
Section 1

Basic Biology and Anatomy of the Tsetse Fly

1.1. INTRODUCTION

The objective of this section is to provide essential information for the subsequent two sections, which give guidelines for conducting baseline tsetse surveys, so that a field worker or planner will have the basic knowledge required to carry out tsetse survey and monitoring work. It is, therefore, not intended to be a comprehensive entomological textbook, and does assume a basic knowledge of biology, as this is expected to be a requirement of anyone employed in this type of work. This section is mostly written as a revision of the now out of print Volume 1 of the FAO training manual for tsetse control personnel (FAO 1982a) and its editor Dr. John Pollock and FAO are gratefully acknowledged as the source of that valuable contribution. Many of the figures used in this section are reproduced from the FAO training manual with permission from FAO and from two important text books, i.e. The African trypanosomiasis (Mulligan 1970) and The natural history of tsetse flies (Buxton 1955), and again acknowledgments are made for their reproduction here. In order to make the key as useful as possible many diagrams are incorporated from other sources in order to make identification of tsetse species as easy and certain as possible. The authors and publishers of these original drawings are also gratefully acknowledged.

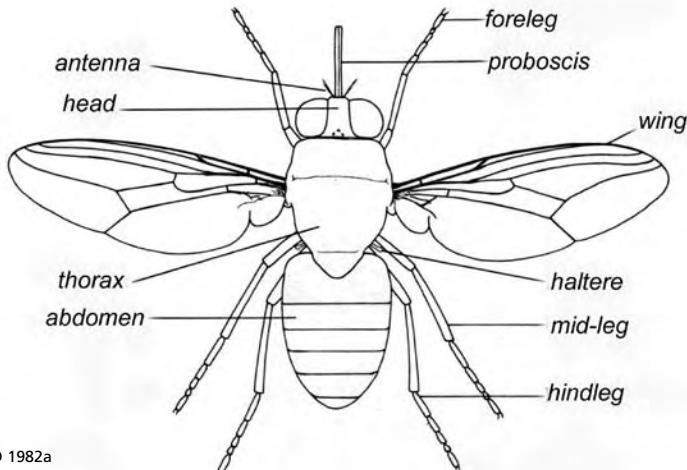
1.2. EXTERNAL ANATOMY

Tsetse flies (**Figure 1.1**) belong to the Phylum Arthropoda, which means they have segmented bodies, and they are two-winged insects, which places them in the Order Diptera. Much of their anatomy is therefore similar to other insects and Diptera, or "flies". In this section we shall concentrate on some of the features that distinguish them from other flies rather than describe all the general features of flies in detail. They have their own Family, *Glossinidae*, which has just one Genus, *Glossina*, with about 34 species and subspecies. The rules of scientific nomenclature are that the Genus and Species name should be written in italics or underlined and should always have a capital "G" for *Glossina* and a small letter for the species name, e.g. *Glossina austeni*.

1.2.1. Cuticle

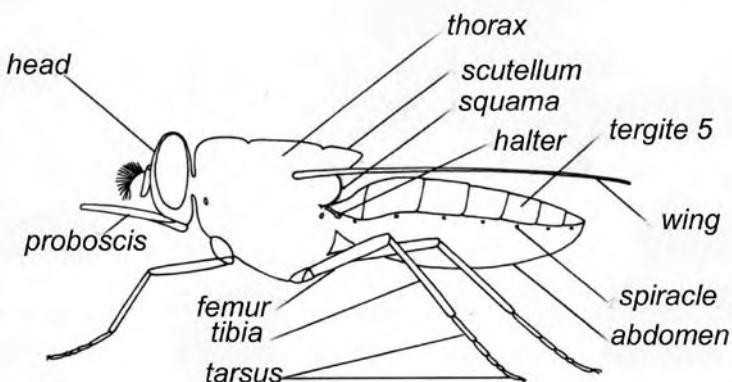
All insects, including tsetse flies have a tough outer covering called the cuticle. This is made out of a protein called chitin and can be transparent, as when it covers the eyes, or darkened, although it is generally hard, it can be flexible where necessary; for example, where the wings join the body or at the joints of the mouthparts and legs. The chitin of the ventral

FIGURE 1.1
Diagram of a tsetse fly indicating the parts of the external anatomy



Source: FAO 1982a

FIGURE 1.2
Diagrammatic side view of a tsetse fly



Source: FAO 1982a

(underneath) surface of the tsetse abdomen is elastic so that it can expand to contain the blood meal after the fly has fed.

As with all insects, the tsetse fly (Figure 1.2) has three main segments; the head, thorax and abdomen. The wings and legs are attached to the greyish-brown coloured thorax.

