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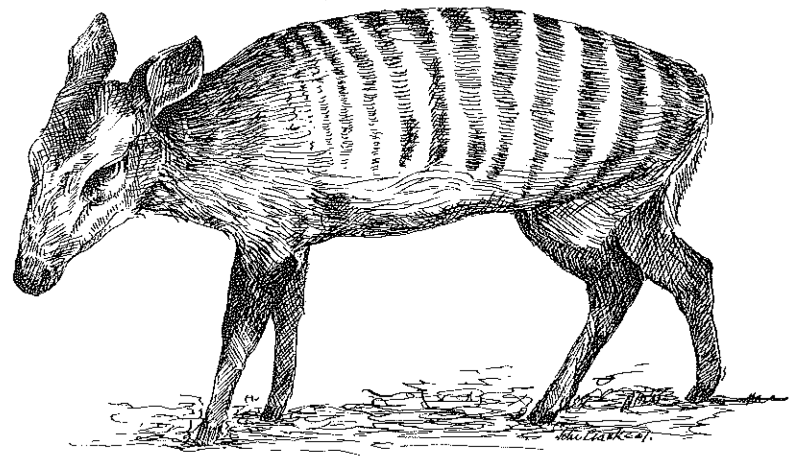
Form 4.2: Specimen Records: bats, rodents and insectivores

Specimen sheet ref:				Field sheet ref:			
Collector:				Date: (dd/mm/yy)		Time:	
Address:							
Collecting site:				Altitude:			
Latitude:		Longitude:		Slope:			
Additional notes:							
Species:		Field no.:		Sex (if known):		Age:	
Pregnant/lactating:		Embryos:		Breeding condition:			
Colour/markings:				Wounds:			
Dental formulae:				Mammary formulae:			
Ectoparasites:				Endoparasites:			
Measurements:				Bats:	FA mm		TR mm
HB mm	TL mm		TV mm	E mm	HF mm		W g
Material Preserved:							
Skin	Skull	Skeleton	Stomach	Faeces	Blood	Liver	Kidneys
Stomach contents:							
Component:				Percentage:			
Remarks/Other							

5. Large and medium mammals

Helen Newing, Glyn Davies and Matthew Linkie



zebra duiker (*Cephalophus zebra*)

5.1 Biology

This chapter will concentrate on the ungulates and the carnivores. Some species are sufficiently abundant in African forests to allow direct counting of animals to estimate popuation sizes, but many others are rarely seen, and therefore surveys rely on signs to assess their presence and gain a rough index of their abundance. The signs include conspicuous footprints in soft ground; large or persistent dung piles; diggings, and broken or trampled vegetation. This applies to many of the larger ungulates (see below), carnivores, pygmy hippo (*Hexaprotodon liberiensis*), and the pangolins or scaly anteaters, which live in burrows or tree-holes and feed on ants and termites.

Ungulates (Orders Proboscidea, Perissodactyla, and Artiodactyla)

Forest ungulates (mammals which walk on the tips of their toes) fall into two distinct size-groups. The small-bodied species (5-70kg) include duikers, chevrotain and bushbuck, which live in well-defined, stable home ranges. Larger species (>100kg) such as bushpig, giant forest hog, bongo, okapi, buffalo, rhinoceros and elephant are often wide-ranging or even migratory. In general, ungulates have a keen sense of hearing and smell, but their eyesight is relatively poor.

Duikers are the most commonly seen terrestrial mammals in many African forests, although daytime sightings all too often consist of a quick movement and rustle in the bushes before you hear a whistle as they bound away. Indeed, their shy and reclusive habit is one of the reasons why they are so poorly studied. For many years they were thought to be a homogeneous group of solitary, nocturnal, monogamous fruit-eaters, but research since the 1980s has revealed that they vary considerably in ecological characteristics (Dubost, 1984; Feer, 1989). They have a varied vegetable diet including leafy browse as well as seeds and fruits that fall to the forest floor. Some species such as the blue duiker (*Philantomba monticola*) and the related Maxwell's duiker (*P. maxwelli*) are active during the day. Others such as the bay duiker (*Cephalophus dorsalis*) are nocturnal, and the larger species (yellow-backed duiker, *C. sylvicultor*; Abbott's duiker, *C. spadix* and Jentink's duiker, *C. jentinki*) are active both by day and by night. Some species are solitary, some live in pairs, and others have been recorded occasionally in groups with one adult male and a number of adult females (e.g. Maxwell's duiker: Newing, 1994; Peter's duiker, *C. callipygus*: Feer, 1989). All appear to have territories that are marked with dung piles and musk from scent glands.

Large-bodied species such as suids (pigs), bongos, okapis, buffaloes, elephants and rhinos have lower population densities than duikers. They may also engage in seasonal migrations. Surveys of these species are therefore based mainly on sign rather than direct sightings, as explained above.

Carnivores (Order Carnivora)

All carnivores range widely relative to their body size – the larger the species the further they range – and they live at low population densities compared with the herbivorous mammals on which they prey. African forest carnivores range in size from the mongooses (300g to 5kg), genets and linsangs (500g to 3kg), otters, and the African palm civet (3kg) to the civet (c. 15kg), golden cat (c. 15kg) and leopard (c. 60–90 kg). Some open forest formations in East Africa are also home to striped hyenas (c. 40kg). All carnivores have good senses of smell, hearing and sight and are seldom seen as a result. Population surveys of smaller species depend on trapping animals using fish and meat baits (see previous chapter), whereas survey methods for larger cats include recording pug-marks (tracks), scats, scrapes and kills, and the use of photo-traps.

5.2 Management issues

There are a number of important management reasons to survey larger mammals. From a conservation perspective, it is important to know how many animals are in different areas so that management plans can take account of migration routes and important locations for food or for refuge, as well as

identifying areas with concentrations of animals that have potential for ecotourism. Where animal populations are harvested, the effects of harvesting need to be monitored to ensure that harvesting is sustainable. Furthermore there are often conflicts between large terrestrial mammals and humans. Solutions to all of these management issues need to be guided by information from biological surveys.

At a time when deforestation is accelerating across Africa, survey information is particularly important to assess and monitor the long-term effects of habitat changes. These range from complete loss of forest to minor vegetation changes due to intermittent use. Forest clearance leaves fragmented islands of forest containing small populations of ungulates that are often not viable in the long term. In contrast, selective logging can create patches of secondary vegetation that benefit a large proportion of forest ungulates that are grazers or mixed browser-frugivores (although a few species do appear truly dependent on old growth forest).

