Expedition Field Techniques
BATS

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Cover illustration: A Noctilio leporinus mist-netted during an expedition, FFI Montserrat Biodiversity Project 1995, by Dave Fawcett. Courtesy of Kate Jones, and taken from the cover of her thesis entitled 'Evolution of bat life histories', University of Surrey.

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Preface

In this book I aim to give an introduction and overview of techniques that can be used in the field to study bats. The book is mainly aimed at fairly small expeditions that intend to carry out quite general surveys and initial studies. It is not intended to be anywhere near an exhaustive review and should not be read as such. I only cover a very small segment of the huge amount of literature available on bats and I do not attempt to include any regional references, as I do not believe that there is sufficient scope in a publication such as this to do this properly. I would very much like to hear people's views and suggestions on the book so please contact me directly or via the EAC with your comments.

Kate Barlow

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Section 1

BATS AND FIELDWORK

1.1 Introduction

Bats (Chiroptera) are among the most diverse and widely distributed groups of mammals and can be found on all continents, except Antarctica. There are around 1000 species of bat in total, only the rodents (Rodentia) are more specious. The diversity and abundance of bats is probably attributable to a number of features of their biology that are unique. Bats are the only flying mammals, many species echolocate and they have a wide range of feeding and roosting habits, social behaviours and reproductive strategies. Their nocturnal habits and the diversity in their biology make bats a fascinating group of animals to study, but also a difficult one.

The order Chiroptera is divided into two suborders, the Megachiroptera and the Microchiroptera (Koopman, 1993). The megachiropterans are all found in the Old World tropics and sub-tropics, feed on fruit, nectar and pollen and roost mainly in trees (Hill & Smith, 1984). There is one family, the Pteropodidae, containing 42 genera and 166 species (Koopman, 1993). The 57 species of the largest genus, *Pteropus*, are mainly island species, and levels of endemism are extremely high; 35 species are found on only one, or on a small group, of islands (Mickleburgh *et al.*, 1992). The megachiropterans do not use high-frequency echolocation but have large eyes and good vision, and use sight and smell as their major locational senses. The microchiropterans are found almost world-wide and there are 16 families, 135 genera and 759 species (Koopman, 1993). Microchiropterans use high-frequency echolocation and rely on hearing as their major locational sense. They may feed on insects, fruit, nectar, pollen, fish, other vertebrates, or blood and they roost in a great variety of sites including caves, buildings and trees (Hill & Smith, 1984). The largest family, the Vespertilionidae, has around 300 species and an almost global distribution.

Insectivorous bats are found throughout the tropical and temperate zones and are thought to play an important role in the regulation of populations of many insect groups. Around 88% of bat species are exclusively tropical (Findley, 1993). In the Old World tropics, the Pteropodidae are the main fruit-eating bats. The superfamily Phyllostomoidea dominates the New World tropics.

Figure 1: *Monophyllus redmani*, a nectarivorous species caught on Puerto Rico in July 1999.

These two groups of bats are important pollinators and seed-dispersers for many plant species and may be 'keystone species' in some communities (e.g. Cox *et al.*, 1991; Fujita & Tuttle, 1991; Rainey *et al.*, 1995). Bat populations appear to be in general decline for a number of reasons, including loss or disturbance of roosting sites (Tuttle, 1979; Makin & Mendelssohn, 1986; McCracken, 1988); loss of feeding habitats, particularly due to the deforestation of rainforest (Cheke & Dahl, 1981; Carroll, 1984; Fujita & Tuttle, 1991; conflict between bats and fruit-growers (Jacobsen & DuPlessis, 1976; Loebel & Sanewski, 1987) and over-exploitation for trade (Wiles, 1987; Fujita & Tuttle, 1991; Wiles, 1992).

Knowledge of the ecology of bats and their habitat and roosting requirements is therefore needed in many areas in order that land management policies may allow for the protection of roosts and foraging areas (Nowak, 1994). An action plan for the conservation of Old World fruit bats (Megachiroptera), which includes species and projects that are considered to be of a particular high priority, is published by the IUCN (Mickleburgh *et al.*, 1992). A similar action plan for the Microchiroptera is in preparation. Bat species of concern appear in the Red List of Threatened Animals (Baillie & Groombridge, 1996). Fieldwork carried out on bats can contribute to the information that is required for their conservation throughout the world. Even in the most basic form, data on species present, altitudinal range and habitat use, for example, from any area that has been poorly studied is worth collecting.

1.2 Literature reviews

It is essential that a thorough literature review of the area to be studied is carried out before going into the field. As much information as possible about the species that are likely to be encountered should be gathered in advance of fieldwork. Identification of bats can be very difficult, especially under field conditions, and measurements often need to be taken for identification. A hand lens will be invaluable for use in the field. A key for identification is essential. A key to the bats of the area may already exist but for many areas there will be no such key published and one should be compiled as far as possible from the information obtainable from the literature on each species.

Internet searches on the area to be visited or on particular species may provide some useful information or contacts. Information on the bats of the area to be studied may also be found by requests sent to recognised authorities, for example the Chiroptera Specialist Group of the IUCN - World Conservation Union, or BATLINE on the Internet, particularly if the area is poorly known. Museum collections may be another source of information, and looking at specimens before going into the field will help with identification once there. Photographs of the species that are likely to be encountered can also help with recognition in the field. Bats that cannot be identified or that are newly recorded within the area may need to be taken as specimens (see Section 5).

Changes in nomenclature and taxonomy may occur frequently, and it is important that all the available literature has been referred to, to ensure correct identification. Current standard reference lists for nomenclature are Corbet & Hill (1991) and Wilson and Reeder (1993). It is also important to consider species that may be found in an area but have not yet been recorded, as well as those already known to be present in an area, particularly in poorly known sites. This may help in the identification of new records if they are encountered.

1.3 Licences

Licences or permits will be required in most countries to carry out any fieldwork or to collect specimens. Information on the necessary licences can be obtained from the appropriate embassy, but often more easily from counterparts in the host country. Licences and permits should be applied for as early as possible as they can take many months to arrange. This is one of the most important parts of planning the fieldwork, as it may not be possible to carry out work of any kind without the appropriate licences or permits. Arriving in a country before obtaining the necessary licences could be a recipe for disaster.

Licences are also required to export scientific specimens, if they are not going to be left in host country collections. Specimens can sometimes be deposited in museum or university collections in the host country. A licence will then only be required to collect the specimens. Many countries require approval of export from the museums or universities, which have collections, before an export licence will be issued. A letter of intent to accept the specimens from the institution in which they will be deposited on return to the UK is also essential to show that they are not for a private collection. In the UK the Harrison Zoological Museum may be interested in taking new specimens, or in sharing specimens with other institutions.

The transportation of rare, endangered and threatened species of plants and animals is restricted and controlled by the Convention on Trade in Endangered Species of Wild Fauna and Flora (CITES). A CITES certificate from an approved institution should be obtained before collecting specimens to prevent them from being impounded by customs officials, along with those that are not listed under CITES. A CITES licence is also required for any bat material imported into the UK other than from another EU range state. Information about CITES certificates can be obtained from The Department of the Environment, Transport and the Regions. Any live bats being brought into the UK would also be subject to quarantine regulations.

1.4 Health and Safety

Health and Safety are important factors to consider before and when carrying out fieldwork. Before deciding on an area or country to work in, it is essential to find out whether it is a safe area for foreign fieldworkers. Information may often be available from the Foreign and Commonwealth Office and from local authorities and aid agencies. Once in the field, medical facilities may be at some distance from the field site so it is important to have good first aid knowledge and sufficient medical equipment and supplies to treat a wide range of possible illnesses and injuries (Winser & McWilliam, 1993). There are various first aid courses available, for example Red Cross or St. Johns Ambulance and it is highly recommended that all expedition members take such a course before going into the field. Fieldworkers should always work at least in pairs, particularly at night when catching bats and other fieldworkers should be aware of the location of all work sites and when their co-workers will be at these sites. Special care should be taken if working in underground sites, and hard hats should always be worn in caves. Trees should only be climbed following training and with suitable equipment. Care should also be taken when handling chemicals used in preparing specimens, as these can be dangerous if they are inhaled or if they enter open wounds.

1.4.1 Hazards associated with bats

A number of potential health problems are known to be associated particularly with bats due to exposure to gases in caves, ectoparasites, urine, rabies and histoplasmosis (Kunz, 1988).

The presence of noxious gases or the lack of oxygen in caves and tunnels is always a possibility. Caves and tunnels should not be entered if nothing is known of the site. Information concerning underground sites can often be obtained from local people. As well as having a potentially deadly atmosphere, caves and tunnels may be structurally unsafe and precautions should be taken when investigating these sites. In some areas, for example in Latin America where vampire bats were controlled by the gassing of caves (Greenhall & Schmidt, 1988), or where bats that roost in buildings are controlled by rodenticides, there is also the possibility of contamination by pesticides (Kunz, 1988).

The urine of bats is not known to transmit disease to man. Contact with urine, however, may increase risk of infection by agents contained in the urine (Kunz, 1988). Gloves should always be worn when bats are handled to avoid the contamination of cuts or wounds on hands.

Rabies is usually transmitted between mammals via infectious saliva when they bite. Man may be exposed to the rabies virus when bitten by a bat. Little is known about human susceptibility to bat rabies virus strains (Kunz, 1988). Pre-exposure immunisation against rabies is therefore essential for bat researchers. This can be done through the health department of most universities or at doctors' surgeries and should be arranged well in advance of going into the field as a course of injections that span several months is required. Exposure can also be avoided by taking precautions while handling bats. Gloves should always be worn and any bat bites should be thoroughly cleansed with liquid Savlon, soap and water and treated immediately with post-exposure vaccinations if the person is not vaccinated against rabies. There is also risk of exposure to rabies when dissecting bats. Therefore rubber or plastic gloves should always be worn when preparing specimens (Kunz, 1988). The Bat Conservation Trust and Bat Conservation International produce fact sheets on bats and rabies.

Histoplasmosis is an infection of the lungs caused by a fungus, *Histoplasma capsulatum*, upon inhalation of the airborne fungal spores. It occurs in parts of the United States, throughout Central and South America, in the Caribbean and through various parts of the Old World. Exposure to the fungal spores is most likely to occur in warm enclosed areas containing large amounts of bat faeces such as in caves and other roosts. Histoplasmosis may also occur in bird guano or free in soil. Infection may result in no symptoms developing (indeed with immunity being established) or may be extremely serious including lesions of the lung, and may even be fatal. There is no vaccine against histoplasmosis and respirators with filter cartridges that filter particles of 2 microns diameter should be worn in sites where there may be a risk of exposure to the fungal spores (Kunz, 1988). Contaminated clothing can infect other people and should be thoroughly cleansed after use or disposed of.

1.5 Ethics

Fieldwork should be carried out in an ethical and scientific manner. Bats have long lives, low fecundity, slow development and their populations are relatively stable. Bat populations may therefore be strongly affected by any factors that could cause a reduction in numbers of bats in an area and in many parts of the world there are few data available on estimated population sizes. Bats should therefore be handled with extreme care and should not be killed unnecessarily. Collections should be made for a valid purpose only and excessive numbers of specimens should not be taken.

