Health and safety in bat work

A. J. Mitchell-Jones

Bat work may involve visits to sites that are potentially dangerous, particularly for those who have received inadequate or insufficient training and are unaware of the correct safety measures. It cannot be emphasised too strongly that safety is of paramount importance in all situations. No site or colony is worth taking risks over, so if in doubt abort the visit. Always ask yourself whether you could get the information you need without entering a hazardous area.

Risk assessment plays an important part in ensuring that bat group members operate in a safety-conscious way and bat groups can help by ensuring that safety procedures are discussed and reviewed regularly. Appendix 8 includes sample risk assessments for entry into buildings and disused mines.

Employers should be aware that bat work is covered by Health and Safety legislation. A summary of the main requirements can be found in Appendix 8, including relevant references.

2.1 Health and first aid

In Britain, bats rarely transmit diseases to man, but the death of a batworker from the rabies-related European Bat Lyssavirus (EBLV) in 2002 illustrates the need to take steps to avoid being bitten, as it must now be assumed that this virus is present in bats in the UK and this fatal disease can be contracted from a bat bite (see Box: *Advice on bats and rabies* for details). In addition, it is always wise to take simple hygiene precautions when visiting bat roosts. Always cover any open cuts before entering bat roosts and wash your hands after handling bats or their droppings and before eating, smoking or drinking. Anyone working with animals or in dirty areas must ensure that their anti-tetanus immunisation is kept up to date.

Visits to or, more especially, prolonged work in, some sorts of sites may carry a risk of disease. Tick-borne Lyme disease is unlikely to be a hazard to bat workers, but work in sites contaminated by sewage or rats carries a risk of leptospirosis (Weil's disease). A small number of cavers have contracted this disease, indicating that there is a risk wherever there is contact with water. If you work in such sites, make sure you observe the hygiene precautions described above and report any influenza-like symptoms immediately to your doctor together with information about your work.

Greater horseshoe bat colony. © Frank Greenaway

A quick reference guide may be available from your SNCO contact.

Carrying a simple first-aid kit, and knowing how to use it, would be a sensible precaution for all site visits including those underground. Standard kits are widely available and could be kept as a permanent part of your site visit equipment.

2.2 Travel and night or lone working

Travelling to and from bat work and working at dusk or at night carries an element of personal risk which can be minimised by taking a few simple precautions.

- Avoid working alone wherever possible. Never go underground alone.
- Avoid sites with a reputation for incidents. This might apply particularly to night-time fieldwork at urban sites.
- Be aware of what is going on around you and the location of the nearest house or phone box. Remember that when wearing headphones with bat detectors you may be unaware of what is going on around you.
- Consider carrying a personal attack alarm.
- Always tell someone reliable where you are going, what time you expect to return and what to do if you don't turn up. Always keep to these arrangements and phone if you are going to be late.
- Some SNCO offices have well-developed 'buddy' systems or recording systems. These should be used where available.
- Don't rely on a mobile phone as you may be in an area with poor reception.

Advice on bats and rabies

See also 9.1.1 – Transmission of disease.

Vaccination

Following the discovery of European Bat Lyssavirus type 2 in two Daubenton's bats in England and the death of a batworker in Scotland from the same virus, it must now be assumed that this virus is present in bats in the UK. Testing of dead bats by MAFF/Defra over the last decade indicates that the overall incidence of infection is likely to be very low, although limited testing of live Daubenton's bats for antibodies suggests that exposure to EBL2 may be more widespread. Nevertheless, infected bat bites have caused human deaths so appropriate precautions against infection must be taken.

The Department of Health's recommendation is that people regularly handling bats should be vaccinated against rabies. Included in this category are all active bat workers and wardens, and those regularly taking in sick and injured bats. The SNCOs and the Bat Conservation Trust urge all those involved in bat work to ensure that they are fully vaccinated and that they receive regular boosters. Bats should not be handled by anyone who has not received these vaccinations.

