Section 3
Implementation of a Baseline Data Survey

3.1. SAMPLING DEVICES

3.1.1. Traps

3.1.1.1. Trap Types

A variety of traps have been designed to catch different species of tsetse, and a variety of odour attractants are available that can be used to make the traps more efficient. Traps and attractants for a given species may function differently in different locations, sometimes because of differences in behaviour of genetically different populations of that species or due to different environmental factors. The types of trap available and an indication of their efficiency for those species for which the trap has been tested are given in **Table 3.1.** Similarly, **Table 3.2** and **Table 3.3** indicate the effectiveness of different odour attractants against species of tsetse flies for which they have been tested in East, West and southern Africa (Kuzoe and Schofield 2005). Some of the recently identified attractants listed in these tables have not yet been widely tested or utilized. When selecting an odour attractant, one must not only consider its index of increase in performance of the trap but economics and practicality. It should also be noted that the indices of increase are obtained comparing specific trapping systems in specific areas and can therefore only be used as a rough guide.

The predominant trap designs in current use are described and illustrated below, and their efficacies for the different species are compared.

Biconical trap (Challier and Laveissière 1973, Challier et al. 1977)

The biconical trap (**Figure 3.1a**) was developed in the early 1970s for catching *Glossina palpalis* (see FAO training manual for tsetse control personnel, volume 1, section 7.2.2.2 (FAO 1982a)). It is still one of the most widely used traps and has been used extensively for sampling *Glossina palpalis palpalis, Glossina palpalis gambiensis, Glossina fuscipes* and *Glossina tachinoides*. The trap is very efficient for *G. tachinoides* but less so for *G. palpalis* and is recommended for both control and for surveys of *G. tachinoides*. The trap consists of two cones each 80 cm wide, an upper cone 73 cm high and a lower cone 60 cm high, joined at their widest point. The trap body is kept open by a metal or plastic hoop sewn into the seam where the two cones join. The blue lower cone has four entrances, approximately 30 cm high and 20 cm wide. The upper netting cone has a 12 mm hole to allow flies to enter the cage. Vertically dividing the inside of the trap is a black cruciform, which acts as

both a target and baffle. The trap is supported by a central pole, but can alternatively, be suspended from a convenient branch. That is not recommended for survey purposes as movement of the trap in wind could increase the variability of the trap catches. The weight of the trap is supported at the upper cone apex by a welded wire cone, which supports a cage (usually of the Geigy type; see FAO training manual for tsetse control personnel, volume 4, section 3.1.4 on cage designs (FAO 1992)). The trap is easily transported and deployed and for this reason may be more appropriate to use than other trap designs with slightly better efficiency but which are more difficult and time-consuming to deploy.

Monoconical trap (Lancien 1981)

Developed as a simplified biconical trap for control of *G. palpalis*, and *Glossina fuscipes quanzensis,* the blue/black monoconicals have an upper netting cone, with the same cruciform target below as the pyramidal trap. The monoconical trap has a polyvinyl chloride cone used as a rain cover for the impregnated material below (**Figure 3.1b**). Instead of a lower cone, blue streamers hang vertically from the cone rim. As in the biconical trap there is a black cruciform target; this is the same width as the cone and extends from the trap top to below the cone rim. The cone is nearly half the size of a biconical, and is self supporting. There have been many subsequent versions of monoconical traps. Type A monoconical has one screen black and the other blue, whilst type L monoconical has the central portion of each screen black and the outer portion blue. One of the better known has no blue streamers, and the cruciform target is black above the level of the cone rim and blue below. The early monoconical traps were primarily developed for control purposes but can also be used for sampling. Most trials have indicated that they catch fewer flies than the biconical.

Pyramidal trap (Lancien and Gouteux 1987)

The pyramidal trap, which was developed primarily for the control of *G. p. palpalis* and *G. f. quanzensis*, is simpler to make and cheaper than the biconical trap (Lancien and Gouteux 1987). Instead of a lower cone or streamers, one diagonal of the black cruciform target is replaced by blue (**Figure 3.1c**). The upper net cone is pyramidal with the blue and black reaching only half way to its top. If free standing, the upper part of the baffles are netting; when used with insecticide and externally suspended for control, the baffles are modified to accommodate an internal net funnel and a collector filled with diesel fuel, gas oil, as a preservative. The cone is kept open by two horizontal pieces of wood inserted diagonally across its base. Its comparative efficiency with the biconical trap varies with location, catching 2–5 times more *G. p. palpalis* in Congo, but similar numbers in Côte d'Ivoire.

Vavoua trap (Laveissière and Grébaut 1990)

The Vavoua trap (**Figure 3.1d**) was designed for control of *G. palpalis palpalis* and to be suspended or fixed to the ground with a pole. Its efficiency is similar to that of both the biconical and pyramidal traps, but it is considerably cheaper. The trap has one arm of the cruciform of the type L monoconical omitted, giving three half screens at 120° to each other. They only reach half way up into the cone and there is no netting baffle above. The net cone is held open by a hoop sewn into its rim. The trap is fixed to the ground using an iron pole, similar to that used for biconical traps although it can also be suspended. The

stick is made from 8 mm concrete reinforcing steel 1.7 m long. To keep the trap in a normal position, after installation, cut four sticks of wood, of bamboo or of any sufficiently rigid plant, to hold the screens without them breaking or bending. They must not be too heavy as the pyramid of netting becomes fragile very rapidly after exposure to the sun.

Monoscreen trap (Okoth 1991)
Developed for community-based control of *G. fuscipes*, this trap has a single half black, half blue screen reaching half way up into a small net cone (**Figure 3.1e)**. Flies are collected in a Geigy-size cage. The cone is held open by a hoop sewn into its base and the trap is free standing.

Bipyramidal trap (Gouteux 1991, Gouteux et al. 1991)
The bipyramidal trap was developed in the Central African Republic (CAR) for community based control against *G. f. fuscipes* (**Figure 3.1f**). Tests in the CAR indicated that the bipyramidal trap was twice and four times as effective in trapping *G. f. fuscipes* as the biconical and monoconical trap, respectively.

F3 trap (Flint 1985)
Developed for sampling *Glossina pallidipes* and *Glossina morsitans morsitans*, the F3 trap (**Figure 3.1g**) has been widely used. From outside, the trap is a blue box, the front lower half of which is folded in to give an entrance with a horizontal shelf above. Other than the rear, all inside surfaces of the upper half of the trap are black, including the shelf. All inside surfaces of the lower half are blue, except for the rear target, which is black. The F2 trap (Flint 1985) is identical in design to the F3, but is white whereas the F3 is blue. The cone is recessed half way into the trap, and is an asymmetric pyramid with its apex to the fore of centre and level with the trap top. Earlier versions used a large wire gauze cage to prevent overcrowding, later replaced by an arrangement of chambers made from plastic bottles and a collecting bag. A blue tarpaulin groundsheet forms the floor of the trap, and this can be greased or sprayed with insecticide to deter ants; the groundsheet is, however, often omitted. The trap is supported internally by a tubular frame, which also provides an external cage support.

NGU trap (Brightwell et al. 1987, 1991)
The NGU trap series (**Figure 3.1h**) were developed primarily to provide an effective, cheap and easily made trap for community-based control of *G. pallidipes*. Three of the series have subsequently been used for both survey and control. From above the NG2G is an equilateral triangle. The rear two sides are blue, the shelf is black and slopes down into the trap from the top. The black target base is attached half way along the base of the two sides and its top is fixed to the upper rear corner. The pyramidal net cone is not recessed and a 12 mm hole in its apex admits flies to the cage. A large polythene cage in the form of a modified tetrahedron is used to avoid overcrowding. The trap and cage are supported externally by poles; the cone is supported internally by a centre pole with three nails in its end. The NG2G has one 1 m blue wing on one side of the entrance, and the NG2F has one 0.5 m blue wing added on each side of the entrance. Both the NG2G and NG2F catch

more *G. pallidipes*, and *Glossina longipennis*, than the original NG2B, but the NG2F version is preferred as it is symmetrical, and hence easier to make and more robust once erected in the field.

Epsilon trap (Hargrove and Langley 1990)

The epsilon trap was developed as an alternative to the F3 and from above, this trap looks like an equilateral triangle (**Figure 3.1i**). Like the F3, it is blue outside, with the lower half of the front folded back into the trap to give a horizontal shelf. The target is a vertical 0.5 × 1 m piece of black cloth sewn into the rear of the trap, all other inside surfaces are blue. As in the F3 the cone is recessed, with its apex level with the top and forward of centre. It uses the same plastic cage design but lacks a groundsheet. It is supported internally by poles held upright by guy ropes.

NZI trap (Mihok 2002)

The NZI trap (**Figure 3.1j**) could be regarded as a variant of the NGU trap, being triangular in cross-section, but having two wings of blue cloth. The trap is efficient for some species of tsetse and has been widely used for sampling biting flies.

H trap (Kappmeier 2000)

The H trap (**Figure 3.1k**) was developed at the Onderstepoort Veterinary Institute, South Africa to catch *Glossina brevipalpis* and *Glossina austeni*. The trap has been used in South Africa, baited with synthetic ox odour (*p*-cresol and 1-octen-3-ol) dispensed from eight sachets with 7 ml mix in each, and acetone (dispensed from a glass bottle with 6 mm hole in top). Unlike sticky panels, flies sampled with the H-trap can be used for release-recapture studies.

S trap (Ndegwa and Mihok 1999)

The S trap (**Figure 3.2**) was recently developed for catching *Glossina swynnertoni* in Tanzania and Kenya. The S1 trap, baited with acetone and octenol, was 3.5 times as effective in catching *G. swynnertoni* than the biconical trap. The trap was less effective in Tanzania. A later modification of this trap, the S3, was 2.9 times as effective as the biconical in Tanzania.

Sticky panel traps (Vreysen et al. 1996, 1998) and water traps

Sticky substances and water traps have been used both to catch flies attracted to coloured screens or trays and to hold flies killed or stunned by other methods such as electric screens.