Precautions should also be taken when capturing bats to minimise the possibility of accidental fatalities. Pregnant females or females carrying young should be handled with particular care and should be released in the shortest time possible. Pregnant females may abort when under the stress of being handled and infant bats carried by their mothers may die quickly if they are not released immediately. Some bats may become particularly stressed or fatigued when caught and these may need to be held for some time before release to allow time for them to recover. Care should also be taken not to cause undue disturbance at bat roosts. In the past, disturbance both by uninformed members of the public and by biologists has threatened many bat populations. It is important that disturbance at or in the vicinity of roosts is kept to a minimum.

1.6 Project planning

Before embarking on an expedition, it is important to have a clear idea of the projects to be undertaken. Throughout this manual I will suggest various types of projects that could easily be carried out by short-term expeditions. Projects should be of conservation value and it is essential to liase with experts on bats or on the area in which work is to be done, to ensure that the project planned will be of the best possible value and produce the most useful results. For Megachiroptera, a good reference to start with when designing a project is Mickleburgh *et al.* (1992) which highlights species that are of particularly high priority from a conservation point of view; a similar publication is currently being produced for Microchiroptera. Authorities in the UK that could be contacted for advice and information on ideas for projects to be undertaken include the World Conservation Union’s Chiroptera Specialist Group, Bat

Conservation Trust and Flora and Fauna International. If at all possible, pre-expedition training on how to work with bats, for example learning how to handle them safely, should be undergone. Training for a Bat Worker's Licence in the UK will provide a lot of relevant experience and can be carried out with trainers from county Bat Groups (contact the Bat Conservation Trust for details).

The types of projects that I will be discussing in this manual include:

Species lists and habitats used by bats in an area - this is the most basic information that can be collected.
Effects of different habitat types on numbers and species caught
Species diversity and richness
Roost surveys
Emergence times of bats from roosts
Estimates of abundance and population size
Assessment of age and reproductive status
Wing morphology studies
Marking bats for recapture studies
Radio-telemetry of bats
Dietary studies
Using bat detectors to survey for bats

Section 2

CAPTURE TECHNIQUES

2.1 Introduction

Bats are difficult to study by direct observation as they generally fly at night. Observational studies can be carried out at roosts (see Section 3), but for the purposes of much fieldwork bats will need to be caught for identification. I will describe several methods that can be used to catch bats. The best method depends on where and when the bats are to be caught, for example at foraging sites at night, in the roost during the day or as they emerge. Also, the method of capture and sampling regime to be used depends on the type of data required. It is equally important to consider how bats in an area are to be sampled and how they are to be caught. The sampling regime used will determine what questions can be answered about the bats that have been studied. Some important factors to consider when designing sampling regimes are discussed.

2.2 Catching bats

Two common methods that are used to catch bats are mist-netting and harp-trapping. Details of these two methods are discussed and the pros and cons of each type are mentioned in the following sections.

2.2.1 Mist-nets

Mist-nets are most commonly used to catch bats and have the advantage of being light, easily portable and easily erectable in the field. It is difficult to obtain mist-nets in the UK without approved experience and the only organisation in the UK to distribute them is the British Trust for Ornithology (B.T.O.). The B.T.O. requires a letter of recommendation from a bat expert in the UK to confirm competence in mist-netting skills before mist-nets can be purchased from them. The Bat Conservation Trust should be approached to discuss the purchase of mist-nets, as they may be able to provide the required authorisation or to advise on requirements for authorisation. Another approach is to arrange for counterparts from the host country to obtain the mist-nets if they have the necessary licences to purchase them. Nets are also available from Avinet in the USA.

Figure 2: Dr. Kate Jones putting up a mist-net in the field.

The standard mist-nets available in the UK and used for catching Microchiroptera have a mesh size of 36mm, are of 75 denier 2-ply polyester, and are available in various lengths including 6m, 9m, 12m and 18m. The short length is often convenient for mist netting in forests but the best size of net to use will depend on the sampling protocol. Much larger mesh and heavier dernier nets (e.g. owl nets) can be used for catching large Mega-chiroptera. Monofilament nets should not be used for catching bats. It is important to have more mist-nets than required for the sampling regime. It is very easy to destroy a mist-net in the field if it is dropped or falls over. Bats also damage the mist-nets very quickly. You will need to take a repair kit for the mist-nets, which includes spare shelf string and a tool for threading the shelf string through the net. This is essential particularly to replace the main strands of the net, as it cannot be used if any of these are broken.

Poles that are required to erect the mist-nets are not usually difficult to obtain when working in tropical forests as they can easily be cut from small trees with a machete. Alternatively, aluminium or bamboo poles can be bought in advance. These lighter weight poles will be useful if nets are to be placed high in the canopy. Plenty of strong string for guy ropes to hold the poles upright are also needed. It is a good idea to practise erecting mist-nets before going into the field, always ensuring that the mist-net is kept clear of the ground. Erecting mist-nets is quite straightforward after some practice, more sensibly done in a back garden for example, rather than in the forest.

2.2.2 Mist-net placement

The position of mist-nets in the field has a great effect on capture success. Placement across trails or streams that are used as flyways or in small clearings are usually the most successful capture sites. Bat detectors (see Section 6) can be very useful to determine potentially productive mist-netting sites (Kunz, 1988). If mist-nets are placed over water, the lowest edge of the net should be as near to the water surface as possible, whilst ensuring that it is high enough to prevent any bats that are captured in the bottom of the mist-net from hanging in the water (Kunz, 1988). When setting these nets it is important to remember that bats will weigh down the nets considerably. Care should also be taken, if mist-nets are erected over water, that all parts of the mist-net are safely and easily accessible so that bats can be removed.

Figure 3: A mist-net being erected across a stream in Puerto Rico.

Capture success may also depend on the vegetation surrounding the mist-net. In one study, more bats were caught when overhanging branches formed a partial canopy over the mist-net (Kunz & Brock, 1975). Capture success may be enhanced if two mist-nets are placed in a shallow V-configuration, as bats are often caught in one mist-net as they turn to avoid the other (Kunz, 1988). Similarly, more bats may be caught if they are funnelled through relatively narrow openings over streams or trails. Pools and water holes are also good sites. Capture success of a mist-net may decrease on the second night at the same site (Kunz & Brock, 1975) and some bats will avoid mist-nets on a second encounter (Kunz, 1973; LaVal & Fitch, 1977). Mist-nets may therefore need to be moved to a new site each night if capture rates are observed to decrease after the first night of netting. Environmental conditions such as rain, cloud cover, moon phase and wind may also affect capture rates and should therefore be recorded on each night of netting.

As well as being placed at ground level, mist-nets can be erected in the forest canopy. One method described by Humphrey *et al.* (1968) involves positioning a horizontal rope between two trees and suspending mist-nets below these. Munn (1991) describes another, less labour-intensive method. This involves modification of a mist-net, and 2m x 12m mist-nets are more suitable for the modification than smaller nets. Both methods require equipment such as a bow and arrow or slingshot to shoot lines over branches. A lightweight line should be used to place an attached heavier rope over a branch that can then be used to support the mist-nets (Kunz; 1988). Accurate placement of lines using these methods can be difficult and may take a lot of practice to get right. Another possibility is to climb trees to position the lines. This should be done only by experienced climbers with suitable equipment; a course in tree climbing should be taken before attempting to climb trees in the field. Local workers are also often extremely good at climbing trees.

It is difficult to set mist-nets very high up so that they are close to the canopy top where bats may be flying. One possible approach is to set poles running out along upward pointing top branches of trees as high as possible, with their ends sticking above the canopy. A top line can then be suspended between such a set of poles and the mist-net hung from this line (Action Comores, 1992). This method of course involves climbing trees and should therefore only be undertaken following appropriate training and equipment as mentioned above. Care should be taken that high-set mist-nets are not irretrievably trapped in inaccessible branches as bats may be caught in these nets and will die. These mist-nets should always be monitored frequently and continually if possible. Catch rates may be lower during the middle part of the night but different species may be caught at different times of night. It is, therefore, worth maintaining the nets throughout the night if possible. This applies to all nets whether they are positioned on the ground or up in the canopy.

Some of the disadvantages of mist-nets are that removing bats from them is very time-consuming and potentially harmful to the bats, mist-nets have to be monitored regularly, and catch rates can sometimes be low. Bats can easily be injured or they can die if they are not removed from mist-nets promptly, and in some areas, predation on bats captured in mist-nets can occur (Fleming *et al.*, 1972; Morrison, 1978a; August, 1979).

2.2.3 Harp-traps

A typical harp-trap is constructed of a rectangular aluminium frame with a double layer of vertical lines tautly strung across it. A canvas catch bag is attached at the bottom of the frame to collect the bats. The bag should have plastic flaps inside the top to prevent bats from escaping (Kunz, 1988). The harp-trap may either be supported on aluminium legs, or suspended by ropes. If the harp-trap is suspended, it should also be stabilised by guy ropes attached to the bottom of the trap. A popular early design of harp-trap was the Tuttle trap (Tuttle, 1974), but since then there have been several modifications designed to improve the catch-efficiency and to make the harp-traps cheaper to build and easier to carry and assemble (Tidemann & Woodside, 1978; Francis, 1989; Palmeirim & Rodrigues, 1993, Klaque, 1998).

Figure 4: A harp trap at the entrance to the cave Mata de Platano, Puerto Rico.

Harp-traps are less portable and have a smaller catching surface than mist-nets, but they have the advantage that bats can be removed from the catch bag very easily. Also, correctly tensioned harp-traps are generally less likely to damage bats and there are likely to be fewer injuries or fatalities. However, predation on bats caught in harp-traps can occur if they are not monitored properly. Predation of one bat species on another may also occur in the catch bag and bats of the same or different species may bite one another; injury to bats is much more likely to occur if the bag is not regularly emptied.

2.2.4 Harp-trap placement

The placement of a harp-trap will affect capture success. Harp-traps can be very successful if placed at the entrance to roosts or along known flyways (LaVal & Fitch, 1977; Tidemann & Woodside, 1978; Kunz, 1988). They have the added advantage that it is much quicker to remove bats and therefore safer for the bats if large numbers are caught. At roost sites, capture success depends on the type of roost exit and speed of the exiting bats (Kunz & Anthony, 1977).

2.2.5 Comparison of mist-nets and harp-traps

The effectiveness of these two methods for catching bats depends on a number of factors including catch site, and there are also interspecific differences. Small aerial insectivorous bats are rarely caught in mist-nets in tropical forests as they generally forage above the canopy (LaVal & Fitch, 1977; Francis, 1989). If they are caught, they can quickly chew their way out of the mist-net. In some areas, more fruit-eating and plant-visiting species of bat may be caught in mist-nets placed in the forest understorey than insectivorous species (LaVal & Fitch, 1977; Francis, 1989). Harp-traps may be very successful in catching insectivorous species, especially near roost sites. Small nectarivorous bats are often able to take off from the ground and can escape from harp-trap catch bags, although modifications to harp-traps may help to prevent this (Petit *et al.*, 1994). In one comparison of mist-nets and harp-traps, larger species of both Megachiroptera and Microchiroptera were more often captured in mist-nets than in harp-traps (Francis, 1989).