Even when fully vaccinated, people should avoid being bitten by wearing appropriate bite-proof gloves when handling bats. Any bat bite should be thoroughly cleansed with soap and water and advice should be sought from your doctor about the need for post-exposure treatment. Further information is available from the SNCOs, the Bat Conservation Trust or the Health Protection Agency (HPA) /Scottish Centre for Infection and Environmental Health (SCIEH). The BCT website http://www.bats.org.uk/batinfo/rabies.htm provides up to date information.

Advice to the public who find grounded bats

Members of the public should be advised not to handle grounded bats. The advice from the Department of Health is that there is no risk to the public provided they do not touch or pick up bats. It may be possible for a bat worker to visit to examine the bat and retrieve it if appropriate. The local Animal Health Divisional Office (or its equivalent in Northern Ireland, Republic of Ireland, Isle of Man and Channel Islands) should be contacted if the bat is behaving abnormally or aggressively and for which no explanation of its behaviour is readily available. It should be remembered that there are hazards to both wild animal and human in inexperienced people handling any wild animal. The bat worker should establish whether the bat has bitten anybody. If so, then the bat worker should consider encouraging the finder to collect the bat (using a box and cardboard slide, bite-proof gloves or a heavy cloth) into a box where it can be examined later.

If a bat has bitten, or may have bitten, a member of the public, they should be advised to seek immediate medical advice. If available, the bat should be retained in captivity for assessment by an experienced person, or euthanasia applied, depending on the assessed risk. Post-exposure treatment, which appears to be highly effective, should be considered after discussions with a doctor or GP. The HPA (tel: 020 8200 4400) or SCIEH (tel: 0141 300 1100) can provide advice to doctors or the public about the assessment of risk.
The BCT office holds a list of all Animal Health Divisional Offices (AHDOs) and their equivalents elsewhere and has details of appropriate health offices. A list of AHDOs can be found at http://www.defra.gov.uk/corporate/contacts/ahdo.htm

Submission of fresh dead bats to the Veterinary Laboratories Agency (VLA)

To encourage an increase in the rabies surveillance:

1. All dead bats should be sent by first-class mail to VLA as soon as possible (but not on a Friday). If there is to be delay in posting, keep in a refrigerator (4–6°C) until the bat can be collected or posted. Rabies-related virus can be isolated from frozen or decomposing material, but the chances are enhanced in fresh unfrozen specimens.
2. If euthanasia is agreed, this can be carried out by a vet using intraperitoneal injection of a small volume of barbiturate; alternatively, gaseous anaesthesia can be used if facilities exist. Other methods are available but should avoid breaking the skin or skull.
3. Details of date, source and circumstances of finding should accompany samples. If there is reason to be suspicious of the animal call your local Animal Health Divisional Office before dispatching the bat.
4. Packaging must comply with the Post Office regulations for pathological material. Carcasses should be packed in a tightly sealed container and surrounded by absorbent material. This should be securely fastened and placed in a stout envelope or padded bag. The package must be marked 'Pathological specimen: Fragile with Care' and sent by first-class post to VLA. Packages should be clearly marked with a large red 'R' next to the address. Suitable pre-paid envelopes, forms and specimen tubes are available free of charge from the Bat Conservation Trust.
5. The package should be sent to Rabies Diagnostics, Veterinary Laboratories Agency, New Haw, Addlestone, Surrey KT15 3NB. Some bat groups have had an arrangement with the Veterinary Officers of their local Animal Health Divisional Office regarding collection of bats for delivery to VLA.
6. As in other countries, the identification of all bats submitted to VLA is confirmed by an appropriate bat specialist and the material is subsequently passed to one of our national museums (mostly to Liverpool or Edinburgh).

Taking bats into captivity

Bats should be held in captivity in accordance with the Bat Conservation Trust guidelines.