Hunting and trapping heavily affect many forest species. Showy species, such as leopards and bongos, are hunted for their skins. Forest elephants, despite having smaller tusks than their savannah relatives, have long been hunted for ivory. Duikers have been hunted and trapped for food for centuries and are still the main source of fresh meat in many forested areas of Africa. Hunting and trapping have increased dramatically over the past few decades – partly because of rural population growth and partly because of increased trade to supply growing markets in urban centres, facilitated by improved access along logging roads. As a result, although the smaller duiker species reproduce quite quickly, their populations have been eliminated from many forest areas near large human settlements and roads (Wilkie & Finn, 1990; Muchaal & Ngandjui, 1999; Noss, 1999); larger-bodied mammals reproduce the slowest.

In addition to human impacts on wildlife, large mammals can have a serious impact on humans. Elephants are major crop pests and the cause of frequent complaint from communities near forest areas. Forest pigs and buffaloes also cause problems for farmers, especially in terms of trampling and digging, and bushbucks eat vegetables in fields near villages. Leopards may prey on goats, sheep and cattle. There must be a balance between wildlife conservation and the control of animal pests, and to accomplish this we need effective monitoring of animal populations (Bell, 1984; Hill, 1998, 2000; Naughton *et al.*, 1999).

On a more positive note, large mammals are an important resource for tourism development, and forest populations of elephants, bongos, rhinos, and to a lesser extent buffaloes, can be attracted to waterholes and saltlicks near lodges for high-quality tourist viewing. However, surveys and monitoring are important to assess impacts of tourism on wildlife. A concentration of large herbivores at waterholes can cause serious damage to the surrounding vegetation. Tourist trails can affect animal distributions in different ways – large animals, such as elephants and pygmy hippos will actually use these trails, because, like people, they find it easier than pushing their way through the undergrowth, but heavy tourist use and inappropriate behaviour by tourists (or by survey teams) may frighten animals away from the area. Conversely, species that are hunted may congregate in areas where there are tourists, because hunters are less likely to come there.

5.3 Methods

General

Mammal surveys can provide three levels of data for managers. At the most basic level they can determine the presence or absence of different species at different sites in order to build up distribution maps. Information from such distribution surveys (see section 6.3.1) is most valuable for rare or endangered species or for species that can be used as indicators of forest condition. At the next level of detail, simple sampling can be used to determine the relative abundance of a species at different sites, or at a single site over time. At the third and final level, much more rigorous sampling, more extensive data collection, and thus use of robust statistical analyses makes it possible in some cases to arrive at a quantitative population density estimate.

Surveys of terrestrial forest mammals are hampered because many animal species are shy and secretive, hiding in the undergrowth. However, several successful survey methods have been developed to overcome this problem for some groups. They can be divided into direct methods, which are based on sightings of the animals, and indirect methods, which are based on counting their signs. The rest of this chapter describes the various methods and indicates the strengths and weaknesses of each of them.

Seasonal variations in climate can result in dramatic changes in animal behaviour, in visibility (according to density of undergrowth), and in the length of time that tracks and signs remain visible. Therefore basic surveys to determine presence or absence of species may benefit from short visits in different seasons, but any comparative studies should be restricted to a single season.

Identification

A number of excellent field guides are available for identifying the larger mammals of Africa. Dorst & Dandelot (1983), Haltenorth & Diller (1984) and Kingdon (1997) all provide detailed information on identification, distribution and ecology. Other useful guides include Stuart & Stuart (1995, 1997) and

Estes (1991). Although not a field guide, Rosevear (1974) is a useful reference for identifying West African forest carnivores.

5.3.1 Hunters' calls, attractants and observation points

Hunters traditionally use a variety of snorts, calls and whistles to attract different species of animals. The best example is the nasal bleat used to attract duikers, and researchers have used hunters' calls to check for the presence of different duiker species (e.g. Wilson, 1990). The results can be impressive: within a few minutes animals will often come running to within a few metres of the caller. This technique is most successful if experienced hunters are employed to do the calling, and they should not be accompanied by more than two surveyors. Calls should be made at distances of not less than 250m from each other. The surveyors should position themselves in an inconspicuous place, such as between the roots of a tree buttress, and remain still and quiet while the hunter calls.

Other attractants include natural or artificial salt licks for herbivores and meat or scent stations for carnivores (see Blum & Escherich, 1979, for the latter). It may take a few weeks for animals to find a newly-sited attractant, so they are not suitable for quick, one-off surveys.

Equipment

- camouflage-netting and string
- machete, for construction of temporary hide

Site selection

Strategic observation points include: natural salt-licks, waterholes and wallows, heavily fruiting trees, tree-fall gaps with a flush of new foliage, forest glades, logging roads, and areas with regular signs of tracks.

Procedure

i) A simple hide can be built either with camouflage-netting hung between trees or buttress roots, or by cutting the fronds of a palm tree to form a see-through wall. In protected areas, check to make sure this is not prohibited. The hide should be located downwind of the observation site. Make sure there is a comfortable sitting place so that you don't fidget. Alternatively, rather than build a hide, one can sit on a low branch in a tree or on a ridge or rocky outcrop overlooking the forest floor below – few terrestrial mammals notice stationary objects above their heads.

ii) Once a hide has been constructed it should be left for at least a day before being used, so that animals become accustomed to it.

iii) The best time to start watches for most species is just before dawn (so that you are settled down before the first light) or a couple of hours before dusk. Approach the hide quietly from the opposite direction to the observation site. Settle in a comfortable position so that you can keep still (use mosquito repellent!).

iv) It is sometimes helpful to visit the 'observation area' to look on the ground for footprints and other signs (hairs, dung, spoor, etc.), especially if watches are not producing many sightings. This can be done in the midday hours so that dawn and dusk watches are not disrupted.

v) A reasonable length of time for a first watch at a site is two to three hours. Leave the hide quietly, and in the opposite direction from the observation area.

Recording

i) Fill in the survey data in the top section of the recording sheet (Form 5.1) before commencing the observation period. Give each survey site a name, and give observation points within each site numbers or codes (e.g. Survey site: Gouleako; observation point 3). Record the type of vegetation, the degree of human disturbance (which you may know from archival information or from direct observation), and any special features that may be relevant (e.g. riverine forest, mature lightly-logged, many-fruiting figs). Include altitude if you are working across an altitudinal gradient.

ii) When one or more mammals are seen, note the time and watch quietly for a few minutes, even if you can identify the species immediately. If they remain at the site, begin to fill in the recording sheet (Form 5.1) very quietly noting the time at the start of the observation, the species and the total number of animals. Additional observations include the number of males, females and young animals, if known, and their behaviour. Make a note of any food eaten, and take a sample if necessary. If you cannot identify the animal species, write a detailed description in your notebook including an estimate of height, the shape (especially of the head and muzzle), horns (if present) and the coat pattern. Make a sketch of it.

iii) Remember to note down the time at which the animals leave. When they have gone you can expand your observation notes and consult a mammal field guide to check any species identifications you're not sure about. Also check the observation area for footprints, hairs, fallen fruits, etc.