Sticky panel traps have been used successfully to sample *G. austeni* (Vreysen et al. 1996, Vreysen et al. 1998). Various designs have been developed, including a 3-dimensional white target and a 60 × 70 cm blue or white plywood target that slots into a metal frame which rotates freely in a rod sunk into the ground or a similar trap suspended from a branch (**Figure 3.1l**).

There are various commercially available sticky substances including Tanglefoot®, Stickem®, and Temoocid®. Before any particular type is used for sampling, it is essential to

FIGURE 3.1
Tsetse trap designs currently in use

(a) biconical trap, (b) monoconical (Lancien) trap, (c) pyramidal trap, (d) Vavoua trap (e) monoscreen trap, (f) bipyramidal trap, (g) F3 trap, (h) NGU (NG2G) trap, (i) epsilon trap, (j) NZI trap, (k), H trap, and (l) sticky panel trap (XT)

Note: See FAO training manual for tsetse control personnel, volume 4 (FAO 1992) for further details

(a, c, g, i) S. TORR, (e) P. ABILLA

FIGURE 3.2
The S3 trap developed for the sampling of *Glossina swynnertoni*

S. MIHOK

ensure that the flies cannot pull themselves free. This is best done by just simply watching a sticky trap in operation over a period of time. The sticky substance is normally applied over a coloured metal, wooden or cloth screen up to 1 × 1 m in size.

Sticky metal sheets/trays: a piece of corrugated iron or a plastic tray about 1.2 × 0.6 m is coated with polybutene or other sticky substance (Tanglefoot®, Stickem®, and Temoocid®).

Water trays: a shallow, 4-5 cm deep, tray of the same dimensions as above is filled with water and a little detergent added. The tray is usually painted light brown to match the soil colour; white water trays are themselves attractive to several tsetse species.

Sticky metal trays were widely used initially, but most workers now prefer water trays for stationary electric nets. This is because it is much easier to collect and handle the flies, and they are in better condition for subsequent studies such as counting, dissection for ovarian ageing, etc.

3.1.1.2. Advantages and Disadvantages of Traps

Advantages

- traps can (see below) provide a standardized system of sampling that is not dependent on the varying ability of people to catch flies with hand nets,
- traps can be used for species to which the odour of humans is repellent, e.g. *G. pallidipes* and *G. morsitans,*
- compared to fly rounds, traps catch a higher proportion of females that is more representative of the true sex ratio of the population,
- traps can operate over the full activity period of the fly. If the activity period changes, depending on climatic conditions, methods that only sample for part of the day can give misleading results, and

- traps provide a relatively cheap method of sampling that can be managed by only a few staff (not necessarily the case in large surveys).

Disadvantages

- traps have to be well constructed and maintained to provide a standardized sample,
- as all sampling methods, trap samples are biased towards certain segments of the tsetse population and the details of bias are insufficiently defined to allow correction of the data,
- the efficiency of stationary traps is very dependent on their deployment sites,
- traps are not sensitive enough to readily detect low-density populations of some species, e.g. *G. morsitans*, and
- traps may give a misleading picture of activity patterns because trap efficiency varies through the day, and also because some tsetse species are crepuscular, active at dawn and dusk, and may not be able to see the trap when light intensities are low.

3.1.1.3. Selecting the Most Appropriate Tsetse Trap

Although the basic design of a trap, e.g. a biconical trap, might be the same, there can be variations in that design that can affect its efficiency. Variations seen in the field include the size of the cage, the colour of the blue cloth and the size of the entrance in the blue cloth. Whilst it is preferable to have a design that will be the most efficient, especially when surveying low-density areas, probably the most important thing is that the traps used for a given survey are of the same design and quality. Without such standardization of design the data are less easy to interpret and could be misleading. Similarly, for any given species it is preferable to use the same trap type for the survey. If there are different tsetse species in the area, then the most suitable trap for each species could be selected.

For riverine species such as *G. palpalis* or *G. fuscipes*, use the biconical (designs currently in use, Challier and Laveissière 1973), Vavoua, pyramidal (designs currently in use, Gouteux and Lancien 1986) or bipyramdial (for *G. f. fuscipes*, Gouteux 1991) traps.

For savannah flies, such as *G. morsitans* subspecies and *G. pallidipes*, the best trap seems to depend on where you are. In East Africa, the NG2G (Brightwell et al. 1987) or NZI (Mihok 2002) traps seem to be the best, whereas in southern Africa the epsilon (Hargrove and Langley 1990) is better. However, the ease of deployment and construction should also be taken into consideration when there are only small differences in efficiency between traps. The NZI, F3 and to a lesser extent the NG2G traps are rather cumbersome to deploy, requiring several sticks to be carefully positioned in the ground to support the trap.

For the *fusca* species *G. brevipalpis*, the H trap (Kappmeier 2000) has been found to be the best in South Africa, whereas the NGU and epsilon traps have been used successfully to catch *G. longipennis* in Kenya and Somalia.

3.1.2. Trap Manufacture: Materials and Construction

It is important to have standardized survey traps based on the same design and fabricated from the same materials, and used in conjunction with standardized odour dispensers that dispense attractants at the same, appropriate, pre-determined rates.

TABLE 3.1
Trap types and their suitability for capturing tsetse species.

	Biconical	Pyramidal	Vavoua	Lancien	Epsilon	F3	H-trap	NGU	NZI	Sticky trap	S-trap
Palpalis											
G. p. palpalis	•	•	•								
G. p. gambiensis	•	•	•								
G. tachinoides	•	•	•								
G. fuscipes	•	•	•	•							
Morsitans											
G. morsitans					•						
G. pallidipes	•				•	•		•	•		
G. austeni							•			•	
G. swynnertoni											•
Fusca											
G. longipennis	•				•			•	•		
G. brevipalpis							•			•	

Few *fusca* group tsetse are listed, which is a reflection of the fact that those species, inhabiting forest areas are generally of less economic importance than species of the *palpalis* and *morsitans* subgenera, that are responsible for most transmission of trypanosomosis to humans and livestock, rather than of the fact that traps are not effective against them. Traps will not have been tested against many of the 13 *fusca* subgenus tsetse.

Although traps can often be made locally, using locally available cloth and tailors, this is often not the best option. Batches of cloth and netting material can differ, even from the same supplier, in terms of colour fastness (persistence of the colour) – there can be significant variability in the time taken for colours to fade in the sun. It is therefore preferable that all material comes from the same batch or from a supplier with good quality assurance. As already described, the type of dyes used and the dyeing procedure itself can significantly affect the durability of the trap, especially regarding the colour fastness, that will affect the traps efficiency. Using commercially available traps from a reputable manufacturer, to agreed specifications, is likely to be a cost-effective approach guaranteeing a high degree of standardization of the efficiency of the traps. For community-based surveys or for control operations, there can be advantages to having the traps made in villages within the area as this enhances local involvement and sustainability; this usually leads to a possible decrease in efficiency and standardization.

If traps or targets are to be made in a village or homesteads, there are certain essential rules to be followed. Designs should be as simple as possible; staplers should be considered rather than sewing machines; welding should be avoided as much as possible. Locally available materials such as rush matting, bark cloth or sacking have been proposed for traps, however, they are not recommended for surveys as their durability and the trap efficiency is likely to be variable. Due to the potential difficulty in making traps to a standardized design,

this sort of local manufacture may not be appropriate even if it initially appears to be more economical and to provide the commonly desired involvement of local communities. Locally available items may be used for certain purposes such as making covers to protect odour dispensers from rain or for some odour dispensers such as those for cow urine.

Having selected an appropriate trap design, the most important thing regarding its production is that all traps produced should be of the same standard specifications in all respects especially size, colour (dye) and type of fabric used. Sometimes, different batches of fabric, even though coming from the same manufacturer and factory, may not be consistent in terms of colour and quality of the dying. An excellent photographic description, developed by the Natural Resources Institute (NRI), of how to make and site commonly used tsetse fly traps and odour attractant dispensers is available on the internet. Further details of trap design are provided in a World Health Organization (WHO) manual on vector control (WHO 1997). Link: http://www.who.int/docstore/water_sanitation_health/vectorcontrol/.

Most tsetse traps have a netting cone, or inverted funnel shape above the body of the trap. This is designed to allow light to pass and elicit the escape response of tsetse, upwards, towards light, leading them to the holding device or cage. For this reason, the netting should be less visible to tsetse flies. For trap cones, the upward escape response is important, and therefore, the degree of light transmission is critical. Netting colour may have some effect on catches and it has been observed that new "shiny" netting seems to reduce the catch compared to old or dull netting. White or grey netting is usually used for traps cones, or where the cone is recessed, black or grey is more common.

The costs of the different parts of a trap can be reduced by rationalizing the manufacture process, although as stated elsewhere, in order to ensure a higher degree of uniformity and standardization it is recommended that traps are purchased from a commercial supplier.

If the traps are not purchased commercially, all the fabric for traps should be cut out by the team that will use the trap or by a team of tailors supervised by them. When constructing many traps it is best to use templates (e.g. of 8 mm plywood) from which the cloth parts can be accurately marked and cut out. The careful planning of the cloth cutting will minimize wastage and reduce costs.

All the materials used in the construction of the trap must be resistant to weathering and the sort of wear and tear expected in a long-term field survey. Several studies have investigated the possibility of using local plants and plant materials to produce the biconical and other traps: it is unclear whether or not traps made out of natural locally available materials would adequately withstand the effects of a harsh climate for a long time, but equally important it might be more difficult to ensure standardization of such locally manufactured traps.

3.1.2.1. Cloth Fabric

Selection of the appropriate materials for trap construction is a compromise between attractiveness to tsetse, durability, cost and availability. It would seem relatively simple to decide on the most attractive material. However the exact blue is very critical and few workers have access to the facilities required to assess spectral reflectance. When selecting

materials by eye, it is useful to compare it with a sample of material that is known to be attractive, such as phthalogen blue cloth for *morsitans* group flies.