Defra has confirmed that any captive bat that is still alive after any necessary treatment and care can be considered safe to release as soon as it is in a fit state

All bats that die in captivity should be submitted to the VLA as soon as possible.

2.3 Safety in and around buildings

Visits to locate or inspect bat roosts in buildings may involve access to parts of the building that present particular safety hazards. It is important that you are properly equipped for such visits and are aware of the hazards that may exist. Refer to the sample risk assessment in Appendix 8. When you visit a building, the occupier of those premises shares a legal responsibility for your health and safety.

2.3.1 Personal protective equipment (PPE)

If it is necessary to enter a bat roost, proper equipment is essential and appropriate clothing should be worn. Overalls are recommended because they protect clothes from dirt and the body from splinters or irritation caused by fibreglass insulation. Shoes or boots with a thick sole should be worn to give protection against projecting nails; industrial safety boots or safety trainers with nail-resistant soles are ideal. Tough gloves, such as gardening gloves, can give protection against splinters, nails and sharp edges. Their use is a matter of individual preference, although gloves must always be worn for handling bats. Dust masks should be worn if you have any form of respiratory sensitivity and eye protection may be advisable when opening a loft hatch from below.

Hard hats can provide considerable protection against falling objects or projecting nails, but they need a certain amount of care if they are to function properly. The hat must be a good fit, with the inner harness and strap adjusted properly. The gap between the harness and the plastic shell is essential for the proper functioning of the hat, so do not store anything there. The plastic shell is tough, but not indestructible, and you should ensure that it is cared for properly; do not apply solvents to it or modify it in any way. Hats that have received a significant sharp blow or are over 5 years old should be replaced. Hats that are over 2 years old should be tested regularly by squeezing the sides and watching for any cracking, whitening or kinking of the plastic. In an ordinary attic, the use of a hard hat is optional, but they should be worn if there is any risk of being hit by a falling object, such as a roof tile or any debris from old or derelict buildings. Baseball ‘bump-caps’, which give protection against projecting nails and bumps against roof timbers, are widely available.

Any roost visit requires good lighting. A head torch is preferable because it leaves you with both hands free and provides light in the direction you are looking. Small dry-battery operated head torches are light and convenient for visits to domestic roosts, but rechargeable caving and mining lamps have a much longer life, although they are fairly heavy. Always carry a spare torch as insurance against being stranded in the dark.

2.3.2 Ladders and tower scaffolds

Many accidents are caused every year by the misuse of ladders, with the most common problems being defective ladders, ladders slipping at the top or bottom, or ladders sinking unevenly into soft ground. Always follow this safety code:

- Check the condition of the ladder carefully, particularly if it is borrowed. Do not use ladders that are damaged or incomplete. Avoid borrowing ladders wherever possible.
- Do not use a wooden ladder that has been painted, as this can hide defects.
- Erect the ladder at a 75° angle, 1 metre out for every 4 metres of height.
- Place the ladder on a firm footing and use a non-slip foot on smooth surfaces.
- Ladders should either be tied firmly in place or held at the bottom by an assistant. Tying the ladder at the top is probably the safest method.
- Do not over reach. Your body should not move outside the line of the ladder.
- Use both hands when climbing. Tools or equipment should be carried in a belt or rucksack.
- Watch out for overhead power or telephone cables.
- Erect the ladder taking full account of site conditions, e.g. exposure, weather, movement of persons or vehicles.
- Make certain the ladder reaches at least 1 metre above any landing platform.
- Use the correct ladder for the job. Never lash two short ladders together to make a longer one.
- When using an extension ladder allow a two-rung overlap for sections up to 5 metres each and a four-rung overlap for 6 metres. The Health & Safety Executive (HSE) advise that any ladder reaching a height of more than 9 metres vertically should have safe landing areas and platforms.

Tower scaffolds are widely used, but they are involved in numerous accidents each year and are inappropriate for most bat work. Obtain a copy of HSE Construction Information Sheet No. 10 (Rev 3) (available at http://www.hse.gov.uk) and follow the instructions set out in the sheet.