Advantages/limitations

This is a time-consuming method, and should be undertaken only at sites where there is evidence that animals are frequent visitors. Some skill is needed in identifying suitable sites, and consulting local hunters and others knowledgeable about local wildlife can save much time and effort. Within these limitations, successful watches are a valuable and rewarding way to record the presence of different species, to study behaviour, and to determine whether sites hold any potential for regular viewing by tourists.

There are several potential negative impacts of longer-term feeding sites. Animals may come to rely on being provisioned at the site, or they may be placed in acute competition for the food at the feeding site. Alternatively, hunters may learn of the site.

5.3.2 Net drives

Net drives are used both for traditional hunting, for example in the Central African Republic (Noss, 1999) and Zanzibar Island (Archer, 1994); and also by researchers to catch small deer and antelope (e.g. Bowland, 1990; Newing, 1994).

There are inherent biases in the use of this method for determining population abundance. For example, radio-tracking has confirmed that Maxwell's duikers and red duikers sometimes move away from the nets or drivers before they are observed (Bowland, 1990; Newing, 1994). Some duikers, especially infants, will be missed because they freeze in thickets and are not flushed out of their resting places. Nonetheless, net drives are sometimes the best option to survey secretive ungulates, especially where thick vegetation makes direct sightings difficult. The biases probably differ for different species, but can be assumed to cause an underestimate.

Net drives can also be extremely noisy and disruptive, and there has been some concern about impacts on resident animal populations. However, evidence from radio-tracked animals has shown that they quickly return to their territories and resume their usual activities once the drivers have departed.

Equipment/personnel

- tape measure
- hunting nets (e.g. 50m x 2m; mesh 25–50mm; dark-coloured, elastic, ideally with a breaking strain of at least 100 kg)
- 60cm lengths of strong nylon cord attached to top of nets at intervals of about 4m
- machetes

- large team (minimum of ten) of drivers/field assistants (with or without hunting dogs)

Site selection

Within a survey site the region is stratified as described for transect surveys (see below) and sample units are selected to cover the full breadth and range of habitats.

Procedure and recording

i) If experienced hunters are taking part in the survey, it is best to follow their normal method (see Noss, 1999), since it is likely that they are successful at finding animals. Hunters usually enclose a large area (typically 4–5ha) with nets linked together.

ii) Where hunters are not involved the procedure will vary according to the thickness of vegetation, the amount of netting available, and the numbers and knowledge of field assistants/drivers. Each drive usually covers 0.5–1.0ha. If the forest is quite easy to walk through and visibility is good, it may be sufficient to set up a single net-line immediately before the drive takes place, on one side of the block to be searched. Where vegetation is very thick, a grid of trails (50m x 50m) should be cleared a few days before the drive takes place. This will allow the nets to be erected quickly and quietly and provide a sighting line for the monitors. In thick vegetation, it is advisable to net at least three sides of the drive area to make sure animals don't escape unobserved. The more nets used, the greater the time needed per drive, but the smaller the number of people needed to monitor the edges of the block.

iii) At the beginning of the drive, the field surveyors should surround the block to be surveyed as quietly as possible. The 2m-high x 50m-long nets should be erected by tying the nylon cords to trees at a height of 1.5–2 m, leaving enough slack on the ground to stop animals diving underneath. Once the nets are up, people should be stationed along three sides of the block with most people on the sides that are not netted, close enough to each other so that they can see clearly along the whole length of each side. This will be a distance of between 15 and 30m, depending on the thickness of vegetation (they usually need to be much closer together on the open sides). These people are the monitors.

iv) The rest of the assistants form a line at one end of the block, opposite a netted side. These are the beaters. Once the nets are set up, the beaters enter the area and noisily dislodge animals from their hiding places by shouting and banging trees, bushes and fallen logs with sticks. Dogs may also be used for this purpose, but they must be kept under strict control at all times.

v) Some animals typically try to break back through the beaters, and so beaters should be positioned closer together than the monitors (10–15m apart). The more people involved, the larger the area that can be included in a single drive. Depending on team size and conditions, each drive (including setting up nets) can take anything from 30 minutes to two hours.

vi) Whenever an animal is detected the species and, if possible, age and sex should be noted. The sighting is called out to the neighbouring monitors to avoid animals being counted more than once. Any animals that are caught should be restrained and examined, noting age/sex and condition. Specimens may also, under certain circumstances, be collected (see section 4.4).

vii) At the end of the drive, the team comes together to compare observations and confirm the total number of animals of each species they have seen. Basic information on the survey site, vegetation, weather and time of drive should also be noted; Form 5.1 can be used, omitting the first and last columns.

Data analysis

The population density is computed as the number of duikers counted divided by the area of forest sampled during the drives. During fieldwork, the cumulative density can be estimated at the end of each day of drives (by summing results from all previous drives), and a graph drawn to get an idea of when the density estimate stabilises and sample size is sufficient.

Advantages/limitations

Net drives are only feasible if a large labour force can be organised and transported for a few days to the survey sites. If this is possible, the method gives a large number of direct sightings and offers one of the most accurate ways of getting population information for management purposes. In areas of thick, secondary vegetation, it is sometimes the only option for surveys of terrestrial mammals.

5.3.3 Survey walks: reconnaissance and transect

The use of observation points or net drives is most suitable for concentrated surveys in small areas of forest. To survey a larger area with relatively small survey teams (two or three surveyors) the only realistic option is to carry out survey walks through the area. Survey walks are used in two ways: either for a 'quick and dirty' first assessment (a reconnaissance survey), or for a more methodical evaluation of relative abundance or population density, through the use of carefully positioned transects (straight trails). They can be based on either direct encounters with animals or indirect signs (footprints and dung – see section 5.3.4). It is not possible for a single surveyor to search thoroughly for both at the same time, but different members of the survey team can concentrate on different aspects in order to maximise data collection from each study site. Surveys should be carried out by night as well as by day, because a) nocturnal species will be seen that otherwise might remain undetected; and b) many diurnal species such as blue and Maxwell's duikers freeze when caught in the beam of a strong torch, thereby allowing the surveyor to determine age and sex of individuals.