Mist-nets and harp-traps should not be placed in a cave entrance unless a reasonable estimate of the number of bats in the cave is known. Thousands of bats may be roosting in one cave and if a mist-net in particular is placed in front of the only exit, a large number of bats may be caught very quickly, and there could be many unnecessary fatalities. Harp-traps are also easier to move quickly out of flight lines or emergence routes if too many bats are being captured as they can be picked up and carried away more easily than a mist-net. Mist-nets and harp-traps should always be placed so that they cover only a fraction of the entrance to avoid excessive disturbance of emergence (Tuttle, 1976). Mist-netting around or underneath individual fruit trees can be very productive, but there should be a sufficient number of experienced fieldworkers available per mist-net to be able to remove and process the large numbers of bats that may be caught, or a harp-trap could be used. Capture of bats at roost sites should be kept to a minimum to avoid disturbance at the roost and it is often preferable to catch bats near to the roost site on flyways rather than immediately at roost exits.

2.2.6 Hand-netting for bats

Roosting bats can be caught during the day with hand-nets on long poles. A hand-net can also be used by holding it just under the exit hole outside a roost to catch emerging bats at dusk. This technique will only work well when bats emerge from a known point and the emergence hole at that point is fairly small. Inside a roost, bats can be caught by placing the hand-net around an individual or cluster of bats. When using this technique, extra care should be taken not to disturb the bats as they are approached or they may fly away from their roosting site before they can be caught. Bats should not be caught with a hand-net in flight as the wings can easily be damaged. Roosting bats are best caught in the late morning, when they are least active (Kunz, 1988), although tropical bats are often very active throughout the day. Hand-net poles can be modified so that the angle of the hand-net to the pole can be adjusted in order that bats can be caught in different situations. Telescopic poles that can be attached to hand-nets can be bought from most fishing shops and are easier to transport and use in the field than poles in many separate sections.

Figure 5: Dr. Nancy Vaughan catching bats with a hand-net in a cave.

2.3 Sampling for bats

Simple species lists and information on the habitat type in which each species is caught are very useful, particularly if there are interesting or important species present in terms of conservation value. However, additional quantitative data can easily be collected by carefully planning a sampling protocol and standardising as many factors as possible. When using mist-nets for example, the numbers and species of bats caught depend on many factors, for example, mist-net position, the number and size of mist-nets that are open at each netting site, the time the mist-nets are opened relative to sunset, the amount of time the mist-nets are left open, how often the mist-nets are checked, weather conditions, temperature etc. By standardising or accounting for as many of these factors as possible in a sampling regime, the result will be data that can be used to compare between different habitats, for example (e.g. Vaughan & Hill, 1996). The number of hours for which nets are open, the habitat type and the time of capture of bats should always be recorded. The most important factors to standardise are discussed below.

Mist-nets

When comparing between a number of sites, the same mist-net area should be opened on each night of sampling at each site. Use the same number of mist-nets each night as far as possible. The nets should also be set in the same configuration each night if possible. This will depend on the vegetation etc. at each site.

Time

Mist-nets should be opened at the same time relative to sunset on each night. Mist-nets should be opened by sunset as there is often a peak in activity immediately after sunset (Kunz, 1988). They should be checked immediately after opening so that any birds that may have been caught can be removed immediately. Mist-nets should also be left open for the same number of hours on each night when possible, whether this is for a few hours or all night. Mist-nets should be checked at regular intervals and at least every 30 minutes. If possible the mist-nets should be monitored continuously so that bats can be removed immediately upon capture.

Environmental factors

Temperature, rainfall, wind, moon phase, cloud cover and altitude can all affect bat activity. Lunar phobia has been reported in several bat species in the Neotropics and has been suggested to occur due to predation risk (e.g. Morrison, 1978a, 1980;Fleming & Heithaus, 1986). However there are other studies that have suggested that there is no influence of moonlight on bat activity (e.g. Negraeff & Brigham, 1995). The potential effect of the moon could be estimated from a combination of moon phase and cloud cover (estimated as a percentage), which can then be correlated to numbers and species of bats caught.

Temperature and rainfall can be measured simply each night and related to the number of bats caught. Alternatively, it may be possible to find a local meteorological station near to the field site (e.g. research stations, airports) that will record such data continuously. Mist-nets can be opened in most conditions, except in very heavy rain or very strong winds, provided that they are checked regularly. Precipitation can be estimated by placing a small marked container near to the mist-netting site during the period in which mist-nets are open. The amount of rainfall collected can then be simply categorised (e.g. no rain, little rain or heavy rain) or measured.

There are a large number of comparisons that can be made by using a paired-sampling approach. For example, two adjacent habitat types (e.g. across a stream and in the forest) can be compared with two identical mist-nets that are opened on the same night for the same length of time, one in each habitat type. Similarly the bats of the canopy and understorey can be compared if one standard mist-net positioned in the canopy and one standard mist-net positioned nearby in the understorey are opened simultaneously. Alternatively, setting mist-nets at different heights may show resource partitioning between species. A paired-sampling approach eliminates many confounding factors such as the effects of weather. A suitable minimum sample size for paired-sampling is about 12 nights. Simple statistical tests, either the paired t-test or Wilcoxon paired-sample test can then be used to analyse the data (Zar, 1984).

There are many other projects that could be carried out during short-term studies; I have mentioned only a few here. Species diversity and richness can be calculated (see Section 7), and community composition can be described if bats have been sampled in an area in a standardised way, for example, in a comparison between different sites or habitat types (e.g. Fleming *et al.*, 1972; Kunz, 1973; Brosset *et al.*, 1995; Rautenbach *et al.*, 1996). Changes in bat species composition and diversity with altitude could also be investigated. One study in Peru shows that species diversity decreases with increasing elevation (Graham, 1983). Numbers of bats also decrease with increasing altitude (Fleming, 1986; Muñoz, 1993). For projects such as these, a paired-sampling approach would not be possible, and it would therefore be essential to standardise or measure as many of the external parameters affecting catch rate as possible, such as mist-net location, the time for which the mist-nets are open and so on. Larger sample sizes are also required for statistical analysis if a paired sampling approach is not used. Catching bats may also be useful for studies of activity patterns, diet, breeding cycles and ectoparasites.

Bats carry a range of specialist ectoparasites or other associates, including several groups of insects and mites restricted to bats. Some spend the whole life cycle on the bats, while others spend part of their life cycle (usually the immature stages) off the host. The life histories for many is unknown. Many have bizarre morphological or life-cycle characteristics and are of interest to specialists. For some groups or geographical areas, the ecology, effect on the host, host specificity, infestation rates related to the age, sex, season, condition or roosting behaviour of the host, or their role in the transmission of arboviruses is poorly known. They can offer an interesting ancillary project to other studies and are relatively straight forward to collect once bats have been caught. Most are best preserved in 70-80% alcohol, but it would be advisable to discuss their collection with an appropriate museum or specialist. For further details see Hutson (1971), Marshall (1981, 1982) and Kunz (1988).

Possibilities for bat survey methods that do not involve the trapping of bats are discussed in the next section.

Section 3

SURVEY TECHNIQUES

3.1 Introduction

In addition to catching individuals, bats can be surveyed, and numbers estimated by using observational techniques. Many bat species roost gregariously in hollow trees, buildings, caves or foliage (Kunz, 1982), and these aggregations allow counts to be made of numbers of bats (Kunz, 1988). Other species roost singly or in small groups and cannot be surveyed using these techniques and in some species roosts may be difficult to locate. Here, several methods for surveying bats in roosts are described and methods for estimating population size from roost counts and sampling data are discussed. For all the methods described below, it is important to replicate counts to ensure that they are as accurate and repeatable as possible. Numbers of bats in a given roost may very considerably between seasons or even between days, so it is important to do several counts at each site.

3.2 Surveys at roosts

Bats at roosts can be surveyed either by monitoring activity from outside the roost, causing minimal disturbance, or by monitoring bats within the roost, which causes much more disturbance. Finding roosts can be a problem, but local people may be able to help out with this (e.g. Action Comores, 1992). Roosts of some species of Megachiroptera may be more easily located than those of Microchiroptera, as the bats are often noisy when they are in the roost and are sometimes visible as they leave and return to the roost (Wiles, 1987b). On small islands, observation from boats can be used to locate roosts (Wiles *et al.*, 1989).

3.2.1 Emergence counts

Many microchiropteran roosts have a limited number of emergence points, so that all of the bats can be counted quite accurately as they emerge at dusk, as long as there are enough observers (Swift, 1980). Tally counters should be used to count the total number of bats exiting the roost. The number of bats returning into the roost should also be counted and deducted from the final tally as during the early part of emergence, bats often loop and re-enter the roost several times. The accuracy of roost counts depends on the number of bats in the roost, although counts have been made of up to several thousand emerging bats (e.g. Kunz, 1974). Counts of roosts containing several hundred bats have been shown to be very accurate (Swift, 1980), but for roosts containing more than 500 bats the accuracy probably decreases (Kunz, 1988). If there is more than one species in a roost, it may be possible to distinguish them if they differ significantly in size and flight style, or emerge at different times (e.g. Swift & Racey, 1983). Additionally, counts of fruit bats dispersing along flyways can be carried out with some accuracy, for example, from an islet roost or other isolated roosts to a mainland foraging area. The length of time taken for all bats to emerge from a roost can also give an indication of roost size, particularly in relative terms.

Species-specific differences in emergence times could be due to avoidance of predation (Speakman, 1991; 1995; Jones & Rydell, 1994) and may be related to resource partitioning (Swift & Racey, 1983). It may be useful to compare emergence times of different species in an area. Ideally, counts should be carried out on the same night at two roosts if times are to be compared directly. To compare emergence times between species, the median emergence time is calculated (Bullock *et al.*, 1987; Jones & Rydell, 1994). To calculate median emergence time, the numbers of bats that emerge in every 1-minute or 5-minute time period are counted over the total emergence period of bats from the roost. The median emergence time is then calculated as the time of emergence, measured as the number of minutes after sunset, of the median bat from the roost.

Very large numbers of emerging bats can be counted from photographs (Kunz, 1988). Photographs have been used to estimate numbers of bats in roosts of *Tadarida brasiliensis* (Humphrey, 1971) and *Pteronotus fuliginosus* (Rodriguez-Duran & Lewis, 1985). Both of these species emerge as a cohesive column of bats with a small diameter and relatively homogenous density; only species with this type of emergence pattern can be accurately counted from photographs (Kunz, 1988). A similar technique has been used to quantify the emergence of several species of bat from one site (Rodriguez-Duran & Lewis, 1987). A large proportion of the bats could be identified to species from photographs, and numbers of each species could be estimated. Stereo pairs of photographs give greater accuracy than single photographs.