2.3.3 Access to roofs

If you are considering access on to a roof at any stage, you should bear in mind that in the construction industry falls from and through roofs cause more deaths than almost anything else. Access to single storey flat roofs, such as garages or house extensions needs only basic care at the edge, but access to any other sort of roof needs a careful assessment of the risks involved and the provision of appropriate safety equipment. Access to roofs should not be required for most bat work and must not be attempted unless you have the training and specialist knowledge to do so safely. The roofs of many industrial and farm building are made out of corrugated cement sheet. These are fragile and brittle and must not be walked on without crawl boards.

2.3.4 Building and demolition sites

Building and demolition sites are dangerous places. The site contractor is responsible for your safety and you should make sure that you are always accompanied by a site representative and follow any safety instructions you are given. Normally the wearing of a hard hat is mandatory.

2.3.5 Visits to roof voids

Visits to roof voids always carry a risk of falling through a lath-and-plaster or plasterboard ceiling. These risks are multiplied in older buildings, where rot or woodworm attack may have weakened the timbers. This is a dangerous and expensive mistake to make and can be avoided by moving steadily and methodically and only ever walking on sound joists. A good torch is essential for checking the position and soundness of the joists, and one hand should always be kept free for holding on to the roof trusses to maintain balance. In some roofs, joists may be in such a poor state that the visit should be abandoned or the search confined to sound areas of the roof. Before entering a confined space like this, always ensure you have a safe means of exit in case of emergency.

There are several other potential hazards.

Dust and insulation

Dust and fibreglass or mica insulation particles, which are often stirred up during visits, can be irritating to the skin and lungs and sometimes cause allergies. A simple dust mask, as sold in DIY stores or builders' merchants, can prevent respiratory trouble and is a sensible precaution. Insulation fibres can be difficult to remove from clothing, so wear one-piece overalls to keep fibres off your normal clothing. Wherever possible, avoid disturbing or handling insulation material.

Pesticides

Although aerial levels of pesticides in roofs that received remedial timber treatment several years previously will be so low as to be negligible for a mammal as large as a human, more care is needed in roofs that have received recent treatment. The risks of even mild irritation are extremely low from a single visit to a treated roof but, if there is a strong smell of solvents or if the wood is still wet or glistening, full protective clothing is advisable or the visit should be abandoned. The label guidance on licensed products will give details of any restrictions on post-treatment access. If in any doubt, wear rubber gloves and wash exposed skin after the visit.

Electric wiring

Houses that have been wired or rewired to current safety standards should present no problems, but in older houses wires may be draped across the joists and the insulation may have perished in places. Avoid standing on any wire, even if it looks in good condition. As well as being a potential threat to the bat worker, unsafe wiring is a considerable fire hazard and so should be drawn to the attention of the owner of the property.

Asbestos

The inhalation of asbestos fibres can cause asbestosis, a type of cancer. Asbestos occurs very occasionally as lagging round hot water pipes in old properties. **If the presence of asbestos is suspected, the visit should be abandoned immediately**. Do not poke at insulation to see if it asbestos; it is difficult to differentiate between asbestos and other

less harmful mineral fibres and disturbance will only disperse the fibres into the air. Rock wool fibre is often used for loft insulation; this is usually a muddy brown colour rather than silvery white. Fibreglass is often pink.

Woodwork

In many roof voids this is fairly rough and there may be nails sticking out of the trusses, joists or sarking. A hard hat, strong shoes and gloves will avoid the possibility of minor injuries. Sometimes loose bricks or stonework may be encountered, especially around chimneys. Avoid dislodging anything.

Wasp, bee and hornet nests

Wasp nests are the most common. Occupied nests should not be disturbed and if you encounter one you may wish to consider abandoning the visit because being stung (or trying to avoid being stung) could put you at risk of a fall.