To carry out transect surveys, new transects should be cut that are carefully located in order to sample different vegetation types and levels of human disturbance in proportion to their estimated occurrence in the study area. The perpendicular distance of each animal or group of animals (or each dung pile or group of piles) from the centre of the transect is measured, so that an estimate of population density (or dung density) can be made. For population estimates, a minimum of 40 sightings per species in each habitat is necessary, and ideally over 100 sightings should be used (Plumptre, 2000). Therefore, transect surveys can only generate population estimates for species that are seen relatively often. In practice, sightings of all species are recorded, and different techniques are used to analyse data for each species, depending on the amount of information gathered.

The procedure for reconnaissance surveys is similar to that described below for transect surveys, but with two major differences – firstly in the sampling, and secondly in the lack of recording of perpendicular distances from the transect. Reconnaissance surveys differ from transect surveys in that they 'follow the line of least resistance' through the vegetation in order to cover as much ground as possible. They may use existing human or animal paths, follow streambeds or concentrate in areas of sparse undergrowth where it is possible to walk in a straight line without clearing vegetation (Walsh and White, 1999). They consist simply of recording all encounters with animals and sign for a given distance walked. Vegetation types and levels of human disturbance can be recorded during an initial reconnaissance survey.

Equipment/personnel

To set up transects

- 30m tape-measure or topofil (hip-chain)
- fluorescent vinyl flagging tape & marker pens
- two machetes
- team of four or more people (including two or more line-cutters)
- maps, GPS, altimeter and clinometer if you are also undertaking mapping

To carry out transect surveys and reconnaissance surveys

- one or, at most, two people
- optional: optical range finder or survey laser binoculars

Site selection

i) As a general rule, transects should cover the main habitats present in the same proportions as they occur in the study area. For studies in undisturbed forest, this is usually done by using the bottom of the valley as the main axis and cutting transects perpendicular to it. For surveys of very large areas, a series of baselines can be cut parallel to the valley bottom – for example, at intervals of 5, 10 or 50km – and transects can be cut perpendicular to each baseline. Transects should be a minimum of 2km apart (preferably more), and should not cross each other. (See White & Edwards, 2000, Chapter 3, for further discussion of stratified sampling).

ii) Surveys that aim to determine the abundance of animal populations at the regional level must usually include areas with different levels of human activity and habitat disturbance (farmbush, secondary forest, logged forest, undisturbed forest). If disturbance is likely to have a greater effect on mammal populations than watersheds (for example, where hunting or farming is very intensive), it is more appropriate to use a road as the primary axis or to balance sampling according to the distance from human settlements (e.g. Lahm et al., 1998).

iii) Once the approximate survey areas are decided, transects should be positioned at least 300–500m apart and at least 500m from the base camp, because camp noises and smells often deter mammals (unless they are searching your rubbish for food!).

iv) Large animals may use existing paths, so new paths should be cut for surveying in order to ensure random sampling. However, cutting paths during surveys would frighten the animals away. As a compromise, new transects can be cut a day or so before beginning the survey. If the cutting of new transects is not felt to be justified and old paths are used, it is better to use narrow trails than wide tracks.

v) Using existing trails and roads is an efficient and useful way to check for the presence of species. However, using long-established trails that hunters and trappers follow, or logging tracks which have very different vegetation to the rest of the area, will seriously bias survey results and influence population estimates.

Procedure — cutting transects

i) Use a random number table to select a starting point and direction (left or right) from the baseline for each transect. Alternatively, select the transect direction to pass through habitats of survey interest. The choice of options will depend upon the overall aims of the study and the degree of habitat specialisation of the animals you are surveying. Each transect should be of a length that can be traversed in a single session (typically 3–5km).

ii) Each transect should be cut perpendicular to the baseline, using a compass to keep it straight and the 30m tape or hip-chain to record the distance cut. Slight detours around obstacles such as tree-falls are acceptable as long as the original direction of the transect is maintained. If the vegetation is thick, two people should take turns at cutting. Record special features (hunters' camps, streams, etc.) as they are encountered, so that they can be mapped immediately.

iii) Cut only the minimum vegetation necessary. If transects are going to be used only during the day for a period of weeks, it is necessary only to make the slightest clearance to allow movement through the area following a compass bearing (e.g. Walsh & White, 1999). If they are to be used at night, they must be visible enough so that they can be followed easily without distracting from the search for animals during night censuses. If a long-term study site is being created, trails should be cleared sufficiently so that they will need only minor maintenance.

iv) Mark the distance along the transect every 50m. If transects are only going to be used for a few months, write the distances on pieces of fluorescent vinyl marker tape and tie to saplings by the side of the path. If permanent transects are being set up, paint the distances on trees, or nail numbered aluminium tags to tree trunks.

v) Allow newly cleared transects to rest for at least one whole day before beginning surveys. This will let animals recover from the disturbance and return to their normal haunts and habits. This is also a good time to draw a sketch map of the transects.

vi) As a precaution against opening up new areas of forest for hunters and trappers, the starting point of a transect may be disguised so as not to draw attention to the new path, or may be started 50m inside the forest (from a road or logging track). Some surveyors even cut transects with secateurs so that no path is left after them. If the transect is not going to be re-used, all distance markers should be removed at the end of the survey period.

Carrying out surveys

i) Daytime surveys should preferably be carried out in the mornings from just after dawn to about 11:00, when animals are most active. If time is short, additional afternoon censuses can be carried out between 15:00 and 17:30, after which visibility becomes very poor. Night-time surveys can be conducted at any time during the night, but 20:00 is a common start time.

ii) Do not carry out surveys in the rain: it will be harder to pick up sounds, and will affect the behaviour of animals (and surveyors!). If it begins to rain, pause the survey until the dripping stops, or if it seems to be likely to continue, discontinue the survey.

iii) Ideally, transects should be walked by a single observer in the daytime, or by two observers at night. Walk very slowly, looking from side to side for movements and listening intently for sounds in the undergrowth, animal calls or gnawing sounds. Aim for an average speed of about 1km per hour, including a pause every 100m or so to stop and listen. Additional time will be taken to record data when animals are sighted. Each transect should therefore take between three and five hours.

iv) Accurate distance estimation is essential, and the use of an optical range finder is recommended (see also section 2.5).

v) If possible, rotate observers between transect lines to cancel out idiosyncratic differences. It also makes it more interesting and gives everyone the chance to see unusual tracks and signs, which can be marked with fluorescent tape.

