper cone. This trap can either be used with a catching device or be impregnated with an insecticide.

The pyramidal trap

The pyramidal trap consists of a pyramid of transparent white mosquito netting surmounting two black and two blue screens arranged in the form of a cross (Fig. 2.10). It was developed in the Congo (5) and is currently being extensively used in Uganda. If provided with a catching device at the top this trap can be used without an insecticide and is then suitable for areas with high rainfall.

In large-scale programmes it offers the advantage that it is very compact for storage. It can be given its final shape in the field by extending the screens with two sticks.
Fig. 2.10
The pyramidal trap.

Fig. 2.11
An impregnated screen suspended from a metal support. Slits can be made in the cloth to discourage theft and reduce the effect of wind.
Impregnated screens

Unlike traps, screens are effective in killing tsetse flies only when impregnated with an insecticide.

The most commonly used screen consists of a strip of electric-blue material made of cotton and polyester or plastic with a strip of black nylon sheeting on either side, giving a total size of about 1 m². The screen is attached to two wooden laths and suspended from a branch by means of a rope or from a metal support driven into the earth (Fig. 2.11) (6).

The flies are attracted to the blue material and then try to settle on the black area. It is therefore sufficient to impregnate the black strips only. Consequently, the black strips have to be made of a material that offers a good substrate for an insecticide; nylon seems to serve this purpose best.

Advantages and disadvantages of traps and screens

Screens

Screens are less complicated than traps, and cost roughly 70% of the price (7). Thus, with a given budget, a larger area could be covered with screens or a higher density of devices could be used over the same area. However, the necessity to re-impregnate the screens more often is a major disadvantage.

Traps

Traps attract more flies than screens because they are visible from all sides. They require less handling, since they remain effective even after the insecticide has lost its activity.

Traps with or without insecticide impregnation

Impregnated traps are 10–20% more effective in killing tsetse flies than unimpregnated traps. With unimpregnated traps it would take more time to reach the same level of control. Unimpregnated traps have to be used with a permanent catching device, such as a catching bag. For quick action these traps can also be impregnated. When the insecticide has lost its activity, after 3–6 months, the traps continue to be effective in catching flies.

Placement

The method of placement depends on local conditions and preferences. Traps can simply be put on a wooden or metal pole. In open windy areas the suspension of a trap from a branch (Fig. 2.12) or other support probably gives more wind-resistance than putting it on a pole. Hanging traps in vegetation entails the risk that they will become entangled. The use of purpose-built supports has the important advantage that the most suitable, sunny sites can be selected (Fig. 2.13).

Screens can be attached to two wooden laths or suspended from the branches of trees by ropes. However, screens are even more easily entangled in vegetation than traps and it is recommended that they be suspended from metal or wooden supports (see Fig. 2.11).

The best location for traps and screens depends on the type of habitat. In general the best places have high densities of tsetse flies and are open and sunny. Such sites offer good visibility; flies that settle on the black screens are
Fig. 2.12
Traps can be suspended from suitable branches to hang 30–50 cm above the ground.

Fig. 2.13
Traps can be suspended from a purpose-built support in a sunny site.
more likely to fly upward into the brightly lit upper cone of gauze where they are retained.

Once the area has been selected, the trap can be moved to obtain maximum efficiency. To find out whether an impregnated trap is in a good place, count the total number of flies collected each day during the first week of operation. The results can be compared with those obtained with other traps, and unproductive traps can be moved to new sites.

**Gallery forests along rivers**

Tvsetse flies often search for a blood-meal by following river banks. This habitat is very suitable for the use of traps and screens, which can easily be put in the flight paths of the flies. Bathing and washing places should be protected by a trap or screen placed at the beginning of the trail leading away from the river (Fig. 2.14). If possible others should be placed around the area. Studies have shown that maximum efficiency can be obtained by placing traps or screens at intervals of 300 m over a distance of about 5 km, both upstream and downstream of the area to be protected.

*Fig. 2.14*
Traps should be placed near bathing and washing places.
Traps or screens should be placed:

— as close as possible to the banks of the river for the best possible visibility;
— in the most open and sunny places;
— in greater number where people frequently visit the river.

The best time to install traps or screens is at the end of the rainy season after the flood waters have gone down because:

— insecticides are likely to be washed out of the material during the rainy season;
— the tsetse fly population concentrates in the gallery forest during the dry season;
— the population of flies is older (there being a higher pupal mortality during the rainy season), and older flies are more responsive to traps.

Fig. 2.15
To protect a village, traps should be placed at the forest edge, at places where tsetse flies commonly attack.