2.4 Safety underground

Survey or monitoring work in caves and mines requires particular attention to safety because the potential for a serious accident is probably greater than in buildings. Inexperienced workers must seek advice and practical guidance from an experienced caver, who should have the appropriate equipment and be familiar with good caving practice. Guides to good caving practice and techniques are available from the mining and caving organisations listed in Appendix 6. A glossary of caving and mining terms is given in Appendix 2. A sample risk assessment for entry into disused mines is given in Appendix 8.

Training in underground techniques, with a firm emphasis on safety, is available from a variety of sources. Courses specifically for bat workers are organised at irregular intervals by some bat groups. Caving clubs and outdoor centres often run a range of courses, and videos and books are available on simple and vertical caving. Specialist caving equipment suppliers can also be an excellent source of advice on the type of equipment that will be required.

The following safety rules are expanded from safety codes produced by caving and mine-history organisations.

- Never go alone. Even the simplest accident can immobilise a lone caver and lead ultimately to death from exposure. Don't split up underground and always ensure the party is within shouting distance. A party of four is the minimum recommended size, so that one can stay with an injured person while two go for help.
- Always tell a reliable person where you are going and what time you expect to be back.
- Take spare lights. Although purpose-built mining or caving lights are reliable, accidents and equipment failures do happen. Make sure that there is always at least one spare light in the party and it is preferable that each member carries their own spare. Chemical lights (Cyalume) can be carried for emergencies, though their low light output restricts their usefulness.
- Wear appropriate clothing. Caves and mines are generally between 8 and 10°C (although some sites, e.g. disused railway tunnels, can be cooler [2–9°C]), so for dry caves normal outdoor clothing is appropriate. Wet sites are more of a problem because heat loss through wet clothing is considerably higher. Wet or dry suits are the preferred solution for many keen cavers, but a good combination for bat workers is a waterproof oversuit together with either a fleece undersuit or old clothes and thermal underwear. Wellingtons are often the best footwear.
- Take appropriate equipment and know how to use it. Many levels, adits and caves can be entered without any special equipment, but even apparently straightforward horizontal passages can contain hidden hazards, such as unsafe floors and roofs, shafts covered with rotting timber or deep water. Abandoned mines should always be treated with extreme caution and old timber or metalwork should never be touched, let alone trusted.
- Vertical shafts should be attempted only with adequate safety equipment and never without proper training on the surface beforehand. The use of wire caving ladders (electron ladders) and SRT (single rope technique) should never be attempted underground until full proficiency is achieved above ground.
- Try to obtain a survey map of the site before the visit. These are sometimes available through local caving clubs. In all but the simplest sites it would be prudent to take a guide who knows the system because it is quite easy to get lost underground.

- See English Nature's Health and Safety Information Notices 11/97 *Visiting Working Mines* and 12/97 *Visiting Disused Mines*.

2.5 Safety at tree roosts

Many tree roosts are in trees that would be classified by an arboriculturalist as hazardous because bats tend to use old trees, which have developed hollow limbs, rot holes in the trunk or loose bark. If you wish to examine such trees using a ladder, follow the ladder code and place the ladder against sound trunk wood, never against a branch. Tie the ladder to the tree by means of a rope or strop.

When checking or erecting bat boxes observe the following guidelines:

- wear a safety helmet;
- do not carry loose tools in the hand – put the tools you require in a haversack with a shoulder strap;
- wrapping a piece of cloth or rubber tube around the top rung will help prevent the ladder slipping on the narrower tree trunks;
- make sure you have an assistant firmly holding the ladder at the base;
- ensure the assistant at the base of the ladder wears a safety helmet too;
- do not climb trees without the help of a ladder – tree climbing requires special training.

2.6 Safety at public events

Health and safety considerations should be considered when organising events or talks and attending shows. At major shows the organisers usually circulate Health and Safety requirements to stand-holders. However, one should remain aware of specific risks around the stand, such as free-standing display boards, which can frequently fall over on uneven ground or on windy days. Electrical appliances should be shielded from any exposure to rain.