Recording

i) At the start of each transect walk, fill out the top part of the form below (Form 5.2). When one or more mammals are sighted (and often this will be of animals in flight), complete the columns in the second part of the table.

ii) The perpendicular distance is taken from the position at which the animal was first detected to the nearest point on the transect, thus it may be necessary to walk along the trail to reach the correct point. It also may be necessary to approach the animals quietly in order to get a clearer sighting. Additional observations can include the number of males and females, and presence of infants, activities and behaviour, and association or interactions with other species.

Data analysis

i) Relative abundance: for species where sample sizes are too small to allow estimates of population density to be made, the number of animals encountered per kilometre walked gives a rough indicator of abundance.

ii) Estimating population densities from line transect censuses involves complex mathematical modelling of the likelihood that animals are detected at different distances from the transect. However, these statistical analyses can be executed by the custom-made computer program *DISTANCE,* which is downloadable from the internet (*www.ruwpa.st-and.ac.uk/distance*) and should be used in conjunction with the accompanying book (Buckland *et al.*, 1993).

Analysis rests on several assumptions:

- that transects are placed randomly with respect to the distribution of animals;
- that all animals on the line (strip width) are always detected;
- that animals are detected at their initial location, i.e. prior to any movement in response to the observer;
- that measurements of perpendicular distances (animal-transect, observer-transect) are exact.

It is rarely the case that all of these assumptions are met perfectly, which means that population estimates must be treated with some caution. For a full review of the key issues on theoretical aspects of analysis, and how to deal with discrepancies, see Buckland *et al.* (1993).

Advantages/limitations

The main advantage of reconnaissance surveys is that they are quick. Also, they can be carried out during routine activities such as patrolling by park guards, so lend themselves to monitoring. The main disadvantage is that samples are likely to be biased in terms of habitat and intensity of human use. However, some studies of elephant dung and gorilla nests have compared results of reconnaissance surveys and full transect surveys and have found a high level of correlation. The general rule is that recce surveys should be backed up by some formal transect surveys in order to evaluate any biases (Walsh & White, 1999; White & Edwards, 2000, Chapter 13).

5.3.4 Indirect methods

When the survey subjects are not seen directly, or seen very rarely, then indirect survey methods are needed. This means that surveys are made for the signs left by the animals, and the population density of the animals producing the signs is estimated. Signs include faeces (e.g. pellet piles of duikers, dung piles of elephants and buffaloes, scats of cats), footprints or spoor, hairs, diggings and nests (for pigs), urine-marking sites (pygmy hippo, rhinoceros and carnivores). In this section, attention is focused on three approaches: dung counts, track counts, and photo-traps.

A. Dung counts

Animal population density can, in theory, be calculated from dung density on the forest floor according to two variables:

- The number of dung piles produced per animal per day (defecation rate).
- The length of time the dung takes to disappear (dung-decay rate).

Unfortunately these two variables are affected by several different factors, and

this introduces many potential sources of error. In addition, for groups such as medium-sized duikers or small carnivores it is difficult to identify dung to species level. For example, only biochemical techniques will enable identification between the scats of golden cats and mongooses. Defecation rates vary with diet (e.g. White, 1995), and, in the case of big cats, with the oestrous cycle of females. Decay rates vary with the weather, microclimatic conditions, and with dung beetle activity. In Ugandan forests, for example, Nummelin (1990) showed that duiker pellets were encountered less frequently when rainfall was high prior to surveys.

Any errors in estimation of decay rate and defecation rate will have a radical effect on the estimation of population density (Plumptre, 2000). Furthermore, territorial species such as duikers and carnivores use droppings to mark their territories, so distribution of dung is not random, presenting complex sampling problems. In the case of migratory or far-ranging species such as elephants, the survey area may not cover their whole range, so dung density will vary according to the passage of elephants through the survey area in the period prior to the survey.

However, in spite of methodological difficulties, dung counts may be the best option available for surveys, since dung is the most frequently encountered sign of many larger forest mammals. In an effort to address the constraints, detailed techniques have been developed to use dung counts for surveying forest elephants (Barnes and Jensen, 1987), and similar methods have been used for species ranging from buffaloes to duikers. If dung density is very high, it may be possible to do away with the need to consider decay rates by surveying the same transects repeatedly and clearing them of dung after each survey. The number of piles produced for the unit area surveyed within a known time period (i.e between the two consecutive surveys) can then be recorded (Plumptre, 2000).

For elephants, density estimates from dung counts have been shown to correlate well with those from other methods (Barnes, 2001). In general, however, the smaller the species the less useful the method, because decay rates are much more variable (see Plumptre & Harris, 1995, for discussion of methodological issues). For this reason, dung counts for smaller species should only be used with caution for a first indication of relative abundance.

Equipment/personnel

- 30m tape-measure or topofil (hip-chain)
- steel tape-measure (1 mm gradations)
- fluorescent vinyl marker tape and marker pens to mark distances, or more permanent numbered aluminium discs, hammer and nails
- team of four people

Site selection

Most aspects of site selection are the same as those for transect surveys (section 5.3.3.). However, new transects should be used for dung transects. These may be along newly cut trails or may simply be unmarked survey routes following a compass bearing.

Procedure

i) It is advisable for every study to begin with dung decay trials to determine the length of time dung piles remain on the forest floor (but see ii below). To do a decay rate trial, at least 50 fresh dung piles should be located and marked. For elephants, each pile should be visited once a week and its state of decay evaluated according to the categories on Form 5.3. In north-east Gabon, an average decay rate for elephant dung was calculated at 2.4% per day, with individual dung piles lasting from a few days to many weeks (Barnes & Jensen, 1987).

ii) Barnes *et al.* (1997) showed that decay times for elephant dung are inversely related to rainfall in the month of deposition, and dung densities are affected by rainfall in the previous two months. However, this varies between different geographical areas (Nchanji & Plumptre, 2001). Therefore, unless detailed baseline studies have been done in a given country or region, further surveys are necessary to estimate decay rates and calculate dung density per elephant (see Form 5.3 notes on elephant dung decomposition states).