3.2.2 Roost counts

Bats can be counted directly in the roost (Kunz, 1988). Low light levels should be used to minimise disturbance. Inside enclosed roosts, for example caves and buildings, counts of all individuals may give accurate results for small colonies; for larger colonies sample areas may be counted and the result scaled up for the total occupied area. Estimates should allow for irregularities in the roost e.g. variation in the cave surface. Direct roost counts have also been made for many species of Megachiroptera, as these bats often roost in tree foliage and can be observed during the day with relative ease and without disturbance to the bats (e.g. Mutere, 1980). Bats are counted by observers using binoculars and tally counters (e.g. Nicoll & Racey, 1981). This method may not always be very accurate as bats can be hidden in foliage and their number is likely to be underestimated (Wiles, 1987b). In one study, the number of bats roosting in an 'average tree' was estimated and the total number of bats was calculated by counting the number of occupied trees (Mutere, 1980).

Numbers of Megachiroptera in roosts have also been counted by using dispersal and disturbance counts (e.g. Racey, 1979; Nicoll & Racey, 1981). Dispersal counts involve counting the bats as they disperse from diurnal roost sites and are most effective if the dispersing bats are silhouetted against the sky or sea. Disturbance counts are carried out during the day, when noisy humans positioned underneath the roost disturb bats. The disturbed bats are photographed from a distance with a wide-angle lens. The slides are subsequently projected and the number of bats counted (Nicoll & Racey, 1981). This method is not very accurate as some bats may be disturbed prior to the intentional disturbance by the human presence beneath the roost, and others may remain in the roost (Mickleburgh *et al.*, 1992).

3.3 Population estimates

Surveys allowing population estimates to be made are an important initial step in determining what management programmes and protection measures are feasible or required for a species. Estimates of population size can be made from roost counts; for example, minimum population estimates can be made for a specified area or island from roost counts within that area (e.g. Speakman *et al.*, 1991). Several factors should be taken into account when estimating minimum population size, including the number of bats counted, the area covered and the habitat type in the area (Wiles *et al.*, 1989). Other factors that need to be considered are the time of day and the time of year that the counts are carried out. Some species of Megachiroptera show seasonal roost use and this must be taken into account when estimating populations sizes (Mickleburgh *et al.*, 1992). Additionally, many species of Megachiroptera may leave the roosts during the afternoon so counts should be made at a standardised time in the morning. The main problem in estimating population size or density is the estimation of the size of the area from which the sample is being drawn (Findley, 1993).

It is difficult to estimate population size accurately from mist-net data, without the use of long-term mark-recapture programmes. Even with a reasonable sample size, bats may not meet the assumptions of many models that give an unbiased population estimate. It is probably outside the scope of most short-term projects to carry out such a programme. However, mist-net samples may be used to calculate relative abundance and captures per net-night. These data may then be used either to compare abundance in different habitats or areas (Findley, 1993), or to make rough estimates of population size (O'Shea & Vaughan, 1980; Marshall & McWilliam, 1982; Findley & Wilson, 1983;

Heideman & Heaney, 1989). If abundance estimates are made, it is essential that data collection methods be standardised. One study suggests that if standardised sampling methods are used, it is possible to estimate approximate abundance from large sample sizes of 300-500 bats (Heideman & Heaney, 1989).

Section 4

PROCESSING BATS

4.1 Handling bats

It is important to handle bats properly,both from the perspective of the bat and the handler. Bats can be damaged easily and the fieldworker may well be bitten if bats are not handled properly. Practice is the best way to learn how to handle bats properly and training should be sought before going into the field. Proper handling techniques are taught as part of the training for a Bat Worker's Licence (see Section 1.6). Different techniques are often also required for larger bats particularly Megachiroptera.

Figure 6: How to hold a small bat, a *Monophyllus redmani* from Puerto Rico.

4.1.1 Removing bats from mist-nets

Removal of bats from mist-nets can be time-consuming. The number of mist-nets that are erected should depend on the number and experience of fieldworkers available, to allow bats to be removed from the mist-nets efficiently and safely. Mist-nets should be monitored constantly to ensure that all bats are removed quickly and to prevent any from escaping. Head torches are essential when removing bats, as hands must be free to manipulate the mist-net and the bat (Kunz, 1988).

There is no fixed method for removal of a bat from a mist-net, although the best approach is as follows:

1. Establish from which side the bat has entered the net. It will usually be lying in a pocket created as it hit the net; the ‘pocket’ will be made of mesh lying beyond one of the main horizontal shelf strings. The bat should be extracted from the same side from which it entered.
2. Use a gloved hand to hold and control the bat and an ungloved hand (usually right if right-handed) to remove the netting.
3. Clear the net so that the lower back or underside area is exposed and remove the feet from the netting, keeping them away from the net so that they do not get re-entangled.
4. Clear the net up the body, releasing the wings one by one and folding them against the body in the controlling hand to prevent them from getting re-entangled in the net. Continue to release the bat from the net working forwards up over the body and the head. Ensure that the head is controlled sufficiently to prevent being bitten. At times when there is a particular risk of being bitten, e.g. by vampire bats or large bats, both gloves should be worn.
5. To remove the wings from the net, clear the mesh away from the body, along the forearm, over the wrist and off the digits.
6. Removal of large bats may be helped by allowing the bat to chew on a bag or loose part of the glove, preventing it from chewing either the net or the fieldworker.
7. Avoid cutting bats out of the net as much as possible as it can in some cases lead to greater entanglement of bats caught subsequently. If necessary, use a ‘quick-n-pic’ or fine pair of scissors to cut individual threads that are causing problems.

If bats are removed promptly after they are caught, they generally should not be very entangled in the mist-net, making removal a quick and simple task. Special care should be taken to ensure that wing bones are not broken or damaged during removal from the mist-net. Two people may be required to remove large Megachiroptera from a mist-net, one with gloves to hold the bat and one to remove the net from the bat.

Figure 7: Handling a hairy-legged vampire bat, *Diphylla ecaudata*, caught in Colombia.

4.1.2 Handling bats

Once bats have been removed from the mist-net, they can be kept hung up in cloth bags until they are processed. Bat bags should be made from untreated cotton, with a drawstring or ties at the top and the seams on the outside to prevent bats becoming tangled up inside the bag. Bags should always be closed properly to ensure that bats cannot escape from them. Several sizes of bag will be required for different-sized species. Bags used for holding birds are available from the B.T.O. and can be used for bats, but it is cheaper to use homemade bags. Bats should be kept individually in bags, and not held for longer than is necessary (Tuttle, 1979). Most bats should be removed from the net, processed and released within an hour at the most. Other holding devices, such as plastic or wire mesh cages and wooden boxes, may also be used (Kunz, 1988).

Small bats should be held with the bat in the palm of the hand and the fingers curled around the body and with the head between the thumb and first finger. The first finger can be used to apply enough pressure to keep the jaw shut (Mitchell-Jones, 1999). Two hands will be needed to handle larger bats to get a firm grasp on the body and wings, along with thick protective gloves. It may be necessary to hold the bat around the neck to stabilise its head and prevent it from biting. Bats should not be held by the thumbs, or by any of the wing bones with wings outstretched, as bones may easily be broken by this method.

If bats are held in bags for some time, they may require water, or sugar water if they are nectarivorous, before they are released. These fluids can be administered with a pipette or a bottle with a nozzle and the solution should be allowed to drip onto the tongue. Nectarivorous species should be processed before insectivorous and frugivorous species and released as soon as possible as they have to feed regularly. If bats have to be taken from the catching site back to the field-station where the fieldworkers are staying, they should be processed and released as a priority on return. Bats should be released as near as possible to the site of capture.

4.2 Assessment of age and reproductive status

The assessment of the age and reproductive status of bats in the field is important, particularly if morphological measurements are to be taken. Seasonality of reproductive status can also be investigated for each species. Sexing is straightforward in bats, due to the presence of a conspicuous penis in males (Kunz, 1988). For most short-term studies, simply categorising bats into broad age groups, i.e. juvenile or adult will be sufficient. Juveniles can be distinguished from adults by the lack of ossification in the plates in the joints of finger bones, which can easily be seen if the joints are illuminated from behind. The cartilaginous ends of the bones in juveniles appear paler and more translucent than the joints of adults (Kunz, 1988). The joints of adults are also more rounded and knuckle-like than those of juveniles.

The reproductive status of males may be assessed in species where spermatozoa are stored by the males after spermatogenesis has occurred, from the distension of the epididymides (Kunz, 1988). In some species this distension can be seen directly. In others, a pigmented sheath of peritoneum covers the epididymides in juveniles so it appears dark, whereas in adults the pigmented cells are separated by the distension of the epididymides and the tubules appear white. This is the case for some species from the families Vespertilionidae and Rhinolophidae, but it is not clear whether or not it occurs in all families (Kunz, 1988). In some other species, testes of juveniles are smaller than those of adults, and also in some species, seasonal testicular descent may occur (Kunz *et al.*, 1983a).

In females, nulliparous (never having bred) and parous (having had offspring) females can be distinguished from the state of the nipples (Kunz, 1988). The nipples of parous females are large and keratinized, whereas those of nulliparous females remain small. Nipples of lactating females become very enlarged and milk may be extruded from them if they are gently massaged (Kunz *et al.*, 1983b), although this practice is not really recommended. Females well into pregnancy can be identified by their distended abdomen, easily determined when slight lateral pressure is applied with two fingers. If a rounded bulge can be felt between the fingers when pressure is applied, the bat is pregnant. If the fingers almost meet and there is little resistance between them, the bat is not pregnant. Care should be taken not to confuse a female with a full stomach and a pregnant female.

4.3 Measuring bats

The most common measurements taken from bats are forearm (mm) and body mass (g). The forearm can be measured by using callipers as the maximum length measured when the wing is folded. Body mass can be measured with a Pesola balance. Balances and callipers of suitable sizes for the bats likely to be caught are required - small Microchiroptera will require a 50g balance whereas some large Megachiroptera may require a 1.5 kg balance. The type and number of balances required will also depend on the accuracy required as this varies between balances. Bats should be weighed in a suitable bag, and the weight of the bag also recorded. A small bag specifically used for weighing that can be used to prevent bats from moving about too much can be useful. It is important to know the age and reproductive status of bats that are weighed, as these factors will greatly affect body mass and need to be taken into account when presenting the data. Other measurements, for example ear length, tragus length, digit lengths, foot length, tail length and so on may be required to confirm species identification. These are often indicated in local or regional keys and identification guides.