3.1.2.2. Colour and Durability

Experiments done on responses of tsetse to colours in the 1970s and 80s showed that an electric or royal phthalogen blue was most attractive to tsetse; black was just about as attractive as blue but significantly, elicited a much better landing response. The majority of traps have, consequently been designed with a combination of these colours, using blue to attract the flies to the trap and black to encourage the flies to land on it. As the intention is to lead the tsetse flies into the trap and subsequently to catch the flies, the black part of the trap is generally internal, to some extent, so that tsetse flies landing inside the trap will go upwards, funnelled towards the catching device (cage) rather than just flying out in the same direction that they entered. Tsetse flies can detect a wider range of the wavelength spectrum than humans, and are sensitive to wavelengths in the near ultraviolet (UV) part of the spectrum. UV light from fluorescent tubes are often used in appliances for killing tsetse flies in areas where food is produced and consumed; tsetse flies are also attracted to UV light and for *palpalis* group tsetse flies, a high UV reflectivity encourages a landing response. This has been made use of in designing targets to control those species.

When selecting appropriate colours it is important to compare them in daylight, rather than artificial light. Shiny surfaces may reduce the settling response of *morsitans* flies, and this may reduce the effectiveness of synthetic fabrics and plastics.

Blue fabric — Extensive testing of the attractiveness and durability of blue fabric resulted in a mixed polyester cotton (33:67%) (approximately 200 g/m^2 fabric), dyed in electric blue (phthalogen blue dye for cotton and plasto-soluble blue for polyester) being recommended. Although this fabric is less suitable for impregnation with deltamethrin, its colouring is very stable and it is highly resistant. Equivalent synthetic fabrics (terylene) are more expensive. The blue dye for all types of trap and target should be phthalogen blue. This is highly resistant to fading by sunlight and has the optimum UV reflectance for attracting tsetse.

Black fabric — Black cloth is particularly prone to fading after exposure to sunlight unless it is dyed twice (double dying), with acid sulphur dyes. A suitable fabric is a 100% polyamide material (approximately 44 g/m^2) dyed with a stable mixture of black and orange (sulphonic sodium acidic salts). The texture of black fabric is less important for the traps; however, it is necessary to choose a fabric with a dye that is resistant to solar radiation. Poor quality material may result from suppliers who dye the cloth just once, with a cheap UV-sensitive dye, or who take cloth originally dyed in another dark colour and dying it just once again with black, and then claiming that the double-dying requirements are met. In both cases the black will become a light grey – or green – after being exposed to the sun.

Mosquito net — A 100% polyamide mosquito net (approximately 30 g/m^2), as above, withstands long exposure to the sun better than 100% polyester netting and is more appropriate for the manufacture of the traps. It is however necessary to change the cones

often (at least once per year, sometimes two). In Côte d'Ivoire, the mosquito netting parts of Vavoua traps were replaced with an opaque white polyamide fabric, which was more resistant and cheaper without significantly reducing their efficiency. The netting must be strong enough to withstand the elements and to give a good base for any sewing to which it is subjected. The "holes" in the netting should be no more than about 4 mm across, i.e., small enough to prevent tsetse flies from squeezing through. For some types of trap, e.g. the epsilon, the netting cone is not visible from outside the trap and so plays no part in visual attraction from a distance. Hence, the colour of the netting is usually not important, provided it allows plenty of light to pass through. For traps such as the biconical and pyramidal, the netting cone is visible from outside the trap and is an important component of visual attractiveness. For such traps the netting is usually recommended to be bright white. However, the netting should not be so opaque as to block more than 50% of through light. The type of fibre for the netting is usually not important and can be cotton or polyester, however, it is important that the netting does not sag under the weight of the trap, deforming its shape. In Zimbabwe, a plastic-coated fibreglass netting has been used satisfactorily.

3.1.2.3. Durability

Materials must be durable under field conditions because an entomological survey can take place over several months and the material must resist handling and bad weather. Fading and other colour changes due to the sun and the rain can be a serious problem; for example white, although highly attractive to *morsitans* species, is now rarely used, as it yellows quickly. Blue dyes vary greatly in their durability, but phthalogen blue on cotton cloth is remarkably colour fast. Blue dyes on pure synthetic materials may rapidly fade to a greyish blue that is much less attractive to tsetse. When selecting materials, the manufacturers should be asked which dyes they use, and how colour-fast they are when exposed to sunlight and rain.

The choice of a suitable type of netting may be difficult. Often, only lightweight cotton net is locally available, and this is easily damaged and rots if exposed to rain; poor quality netting often stretches asymmetrically, deforming the shape of the trap and potentially affecting its efficiency adversely. Nylon netting only lasts a few months if exposed to sunlight, and other more expensive synthetics are preferable.

Summary of optimal fabric requirements for trap construction

- blue: phthalogen electric-blue dyed cotton/polyester mix,
- black: 100% polyamide cloth (44 g/m^2) dyed with black and orange sulphonic sodium acidic salts, and
- white mosquito netting: 100% polyamide, approximately 30 g/m^2.

3.1.2.4. Poles

The poles used for supporting biconical and monoconical traps are usually made out of the sort of metal pipe used for water pipes, cut to about 1.7 m length and with a metal spike, approximately 20 cm long welded to one end. These poles are strong and durable, although heavy to carry for long distances.

3.1.2.5. Cages

One of the most important components of a trap is the cage. The Geigy cage is the most widely used cage design. This rectangular cage measures 10 × 7 × 20 cm, although these dimensions may vary. If the trap cage is too small in relation to the number of flies caught, the flies will be so crowded that they stop light passing down through the cage and into the top of the netting cone. This may reduce the catch by inhibiting the transfer of flies from the trap cone to the cage. Moreover, if there are many flies in the trap they can accumulate at the base, so that they spill over the entrance to the cage, fall to the ground and avoid being recorded in the catches. The cage can be tilted or manufactured as a trapezium rather than a rectangular shape to avoid this. A potential source of error is that the trap efficiency may decrease beyond a certain threshold of flies caught before the cage is emptied. An alternative, in areas where the tsetse density is expected to be high, is to use an arrangement of plastic bottles, shown in **Figure 3.3**, which concentrates live flies away from the cone apex and allows dead ones to fall into a bag for ease of collection.

Another possible solution is to use a larger cage. Large cages have been used in Zimbabwe, especially with F3 traps, however, their size can be inconvenient if many traps are being deployed and only for a short time, especially in areas where the numbers of tsetse expected to be caught are not so high. If the flies are not required for dissection they can be directed away from the cage into a container (a sink), such as a plastic bottle, in which they are killed, either with insecticide or a preservative liquid (formaldehyde solution). For moderate numbers of flies, an internal collecting jar containing preservative can be used to store dead flies away from the cone apex and allows catches to be monitored.

FIGURE 3.3
Photo showing an arrangement of plastic bottles on an epsilon trap that concentrates live flies away from the cone apex and allows dead flies to be collected in a bag

S. TORR

3.1.2.6. Cost and Availability

Maintenance of traps or targets constitutes a major component of total costs. Hence it may be cheaper to use more expensive materials that last a long time and need less maintenance.

In view of the difficulties of importing materials in many instances, local availability is likely to determine the choice of materials. Shortage of a relatively cheap item that has to be imported, or is intermittently available, can seriously disrupt survey programmes. Some imports (e.g. acetone) are in such general use that this may not be a problem, but even locally made supplies may fluctuate in availability. Importation of acetone has become more difficult due to controls imposed to prevent its use for preparation of illegal drugs and due to its flammability. Before existing trap materials are substituted by new ones, their effectiveness should be checked.

3.1.2.7. Alternative Survey Methods for Low-Density Tsetse Populations or Difficult-to-Trap Species

There are a number of additional survey methods that are not in common use, yet may have some merit under certain circumstances, particularly for tsetse species at very low densities or which do not come readily to available standard trap designs.

Odour-baited fly rounds — Hand nets can be used to capture tsetse flies that have been attracted to a man or a bait animal, or to an odour-baited target. One of the earliest ways of sampling tsetse flies was for two or more men to walk along a marked path through the bush stopping at set intervals to collect tsetse flies using hand nets. This is known as a fly round. The technique was used for surveys over very large areas (in Zambia and Zimbabwe) in the past, but has been superseded by traps, especially after it was shown that humans were repellent to *morsitans* group tsetse species. Details of this technique can be found in the FAO training manual for tsetse control personnel, volume 1, section 7.8 (FAO 1982a).

The addition of odours makes this method more sensitive for certain species. A bottle of acetone with a release rate of about 500 mg/h carried at one end of a black cloth screen will increase numbers of *G. m. morsitans*. Traps are not very sensitive for this species. In the past, instead of using bottled odours, an oxen has been led on a fly round and tsetse attracted to its movement and natural odours have been captured in hand nets at intervals along the path of the fly round. This is commonly known as an ox fly round. The technique was used to detect *G. austeni* in an area of low-density infestation at the coast of Kenya (Paling et al. 1987) but is not a widely used technique.

Searching for tsetse pupae — Pupal searches are of limited applicability, but can be useful for detecting tsetse that do not readily come to traps and for low-density populations. Pupal searches have been used to survey tsetse on Unguja Island, Zanzibar (Turner and Makishe 1985) and in Kenya (Paling et al. 1987). The method entails sieving soil samples from likely larviposition sites of tsetse and searching for puparia or empty pupal cases.

Use of artificial refuges — Refuge traps work on the principle that when the ambient temperature rises above 30ºC, *morsitans* tsetse flies naturally seek favourable microclimates (Vale 1971). They provide artificially cool dark places to attract resting flies during hot weather. A variety of refuges have been used ranging from complex devices to simple shelters providing shade and lower ambient temperatures. Artificial refuges have so far only been widely used for the savannah species (*G. pallidipes, G. morsitans,* and *G. longipennis*) and mostly for research purposes and sampling. They are not recommended for general survey purposes but can be useful for obtaining samples of tsetse for specific types of information and for dissection. They appear to give more representative population samples for the age distribution, and can also be used to collect recently fed flies for blood meal analysis. They cannot be used to give a measure of apparent density because the number of flies entering is directly dependent on the temperature, i.e. tsetse flies only seek refuges above about 32ºC and the higher the temperature, the more flies will enter.