When organising bat walks involving members of the public, carry out a short risk assessment of the proposed route and have a contingency plan in case of accident. Some landowners may require the submission of a risk assessment before giving permission for the event. BCT can provide risk assessment forms and guidelines for bat walks and events.

- ensure that there is a sufficient number of torches amongst the group and people come wearing suitable clothing and footwear;
- announce some basic safety considerations at the beginning of the walk and highlight any potential hazards along the route;
- have a helper bringing up the rear, particularly with large groups;
- do not let young children attend the walk unaccompanied;
- know the location of the nearest telephone or carry a mobile telephone;
- carry a basic first aid kit.

2.7 Working with others

Working with young people may impose certain legal and ethical requirements related to safety and supervision. This is unlikely to affect most bat group work, but further information can be obtained from the Child Protection in Sport Unit (Tel: 0116 234 7278/7280, website http://www.sportprotects.org.uk).

2.8 Insurance

Matters of insurance for bat workers are not always clear and may vary for different bat groups. Some individuals may be covered for some or all aspects of bat work by their own private insurance but some bat-workers, including those not members of a local bat group, may have no cover at all.

Bat workers carrying out roost visits for the SNCOs are covered in the same way and have the same rights as members of staff. Some of the SNCOs provide additional limited personal accident insurance. Bat workers should check the status of their insurance with the relevant local office if in any doubt.

Bat group members involved in bona fide bat group activities can be covered for public liability insurance (including member to member) under the Bat Conservation Trust's policy, provided the bat group is affiliated to the BCT. The policy has a maximum liability of £5 million. The BCT policy does not provide cover for personal accident or equipment loss.

Some landowners are uncomfortable with letting bat workers on their land or property without proper insurance, particularly if the visit is to an abandoned mine.

When attending shows or hiring rooms check with the organisers or room owner that they have the necessary public liability cover.

Survey and monitoring

A. Walsh & C. Catto

3.1 Introduction

Surveying for bats and their roosts is an important aspect of bat work for both research and conservation purposes. Until recently, bats were probably one of the most under-recorded groups of vertebrates. However, rising interest and the accumulation of data from enquiries and other initiatives have led to a great increase in the number of records and a better idea of the distribution and relative abundance of the various species. Advances in equipment, notably bat detectors, have increased the potential for surveying bats away from roosts and created a doorway to understanding the foraging and habitat needs of bats.

A National Bat Monitoring Programme was initiated in 1996 and is run by the Bat Conservation Trust. This aims to track the population changes of target species on a UK-wide basis. The Agreement on the Conservation of Populations of European Bats also has target species for Europe-wide monitoring.

For the purpose of this chapter, the monitoring of sites and bat populations can be considered as an extension of surveying. Survey includes the discovery of bat sites and the mapping of species distribution, key bat roosting / hibernation sites and feeding areas. Monitoring is the repeated counting of bats either in roosting / hibernation sites or feeding areas over a period of time. Specialised techniques such as ringing and other types of marking are covered in later chapters.

3.2 Purpose and design

All survey and monitoring techniques for bats are to some degree selective and no single technique will give a complete and unbiased picture of the bat population of an area. Surveys in buildings overemphasise the frequency of those species that habitually roost in buildings, bat detector surveys under-record species with weak echolocation calls, hibernacula surveys concentrate on cave hibernators, and mist-nets tend to catch those species that fly low or close to vegetation. All these factors must be borne in mind when organising bat survey work.

The most important factor to consider at the outset is the purpose and scale of your intended study. Appropriate methods for a particular study become more obvious if there is a clear aim, specified in advance. Three main aims at either a local, regional or national scale are:

Pettersson D240x Bat Detector. © Alana Ecology.