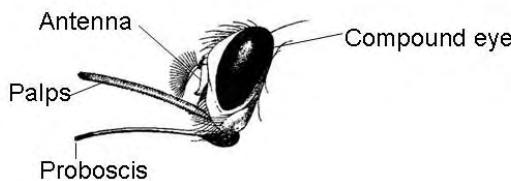
The compound eyes (Figure 1.3) are comprised of thousands of small units called ommatidia; each ommatidium has a lens at the surface of the eye. Experimental observations suggest that the compound eye allows tsetse to see things at a distance of up to

FIGURE 1.3
Lateral view of the head of a female *Glossina pallidipes*



A. PARKER

FIGURE 1.4
Diagrammatic side view of the tsetse head



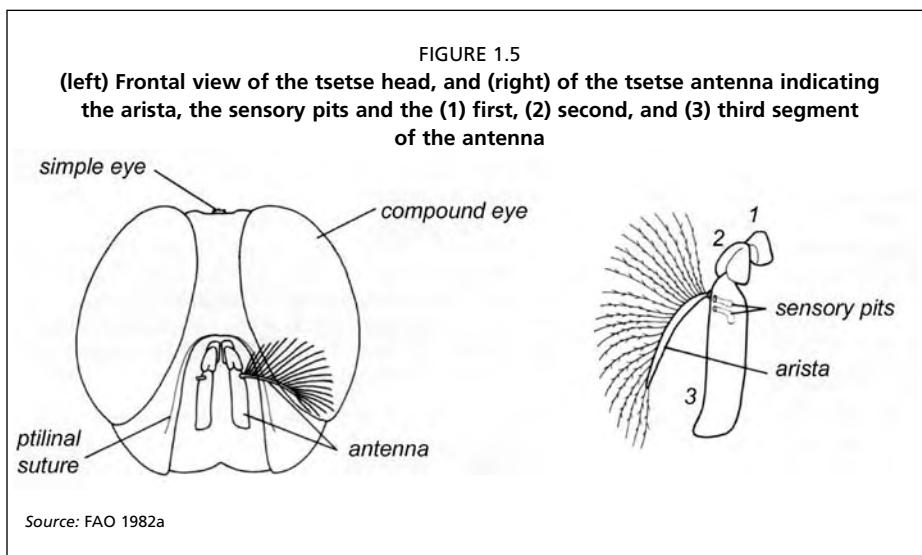
Source: Buxton 1955

130–140 metres, but they are best for detecting small movements at close range. In addition to the compound eye the fly has three simple eyes, called ocelli.

There are two antennae (**Figures 1.3, 1.4, and 1.5, right**) at the front of the head, each comprised of three segments. Attached to the upper side of the largest segment is a long thin structure with a row of branched hairs; this is called the arista. These characteristic antennae are important for species identification.

There are two sensory organs called sensory pits, containing sensory hairs (sensillae) on the third antennal segment; these sensory pits are important to the tsetse for detecting odours (e.g. attractants).

When the adult tsetse emerges from a puparium under the ground, it does this aided by a balloon-like structure called a ptilinum that comes out from the front of the head when



inflated. After emergence this ptilinum retracts back into the head and all that can be seen is the fold from which it retracts, termed the ptilinal suture (**Figure 1.5, left**). In a young, unfed fly, these structures are still soft and by squeezing the head gently it is possible to make the ptilinum come out from the head. This is useful in categorizing the age of a fly, a young fly which is unfed being termed a “teneral” fly.

1.2.2. Mouthparts

The tsetse mouthparts are also characteristic features that can be used to distinguish tsetse from other types of fly (**Figure 1.6**). The mouthparts are attached to the head by a bulb-like swelling at the end of the labium, called the thecal bulb (**Figure 1.7b**). This bulb contains muscles to manipulate the mouthparts. At rest, the mouthparts point forward (**Figure 1.7a**) and are protected by a pair of maxillary palps (**Figure 1.7c**). When the fly feeds, the mouthparts are lowered from the palps and point downwards (**Figure 1.7c**).