Electric nets — Stationary or mobile electric nets supplied with an odour can be used for sampling species that are reluctant to enter traps. Mobile electric traps have been available for at least 30 years but have been little used (stationary electric screens have been very useful for research purposes for evaluating traps, odour attractants and tsetse behaviour and are especially useful for looking at the daily activity patterns of tsetse). Among the main reasons for the fact that electric traps have been little used for survey work is their vulnerability to damage, their high cost and high maintenance requirements. These same factors will likely restrict their future use, except perhaps for specific purposes such as for surveying populations of *G. morsitans* subspecies that do not readily come to stationary traps. Further details are given in the FAO training manual for tsetse control personnel, volume 4 (FAO 1992).

An electric net normally consists of two grids of wires (about 95 x 95 cm) spaced 12 mm apart and separated by a sheet of fine black terylene mosquito netting. Each grid is made up of 0.2 mm diameter copper wires, running parallel and vertical, 8 mm apart. Alternate wires are electrically connected to the top or bottom of the frame via a spring and insulated from the other by a nylon loop. A high voltage is applied between the wires so that any tsetse colliding with the grid is electrocuted and drops down into a collecting device.

Since many flies are only stunned by the nets some form of retaining system is essential. On backpacks, this retaining system consists of a "funnel collector". Stunned or killed tsetse flies fall into a funnel at the base of the screen and slide down the funnel into a collecting bottle.

Stationary electric traps have only been used for research purposes, for which they have been invaluable for gaining an understanding of trap efficiency and behaviour of tsetse towards traps and odours (reviewed in Leak 1998). They are not very useful for survey purposes because of their expense and maintenance requirements and because they do not adequately retain killed or stunned tsetse for counting or dissection.

Mobile electric nets are potentially more useful for survey purposes, although they do suffer from the same constraints of expense and maintenance requirements. Nonetheless, they can be useful tools for trapping species that are not readily caught in other forms of

trap. Two main devices have been used: these are electric backpacks and vehicle mounted electric screens.

Electric back-packs — A portable electric screen is strapped to the back of a man who then walks along a fly round; a modified back-pack has been designed that can be held close to the ground to catch flies approaching below waist level. Electric back-packs have been used to sample *Glossina morsitans submorsitans*, *G. tachinoides*, *G. palpalis*, and *Glossina morsitans centralis*. They have also been used for behaviour studies on *G. m. morsitans* and *G. pallidipes*. The back-pack can be worn all the time, or it can be taken off and held close to the ground at regular stops along the fly round, mainly for *G. palpalis*. Electric back-packs are more efficient for catching flies attracted to man when densities are high, but may be less so at low densities. The female percentage is similar to hand net catches for *G. palpalis* but higher for *G. m. submorsitans*.

Vehicle electric nets — An electric net is fixed at the back of a motorbike or in the back of a pick-up vehicle that is then driven slowly along a sampling transect (**Figure 3.4**). Electrical nets have several advantages and disadvantages.

Advantages

- electrical nets provide a sensitive method of sampling *G. morsitans* when put on a motorbike or a larger vehicle, and
- the efficiency of catching flies by electric nets is less dependent on the number of flies attracted than is catching them by hand nets.

FIGURE 3.4
Vehicle-mounted electric screen for monitoring *Glossina morsitans*

Disadvantages

- electrical nets require a high level of maintenance compared to other sampling methods, and tend to break down frequently under field conditions,
- electrical nets are more expensive than other sampling techniques and impractical for large surveys,
- although their efficiency was formerly thought to be close to 100%, it now seems that the figure is closer to 50% and some flies may actively avoid the nets. To improve the efficiency of electric nets in certain situations it may be advisable to erect a 1-m^2 black or blue target to enhance the visual stimulus, together with an odour, if appropriate.
- electric nets can only be used when the weather is dry, and
- vehicle-mounted nets can only be operated where access is suitable.

3.1.3. Interpretation of Trap Catches

3.1.3.1. Trap Efficiency

Traps differ in their efficiency even for the same species from one geographical area to another, and therefore, modification of traps is justifiable in order to improve their efficiency. However, this may present complications when comparing traps between one geographical area and another. Unless specifically altered for that purpose, and tested, trap manufactures should follow the original specifications as closely as possible. If any modifications are made this alterations should be reported, together with test results to avoid inaccurate comparisons being made.

An efficient and attractive trap must stimulate tsetse flies not only to come to the trap but also to enter it. Only 7.5% of *G. palpalis* attracted land on the fabric of a simple blue screen; the addition of two black lateral panels will increase this to 15%. With this same system 82% of the tsetse flies coming directly to the screen land on a blue fabric with high UV reflectivity compared to an ordinary blue fabric for which only 47% do so.

In surveys at cattle ranches in north-eastern Tanzania, catches of *G. pallidipes*, *G. brevipalpis*, *G. m. morsitans* and *G. austeni* were usually about two to three times greater in traps of the NGU, epsilon and F3 types than in the blue biconical and pyramidal traps when used with odours. Catches from moving men were improved about three times when the men carried a black screen, and increased by about another seven times for female *G. pallidipes* when a vehicle was the bait. The sensitivity of surveys for tsetse flies was improved by an estimated 300 times for *G. pallidipes* and two to five times for *G. brevipalpis* and *G. m. morsitans* when surveys use traps instead of vehicles as baits.

3.1.3.2. Attractiveness

The optimal attractiveness and efficiency of a trap will depend upon the judicious choice of a trap site: clear sites, with sufficient sunshine, are optimal, having good visibility providing strong UV reflectivity. The trap must be sufficiently attractive to attract tsetse flies at least from a distance equal to their capacity for perception. Its size must therefore be sufficient (within the bounds of economic feasibility), and it must be constructed with materials for which the attractiveness for the species envisaged has already been tested (these trials can

be easily conducted using electric screens). It cannot always be assumed that a trap that has been tested elsewhere will work as efficiently in another geographical area, or for a species that it has not been tested for. In Côte d'Ivoire, certain blues and white exhibit, for *G. palpalis*, a very high attractiveness proportional to their reflectivity for UV light; in contrast, black has little or no attractiveness.

To sustain a high level of attractiveness over a sufficiently long period it is necessary to use material that is physically durable and chemically stable (see 3.1.2.3.). The attractiveness can be enhanced and maintained by using the trap with a suitable odour attractant if available for the species in question. Features of a good attractant, in addition to stimulating the appropriate response from tsetse, are long-range activity and a sufficiently low volatility so that it does not require constant replenishment (see 3.1.4).

3.1.3.3. Relationship between Trap Catches and Absolute Density

In many situations it would be very useful to know how daily catches compare with the real or absolute population density. If traps are sited in all the vegetation types occupied by the flies, and the trapping intensity is related to the area covered by each vegetation type, i.e. if most of the area is covered by open woodland, most of the traps are in this vegetation type, then there is a good chance that the changes in catches are mainly related to changes in density.

Several studies on *G. pallidipes* in Kenya, *G. pallidipes* and *G. morsitans* in Zimbabwe, and on *G. palpalis* and *Glossina pallicera* in Côte d'Ivoire have shown quite good correlations between trap catches and estimates of population size by mark-release-recapture (FAO 1982a). Such relationships may not, however, be linear. It would be unwise to use these relationships to predict absolute densities in other areas, because they will depend on many factors, especially on the distribution of traps in vegetation types and particularly if the fly distribution is uneven.

3.1.3.4. Sampling Bias with Traps

All methods of sampling tsetse are biased and traps are no exception. Bias can result from (1) flies of certain categories being less active, and therefore less likely to encounter the trap, or (2) flies of certain categories responding differently to the trap once it is encountered.

For a given species, the sample may be biased with respect to sex ratio, physiological age category, pregnancy stage and hunger stage. It is useful to understand and measure the biases of different sampling methods, e.g. low catches in cold weather may be due to the flies being inactive or low trap efficiency rather than a small population. Practically, there is little that can be done regarding the biased samples that might be collected in a survey, but it is important to be aware of them.

Sex ratio — Most traps catch a higher proportion of females than other sampling methods; especially compared to fly rounds that catch predominantly male flies. This does not mean that traps are necessarily unbiased in this respect, only that they are less biased than other sampling methods. In fact, electric screen experiments have shown that most trap designs are more efficient for males than they are for females. The performance of

traps in terms of the segment of the population that they catch can vary with location; in Côte d'Ivoire, it was found from mark-release-recapture experiments that whilst biconical trap catches give an unbiased estimate of the percentage females of *G. palpalis* in villages, they underestimated the percentage females of *G. palpalis* and *G. pallicera* in plantations. Different trap designs vary in their sex-ratio bias. For *G. pallidipes*, NGU and F3 traps catch a higher proportion of females than do biconical traps. The same applies for *G. longipennis*; in biconical trap samples females make up only about 25% of the total compared to 50% in NG2B traps.

Age composition — Very young flies of some tsetse species are generally underrepresented in population samples. This may be because they are less active than older flies. Electric screen experiments have shown that the biconical and NGU trap efficiency for teneral *G. pallidipes* is the same as for other age categories. For 4–9 day-old flies, the efficiency is actually slightly higher than for older flies.

It has recently been suggested that it is not only very young flies that are less active. With savannah species, activity may increase gradually for the first 40 days of adult life, resulting in undersampling of all the younger age groups. If this is the case, estimates of mortality rates derived from age distributions would be underestimated. Different trap designs may give quite different age compositions. Biconical trap samples of *G. longipennis* usually have a high proportion of 0–9 day old flies — at least 20% — but NG2B trap samples have less than 10% of this category.

Pregnancy stage — The later pregnancy stages are usually underrepresented in trap samples, probably because pregnant females spend more time inactive until very shortly before they larviposit, at which time there is a burst of activity as they respond to the requirement to find larviposition sites.