Other morphological data can be obtained if wing tracings are made from bats. Standard aerodynamic measures can be calculated from wing tracings of bats (Norberg & Rayner, 1987). Wing morphology determines the range of habitats in which a bat can fly and the foraging strategies it can use. Therefore, information on the wing morphology of an assemblage of bat species may help

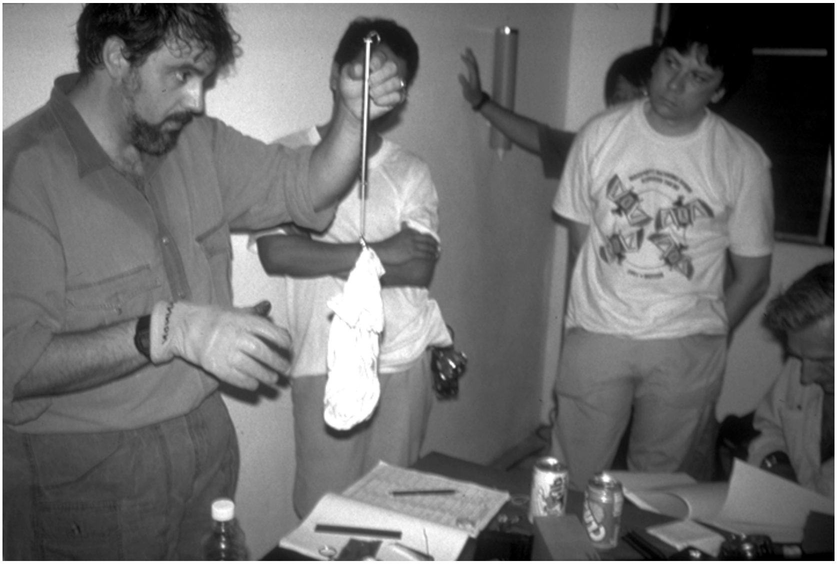

Figure 8: Weighing a bat in a bag.

in the understanding of the ecology of that community (Fenton & Rautenbach, 1986; Aldridge & Rautenbach, 1987; Norberg & Rayner, 1987; Fenton, 1990). To take a wing tracing, the bat is placed stomach down on graph paper and held firmly with one wing outstretched so that the wing membrane is flat. The wing and head is then traced around. To trace the tail membrane, the leg must be extended and the membrane stretched out as much as possible. This process is much easier with two people, especially with larger species. Once the wing has been traced around, the position of the leg and outline of the body are also drawn.

To analyse the data, the areas of different parts of the wing can be calculated by counting squares on the graph paper, and standard aerodynamic measures calculated, following Norberg & Rayner (1987). This technique takes some practice, and the areas calculated vary between workers. If possible, one person should always take the wing tracings and calculate the wing areas from them to standardise this variation. Also, the same wing (i.e. either left or right) should always be used to measure forearm length and for wing tracings.

Figure 9: Taking a wing tracing from a bat in the field.

4.4 Identification

For bat identification, either an existing key to bats in the area or one that has been compiled from the literature studied before going into the field should be used. Keys based on external features are the most useful in the field and may reduce the need to kill animals. A good knowledge of the species likely to be found in an area and the literature available on those species will also reduce the necessity for taking specimens. Many existing bat keys are based on dental features and fieldworkers should be familiar with general bat dentition to aid in identification (see e.g. Greenaway & Hutson, 1990). A hand lens is essential for looking at teeth in the field. It may be useful to take photographs of bats to help with later identification, particularly of the head and tail areas.

Dental casts may also be taken from bats in the field to aid identification and reduce the need to take specimens. Briefly, dental putty is placed in the mouth against the upper and then the lower jaw to produce a negative impression of the teeth. Once the putty has set, a plaster cast is made of the mould to match the dentition of the bat. Two people are required to prepare the moulds and the mouth of the bat must be held closed whilst the impression is being made. Species that are caught outside their described geographical range may represent range extensions or new records for an island or area, especially in areas that

Figure 10: The teeth of bats are often used to aid species identification.

have been poorly studied. Identification should be confirmed by specimens before information on range extensions or new records is published (see Section 5). Sampling for DNA by taking tissue samples from the wing membrane of bats may also be useful in species identification. A museum or university with an interest in DNA samples should be found, however, before this type of work is undertaken.

4.5 Data recording

Detailed data recording is essential in the field. Notes should be kept on the habitats in which mist-nets or harp-traps are used, and the number and size of mist-nets that are erected each night. Descriptions of habitats being compared are also required. Habitat photographs can be useful as extra records. Notes on identification features can be useful, in case of misidentifications. Notes should be kept in pencil if possible as this does not run when wet. Waterproof notebooks can also be a good idea at very wet field sites. It is important to keep a separate day to day record containing copies of all work carried out by all the fieldworkers in case the originals are lost or stolen. The original notes and the copies should be kept separate and always transported separately. Further copies of field notes should be made as soon as possible, at least before leaving the host country to return home, in case luggage is lost. Months of work can so easily go missing in a few minutes if this is not done.

Recording the locality of the study sites used can be a problem in poorly mapped areas. If no good maps are available, Global Positioning System devices can be used to give an accurate position. It is possible to buy relatively inexpensive hand-held devices, if funds permit. Altimeters are also useful if sites of different elevations are to be compared, or in habitats where altitude changes rapidly as the elevation may affect the bat species caught.

Section 5

SPECIMEN PREPARATION

5.1 Introduction

There may be occasions when it is necessary to take a specimen of a bat that is caught, usually as a voucher specimen for verification of identification. A general guideline is that specimens should only be taken when absolutely necessary. General collecting is difficult to justify for expedition projects, especially those that have a conservation aim. Accidental fatalities should always be prepared as specimens if possible. A clear policy on taking specimens should be agreed on by all before any fieldwork begins. There are a number of reasons why specimens may need to be taken:

Euthanasia

It may be necessary to kill a bat that has been severely injured when caught. This should only be necessary very rarely if mist-nets and harp-traps are checked regularly and bats are removed with care.

Voucher specimens

If a bat cannot be identified, or a species is caught that may be new to the area of the study, a voucher specimen may need to be taken. A record of a new species to an area or range extension is unlikely to be accepted for publication unless a voucher specimen exists. It is essential to have obtained the necessary licences, both to collect specimens and to deposit them in a collection, before going into the field (see Section 1).

Host country collections

Counterparts from the host country may request that specimens of each species caught are collected and deposited in the museum or university collections in that country. All expedition members before going into the field should agree upon the policy for collection, and the appropriate equipment and licences that are required should be obtained in advance. It is also important to determine who is going to receive the material and that they have agreed to do so before embarking on the fieldwork.

5.2 Specimen preparation

5.2.1 How to kill a bat

The simplest and quickest method to kill a bat is to break its neck. This is appropriate for small species and can be accomplished by holding the bat around the neck and using pressure from the thumbnail on the back of the neck to separate the vertebrae (Kunz, 1988) or by placing a pencil across the back of the neck and rolling it forwards. Alternatively, and for larger species, the bat should be over-anaesthetised with chloroform or ether. The bat should be placed in a sealed plastic bag with cotton wool soaked in the anaesthetic. The bat should be left in the bag for at least 10-15 minutes. It is safer to leave the bat in the bag for longer than you think is necessary to kill it. The cotton wool can be replaced for a second dose if necessary, although the administration of only one dose is preferable. The specimen should then be prepared immediately. A photograph should be taken of the specimen and the body measurements taken from the bat straight away. If a wing tracing is to be taken, it should also be done at this point.

5.2.2 How to prepare a specimen

Specimens may either be preserved wet or dry but dry preservation is very time-consuming and often difficult to do properly under field conditions, particularly in hot and humid environments. Bats should be measured and labelled before preparation. Generally the skin and skull are preserved. The skull is the most important part of the specimen to preserve for identification purposes. If the skin and skull are preserved separately, it is important to ensure that they are carefully labelled so that they can be re-united once in museum collections. Preparation should be done soon after the bat is killed, and quickly, as the skin and wing membranes may dry rapidly. The specimens should be labelled carefully as described below. The method for dry preparation is described in detail in Kunz (1988). I will not describe this method in detail as it should only be used as a secondary alternative to wet preservation. Dry specimens may be attacked by insects or fungi and should be thoroughly dried and stored in a dry place, for example in boxes containing sawdust. Specimens can also be stored with bags of silica gel to aid in desication. Specimens should be stored in several places to avoid losing them all together if accidents occur.

In the tropics in particular, preparation, storage and maintenance of dry specimens is very difficult and wet preservation is the best method to use. Bats can often be identified from good wet specimens, unlike other groups of animals (Kunz, 1988). A label on waterproof paper written in pencil or Indian ink should be attached to the specimen with a specimen number, location and date and the initials of the collector. The label can be attached by tying it around the tibia. Other information and measurements should be recorded separately. The date, collecting locality, altitude and habitat type should be recorded along with the species (if known), sex, age and reproductive status of the bat. The standard measurements that are also recorded from a specimen are body mass (g), total body length (mm), forearm length (mm), tail length (mm), hind foot length (mm) and ear length (mm) (Kunz, 1988). These can be measured with callipers or a ruler and a Pesola balance.

Alcohol, for example ethanol at 70%, is the most widely available preservative and has few health hazards. For preservation, the mouth is held open with a wad of cotton wool or a piece of matchstick. Some preservative is injected into the thorax, and an incision is made into the abdomen to open the abdominal cavity. The fur is then wetted with water to allow the alcohol to sink into the skin. The bat is wrapped in muslin or paper towels and dropped into a container of alcohol so that it is fully immersed (allow approximately double the volume of the bat). Containers used to store the specimens should have a good screw cap. Containers with plastic lids are preferable to those with metal lids to avoid rusting. The ethanol should then be changed every month until the specimens are deposited in the collection (Kunz, 1988). Some preservation methods (e.g. Kunz, 1988; Yates *et al.*, 1996) suggest that formalin should be used to preserve the specimen initially, and the specimen transferred to alcohol later. There are several health and safety hazards associated with using formalin and this should only be done as a secondary alternative to using alcohol. Ensure that the alcohol used for preservation is of good quality.

5.2.3 Storage of specimens

Once the specimens have been prepared, the collection should be stored safely. Specimens that are to be transported should be well packed to avoid damage. Wet and dry specimens should always be packed separately. Dry specimens should be completely dry before being packed. They should be packed in airtight containers, separated and surrounded by cushioning material such as cotton wool or polystyrene (Kunz, 1988). Wet specimens should be removed from the preservative and wrapped in several layers of muslin or paper towel to keep the specimens moist in transit. Each specimen should then be placed in several layers of watertight plastic bags and sealed. The specimens can then be packed together in a container. Alternatively, wet specimens can be transported in the containers in which they were originally placed if care is taken to ensure that they are carefully sealed and packed. Copies of the correct documents should accompany the specimens while they are in transit.

5.3 Identification

It may be difficult to get specimens identified in museums in the UK and it is therefore important to contact the museums well in advance of going into the field. Museums may already have large collections of unidentified specimens and museum staff may not have time to identify bats unless a prior agreement has been made. It may also be possible to have specimens identified in the host country if they are to be deposited in collections there. It may be possible to arrange to borrow specimens from these collections at a later date if necessary, although this should be arranged well in advance and discussed before specimens are collected.

Dry specimens can be identified as soon as the skulls have been prepared as they are preserved separately. Skulls may have to be removed from wet preserved specimens before identification is possible. In some collections, this is done after the specimens have been preserved according to the method described above. The method used for preserving the specimens in the collection in which any new specimens are to be deposited should be checked before going into the field, so that anything that is collected can be prepared appropriately.