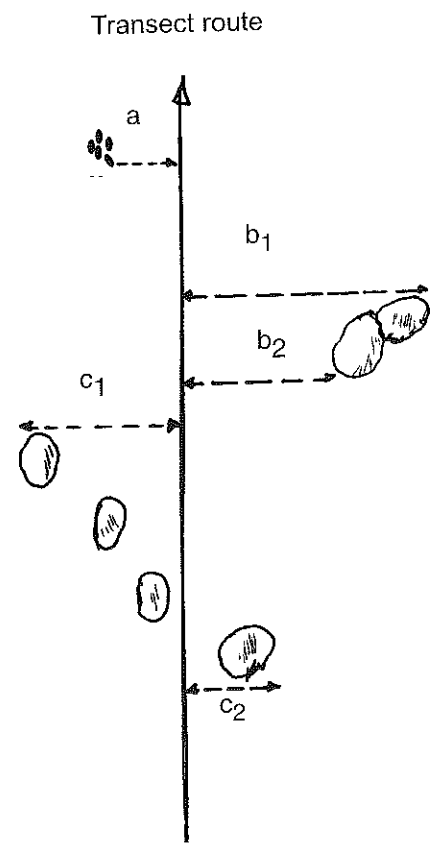
iii) The principles and procedures for dung surveys are similar to those explained for transect surveys in the previous section (section 5.3.3).

iv) During dung surveys, one person should search the ground for dung piles while the others maintain the compass route, measure the distance walked, and cut a path. The searcher should advance slowly, scanning the ground from side to side. This takes a lot of concentration, and a different member of the team should take over as searcher every 250m or so. It may be worth surveying shorter distances (subsamples of the main transect) more slowly and carefully for the pellets of smaller species (e.g. duikers), at least for presence/absence data.

v) For leopards and many other carnivores, cutting a transect through the forest will yield little information, and it may be best to survey along roads and trails. Distances can be measured by routing on a GPS.

Recording

i) When a dung pile is detected, record the distance along the transect (with the 30m tape or hip-chain), the perpendicular distance from the centre of the transect to the centre of the dung pile (with the steel tape-measure), the state of decomposition of the boli (the individual spheres of dung), and the vegetation type at that location. See Fig. 5.1



ii) You can also record tracks encountered incidentally on the same sheet (Form 5.3), putting track measurements and other comments in the general observations column.

Fig. 5.1: Dung counts

Transect measures for pellet/pile counts. Measure the perpendicular distance from the centre of a duiker pellet pile to the transect (a). For elephants, piles may be more dispersed and need to be measured in two ways: i) pile clusters on one side of the transect should be measured to the outer (b_1) and inner (b_2) limit, these added together and then divided by two; and ii) for a dispersed pile on either side of the trail, measure the outermost perpendicular distance on either side (c_1 & c_2), then subtract these two distances and divide by two (after White & Edwards, 2000).

Data analysis

i) Calculating the width of the survey transect is done as for sighting transects (above), using the perpendicular distances from the trail to each pile detected (in the case of elephants, excluding E state bolus piles, Barnes & Jensen, 1987). The mathematical calculations used to assess the variable strip width are complex but can be done using the computer program *DISTANCE* (section 5.3.3.). If possible, a minimum of 100 dung piles should be recorded (Plumptre, 2000), and the absolute minimum for this method of analysis is generally taken to be 40.

ii) The area of the transect is calculated as length multiplied by width, and the density of droppings as the number of dung piles divided by area.

iii) Once dung density has been calculated, figures are required for defecation and decay rates. Unless you have been able to calculate a defecation rate, use a standard rate of 17 boli/day for elephants (based on Wing & Buss, 1970). For duikers the situation is more problematic, because it is unlikely that defecation or decay rates will be transferable between different species, forests or seasons, and few have been studied (Koster & Hart, 1988).

Short-cut method for elephant dung counts

In an effort to reduce the time needed for detailed surveys, Barnes (1988) describes a short-cut method, whereby an observer follows a compass bearing without cutting a trail, and records the presence of all elephant dung piles (decomposition states A to E). At the most basic level of analysis, the proportion of 500m sections along the transect which contain dung is fitted to a calibration curve established during more thorough research efforts, and the dropping density (piles/km^2) read from the graph. The same data analysis procedures as described above are then used to derive population estimates. This is a very coarse-grained method of estimating densities. However, as with reconnaissance surveys, the advantage is that a great distance can be covered relatively quickly. It provides distribution data and gives some indication of the relative importance of different areas for elephants in different seasons.

Fuller use has been made of field data (the recce method) in elephant surveys in Gabon. Unlike in the full method described above, distance to each dung pile was not measured, but estimates were made from the number of piles/km. This method is obviously less accurate, but it can cover about four times more ground than the full method above (with the same effort). Walsh & White (1999) suggest using both methods, and calibrating different estimates.

B. Track (footprint) surveys

Footprints or spoor (e.g. tracks of duikers, pug-marks of cats) give vital information on the presence of species, including those that are rare or hard to spot, and can be carried out alongside other types of survey work. However, this method is less robust than dung counts for estimates of relative abundance because track densities are affected by the type and dampness of the soil substrate, rainfall, and the movement patterns of animals through the survey area. Also, track size and shape change with the animal's gait, the soil substrate, and the age of the track. Fresh tracks in an ideal soil type have well-defined, vertical edges, making it relatively easy to measure them accurately, but most tracks found will show some degree of spread as they fade. Edges become sloped and poorly defined, making measurements difficult.

As a result of these variables, similar-sized species are hard to distinguish from their tracks. Also, young animals leave tracks that resemble those of adults from a smaller species (e.g. tracks of young red duiker resemble those of adult blue duiker). Some traditional hunters have been reported to be able to distinguish the tracks of all species (Koster & Hart, 1988), but, so far, biologists have been unable to come up with objective methods to do this, and most track surveys lump forest antelopes together into two or three size categories. Species identification is less of a problem for cats since only the leopard and the golden cat are present in forests, and they are very different in size.

If it is possible to distinguish individual animals by their tracks, an estimate of population density can be made. Stander (1998) succeeded in doing this for leopards in a semi-arid environment, with the assistance of experienced San hunters and the advantage of being able to survey large distances from vehicles (he only found an average of one spoor each 38.1km). However, as with distinguishing ungulate species, biologists have found it very difficult to pin down an objective methodology (see also Smallwood & Fitzhugh, 1993).

Equipment

- ruler (marked in mm)
- hand-rake
- for tracing prints: sheets of acetate or glass and marker pens
- for making casts of prints: plastic drinking straws, talcum powder, plaster of Paris powder, mixing container, stirrer, paper casting frames, water, scalpel/sharp knife, and fine brush. Vinegar can also be used to make casts set faster

Site selection

Site selection can be:

i) Opportunistic – wherever tracks are seen.

ii) Strategic – search any area where there is a damp, soft or sandy damp substrate which will take an impression of a light footprint. Ideal places include damp, sandy or dusty areas on roads and paths and sandy stream beds (in the dry season) or river banks.

iii) Systematic – set up track stations at regular intervals (e.g. every 50–100m) along a transect. Clear all leaves and debris and rake the ground so that it is smooth and soft enough to take animal footprints (e.g. Wilkie & Finn, 1990).