Hunger stage — Once flies have fed they are inactive for a period of time, and therefore unlikely to be trapped. After this period they become more active and hence more vulnerable to capture; whether this is a sudden or gradual change in the fly behaviour is still not clear. Once they encounter a trap, their entry response may also depend on their hunger stage.

The result of these biases is that samples are composed predominantly of flies in the latter part of the hunger cycle. Much can be learnt about fly populations from looking at the hunger stage using fat-haematin analysis, but there are difficulties in interpretation of such data.

3.1.4. Odour Attractants

Traps on their own are of limited efficiency for catching tsetse and consequently a lot of work was done to identify the substances that attract tsetse to their hosts so that these compounds could be used to increase trap efficiency. These compounds, largely components of host breath, urine and skin secretions are now available for baiting traps and increasing trap efficiency for some tsetse species. They are most effective against *morsitans* group tsetse (although not very effective for *G. m. submorsitans*), but less effective for the

palpalis group. Little work has been done on odour attractants of *fusca* group flies other than *G. brevipalpis* and *G. longipennis*.

3.1.4.1. Available Odour Attractants

Research is still ongoing for effective odour attractants for *palpalis* group tsetse, especially *G. fuscipes*, one of the main hosts of which is the cold-blooded monitor lizard (*Varanus* spp.). The conditions of high humidity and gallery forest habitat (reducing volatility and obstructing odour plumes) may contribute to the lower efficiency of attractants for *palpalis* and *fusca* group tsetse flies. The available odour attractants for tsetse flies were reviewed by Leak (1998), and in a technical document of the FAO/IAEA (IAEA 2003). **Table 3.2** and **Table 3.3**, provide the latest data on odour attractants from East and southern Africa and from West Africa, respectively, reproduced from the IAEA report. Performance of odour attractants for tsetse species against which they have been tested are summarized here in the **Table 3.4** and **Table 3.5.**

TABLE 3.2
Efficiency of odour attractants for tsetse species against which they have been tested.

Species	Odours	Release rate mg/h	Expected increase in catch
G. pallidipes	acetone	150	
	octenol	0.5	
	4-methylphenol	1.5	
	3-n-propylphenol	0.5	
	bovid urine	1000	10–20 ×
G. morsitans	acetone	150	
	octenol	0.5	1.5–7 ×
G. longipalpis	acetone	500	
	3-methylphenol	1	
	4-methylphenol	1	3.4 ×
G. tachinoides	3-methylphenol	1	
	octenol	0.5	1.5–2.5 ×
G. medicorum	3-methylphenol	1	2.8 ×
G. longipennis	acetone	150	
	octenol	0.5	
	4-methylphenol	1.5	
	3-n-propylphenol	0.5	
	bovid urine	1000	5–10 ×
G. brevipalpis	acetone	500	2–3 ×

TABLE 3.3
Efficiency of traps for tsetse species against which they have been tested.

	Species	Trap	Expected increase compared to biconical as standard
East Africa	*G. pallidipes*	NG2F/F3/Epsilon	1.4–2.3 × (males)
Zimbabwe	*G. pallidipes*	F3/Epsilon	10 ×
		NG2F	not tested
	G. morsitans morsitans	F3/Epsilon	4 ×
Kenya/Tanzania	*G. swynnertoni*	NG2F/F3/Epsilon	not tested
		S1 and S3 Trap (acetone + octenol)	2.9–3.5 ×
	G. longipalpis	Biconical or NG2F/F3/Epsilon	not tested
	G. austeni	Sticky panel	not tested
Cote d'Ivoire	*G. palpalis*	Biconical	
		Pyramidal	2–5 ×
Congo	*G. palpalis*	Pyramidal	1 ×
	G. tachinoides	Biconical	
	G. fuscipes quanzensis	Biconical/Pyramidal	1.6–4.2 ×
	G. fuscipes fuscipes	Biconical/Pyramidal	1.5– 3.2 ×
	G. medicorum	Biconical	
	G. longipennis	NG2F/Epsilon/F3	1–2 × males 3–8 × females
	G. brevipalpis	Biconical	

3.1.4.2. Odour Dispensers and Dispensing Rates

Details of types of odour dispensers, including how to prepare sachets of synthetic odours are given in chapter 2 of the FAO training manual for tsetse control personnel series, volume 4 (FAO 1992).

Cow urine — The more the better for attractiveness. Usually dispensed in 500 ml containers with wide opening protected from rain, e.g. 1-litre plastic washing up liquid bottle with the top cut off. Dispensing rate is variable according to temperature: 500–1500 mg/hour.

Obtaining cow urine — It should be possible to make arrangements with livestock-keepers in the area to collect urine from their cows/oxen usually before being released for grazing in the morning or whilst being milked. Provide farmers with a 20-litre sealable plastic container to store the urine. It has a strong and persistent smell so care is needed not to spill it inside of a vehicle or over other survey equipment. A small payment to farmers might be advisable to ensure their cooperation in maintaining a regular supply. This supply needs to be set-up before the survey operation, not only so that 3-week old urine

TABLE 3.4
Indices of catch increase from odour attractants* in East and southern Africa.

Location	Tsetse species	Odour attractants	Index of increase	Reference
Zimbabwe	*G. m. morsitans*	carbon dioxide 2.5–15 l/min	6	Vale 1980
		acetone 0.3–300 g/l	6	Vale 1980
		octenol	3	Hall et al. 1984
	G. pallidipes	carbon dioxide 2.5–15 l/min	6	Hall et al. 1984
		acetone 0.3–300 g/l	6	Hall et al. 1984
		acetone, phenol mix	20	Vale and Hall 1985
		octenol	3	Hall et al. 1984
Kenya	*G. pallidipes*	acetone, phenol mix	6-8	Baylis and Nyambiro 1993
		buffalo urine	9.6	Owaga 1985
		cow urine	1.8	Owaga 1985
		octenol + acetone	>7	IAEA 2003
		POCA	>4	
		POCA + decanal	2.8 – 9	
		POCA + *Pinus sylvestris* oil	4-5	
		POCA + *Pinus pumilionis* oil	4-5	
	G. longipennis	acetone and cow urine	4-5	Kyorku et al. 1990
	G. brevipalpis	POCA + decanal	>4	IAEA 2003
		POCA + *P. sylvestris*	>4	
		POCA + isovaleric acid	>11	
	G. austeni	octenol + acetone	>2	IAEA 2003
		POCA	>2	
Tanzania	*G. swynnertoni*	acetone	~1.7	IAEA 2003
		POCA	~1.5	
		POCA + decanal	~1.8	
		POCA + octyl formate	~1.6	
	G. pallidipes	POCA + decanal	>4	IAEA 2003
		POCA + octyl formate	>5	
		POCA + *P. sylvestris* oil	>4	
		POCA + *P. pumilionis* oil	>4	
		acetone	>2	
	G. morsitans centralis	POCA	>9	IAEA 2003
		POCA + octyl formate	>12	
		POCA + decanal	>10	
		P. sylvestris oil	>2	
	G. brevipalpis	POCA + decanal	>6	IAEA 2003
		POCA + *P. sylvestris* oil	>7	
Uganda	*G. fuscipes fuscipes*	*P. pumilionis* oil	>2	IAEA 2003
Ethiopia	*G. pallidipes*	cow urine + acetone	2-3	
Somalia	*G. pallidipes*	acetone, phenol mix	3-4	Torr et al. 1989
		phenol mix	1.6	Torr et al. 1989

*Carbon dioxide also exhibits good attractive properties for use with several tsetse species but is rarely used in the field because of the difficulties involved in providing a continuous supply to a number of widely dispersed traps. POCA is an odour blend of propylphenol, octenol, p-cresol and acetone.

TABLE 3.5
Indices of catch increase from odour attractants* in West Africa.

Location	Tsetse species	Odour attractants	Index of increase	Reference
Cote d'Ivoire	*G. tachinoides*	3:1 4-methyl-phenol + octenol	2.5	Filledier and Mérot 1989
		phenolic fraction of bushbuck urine	1.8	Späth 1997
		monitor lizard skin washings	1.34	Späth 1997
		warthog skin washings	1.46	Späth 1997
	G. longipalpis	warthog urine	1.58	Späth 1997
		domestic pig urine	1.91	Späth 1997
		bushbuck urine	2.51	Späth 1997
		ox urine + acetone	6	Hendrickx et al., unpublished (reported in Hendrickx et al. 1999)
Burkina Faso	*G. p. gambiensis*	POCA	~1.9	IAEA 2003
	G. tachinoides	POCA	>2	IAEA 2003
		POCA + *Pinus sylvestris* oil	~1.8	
		POCA + *P. sylvestris oil* + decyl formate	>2	
		POCA+ *P. sylvestris* oil (monoconical)	>2	
Mali	*G. m. submorsitans*	m-cresol + octenol (2:2)	~2	IAEA 2003
		octenol + cow urine	2.5 – 10	
		octenol + cow urine + acetone	2–7	
	G. p. gambiensis	octenol + cow urine	~2	IAEA 2003
		octenol + cow urine + acetone	~2	
		octenol + dodecanal + acetone (monoconical)	~2	
	G. tachinoides	m-cresol + octenol (2:2)	~2	IAEA 2003
		octenol + cow urine	~2	
		octenol + cow urine + acetone	~2	
		m-cresol + octenol + acetone	~7	
		P. sylvestris oil	~4	

* Different trapping systems and rates of dispensing odours were used to obtain these indices of increase, thus, the figures provide only a rough guide. Details of experimental methods are given in the references. POCA is an odour blend of propylphenol, octenol, p-cresol and acetone.

is available (bacteria convert chemicals in the urine to phenolic compounds over time) but also to ensure that the system will work in supplying the necessary quantity as required. The cow urine can be used for a long time (months), especially if it is occasionally topped up as required.

TABLE 3.6
Summary of available odour attractants and their usefulness for trapping different species of tsetse flies.