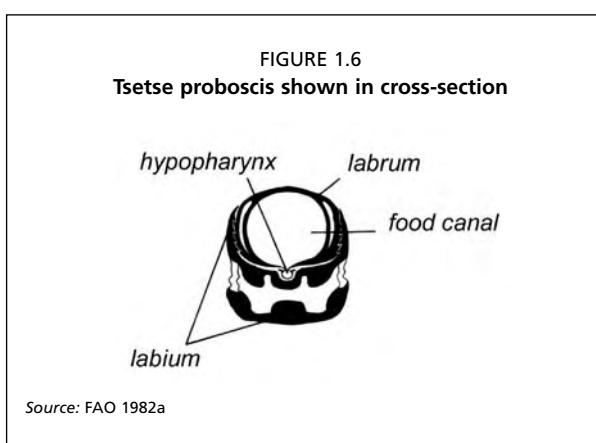


FIGURE 1.7
 (a) Head and mouthparts when at rest, (b) head when mouthparts are lowered from the maxillary palps for feeding, and (c) components of the proboscis

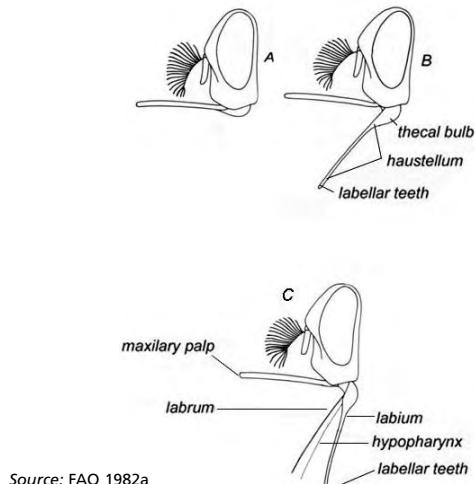
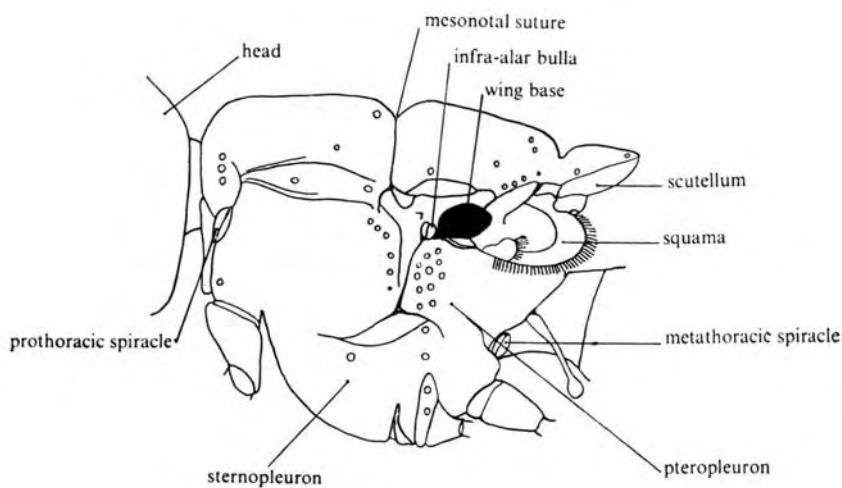


FIGURE 1.8
 Diagram of the left side of the thorax of *Glossina palpalis*



Source: Buxton 1955

The tube for sucking blood is made up of two parts that are shaped like the gutter of a building and they fit closely one on top of the other to form the tube (**Figure 1.6**). These two parts are called the labium, which is the thickest and darkest section and the labrum, which is thinner and more transparent. The labium has small teeth (labellar teeth) at the tip, which are used to pierce the hosts' skin. The small tube within the blood-sucking tube is called the hypopharynx that is used to inject saliva into the host blood to stop it from coagulating. It is important to recognize these structures as they are sites for trypanosomes in infected flies and therefore can be dissected and examined microscopically to determine infection rates of tsetse with trypanosomes (see 3.2.5.4.).

1.2.3. Thorax

The thorax (**Figure 1.8**) has already been briefly described; the three pair of legs and one pair of wings are attached to the thorax. As with other Diptera, there is a pair of small club-shaped organs called halters attached close to the wing attachment. These vibrate and are used to help balance and steer the fly during flight. There are a variable number and size of bristles attached to the thorax that are used for species identification. There are two pairs of spiracles in the sides of the thorax; these are openings leading to tubes called trachea that branch throughout the inside of the tsetse body. These are for respiration, the spiracles allowing air to pass into the trachea to provide oxygen.

1.2.4. Legs

The leg structure (**Figure 1.9**) is similar to that of other insects, being made of four main segments, the coxa, trochanter, femur and tibia and then five smaller tarsal segments ending with two claws and two small pads called pulvilli. All segments except the coxa, which is attached to the thorax, are flexible and can move.