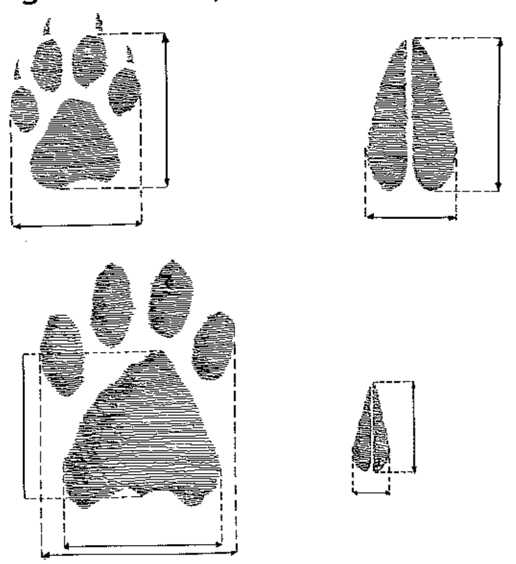
Procedure and Recording

Site features and track details for different species/mammal groups should be recorded on Form 5.4 (see White & Edwards, 2000, Chapter 10, for more detail). These measurements should be taken for up to three footprints of the same animal if possible. If unsure of the mammal group, make a sketch indicating scale and dimensions measured. Tracing onto acetate or glass sheets makes identification of individual cats from pug-marks easier (Panwar, 1979).

Identification

There are very few field guides that give details of footprint size and dimensions for larger terrestrial mammals. Walker (1991) is a noteworthy exception, but covers mostly savannah mammals. Stuart & Stuart (1995, 1997) may be helpful for people working in East Africa, while the books by Liebenberg (2000), although restricted to southern Africa, may prove useful to anyone trying to master the art of identifying mammal or other spoor.

Fig 5.2: Footprints



bottom: leopard & blue duiker, top: bushbuck & civet.

The basic footprint measurements (in mm) are length and width – as shown on the figures. For carnivores, length of pad and claws should be distinguished, and for larger carnivores the length and width of the large heel should be measured (note if claws included). Length and width of toes can also be taken.

Where possible, tracks of captive animals should be measured (e.g. in zoos) to get a clear idea of footprint shapes and sizes. One study of antelopes in the West African forest zone (Newing, 1990), distinguished four, clear footprint size classes (Table 5.1). In addition to the species listed below, tracks of the sitatunga are distinctive because of their very long, splayed hooves.

Table 5.1: Footprint lengths of species in West African forests

Max length (mm)	Species
80–100	Bongo
50–75	Large duikers (yellow-backed, Jentink's, Abbot's)
18–45	Bushbuck (30–45mm), medium/small, duikers, chevrotain
Below 18	Dwarf antelopes (*Neotragus* spp.)

Taking permanent records of tracks

When unusual tracks are found and cannot be identified immediately, it is worth taking a record for identification back at base camp for future work. This can consist of a photograph, a tracing of a footprint, and/or a plaster of Paris cast.

The first step is to carefully clear any obvious debris obscuring the outline of the print with tweezers, making sure the edges of the print are not altered.

Photographing prints:

i) Place a ruler next to the print for reference and photograph.
ii) Record the film exposure number, species name, collection date, location, identification number and collector's name in a notebook.

Tracing prints:

i) Place a glass plate over the print, ensuring the plate is flat, which can be done using adjustable screws as legs in the four corners of the plate.
ii) Trace the print outline, paying particular attention to its definition.
iii) Record the species name, collection date, location, identification number and collector's name, either on the corner of the plate or in a notebook if the print is then to be traced onto paper.

Casting Prints (in addition to photographs):

i) Using the straw, blow talcum powder over the print to prevent soil particles from sticking to the cast.
ii) Place a casting frame around the print (e.g. paper, cardboard, stiff plastic).
iii) Prepare the plaster of Paris – add water to the powder stirring continuously until the mixture has a pancake batter texture.
iv) Slowly pour the mixture into the mould evenly, gently tapping to remove any air bubbles, which may distort the impression.
v) Engrave an identification number onto the cast before it solidifies.
vi) Record the species name, collection date, location, identification number and collector's name in a notebook.
vii) Leave casts to harden for approximately two hours (cover with plastic if rain is imminent).
viii) Remove casting frame and trim excessive edges, leaving a 10mm border around the print.

ix) Brush any loose debris from cast.
x) Package in tissue or bubble wrap.
xi) Store in a cool dry room.

Data analysis

For most species, analysis will be limited to presence/absence, or the number of track sets and other signs recorded for each species per kilometre walked. For large carnivores it may be possible to carry out multivariate analyses to identify individuals (e.g. Smallwood & Fitzhugh, 1993) if there are many measurements.

C. Photo-recording

Photo-recording is expensive and requires patience to overcome malfunctions of cameras, but it can be invaluable in recording the presence of hard-to-detect species. Setting cameras with automatic trigger mechanisms allows low-labour monitoring of natural attractions (e.g. salt licks), baited sites or commonly used thoroughfares. Camera-trapping can also be used to determine activity patterns (nocturnal, diurnal, crepuscular), reactions to disturbance (e.g. Griffiths & van Schaik, 1993), seasonal movements and breeding patterns, and social structure. If enough cameras are used, it can also provide some information on abundance. Seydack (1984) gives a good example in South African forest, and Griffiths (1994) documents successful use in rainforest conditions for carnivores in south-east Asia. A full discussion of camera-trapping is beyond the scope of this manual. Interested readers should refer to Karanth & Nichols (1998) and Carbone *et al.* (2001).

Equipment

- Photographic data-recording units, comprising: a) a camera with autowinder (or Polaroid camera), enclosed in weather-proof casing, and mounted on a stand; b) a flash system with casing; c) a trigger device such as a trip-plate (300mm x 400mm), trip/bait wires, or a movement or heat sensor; and d) wires/other connectors between trigger and camera.
- Passive cameras have either a trip-plate or a movement/heat sensor. A problem with movement sensors is that most types are triggered too easily (for example, by falling leaves or fruit). However, a laser sensor is available that can be set to send a beam at different pulses, and when the beam is broken for a certain length of time it activates the camera; thus, the pulse rate can be set for a specific species.
- If a trip-plate is used, it is placed in a narrow place along a path. When an animal stands on it an electrical connection is made, causing the camera to expose a frame when the flash goes off, and the whole system automatically reloads for the next passing animal.
- If bait is being used to attract carnivores, then a mechanical trigger attached to the bait will set off the film and flash when tugged.