Species	Acetone	Octenol	4-methyl phenol	3-n-propyl phenol	3-methyl phenol
G. pallidipes	Yes	Yes	Yes	Yes	No
G. morsitans morsitans	Yes	Yes	No	No	No
G. morsitans centralis	Yes	Yes	No	No	No
G. morsitans submorsitans	Yes	Yes	No	No	No
G. longipennis	Yes	Yes	Yes	No	No
G. austeni	No	No	No	No	No
G. brevipalpis	Yes	Yes	Yes	No	No
G. tachinoides	No	Yes	No	No	Yes
G. fuscipes	No	No	No	No	No

Adapted from Natural Resources Institute.

Acetone — Acetone is more volatile so a smaller opening to the container is used, e.g. a 16 mm aperture in a glass or suitable (polyethylene) plastic bottle (note that acetone dissolves some types of plastic!). Dispensing rate will be 500-800 mg/hour depending on ambient temperature, wind and aperture.

Synthetic phenols — These chemicals are often supplied in sachets, although they can also be mixed and put in sachets by the project staff. The size of the sachets is small, usually only about 2 ml. The dispensing rate will depend upon the thickness of the wall of the sachet; it is usually about 0.5 mg/hour for octenol, 1.0–1.5 mg/h for 4-methylphenol, and 0.5 mg/h for 3-n-prophylphenol. Note that octenol is repellent at high concentrations.

3.1.5. Deployment of Traps

Trap efficiency can vary according to the tsetse species targeted, season, geographical area and the way that the trap is manufactured, maintained and deployed. An odour-baited epsilon trap may catch only 1–2% of the *G. pallidipes* population in the square kilometre surrounding the trap each day — thus for every fly that we catch there are roughly 100 flies that are not captured. Possibilities for such variability could obviously lead to misleading results. For that reason it is important to:

- standardize the deployment of traps,
- use sufficient number of traps to allow pooled density estimates to be more representative, and
- deploy the trap for a sufficient number of days at each site.

Even for the most efficient traps, about half the tsetse flies that approach a trap, do not enter (Vale and Hargrove 1979). An old, poorly sited trap, that is faded and has holes

in the netting will obviously be much less efficient and may not be very useful in providing the information required from a survey (Green and Flint 1986, Vale 1998).

3.1.5.1. How to Deploy a Trap

Having selected the most appropriate trap for a survey, the deployment of that trap can also significantly affect its efficiency. Trap catches have a degree of variability due to many factors, some of which are known, particularly environmental factors, and some of which remain unclear. It is important to maximize the traps efficiency as much as possible, especially when trying to detect flies in areas of very low density, such as at the limits of their distribution. The site of a trap used for a survey will not be the same as for tsetse control using traps. As the purpose of using traps in a survey, in addition to determining abundance in a given area, is to determine absence and presence and to identify the habitats used at different times of year, traps need to be sited in places where the habitat is not optimal and consequently expected density will be low to absent. For control purposes traps would be sited predominantly in areas of optimal habitat where the largest number of flies can be quickly killed.

The following factors should be taken into consideration when deploying a trap:

1. Height of the trap above ground level — Different tsetse species fly and feed at different heights above ground level and the height of a trap will affect its efficiency. Most tsetse species fly fairly low, but for many species no studies have been carried out. *G. austeni*, *G. tachinoides* and *G. pallidipes* are among the species known to feed at low heights above ground level and may be more readily caught in traps whose entrance is closer to the ground. More is known regarding the economically important species of the *palpalis* and *morsitans* subgenera for which studies have been conducted in relation to control using traps, targets and insecticide-treated cattle. Studies carried out for the purpose of increasing efficiency and reducing costs, showed that the majority of *palpalis* group tsetse land on the lower half of a cloth target; therefore, in suppression programmes based on insecticide-treated targets, savings could be made by just applying the insecticide to the lower half. Similarly, the majority of *G. pallidipes* feed on the lower legs of livestock; thus in programmes that are using insecticide pour-ons on livestock, savings can be made by treating only the legs with insecticide. The height of a biconical trap for catching *G. palpalis* should be approximately 45 cm from the ground as shown in **Figure 3.1a.** Of course in many situations there is more than one species of tsetse (*G. palpalis* often occurs in West Africa with *G. tachinoides*) so the height of the trap may have to be a compromise depending on the behaviour of each species. The most important thing is that the height is appropriate and is standardized for all traps.

2. Light — Tsetse flies exhibit a preference for resting in shaded places with sufficiently high relative humidity and cooler temperatures, which protects the flies from desiccation. As such, traps are more efficient when sited close to such shaded areas but in sunlight where visibility is greater and there is a greater degree of reflectance of UV light from the blue cloth of the trap. Very open areas of grassland (pasture) or grassed wetlands should be avoided. Tsetse flies caught in traps in open places and exposed to the full sunlight, will

more quickly become desiccated and die. Therefore, if flies are needed alive for dissection, traps should either be visited for collection at shorter intervals (2-hourly) or placed in locations with some shade.

3. Wind direction and trap entrance orientation — A lot of work has been carried out on the way how tsetse detect and approach a trap, particularly in relation to odours and the behaviour of odours in wind (summarized in Leak 1998). Tsetse detecting an odour source whilst resting will take off and fly upwind. Depending on wind speed and characteristics of the vegetation, odour plumes may break up and become disrupted and tsetse have evolved behavioural adaptations helping them to redetect lost odour plumes. Tsetse will therefore tend to fly upwind, following an odour plume to an odour-baited trap. The trap entrance should therefore be orientated appropriately, i.e. facing downwind so that approaching tsetse will be led straight to the trap entrance.

4. Protection from predators and prevention of trap losses — The captured flies must be protected from predation by ants and other insects as much as possible. Even though signs of ant damage, severed wings, legs, etc., are not visible, there may still be a problem. Some species of ants may remove the whole fly from the cage. The best protection is to coat all trap supports with car grease, which has no reported effect on trap catches, or, if safari ants are present, Stickem®. The disadvantage of this is that for traps that are being re-deployed every 3–4 days, the grease can be an inconvenience unless it is adequately cleaned off the poles each time the trap is removed. If the flies are not required alive a collecting bottle with a preservative can be used. Frogs and other creatures have been known to get into trap cages occasionally.

Immediately prior to trap deployment, a workshop should be organized for the trap assistants and other persons involved in trap deployment in order to refresh their knowledge from previous training courses, regarding all aspects of trap deployment, with special emphasis on standardization of procedures.

Checklist for equipment needed when deploying traps — At the beginning of the survey it is quite possible that some items that are required in the field are overlooked. Think what is going to be done in advance, step by step, and prepare a checklist of the items required. These items can be prepared and ticked off before leaving for the field. For example, (1) in addition to the traps and cages, something will be needed to hammer the poles into the ground (in the dry season some areas of ground are very hard or rocky). People often use nearby rocks but a good strong steel mallet is preferable — one will be needed for each team, (2) grease (or Stickem©) for protecting the trap catches from ants, (3) paper and pens for recording information, and for labelling trap cages, (4) recording sheets and a clip board for supporting the sheets — don't go to the field without these and end up writing information on scraps of paper that can get lost, (5) batteries for GPS instruments and rubber bands (of a suitable size) for holding cages onto the traps and avoiding gaps between the cage netting and the trap netting through which tsetse can escape are likewise needed.

3.1.5.2. Where to Deploy Traps — Selection and Characteristics of Suitable Sites

Together with survey team members, each survey team will study the maps, satellite images, and vegetation/land use maps and identify areas for trap deployment. Criteria to be taken into account are:

1. Areas of suitable habitat — Identify areas of suitable habitat (riverine forest, thicket, savannah woodland, forest) and allocate trap deployment sites according to the proportion of each habitat within the grid square, weighted towards the favoured habitat of the target tsetse species.

2. Accessibility — In addition to the above criterion, select sites that have suitable access – even if it is desirable, it will not always be practical to deploy traps in locations that will take an hour or more to reach on foot. A compromise has to be made between what would be desirable in theory and what is achievable practically, given the time and human resources available. This does not mean, however, that all traps should be sited right next to a road where the habitat might be quite unfavourable and the trap subject to interference.

3. Location within the survey zone — As mentioned previously, one of the principal objectives will be to determine the limits of the tsetse distribution. In the middle of the infested zone, where there might be a large expanse of suitable habitat, a few traps will be sufficient to determine the mean apparent density. In contrast, on the borders of the area, and particularly where there might be a narrow tsetse-free corridor between two distinct areas of infestation, it will be important to determine the precise seasonal limits, and consequently a larger number of traps should be deployed in such areas (bear in mind that catching a tsetse proves their presence, but not catching tsetse does not prove their absence).

Having identified locations on the map, when deploying the trap it will be necessary to verify the true suitability of the site in the field and some modification might have to be made accordingly. The position in which a trap is sited will vary according to the purpose (a survey, ecological study or for tsetse suppression) (see 3.1.5.1.). Whatever the site, the vegetation should be cleared within a set radius (3–4 m) around the trap. This helps to standardize visibility of the trap and will minimize the possibility of damage by fire. Each trap position should be marked, numbered and georeferenced.

3.1.5.3. Habitat Characteristics

Species of the three tsetse subgenera have different ecological niches, requiring different approaches to their sampling and the design of a survey scheme. A variety of traps have been developed, each one usually targeting a particular species or group of species. These traps do not work with the same degree of efficiency against other species and even against the same species. Variations in efficiency have also been found from one country to another.

Savannah habitats

Select an area of tsetse habitat, such as woodland or thicket, and avoid open areas such as fields and open, low-lying grasslands (called vleis, or dambos in southern Africa), and within the habitat, select an open site, ideally with paths or linear openings leading to the site that will make the trap clearly visible from a distance.

The specific point where the trap is erected should have:

- no leafy canopy overhead, especially if this might shade the trap when tsetse are active in the early morning or late afternoon,
- no leafy bushes or obstructions, such as termite hills or dense bushes, within 3 m of the trap, and
- no fallen tree boles within 15 m of the trap. Why? Because that site may be chosen in preference to the trap as it offers a typical larviposition site for females, or resting site for recently fed flies.