1.2.5. Wings

Characteristic of tsetse flies is that at rest, the two wings lie one on top of the other over the back of the abdomen. The rear trailing edge of the wings is not protected by a thick-

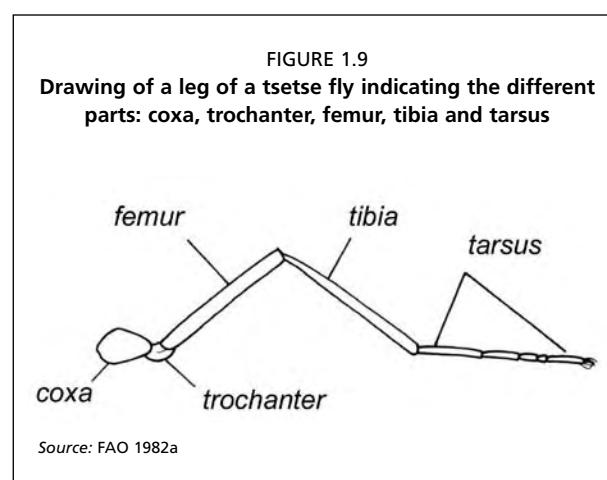
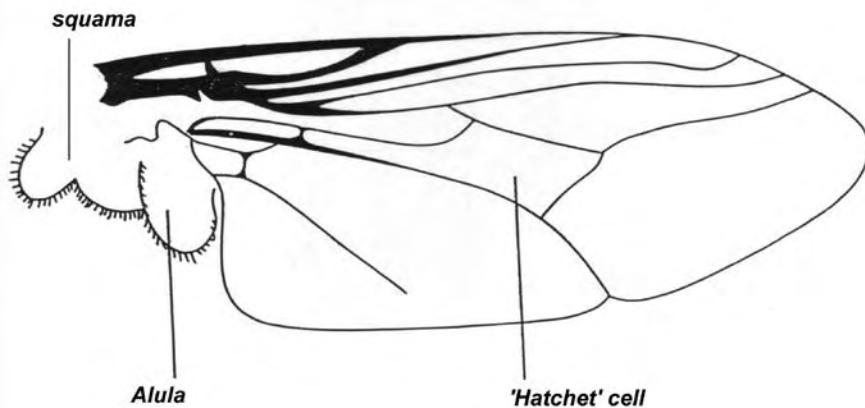


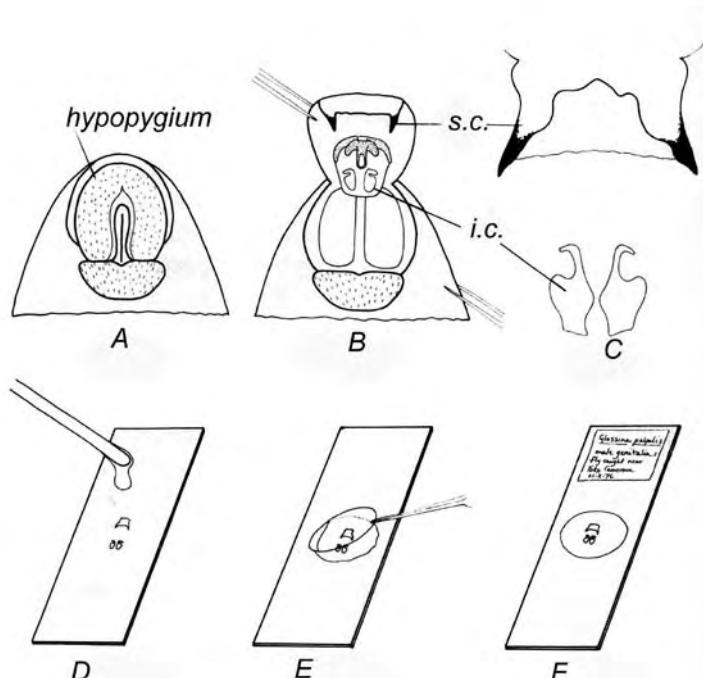
FIGURE 1.10
A diagram of a wing of a tsetse fly indicating the "hatchet cell"



Source: Mulligan 1970

FIGURE 1.11

Drawing indicating (a,b) the location of the hypopygium of the male external genitalia, the inferior (i.c.) and superior claspers (s.c.), and (d,e,f) an illustration of the dissection of the hypopygium for microscopic examination



Source: FAO 1982a

ened vein as the front edge is, and consequently can become increasingly damaged with age as it frays. This can be used as a crude measurement of the relative average age of a tsetse fly population. Another characteristic feature of tsetse that can be used to distinguish them from other flies is that some of the veins in the wings form a cell in the shape of a hatchet or machete; this hatchet cell (**Figure 1.10**) is often cited as a feature for tsetse identification and can also be used as a measure for the size of a tsetse fly.