Section 6

OTHER TECHNIQUES

6.1 Marking bats

There are a number of techniques that can be used for marking bats, including wing-bands, necklaces and light-tags (Buchler, 1976; Kunz, 1988; Gannon, 1993). However, for the purposes of most short-term projects, it is probably not necessary to mark individuals permanently. Most of the marking techniques are time-consuming, and some may harm the bats. The likelihood of recapturing sufficient numbers to carry out a mark-release-recapture programme to estimate populations is small within the scope of most expedition projects. In previous mark-recapture studies of pteropodid bats, only small numbers of bats were recaptured (Marshall & McWilliam, 1982; Wolton *et al.*, 1982). However, if population size and density are to be estimated, bats need to be marked (e.g. Morrison, 1978b). It may be worthwhile considering marking bats if the work is part, or is likely to be part, of a long-term study.

Figure 11: A *Pteronotus quadridens* carrying a wing-band.

There are a number of ways in which bats can be marked temporarily. Temporary marks may be useful for short-term studies, or to ensure that bats are not caught again immediately after release. Dorsal fur can be clipped from different areas to allow individuals to be identified; clipped patches will be visible for a few weeks. Unique tattoos can be applied to bats by pinpricking the wing membrane. Pinpricks can be made to mark different shapes, for example numbers or letters, to identify individuals. The tattoos may last for several months (Heideman & Heaney, 1989).

Cyalume (American Cyanamid Corporation) light-tags (Buchler, 1976) are inexpensive and relatively easy to use. They are available as gelatine pill or glass capsules in various sizes and can be bought from most fishing shops in the UK. The capsule is broken to initiate the chemiluminescent reaction of the chemicals inside. The light-tags are attached with surgical appliance adhesive (Skin-bond) to the dorsal fur or an area of skin from which the fur has been clipped. This adhesive is non-toxic and easily groomed off by the bat within a few days. A small amount of adhesive should be used and the bat held until the adhesive is dry (Kunz, 1988). The light-tags may be seen with the naked eye at distances of up to 200m, which can be increased with the use of binoculars (Buchler, 1976; Brown *et al.*, 1983; Racey & Swift, 1985). Light-tagged bats are often difficult to follow, particularly if they disappear quickly into dense vegetation. However, the technique has been successfully used to study foraging habitats, foraging ranges and flight behaviour of some bats (LaVal *et al.*, 1977; Buchler, 1980; Buchler & Childs, 1981; Brown *et al.*, 1983; Saunders & Barclay, 1992). If roost sites are known, this method can be used to determine where the bats go when they leave their roost, and the habitats in which they forage, assuming that there is sufficient manpower available to search potential foraging areas. This is done by catching the bats as they exit the roost, equipping them with a light-tag, and then following them and searching for them in the area surrounding the roost (e.g. Racey & Swift, 1985).

Figure 12: An *Artibeus jamaicensis* carrying a light-tag. Note also that this bat has a necklace as a permanent marker.

6.2 Radio-telemetry

Radio-telemetry is used extensively to determine the movements, activity patterns and foraging behaviour of many animals, including bats (e.g. Audet, 1990; Brigham, 1991; Krull *et al.,* 1991; Jones *et al.*, 1995). It can also be used to locate the roost sites of bats caught in their foraging areas. Radio-telemetry techniques and the equipment required are described in Kenward (1987), White & Garrot (1990) and Priede & Swift (1992).

One method commonly used to evaluate foraging behaviour and home range by radio-telemetry is triangulation, when the position of a bat marked with a radio-transmitter is calculated by using two receivers (e.g. Gannon & Willig, 1994). Radio-telemetry is a very expensive and labour-intensive method of studying bats. There are many problems associated with tracking bats marked with radio-transmitters. For example, to carry out triangulation, two receivers and antennae are required, both expensive pieces of equipment. The equipment is easily damaged in wet weather or when carried over rough terrain and a spare set of equipment should be available in case of problems that arise once in the field where it may not be a simple task to get items mended. It requires much practice to become proficient in radio-telemetry techniques, particularly when bats are moving quickly through dense vegetation at night. Attachment of the radio-transmitters also requires some skill, and can affect the ability of the bat to fly if not attached properly. The radio-transmitters themselves are expensive and the correct size is required for each species being studied. For small species (<70g), radio-transmitters should weigh less than 5% of the body mass of the bat (Aldridge & Brigham, 1988). For larger species (>70g), the weight of the radio-transmitter should be determined by using the calculation of Caccamise & Heddin (1985).

The analysis of data obtained from radio-telemetry is not straightforward and it is beyond the scope of this book to discuss the different methods in detail. There are a number of techniques available for analysis (see White & Garrot, 1990) which have different advantages and disadvantages. Compositional analysis can also be used, which overcomes some of the problems encountered (Aebischer *et al.,* 1993).

It may be outside the scope of many short-term projects to use radio-telemetry, unless the fieldworkers have previous experience of the technique, there are sufficient funds available to purchase all the necessary equipment and it is specifically required by the aims of the project. An alternative would be to plan a project to take part in a radio-telemetry study that is already underway.

6.3 Dietary studies

Information on the diets of different bat species can be useful as part of a study of a community of bats, as it may provide insight into how resources are partitioned within that community (e.g. Black, 1974; Heithaus *et al.,* 1975; Findley & Black, 1983; Humphrey *et al.,* 1983). Dietary information may be obtained from a number of sources including stomach contents (e.g. Kunz *et al.*, 1995), analysis of faecal pellets (e.g. Sullivan *et al.*, 1993), collection of rejected fruit pellets (e.g. Thomas, 1984), culled parts of insects below roosts (e.g. Belwood & Fullard, 1984), and collection of pollen directly from nectarivorous bats (e.g. Heithaus *et al.*, 1975). The methods most commonly used are faecal analysis and collection of pollen directly from bats, and these are described here. The procedure for identification of dietary items is different for insectivorous, frugivorous and nectarivorous bats.

6.3.1 Insectivorous bats

Insectivorous bats should be kept individually in clean cloth bags for about an hour after capture to collect faeces from them. Bats that have been caught during, or soon after, a feeding bout should be used for faeces collection and not those taken directly from a roost, as food travels rapidly throughout the gut (Kunz, 1988). The droppings from each bag can then be stored in a small sample tube containing 70% ethanol and kept for later analysis. Unless a very detailed analysis is to be carried out, droppings from all individuals of one species can be stored together. If large numbers of bats are to be caught, it may be useful to store droppings from different nights separately, and then temporal variation in diet can be investigated in the later analysis. Alternatively, if roost sites are known, droppings can be collected from them. A plastic sheet is placed underneath the roost area or entrance to the roost site and droppings are collected from this sheet daily, for example. It is important to know what species are present in a roost if droppings are to be collected from it. It is also important to collect insects from the habitats in which the bats are caught, as identification of insect remains in faeces is likely to be virtually impossible without a reference collection of whole insects (Kunz, 1988; see below for ways to trap insects). Insects can simply be stored in ethanol (70-80%).

Identification of insect remains in bat faeces takes practice. Each pellet should be placed in a petri dish and softened in water, or a mixture of water and alcohol, for a few hours. After softening, the pellet should be teased apart under a dissection microscope in order that individual identifiable items may be seen. Entomological pins mounted in pin holders are good for teasing droppings apart (McAney *et al.*, 1997). The individual items may then be identified by comparison with a reference collection, for example in a regional or national museum. It will be possible to identify some items to the species level, but others may only be identifiable to the order or family level.

6.3.2 Assessment of diet

Qualitative assessment of diet can be made from very small numbers of samples. In many cases there are no data available on the diet of tropical bat species, so qualitative information alone is useful. If larger sample sizes are collected, quantitative assessment of faecal composition can be made. Once items have been identified, there are various methods for assessing dietary composition and the relative importance of different prey groups (Kunz, 1988), each with different biases (e.g. Robinson & Stebbings, 1993), but overall faecal analysis is probably a reliable technique for evaluating bat diet (Kunz & Whitaker, 1983). Percentage volume can be calculated for each prey group in all the faecal pellets analysed. Alternatively, the composition of the diet can be described in terms of the individually identified items. This can been done in several ways (Vaughan, 1997). The best method is to calculate the ‘percentage items’ for each prey group. This is the number of items found in the whole sample of each prey group expressed as a percentage of the total number of identified fragments of all prey groups (e.g. Catto *et al.*, 1994).

The diet of insectivorous bats can be related to insect availability, in order to investigate the selectivity of different bat species (e.g. Anthony & Kunz, 1977; Swift *et al.,* 1985). The accuracy of this method depends on how closely the insect sample collected relates to actual insect availability, and on the reliability of faecal analysis (Kunz, 1988). It is important that insect samples should be collected at the same time and from the same site as the bats are captured, as many factors including time, temperature and habitat affect insect abundance and distribution. Different methods of sampling for insects also have different biases and these should be taken into account in any analysis. If prey selection is to be investigated in association with faecal analysis, the 'percentage numbers' of insects in faecal pellets should be calculated (Swift *et al.*, 1985; Vaughan, 1997). From each pellet, the minimum number of individual insects of each prey group consumed are estimated (Swift *et al.*, 1985). These estimated numbers can then be related to insect availability in the same groups. Graphical analysis can be used to assess whether or not a prey group is over-represented or under-represented in the diet (Murdoch, 1969). The simplest method is to plot the proportion of a prey group in the diet against the proportion available from insect samples (Cock, 1978). Deviation from the line of no selection can then be assessed (Swift *et al.*, 1985). Statistical analysis may also be used to assess selectivity (Anthony & Kunz, 1977). The question of the relation between insect samples and bat diet is a complex one and these are only some simple ideas for investigation. It may also be that the insects eaten by bats are not the same as those caught by traps; something to consider when deciding whether or not to sample for insects.

6.3.3 Sampling for insects

There are a number of methods by which insects can be sampled. Southwood (1978) describes these in detail and I will only mention a few of them here very briefly. Many of the methods require expensive traps, but some are very simple. There are inherent biases in insect sampling, as different groups of insects will be caught at different rates in each style of trap (Southwood, 1978). There are two main types of trap: non-attractant traps capture insects randomly, and attractant traps use sensory stimuli to attract insects to them (Kunz, 1988). Different types of non-attractant trap include suction traps (Johnson & Taylor, 1955), which can be large and bulky to transport although portable versions are available (Kunz, 1988); malaise traps (Townes, 1972; used in Belwood & Fenton, 1976), which are simple and versatile but biased towards insects that are attracted to light; interceptor traps, which can be used in conjunction with Malaise traps; sticky traps (Southwood, 1978), which are cheap to construct and simple to use for small insects; pitfall traps (Southwood, 1978) for terrestrial arthropods, which are useful in assessing the diet of ground-feeding bats, and sweep nets which are also inexpensive.

6.3.4 Frugivorous bats

The diets of frugivorous bats may also be assessed from faecal analysis. Droppings from frugivorous bats usually contain fruit pulp and seeds. Droppings can be collected in the same manner as for insectivorous bats and then stored in small envelopes (e.g. glassine envelopes used by stamp collectors) in an insect-proof, but not airtight, container or in ethanol for later analysis. A reference collection of seeds from fruiting trees should be made for later identification (Heithaus *et al.,* 1975; Kunz, 1988). Also, seeds collected from faeces can be germinated and the plant subsequently identified (Kunz, 1988). Droppings can also be collected from under fruiting trees by placing plastic sheets or tarpaulins on the ground. The problem then may be to identify the species producing the droppings, but fruit identification may be made easier.