The trap must be assembled correctly as small errors can greatly reduce the efficiency of a trap. For instance, a small gap between the top cage and the netting cone of an epsilon trap will allow flies to escape.

Sometimes grease or other sticky material is put around the supporting poles of the trap, or even on the lower cloth components, as a barrier to ant invasion. However, this is messy, and before long the grease can get on other parts of the trap. Moreover, the grease can rapidly become covered in dust, so that ants can walk over it. Often wind-blown leaves lodge at the trap's base, forming ladders to by-pass the sticky deposit. More info and slide shows on how to assemble traps can be found on http://www.tsetse.org/

Vale (1998) listed the following rules for optimal siting of traps:

- choose level ground on which the trap can be most easily erected, but if such ground is not available, gentle slopes will do,
- avoid shade from dense canopies overhead, or from nearby trees that obscure the afternoon sun,
- keep 5 m clear of large obstructions such as dense leafy bushes, fallen trees, tall grass and large anthills. Be sure that there are paths at least 1 m wide radiating from the site, especially in a downwind direction. The downwind path should connect with other paths in various directions, and
- if, in a few minutes search you do not find a site that is naturally unshaded and unobstructed, choose the site where minor trimming of vegetation will allow you to create the desired site as nearly as possible. Then clear the grass and herbs within 3 m of the trap or within 5 m if there is a risk of bush fire. Traps should be deployed with its entrance facing down the prevailing wind. Keep the site clear and trim on return visits.

Free standing or hung from a branch — For some traps (e.g. the biconical, mono-conical and pyramidal), one means of reducing costs may be to hang them from trees rather than their being "free standing". Apart from reduced cost, this has the added advantage that they cannot be easily knocked over, although they may still be affected by strong wind.

However, there is not always a convenient tree branch available, and some traps due to their design (NGU, F3 and epsilon) must have supports, either internally using a frame or externally by means of poles or guy ropes. External supports are usually cheaper, and have the advantage that guy ropes can be adjusted when the cloth stretches.

Forest and riverine habitats

In riverine habitats of *palpalis* subgenus tsetse, traps should be deployed along the length of gallery forests:

- every 300 m (the interval of 300 m does not have to be precise),
- close to the banks,
- in open and sunny places (they can be in a range of up to about 10 m from the 300 m mark),
- at closer intervals in places frequented by people (one every 100 m or less),
- bathing places or washing places,
- bridges and fords,
- sites for mooring/landing pirogues and mending of fishing nets,
- all other places of human activity, and
- orchards — irrigated citrus or mango orchards may be good habitats for *palpalis* group tsetse as in the Niayes area of Senegal close to Dakar.

The deployment of traps may be done on foot, following the banks for the surroundings of a village and by pirogue for sites further off. This method is easy, rapid and allows one to cross from one bank to the other to choose the best site. In West Africa (e.g. Côte d'Ivoire), small motorbikes are often used for the deployment of traps, these being easy to use around villages linked by paths and small tracks rather than roads along which vehicles can pass.

When trapping riverine tsetse species — although it will generally be preferable to deploy traps on fixed poles — there may be occasions when traps will be suspended from trees over wet places. The movement of suspended traps in the wind may enhance their efficiency as tsetse may be attracted by the moving object however, unless deployed carefully, there could also be a danger of the trap swinging into branches, stopping it from functioning. On the other hand, in high-risk sites such as certain bathing places, there may be few or no trees from which the traps could be suspended, and in such cases it is necessary to use a pole.

Traps in mangrove swamps must be placed in all the potentially dangerous contact sites between tsetse and humans. The deployment is complicated by tidal marshes that present the risk of traps being submerged and if they are placed away from those areas they will not function well.

The following places are recommended for trap sites:

- at the edges of villages and near to camps if they exist; deployed with conventional supports (poles),
- near water points,
- at points of disembarkation,

- landing points of pirogues where the steepness means that the distance between low and high tide marks is not great, and
- on firm ground near all workplaces or collection places such as places for collection prawns.

In places where there are channels frequently used by fishermen or at places used by people for boarding or loading boats, floating traps can be deployed. Floating traps have been used successfully for small-scale tsetse surveys in sleeping sickness foci close to Conakry, Guinea. The flotation units must be fixed to avoid them being carried away or moved by the tides or currents. The sites chosen should preferably be flat so that the trap remains upright in shallow water.

Some towns and even capitals have sites for tsetse flies on the edges or even in the centres, for example, Stanley Pool near Kinshasa is a known tsetse habitat and tsetse are found in the centre of Dakar, in the zoological gardens.

Traps can be deployed:

- along water courses,
- near to all water collection points,
- along the edges (ecotones) of orchards (e.g. forest gardens), and
- near to enclosures of animals (e.g. zoos, livestock units, etc.).

It is essential to verify certain epidemiological factors in the field by visiting or questioning, in order to identify all the other potential habitats for tsetse, e.g. sacred forests, mango plantations, citrus orchards, etc.

When carrying out surveys in respect of human sleeping sickness, it can be useful to administer questionnaires addressing the activities and behaviour of the people in order to get a better understanding of the potential areas where transmission is taking place; this transmission is quite likely to be outside the villages at places where people conduct their other activities. These activities may even take place on different river systems at some distance from the village.

The identification of the origins (homes) of sick people may only give an approximation of the limits of the endemic zone, as it does not take into account the distances that the people may have travelled to become exposed to the disease. This should be taken into account by including the locations of activity sites when designing epidemiological questionnaire surveys.

Surveys in some savannah areas and surveys along the banks of rivers for *palpalis* group tsetse, particularly in West Africa, can be subject to the very specific problem of seasonal flooding. At the beginning of the rainy season water levels can rise very quickly, submerging and carrying away traps. Seasonal flooding is usually part of local knowledge that has to be taken into account during planning.

Surveying in fragmented habitats such as occur in many areas of West Africa where human population growth and associated activities have altered the vegetation can become more complicated. An example is the Niayes area of Senegal. The Niayes refers to areas of natural vegetation (oil palms, etc.) in low-lying coastal areas that have traditionally been infested by tsetse. Human activities have fragmented many of these areas, some of

which are quite small and frequently used for horticultural activities because of the possibility of obtaining water from wells in the depressions. Surveying thus becomes more complex in peri-urban areas with this type of habitat; there is no clear "edge" of the distribution and the probability of missing an area of suitable habitat is higher. In such a situation high resolution, recent vegetation maps and satellite images will be very useful.

3.1.5.4. Trapping **morsitans** *Group (Savannah Habitat) Tsetse Species*

***Glossina pallidipes* —** This species enters traps readily, and was the first species to be controlled by trapping (using the Harris trap in the 1920s). The biconical trap has been used widely in the past in East Africa to sample this species. It is adequate for ecological work when fly densities are fairly high, but more sensitive traps have now been developed. The most commonly used being the F3, those of the NGU series and the epsilon.

In south-western Kenya, the F3 and the winged NGU's (NG2F and NG2G) perform similarly, catching about twice as many males and 3–5 times as many females as the biconical. The epsilon catches fewer flies than the NG2G, although it is still better than the biconical. On the Kenya coast the NG2G and epsilon catch about 1.4 times more males and twice as many females as the biconical, with the F3 catching similar numbers of males and about 1.5 times more females than the biconical. In Somalia the F3 is about 2-3 times better than the biconical, whilst in Ethiopia the NG2B is about 2–3 times better than the biconical.

In Zimbabwe, the F3 catches 10 times more *G. pallidipes* than the biconical. Unlike in East Africa, the F3 is about twice as effective as the NG2B; the epsilon catches similar numbers to the F3 trap.

For survey and monitoring of *G. pallidipes*, either the NG2G, F3 or epsilon traps are recommended.

***Glossina morsitans* subspecies —** Traps are generally less efficient for catching the *G. morsitans* subspecies than they are for *G. pallidipes.* For monitoring low-density populations, sampling with mobile electric nets or odour-baited fly rounds has been recommended although neither method has been widely practiced (in view of their cumbersome nature), especially for surveys of large areas. The biconical, the F2 or F3, the epsilon and the NG2G traps have all been used in recent years for sampling.

Again, the newer traps are more effective than the biconical for *G. m morsitans*, although the difference is not as significant as it is with *G. pallidipes*. In Zimbabwe, the F3 is about four times as effective as the biconical. For *G. m. submorsitans* in The Gambia, no significant difference was observed between catches in F2 and biconical traps.

F3, epsilon or NG2F traps are recommended for survey and monitoring of *G. morsitans*, although more testing is needed for the various subspecies.

G. austeni is very reluctant to enter traps, although high catches have sometimes been recorded in biconical traps. The pyramidal may also be effective for this species. The newly developed H trap and the sticky two- and three- dimensional panel traps were more effective and are recommended for this species.

The biconical trap can also be used to sample *G. longipalpis* and *G. swynnertoni.*

3.1.5.5. Trapping palpalis *Group (Riverine Habitat) Tsetse Species*

***Glossina palpalis* —** The biconical, pyramidal and Vavoua trap are recommended for these species.

***Glossina fuscipes* —** The most frequently used traps for sampling *G. fuscipes* are the biconical, bipyramidal and the pyramidal. For *G. f. quanzensis*, the pyramidal is 1.6–4.2 times more effective than the biconical. For *G. f. fuscipes* in Kenya and Uganda, results are conflicting, with the pyramidal sometimes more effective than the biconical and sometimes *vice versa*.

Early trials in Uganda suggest that the monoscreen trap may catch more *G. f. fuscipes* than the pyramidal, but it is less effective than either the biconical or pyramidal in Kenya. The F3 and the NG2B and NG2G are certainly less effective than either the pyramidal or biconical traps.

Either the pyramidal or the biconical (unbaited) are recommended for monitoring, with either of these or the cheaper monoscreen trap being effective for control.