3.2.1 Inventory and distribution studies

The simplest aim is to ask what bat species are present or absent in a given area. Knowledge of the distribution of species is important because it can be related to land use and can provide valuable information on the relative value of areas for bats. Such data can be used to assist in the process of Environmental Assessment and for issues of planning and land use.

3.2.2 Location of key sites and feeding areas

A second aim is to ask where bats are roosting, hibernating or feeding in a given area and how many of these sites exist. This has two main purposes: first to improve our knowledge of the ecology of bats and second, to improve the identification of important sites for special protection.

3.2.3 Monitoring the status of sites and populations

An increasingly important aim is to track how sites and bat numbers at sites are changing over time, so that declines and potential threats to populations can be identified at an early stage. Tracking changes in distribution of species over time is also a valuable method in assessing the status of populations.

3.3 Inventory and distribution studies

The great majority of species records are collected at a county level. Records are generally collected on a casual basis over time and are derived from roost visits at the request of householders, reports of dead, trapped, injured or grounded bats, reports from the public, from bat walks or from specific roost, feeding area, bat box or hibernation site surveys. Plotting records collected in this way by some map unit (e.g. 2-km squares), gives an indication of the distribution of species, but care should be taken in interpreting such maps. There are inherent biases in the ability to find some species. House-dwelling species, such as pipistrelles, are more likely to be located than tree-dwelling species, such as noctules. In surveys of free-flying bats, loud echolocators, such as serotines, are more likely to be located than weak echolocators, such as Natterer's bats. If coverage of an area is uneven, maps may show the distribution of observer effort as much as the distribution of bats. A more accurate picture of distribution can be gained if a specific atlas survey is organised, which is designed to ensure a fairly uniform coverage in different areas, and uses standard searching and species identification checking procedures. Failing this, coverage and search effort need to be measured and reported. A good example of an atlas study at a national scale is one completed in the Netherlands (Limpens *et al*., 1997).

3.4 Location of key sites and feeding areas

3.4.1 Finding roosts in houses, trees or other structures

Promoting reports of roosts

The great majority of records of bat roosts arise from requests for advice from householders. In order to maximise the numbers of reports of bats received by yourself or your bat group, it is useful to develop good relations with the local building professions because they are most likely to come across bats or signs of bats during their work. Other than this, possible roost sites can be found in a number of ways. Placing posters that request details of any known roosts in public places, such as petrol stations, shops and post offices, is a relatively simple and cheap technique. Similarly, appealing for information through local newspapers, television and radio is a good way to stimulate public interest in bats and produce a list of potential roost sites. Posting questionnaires or leaflets with a returnable slip through letterboxes of every building or a proportion of buildings selected at random in the study area is a slightly more costly method but is probably the most thorough way of locating roosts in buildings. A much higher response rate will be achieved if you provide a stamped addressed envelope, although this will increase costs. With all of these methods, respondents claiming to have roosting bats in their building, or knowledge of a roost elsewhere, should be contacted by telephone and, where possible, the site visited to validate their claim and identify the species concerned. Speakman *et al*. (1991) is a good example of the use of these methods in a survey conducted in Scotland.

Day surveys of potential roost structures

Inspecting every building or structure (e.g. trees, bridges, barns, outhouses) likely to be inhabited by bats during the day is a time-consuming process. However, survey time can be reduced if roost preferences of individual species are taken into account. For instance, long-eared and lesser horseshoe bats show a marked preference for older buildings, while pipistrelles are commonly found in modern buildings. Daubenton's bats are frequently found roosting underneath bridges, and noctule colonies are most frequently found in big trees.

When surveying buildings, ask the householder first whether bats are known to be present. A negative response should be treated with some caution because, often, bats are present without the householder's knowledge, but positive replies should always be followed up. Carefully survey the outside of the building for droppings, paying particular attention to sheltered areas such as window ledges or pipes where droppings can lie undisturbed. Cobwebs can often trap droppings and are always worth a close inspection. Scan the outside of the building for potential access points such as broken ventilation bricks or loose slates and look for droppings under these points (see also Hutson 1987, 1993).