Figure 13: A Piper tree, a fruit commonly eaten by bats in the Neotropics.

6.3.5 Nectarivorous bats

The diet of nectarivorous bats can be assessed from pollen studies. The presence of pollen on bats suggests that they visit flowers to take nectar, and the plants that they visit can be identified from the pollen. Pollen is often found in faeces, or it can be collected directly from the bat. Pollen-covered fur can be clipped from the bat and stored in glassine envelopes for future mounting onto slides (Kunz, 1988). Alternatively, pollen can be collected from the fur of the bat using invisible Scotch Tape

Figure 14: Collecting pollen from a bat, *Monophyllus plethodon*, using Scotch tape.

which is stuck to a slide. The tape will then be dissolved during the pollen staining process. It is important to establish who will carry out pollen identification before leaving for the field and to determine how they would like the samples collected.

Beattie (1971) describes a method for the collection of pollen to make a permanent slide. The fur of a bat is swabbed with small cubes of fuschin-stained gelatine, which can be stored temporarily in glassine envelopes. The gelatine cube is later placed on a slide under a coverslip and warmed. The fuschin-stained gelatine is prepared by mixing and warming 175ml distilled water, 150ml glycerine, 50g gelatine and 5g crystalline phenol. Crystalline basic fuschin is then added to stain the pollen.

A reference collection of pollen from plants likely to be visited by bats should be made for identification. Bat-pollinated flowers usually open at night and are strong smelling, robust, either pale or reddish in colour and easily accessible to the bat either by protruding upwards or hanging down from the plant (Fenton, 1992). It can be very difficult; however, to collect pollen from the

Figure 15: Swabbing a bat, *Monophyllus plethodon*, with fuchin-stained gelatine to collect pollen.

trees that the bats are visiting as they may be high up in the canopy for example. It is not easy to obtain quantitative dietary data from these techniques (Kunz, 1988), but as in the case of insectivorous bats, purely qualitative data are very useful.

6.4 Bat detectors

Ultrasonic bat detectors can be used to locate areas of high bat activity. In the Neotropics, most bat species from the family Phyllostomidae produce low intensity echolocation calls, some of which are only detectable at distances of up to 2m by most bat detectors (Novick, 1977). Therefore bat detectors are often not suitable for sampling phyllostomid bats (Fenton *et al*. 1992). Bat detectors can be used, however, to locate insectivorous bat species. They can also be used to assess bat activity (e.g. Fenton, 1970) and to identify species from echolocation calls (e.g. Fenton & Bell, 1981; Jones 1993; Vaughan *et al*. 1997). Detailed studies using expensive equipment and sound analysis software are required if bat detectors are to be used for assessment of bat activity or species identification and may be beyond the scope of most short-term projects.

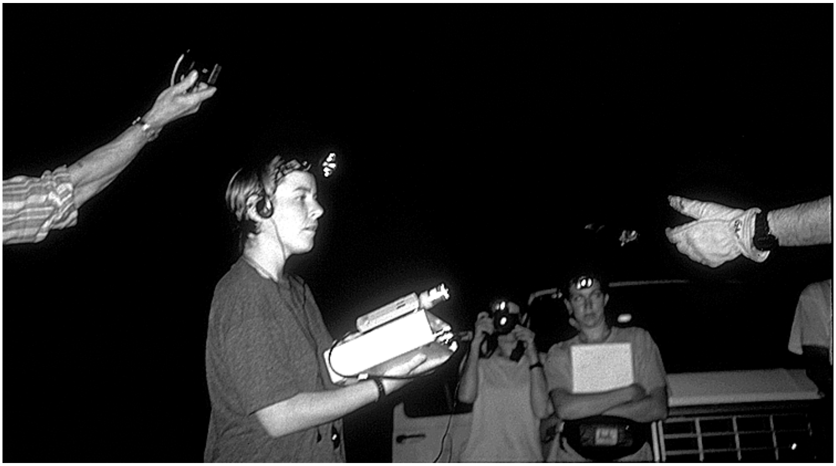

Figure 16: Using a bat detector in the field to record echolocation calls of a bat as it is released.

6.4.1 Types of bat detectors

A variety of ultrasonic detectors are commercially available, or they can be homemade. The Bat Conservation Trust produces an informative fact sheet on the different bat detectors available. There are several different systems of ultrasonic detectors, which have different uses in the field for sampling bats (Thomas & West, 1989; Pye, 1992). Heterodyne detectors mix an internally generated pure tone with the ultrasonic call to generate a sound at an audible frequency and the frequency can be tuned (Pettersson, 1993). These detectors are very sensitive and can be used in the field to determine the approximate frequency of a call. They cannot, however, be used to collect very detailed information about echolocation calls and often are not good enough for positive species identification. Heterodyne detectors also have a limited frequency range and bats producing echolocation calls at frequencies outside the selected frequency will not be detected (Pettersson, 1993). Species identification is not usually possible with heterodyne detectors. However, they may be helpful for locating roosts or areas of activity, which may be suitable sites to place harp-traps or mist-nets. These detectors also have the advantage that they are relatively cheap to buy. There are a number of different types available in the UK, including Skye detectors and the Bat Box III.

Frequency-division detectors reduce the frequency of ultrasound with digital frequency counters (Andersen & Miller, 1977). Frequency division has the advantage that it is a broadband method and therefore can sample a range of frequencies at one time, but it is less sensitive than heterodyning. The signals can be recorded to a tape recorder and analysed, so this method can be used both for monitoring activity and in some cases for species identification (Vaughan *et al*. 1996). However, sound analysis software is required for species identification, and frequency division detectors are more expensive to buy than heterodyne detectors, although simple frequency division detectors can be built (Miller & Andersen, 1984).

Time-expansion detectors capture and digitise a short sequence of echolocation calls. This sequence is then slowed down and replayed onto a tape recorder. Time-expansion is a broadband method and retains detailed information on echolocation call structure. It is more accurate for species identification than frequency division. Sound analysis software is required for analysis of recorded calls. A freeware programme can be found on the Internet at www.monumental.com/rshorne/gram.html. Time-expansion detectors are the most expensive of all detector types available.

6.4.2 Using bat detectors

Bat detectors can be used to monitor bat activity in different habitats or by different species (Fenton *et al*. 1977; Furlonger *et al*. 1987; Crome & Richards, 1988). Bat activity is usually measured by counting the number of bat passes recorded. A bat pass is the continuous string of echolocation calls heard on a bat detector as a bat flies over within range (Fenton, 1970). The number of bat passes in a specified time period are counted to determine bat activity (Fenton 1970; Thomas & West, 1989). There are limitations to using bat detectors to sample bats, as there are with capture techniques. Bat passes only give a measure of the level of activity (Fenton *et al*. 1973; Thomas & West, 1989), which can then be compared among sites. Species identification is often very difficult and all species may have to be considered together. Echolocation call intensities differ between species and therefore species have differing detectabilities (Fenton & Bell, 1981). The advantage of sampling with bat detectors is that a large area can be studied with relative ease (Thomas & West, 1989).

The factors that influence which bats are sampled by detectors differ from those that affect which bats are sampled by catching techniques. One study of an insectivorous bat community suggested that temporal activity can be assessed equally well with bat detectors or mist-nets (Kunz & Brock, 1975). However, a more complete picture of a bat fauna and habitat use may be gained by using both techniques together (Fenton *et al*. 1992; Rautenbach *et al*. 1996).

The location of roosts is often overlooked by field surveys of bats. The addition of a roost record for a species is a very useful piece of information, and may be of more use in terms of conservation implications for a site than simply a record of the presence of a bat foraging in a particular habitat. Searching for roosts can be a very time-consuming activity, although local people are often very knowledgeable and may be able to help. Bat detectors can be useful in locating roost sites either by following bats back to a roost at dawn or by locating bat activity as bats emerge from, or swarm around a roost. Once a roost has been located, there are a number of methods that can be used to estimate numbers of bats in the roost (see Section 3), or more detailed studies of the bats in the roost can be carried out.

Section 7

DATA ANALYSIS

7.1 Introduction

The data collected in the field will be in various forms: first, qualitative data on the species captured in the area and the specimens taken, and second, quantitative data collected from the specific projects carried out. The quantitative data may be analysed statistically. For example, differences in catch rate and species composition between habitat types may be investigated, or species diversity and abundance may be determined at different sites. Some of the data collected during short-term projects may not be suitable for statistical analysis. However, the use of standardised sampling techniques will allow simple data analysis to be carried out.

7.2 Data analysis

A number of statistics books are available that are reasonably straightforward to understand. In many cases only simple tests such as those described by Barnard *et al*. (1993) will be required to analyse data collected during expedition fieldwork. Some general references on statistics are Zar (1984), Siegel & Castellan (1988), Fowler & Cohen (1990), Marriott (1990), Altman (1991) and Sokal & Rohlf (1995). The choice of statistical tests in data analysis will depend on how the data were collected. The importance of designing a standardised sampling regime and having specific aims before starting out on fieldwork becomes clear when deciding how data should be analysed and cannot be emphasised enough (Barnard *et al*. 1993). Discussions with university lecturers on statistics before going into the field are recommended when possible.

7.3 Species diversity

The diversity of a community is affected by the number of species (species richness), and also by the relative abundance of each species (evenness). Species diversity and evenness are often calculated for bat communities (e.g. Fleming *et al*. 1972; Kunz, 1973 and Brosset *et al*. 1995). This may be done for a number of reasons including investigating altitudinal changes (Graham, 1983) and latitudinal changes in bat communities (Rautenbach *et al*. 1996). Research targeting the conservation of habitats or areas may aim to calculate species diversity. Species-rich communities are often considered to be superior to species-poor communities. Knowledge of the biodiversity of a site may be important for the selection of sites for conservation (IUCN/UNEP/WWF, 1991; ICBP, 1992) and for future management and maintenance of protected areas (e.g. Smith & Kerry, 1996).

There are many ways of measuring species diversity and they should be investigated in detail before choosing an appropriate index for the sampling method used (Magurran, 1988). There are three categories of diversity indices: those that measure species richness, those that measure species abundance, and those that are based on the proportional abundance of species (Magurran, 1988). The Shannon index of diversity (H'), commonly used in studies of bat communities, is placed in the final category. Details on techniques that can be used to estimate abundance and species richness in mammalian communities can be found in Wilson *et al*. (1996).

Data from mark-recapture studies can be used to estimate population size and density. These parameters can usually only be calculated for large data sets collected over long periods of time. In many cases, not enough data can be collected during short-term projects. Several different models can be used for population estimates (Zippin, 1956; Southwood, 1978; Fischer, 1973; Otis *et al*. 1978; Pollock, 1981; Seber, 1982; White *et al*. 1982). There are a number of assumptions that need to be considered in most models used to estimate population parameters and these should be considered in the analysis. The main problem usually encountered is that the area being sampled is not normally precisely known (Findley, 1993).