Little comparative work has been done to compare trap types for *Glossina caliginea* and *G. pallicera*. Mark-release-recapture and trapping studies on *G. pallicera* in Côte d'Ivoire have shown that the biconical is an effective sampling tool for this species, and is about as sensitive as it is for *G. palpalis*.

3.1.5.6. Trapping fusca *Group (Forest Habitat) Tsetse Species*

***Glossina longipennis* —** The biconical, F3, NGU series and the epsilon trap have all been used to trap *G. longipennis*. In south-western Kenya, the F3 and the NG2G traps are considerably more effective than the biconical, especially when the F3 is used without the blue floor, being significantly more effective at catching females than males. On the Kenya coast, the NG2G, the epsilon and the F3 traps all caught about twice as many males, but only about 2-3 times as many females as the biconical.

Various traps have been tested for *G. brevipalpis*, including the biconical, NG2B and NG2G. The biconical and the H trap are probably the best traps, although the H trap is much more cumbersome to deploy that the biconical trap. In Tanzania, comparisons were made between the H trap and the biconical, but trap catches were too low to draw meaningful conclusions (IAEA 2003).

The biconical will also catch a number of other species such as *Glossina medicorum*, *Glossina tabaniformis*, *Glossina nashi* and *Glossina nigrofusca*. Numbers are usually small, but normally it is not known if this reflects a low efficiency of the trap or low densities. The biconical is, however, known to be less sensitive for *G. nigrofusca* than it is for *G. palpalis*.

3.1.5.7. Collection Procedures

Once a survey trap has been sited in a georeferenced position, that position should during subsequent survey occasions, not be changed under normal circumstances. Any site change of even a few metres can alter the catch significantly (site effect).

On reaching a trap:

- check its condition to ensure that it has been functioning properly,
- record the time of collection on the data-recording sheet,
- check for flies that are still in the body of the trap and if there are any, either chase them into the trap cage or catch them manually,
- remove the cage, being careful not to allow any flies to escape or dead flies to fall to the ground. Add any manually caught tsetse to the cage, being careful not to allow any flies to fall or escape,
- attach a label to the cage (or put it inside) giving the unique trap identification number and date, and
- carefully place the cage in a cold box, or other box for transportation, that will protect the cage from damage and help preserve flies alive for dissection.

If further trapping is going to take place:

- fix a replacement cage to the trap, ensuring that it has no holes in it through which tsetse could escape,
- put a rubber band around the base of the cage making a tight fit between the extended cage netting and the netting of the body of the trap,
- verify that the odour attractant dispensers (if any) are upright and have a sufficient quantity of attractant,
- top-up attractants if necessary and check protectors from rain are in place,
- check, and repair if necessary, protection from ants (e.g. grease on trap pole), and
- record time of resetting the trap and details of attractant replenishment on recording form.

If no further trapping is going to take place:

- remove the cloth parts of the trap and pack carefully to avoid damage during transportation,
- remove grease from the trap pole and pack carefully to avoid damage during transportation,
- either throw away cow urine or return to large container if still usable — pack container in a sample box, and
- collect and store other odour attractants and dispensers safely to avoid spillage (especially of acetone which dissolves paint and can cause some damage).

Time schedule for deployment and collection — To take into account the different activity peaks of tsetse, that differ between species and between seasons it is preferable to have a fixed schedule for inspection of traps for collection of trapped flies. If this is not done it is possible for collections to be made in a way that could provide misleading results by missing activity peaks at the time of deployment and trap inspection. For this reason, the time of trap deployment (setting) and collection (harvesting) are recorded on the appropriate sheets (**Table 2.6**). Tsetse should be collected from the traps at the same time each day, preferably at a time when tsetse flies are inactive, e.g. very early morning. Thus it is important to maintain a sequence of trap deployment and "harvesting".

Any damage to the trap or odour dispensers should be recorded, and a needle and thread, or stapler, should always be carried to repair any minor damage. Cages must be checked for holes before deployment every day before putting them on the trap, and odours replenished when necessary.

The base of the lower cone of a biconical trap, and the shelf of an F3 trap, should be checked for any dead flies that may have dropped down. These should be put into the cage for counting. If there are live flies in the cone that have not yet entered the cage, they can be caught and included in that days catch or left to enter the cage to be counted the next day. Most mosquito net cones or pyramids are very worn out after about six months and it is necessary to replace them although the rest of the trap can be re-used.

Collecting flies 2–3 times per day is sometimes advisable for samples required for dissection in order to avoid high mortality and high abortion rates in cages.

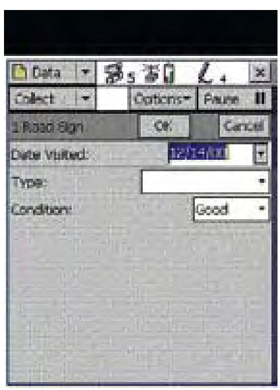
Labelling of trap cages — The labels for trap cages should be made of something durable, as scraps of paper can easily become illegible or get lost. Card, or plastic labels, e.g. 2 cm squares of plastic cut from an empty five-litre (for example, cooking oil or engine oil) container with trap numbers written on them in indelible ink are suitable alternatives (suitability depends on the numbering/labelling system used for traps). A label giving trap position should be put inside the cage, and the cages kept in a box, preferably covered with a wet black cloth to keep the flies quiet, especially if they are to be dissected later.

The trap assistant records the date of collection, the number of tsetse captured by each trap, trap identification and the type of site where each trap is situated.

3.1.5.8. Using a Data Logger GPS to Enter Trap Details

When locating traps with a data logger GPS, the data relevant to each trap can be brought up on the GPS screen for the selected trap. The GPS will direct you to the location (**Figure 3.5**).

FIGURE 3.5
View of a data entry screen on a data logger GPS



The software application that accompanies a data logger GPS will allow us to define a list of attributes for each feature to be collected. For example, for each tsetse trap we will want to record the trap identification number, the type of trap, the surroundings, the date the trap is placed. The trap ID will most likely be a numeric field, but the trap type as well as the surroundings should be chosen from a drop-down list. Creating a "data dictionary" on the PC using the software package that interfaces with the GPS allows us to define each attribute as we chose, then to upload this data dictionary to the GPS. The resulting data collection screen on the GPS reflects the type of attributes we defined in the data dictionary. Collecting trap details in this manner avoids error and saves time.

3.1.6. Maintaining the Survey Equipment

3.1.6.1. Traps

There are many factors affecting the number of flies caught over which we have no control, e.g. climate, movements of wild or domestic animals, etc. This means care has to be taken to minimize the sources of variability — such as ensuring the good condition of the traps, especially repairing holes in cages — over which one does have control.

Keeping traps in good functioning condition is vital because traps with holes in the netting, faded or otherwise in poor condition will not function properly and are almost useless for determining presence of tsetse in low densities. It is therefore important to store them well, and to carry out continuous routine maintenance; unfortunately this is often not carried out during survey operations. The reasons are sometimes understandable: traps may be in constant use with survey personnel often coming back from the field late, having worked under difficult conditions. With sufficient planning and adequate funding these difficulties can be overcome. A large amount of damage done to traps comes about during their transportation to and from the field. Traps and cages tend to be thrown in the back of a pick-up or similar vehicle after collection or before being deployed and netting is rapidly damaged from bouncing around in a vehicle on rough roads or from poles tearing holes in netting fabric. Consequently, it is common for old cages with holes to be used resulting in data gathered from trap samples that is of little value. If a hole is found in a cage the trap should be recorded as non-functional. Much of this damage could be avoided with more care in packing the traps in the vehicle and using suitable boxes for packing. Nonetheless, with field personnel working long hours under difficult conditions in the field, it is inevitable that damage will occur.

A number of traps in excess of requirements should be kept so that damaged traps can be withdrawn and replaced with others whilst they are being repaired.

Somebody who does not go out to the field on surveys should be responsible for their storage and maintenance. Traps should be stored carefully in a dry place with no possibility of damage by rats, mice or termites. Cages, cones, poles and fabric components should be stored separately where possible.

Traps and cages should be carefully checked before being deployed and holes should be mended with a needle and thread, paying particular attention to the netting. If damage is minor, this can be done in the field as traps are deployed, although it is preferable that they are checked and repaired at the field station store.

It is desirable to have an additional routine scheduled check of traps every month. The use of check-lists that have to be ticked off, signed and handed to a supervisor is useful; otherwise routine activities that are supposed to be done but are not otherwise planned are often eventually forgotten or neglected.

3.1.6.2. Vehicles

It is rare that there will be spare vehicles available for use if one of the vehicles used for a survey is off the road for some reason, although of course it would be desirable to have such a spare vehicle so that routine maintenance and repairs that will be necessary from time to time can be carried out without disrupting a survey. As that is unlikely to be the case, it is important to do whatever possible to prevent vehicles from being out of service. This can be achieved by regular servicing and replacement of worn parts before they have caused a problem and by keeping a stock of frequently used parts (oil and fuel filters, tyres, brake pads, etc.). Keeping such a stock of parts may not always be easy within government administrative and procedural structures. Routine checking of vehicles (see check-list in **Table 3.7**) will also identify arising problems so that they can be dealt with swiftly.

3.1.6.3. GPS Instruments

Some early models of GPS instruments used up batteries rapidly. Although the rate of battery consumption is now greatly improved, a stock of batteries will be required and field teams should be equipped with spare sets of batteries. These batteries should be of a good quality, which are frequently not found in rural areas. Most GPS come with a carrying case that should be used to avoid the glass display panel from becoming scratched or otherwise damaged.

TABLE 3.7
Example of a monthly check-list.

Date:	**Checked by:**			
	Number checked	*Good condition*	*Needing repair*	*Initials*
Traps				
Cages				
Odour attractant dispensers				
Vehicles	*Kilometres*	*Condition*	*Items needing repair*	*Next service due*
Vehicle 1 (reg)				
Vehicle 2 (reg)				
Vehicle 3 (reg)				
Vehicle 4 (reg)				
Signature of Supervisor:			Date:	