1.2.6. Abdomen

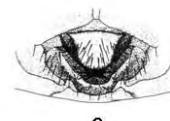
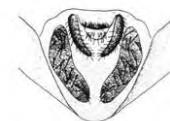
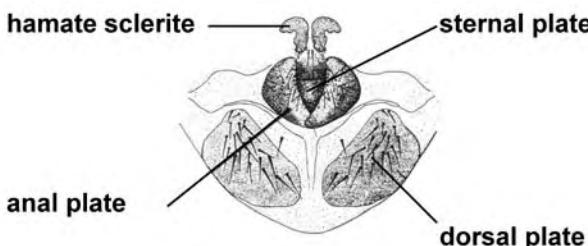
The abdomen has seven visible segments and the male fly has a structure at the posterior tip, folded underneath the last two segments called the hypopygium (**Figure 1.11**), forming part of the external genitalia. Each segment of the back of the abdomen has a harder cuticle forming a plate or tergite, unlike the elastic ventral surface referred to earlier. The colouring and markings of the tergites are sometimes useful for species identification. There are seven pairs of spiracles, one pair for each segment, along the sides of the abdomen, and an anus at the posterior end.

1.2.7. Genitalia

The genitalia, particularly of the male, are useful features for species identification and are therefore described in some detail here. It is easy to distinguish the sexes of tsetse by the presence of the folded hypopygium at the posterior tip of the abdomen, compared to the female in which there are no equivalent obvious structures, simply a small hole surrounded by a variable number of small flat chitinous plates (**Figure 1.12, left**).

FIGURE 1.12

(left) The external genital armature of female tsetse indicating the dorsal plates, the anal plates, the sternal plate and the hamate sclerite (after Mulligan 1970), and (right) a diagram showing the differences of the genital armature between the (a) *fusca* group, (b) *palpalis* group, and (c) *morsitans* group



Source: Jordan 1993

On the male, in addition to the hypopygium, there are hairy plates just in front of it called the hectors. The hypopygium and the hectors are used by the male to hold onto the end of the female's abdomen during mating. When mating starts, the male unfolds the hypopygium revealing the superior and inferior claspers and the penis (or aedeagus). The hypopygium can be unfolded and examined under a dissecting microscope, especially for looking at the superior claspers, in the way shown in **Figure 1.11**.

1.3. INTERNAL ANATOMY

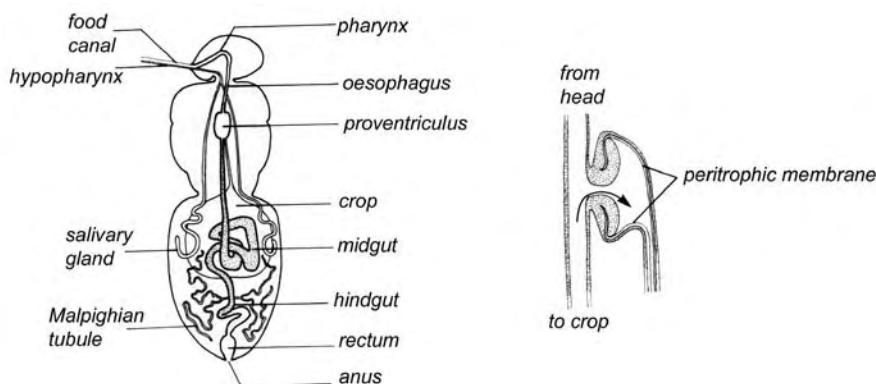
The tsetse fly has two salivary glands that stretch through from the abdomen, through the thorax and head to the proboscis into which they open into the hypopharynx (**Figure 1.13**). The salivary glands produce saliva containing an anticoagulant, preventing the blood of the host from clotting whilst the fly feeds. The glands are very transparent small tubes that can be difficult to see without a microscope but they may be important to recognize as they are the site for development of *Trypanosoma brucei*-complex trypanosomes, which can infect livestock and cause sleeping sickness in humans.

1.3.1. Organs Associated with Feeding and Digestion

When a tsetse fly feeds, it first disengages the proboscis from the maxillary palps and lowers it to the hosts' skin. Using the labellar teeth it then penetrates the skin and cuts small blood capillaries. Blood from these capillaries forms a small pool under the skin and is sucked up through the proboscis by means of a muscular pump in the pharynx. The blood is mixed with saliva from the hypopharynx and then passes down the oesophagus into the muscular proventriculus. Most of the blood continues on from the proventriculus into the crop where it is stored temporarily before being passed back up into the proventriculus

FIGURE 1.13

(left) Digestive system of the tsetse fly, and (right) the internal structure of the proventriculus with arrow showing the route that the blood makes to get from the crop to the midgut



Source: FAO 1982a