Section 8

POST-FIELDWORK ACTIVITIES

8.1 Introduction

After completing the fieldwork, the data should be compiled and reports should be written, published and distributed promptly in order that the findings of the project are documented and the sponsors are satisfied. This is one of the most important aspects of any project, once the fieldwork is finished. Reports should be relatively straightforward to complete if written promptly and if writing up was considered during the project planning. If report writing is delayed, reports become harder to complete.

8.2 Reports and publications

A preliminary report can be compiled while still in the host country, and distributed to counterparts, and also on returning home to sponsors and others. The preliminary report should contain at least a summary in the local language and should summarise concisely the main findings of the fieldwork. Methods can also be written up while doing the fieldwork.

The full report should be distributed to sponsors and everyone who was involved in making the project possible, particularly in the host country. Again, a summary in the local language should be included and a translation of the full document made if possible. Copies should also be sent to libraries in order that others may refer to the work in the future. A list of potential recipients for reports can be found in Barnett (1994). Guidelines for writing expedition reports can be found in Winser & McWilliam (1993). Good presentation of the findings and the implications of the work carried out is very important to ensure that they are communicated effectively to those reading the report (Barnard *et al*. 1993).

If possible, the results should be published in scientific journals. These will be much more widely read than reports. The data may be suitable for a short note, or for publication in a journal of the host country. Several books are available that give advice on writing scientific papers (e.g. Day, 1989). Acknowledgements should always be given where they are due, both in reports and papers. Copies of any published papers should be sent to counterparts in the host country.

Section 9

EQUIPMENT CHECK-LIST

In addition to the information given below, the Bat Conservation Trust produces a leaflet called the ‘Bat Workers Equipment List’.

9.1 Sampling equipment

Harp trap
Mist nets and poles
Machete to cut areas for mist nets
Mist net cord and threader for repairs
Tent pegs and guy lines
Ropes and pulleys etc. for erecting canopy nets
Slingshot
Hand net and poles
Hard hat
Thermometer
Beakers for measuring precipitation
Binoculars
Tally counters

9.2 Processing equipment

Gloves
‘Quick-n-pic’
Scissors
Head torch plus spare batteries
Maglite torch plus spare batteries
Bat bags
Pipette
Callipers
Pesola balance
Weighing bag
Tape measure
Notebook and graph paper
Pencils
Identification keys
Hand lens
Forceps

9.3 Specimen preparation (Wet preservation)

Ether
Dissecting scissors
Scalpel and blades
Forceps
Syringes (fine needle and heavy needle)
Sewing needles and thread (No. 30 cotton)
Permanent marker pens
Cotton wool or cotton wadding
Cheesecloth
String
Measuring beaker
Containers for specimens
Plastic bags (ziplock are useful)
Waterproof labels
Alcohol

9.4 Other equipment

Light tags
Skin-bond
Bat detector
Collection tubes and labels
Glassine envelops
Scotch tape
Alcohol
Insect traps
Gelatine
Fuschin stain
Altimeter
Global Positioning System

Section 10

USEFUL ADDRESSES

Many of the techniques described in this manual take some experience to carry out correctly. Previous experience of these techniques will be invaluable in the field, particularly handling bats, distinguishing between adults and juveniles, and taking wing tracings. In Britain, each county has a local Bat Group that may be carrying out fieldwork, and will also have a number of captive bats that may be available on which to practice some of these techniques. It is also possible to train with members of Bat Groups for a Bat Worker's Licence, issued by English Nature or the equivalent in Scotland (Scottish Natural Heritage) and Wales (Countryside Council for Wales). This licence is essential if you plan to carry out bat work in the UK. If possible, fieldworkers should undertake the training for a Bat Worker's Licence before going into the field. Local Bat Group contacts can be found through the Bat Conservation Trust. The Bat Conservation Trust also produces a number of fact sheets and is an excellent source of useful information.

The Bat Conservation Trust
15 Cloisters House, 8 Battersea Park Road, London SW8 4BG.
Tel: 020 7627 2629, Fax: 020 7627 2628
Email: enquiries@bats.org.uk
Website: www.bats.org.uk

The Chiroptera Specialist Group
is chaired by A.M. Hutson at BCT (Email: thutson@bats.org.uk) and Prof. P.A. Racey at Aberdeen University (Email: p.racey@abdn.ac.uk)
Dept. of Zoology, Tillydrone Avenue, Aberdeen, AB24 2TZ
Tel: 01224 272858, Fax: 01224 272396

Other conservation organisations hold a lot of information including previous expedition reports data on protected areas and species etc.

Flora and Fauna International
Great Eastern House, Tenison Road, Cambridge CB1 2DT
Tel: 01223 461471, Fax: 01223 461481
Email: info@ffint.org
Website: www.ffi.org.uk

World Conservation Monitoring Centre
219 Huntingdon Road, Cambridge CB3 0DL
Tel: 01223 277314, Fax: 01223 277136
Email: info@wcmc.org.uk
Web: www.wcmc.org.uk

Bat Conservation International
PO Box 162603, Austin, TX 78716, U.S.A.
Tel: +1 (512) 3279721, Fax: +1 (512) 3279724
Email: batinfo@batcon.org
Website: www.batcon.org

Birdlife International
Wellbrook Court, Girton Road, Cambridge CB3 0NA
Tel: 01223 277318, Fax: 01223 277200
Email: birdlife@birdlife.org
Website: www.birdlife.org

Lubee Foundation
18401 N.W. County Road 231,
Gainesville, Florida 32609, U.S.A.
Tel: +1 (904) 4851250, Fax: +1 (904) 4852656
Email: lubeebat@aol.com
Website: www.lubee.org

Harrison Zoological Museum
Bowerwood House, 15 St Botolphs Road, Sevenoaks, Kent TN13 3AQ.
Tel/Fax: 01732 742446
Email: hzm@btinternet.com
Website: www.harrison-institute.org

Mist nets and accessories are available from the B.T.O., as well as Pesola balances and callipers. More information and prices can be obtained from the sales department. Mist nets can also be bought for use overseas from Avinet.

British Trust for Ornithology
The Nunnery, Thetford, Norfolk IP24 2PU
Tel: 01842 750050, Fax: 01842 750030
Email: info@bto.org
Website: www.bto.org

Avinet
PO Box 1103, Dryden, NY 13053-1103, USA.
Tel: +1 (607) 8443277
Website: www.avinet.com

Callipers can also be bought quite cheaply from the following suppliers:

Camlab Ltd
Camlab House, Norman Way Industrial Estate, Over, Cambridge CB24 5WE (formerly CB4 5WE), United Kingdom
Tel: 01954 233 110
Website: www.camlab.co.uk

Philip Harris Education
Philip Harris, Hyde Buildings, Hyde, Cheshire, SK14 4SH
Tel: 0845 120 4520
Fax: 0800 138 8881
Website: www.philipharris.co.uk

Charles Francis has a design for a modified harp trap that is easily portable. He can be contacted at the address below:

Dr. Charles Francis
Long Point Bird Observatory, PO Box 160, Port Rowan,
Ontario Canada N0E 1M0
Tel: +1 (519) 586 3531 (work), Tel: +1 (519) 875 1505 (home)
Fax: +1 (519) 586 3532
Email: an759@freenet.carleton.ca

Copies of The Bat worker's Manual and more information about the Bat worker's Licence can be obtained from English Nature (formerly the Nature Conservancy Council).

Natural England
Natural England, Northminster House, Peterborough, PE1 1UA
Tel: 0845 600 3078 (local rate), Fax: 01733 455103
Email: enquiries@naturalengland.org.uk
www.naturalengland.org.uk

Detail and prices of bat detectors are available from the manufacturers listed below (see also the Bat Conservation Trust fact sheet).

Pettersson (D100 Ultrasound detector)
Dag Hammarskjolds v. 34A S-751 83 UPPSALA Sweden
Tel: +46 1830 3880, Fax: +46 1830 3840
Email: info@batsound.com
Website: www.batsound.com

Skye Instruments Ltd
21, Ddole Enterprise Park, Llandrindod Wells, Powys LD1 6DF UK
Tel: 01597 824811, Fax: 01597 824812
Email: skyemail@skyeinstruments.com
Website: www.skyeinstruments.com

Ultra Sound Advice (Mini-3 detector)
27 Merton Hall Road, London, SW19 3PR
Tel: 020 8287 4614
Email: sales@ultrasoundadvice.co.uk
Website: www.ultrasoundadvice.co.uk

Stag Electronics (Bat Box III)
4 Esprit Court, New Road, Shoreham-by-sea, West Sussex BN43 6RB
Tel/Fax: 01273 455408
Email: info@batbox.com
Website: www.batbox.com

Titley Electronics Pty Ltd (AnaBat)
P.O. Box 19, Ballina, NSW 2478, Australia
Tel./Fax: +61 66 866617
Email: titley@nor.com.au
Website: www.titley.com.au

David Bale
3 Suffolk Street, Cheltenham, Gloucestershire GL50 2DH
Tel/Fax: 01242 570123
Email: courtpan@globalnet.co.uk
Website: www.users.globalnet.co.uk

Hand nets for catching bats and Malaise insect traps can be ordered from the following company:

B&S Entomology (suppliers of the Marris House range of entomological nets)
Email: enquiries@entomology.org.uk
Website: www.entomology.org.uk

Altimeters and head torches can be bought from many outdoor suppliers including those mentioned below.

Field and Trek
Langdale House, Sable Way, Laindon, Essex, SS15 6SR
Tel: 0844 800 1001, Fax: 0844 800 1004
Email: sales@fieldandtrek.co.uk
Website: www.fieldandtrek.com

Taunton Leisure
Camping & Leisure Goods, 72 Bedminster Parade, Bristol.
Tel: 0117 9637640, Fax: 0117 9669102
Email: bristolshop@tauntonleisure.com
Website: www.tauntonleisure.com

Skin-bond is made by the following manufacturer in the USA and is also distributed in Europe:

Smith and Nephew United Inc.
Largo, FL 34643, USA

Waterproof notebooks can be bought from the following suppliers:

Aquascribe Hawkins and Manwaring
Westborough, Newark, Nottinghamshire NG23 5HJ.
Tel: 01949 843917
Fax: 01949 844051
Email: Info@aquascribe.com
Website: www.aquascribe.co.uk

H.W. Peel and Company Ltd
Chartwell House, Lyon Way, Greenford, Middlesex UB6 0BN
Tel: 020 8578 6861

Entomological equipment can be obtained from:

L.Christie
129 Franciscan Road, Tooting, London SW17 8D2
Email:
Website:

Watkins and Doncaster
PO Box 5, Cranbrook, Kent TN18 5E2
Tel: 0845 833 3133
Email: sales@watdon.com
Website: www.watdon.com

Tree climbing courses can be taken at the following college:

Merrist Wood College
Worplesdon, Guildford, Surrey GU3 3PE
Tel: 01483 232424, Fax: 01483 236518
Website: www.guildford.ac.uk

On-line Discussion Groups

BATLINE is a discussion group available on the Internet for those interested in bat research. To subscribe to BATLINE, send the following message to listserv@unm.edu: Subscribe batline 'your name'

http://www.basicallybats.org/BATLINE/

CARIBBEAN-BATS GROUP
http://groups.yahoo.com/group/Caribbean-bats

SECTION 11

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