Site selection

The camera needs to be facing a path, track or road along which mammals commonly walk. A suitable position can be determined by finding animal trails crossing paths and by the presence of dung, scrapes and tracks. It is also important to find places where the track is narrow, and animals pass near the camera. A set of camera lines can be established to cover the whole survey area, or in the centre of several sampling units (e.g. Seydack, 1984). A suitable alternative is to use a baiting station and set the camera so that it will record any animals that come to the station. This would be preferable in cases where trails get too much human activity, or to sample small carnivores and other animals that do not habitually travel along roads/trails.

Procedure and Recording

i) Each camera is positioned at a strategic point and can be systematically rotated to maximise the area sampled. If a single camera is used, it can be moved to different sites at intervals of a few days. Also record weather.

ii) Some trials are necessary to get the best pictures. Film speed, shutter speed, aperture, distance from the plate, etc. all need to be adjusted to suit local conditions (e.g. Seydack, 1984).

iii) The majority of camera traps automatically record time and date upon activation. If not, a board giving the camera number, location and date can be placed within the field of the photograph, but without interfering with the subjects.

Data analysis

i) The photographs are developed and the species identified, along with age and sex where possible. For rare species this gives good information on presence, and sometimes information on population structure. However, be prepared that the majority of photos will be of empty trails or individuals of a large group of a single species, such as mangabeys. A lot of film will be required to obtain a few photos of rare species.

ii) For species where individuals can be distinguished by markings (such as coat patterns), photos from camera lines or cameras placed in sampling blocks can be used to count individuals, describe ranging patterns, and calculate population densities. Plotting the number of new individuals caught on film against the cumulative photographic effort will give an indication of when the majority of individuals have been photographed in the sample area, and will enable you to use mark-recapture analysis techniques to estimate densities.

5.4 Conclusions

All observations of animals or their signs should be recorded to build up a broad picture of their distribution and abundance. For most species this is all that rapid surveys can accomplish, especially where relatively few animals or their signs are encountered. However, relative abundance can be determined more accurately for elephants (with dung transect surveys) and duikers (with a mixture of day and night transects and net drives). Long-term studies are essential for reliable population density estimates.

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Form 5.1: Recording Sheet for Sightings from Observation Points

Surveyor: (total observers)	Address:		Date: (dd/mm/yy)	Field sheet ref:
Survey site:	Observation point:		Vegetation:	
Latitude:	Longitude:	UTM (if available):	Altitude:	
Weather:	Time at start of watch:		Time at end of watch:	
Other:				

Start time of obs.	Species	No. of animals			Additional observations (behaviour, food eaten etc.)	End time of observation
		Male/ Female	Sub adults	Juv/ inf		

Form 5.2: Recording Sheet for Sighting Transects

Surveyor: (total observers)	Address:	Date: (dd/mm/yy)	Field sheet ref:
Survey site:	Vegetation:	Weather:	
Latitude:	Longitude:	UTM (if available):	Altitude:
Transect length:	Start time:	End time:	
Other:			

Time	Distance along transect	Vege-tation	Species	No. of animals			Cue	Perpen-dicular distance	Group spread	Additional observations
				Male/ Female	Sub-adult	Juv/ inf				

Cue – H (heard) or S (seen) Perpendicular distance = distance from nearest point on transect to position at which animal was first detected (in metres) Group spread = spread of group of animals of a single species, recorded in a single sighting (in metres) Observations = behaviour, association with other species; any other comments

Form 5.3: Recording Sheet for Dung Transects

Surveyor: (total observers)	Address:	Date: (dd/mm/yy)	Field sheet ref:
Survey site:	Vegetation:	Weather:	
Latitude:	Longitude:	UTM (if available):	Altitude:
Transect length:	Start time:	End time:	
Other:			

Distance (km)	Species	T/D	Bolus. state & diam.	Distance from transect (cm)	Vegetation type and general observations (including description and max. width and length (mm) for tracks)

Notes: Distance from start = from start of transect; T/D = tracks/dung; Bolus state: A – fresh, whole, moist and smelly; B = fresh, whole and odourless; C1 = > 50% boli intact; C2 = < 50% boli intact; D = formless, flat mass; E = Decayed to a stage that it cannot be detected at a range of two metres, and would not be seen on a transect unless underfoot (adapted from Barnes & Jensen, 1987) Make measurements of the diameter of intact elephant boli (in cm)

Form 5.4: Recording Sheet for Tracks

Surveyor: (total observers):	Date: (dd/mm/yy)	Field sheet ref:
Address:		
Survey site:	Vegetation:	Weather:
Latitude:	Longitude:	Altitude:
Transect length:	Start time:	End time:
Other:		

Location (transect marker number)	Species	Soil type	Soil mois-ture	Vegeta-tion type	Clarity of print	Measurements (mm)

Soil type: S = mostly sandy; C = mostly clay; St = stones; Si = mostly silt.
Use combinations where necessary, e.g. C+St = mostly clay + stones
Soil moisture: dry; damp; wet
Clarity of print: distinct = well-defined with clear edges; fair = mostly well-defined but some edges 'spread' or confused by other tracks or debris; indistinct = clear enough for identification but measurement difficult because of spread, other tracks or debris.

6. Primates

Glyn Davies

6.1 Biology

African primates are divided into three taxonomic groups (Oates, 1996): the small, nocturnal prosimians (20+ species); the monkeys (45+ species); and the apes (3+ species). Like humans, non-human primates that are active in the daytime generally have a poor sense of smell, moderate hearing and excellent eyesight (nocturnal species are obviously very different, having weak distance-vision and acute hearing). Savannah species (e.g. baboons) and the lemurs of Madagascar are not discussed in this chapter, but the forest survey procedures still apply to these species where they do occur in forests.

mona monkey (*Cercopithecus mona*)

Prosimians

These primitive primates are separated into two families: the galagos *(Galagonidae)* and the lorisids *(Loridae)*. All species are primarily nocturnal (Charles-Dominique, 1977). Forest galagos are generally small (18+ species; 50–300g), although three species exceed 1,500g in weight. They live in small family units, travelling and foraging in the understorey and middle canopy of