Search the loft space, although check with the householder first about safety and potential hazards (see Chapter 2). Gable ends and chimneys are often roosting points for pipistrelles and serotines, although long-eared bats can be found anywhere

along the roof ridge. Look for droppings and listen for squeaking or movement from between the tiles and felt on hot days. Bats have frequently been found drowned in open water tanks, so it is always worthwhile to check them.

It is hard to locate tree roosts by day surveys because there are often no external signs of bat occupancy. One technique is to survey trees in winter when the foliage is not present and look for obvious holes. If large colonies use them in the summer the wood may be smoothed at the entrance. Brown staining from urine, faeces or fur rubbing can be present but often brown stains are connected with rot so their presence is not conclusive. Likely trees can be marked and re-visited in the summer at sunset to watch for emerging bats. On hot days colonies are active and can be quite noisy so it is possible to walk through woods listening for the sounds of colonies. Walking through woodland an hour before sunrise during July and August can also reveal roosts (see Appendix 4).

Case study – Bats in Barns Survey

During a survey of 92 barns in Hertfordshire and Middlesex, carried out over an 18-month period, various criteria emerged that typified barns most likely to be used by bats. These included an age of over 100 years, a floor space of at least 300 sq m, and the presence of thick beams and a roof. The roof could be of any type including corrugated iron. Barns in a poor state of repair were found to be used but those housing grain drying machinery were not, presumably because they were too dirty.

The features found to be most attractive to bats were the crevices in the mortice joints of beams. Most of the barns examined during the survey were constructed with post-and-truss frames, a type typically built in the south and south-east of England between the 12th and 19th centuries. Nails were uncommon before the 19th century, so looking for wooden pegs and wedges can give an indication of the age of a barn.

Forty of the surveyed barns contained evidence of use by bats. The species most often present were Natterer's bats (15 barns) and brown long-eared bats (13 barns). The brown long-eared bats tend to roost along the central ridge beam and, therefore, often leave a line of droppings underneath, which can be a useful clue to their presence. The Natterer's bat roosts were all in listed buildings, close to woodland, with hollow mortice joints, open or absent doors and unimpeded flying space inside. It was found that Natterer's bat colonies were often mobile, regularly moving between joints and making use of all that were available. Signs that joints were being used included staining and lack of cobwebs around the joint gaps. Droppings may be visible but, even in larger roosts, the number easily seen may be relatively small.

Owners were often unaware that their barns were used by bats. This may be, in part, due to the late emergence of these species and the fact that they were only present in significant numbers during the summer breeding period.

Suitable barns are increasingly being converted for residential use and, consequently, their suitability as bat roosts is often lost. It may be possible to reduce this loss by retaining features that are required by bats, such as hollow mortice joints and room within the roofspace for bats to fly in.

Source: Extract from *Bat News*, No. 44, January 1997 (see Briggs, 1995).

Case study – The 'Bats in Churches' Project

The Bats in Churches Project was established by The Bat Conservation Trust in 1991. This 3-year study of the use made of churches and chapels in England by bats aimed to improve the conservation and management of bats in churches. Volunteer bat workers carried out the survey work and visits to 538 churches and chapels, of which 142 were occupied by bats. There are estimated to be 30,534 churches and chapels in England and the results of this survey indicated that, correcting for those no longer in use by parishioners, 6398 could be occupied by bats. The summary below shows the relative abundance of species occurring in churches and chapels as found in the National Bats in Churches Survey.

Species	Churches occupied by bats	Chapels occupied by bats	Proportion of roosts occupied by species (%)
Pipistrelle	63	16	50.6
Long-eared	44	12	35.9
Serotine	7	3	6.4
Natterer's	4	1	3.2
Lesser horseshoe	3	0	1.9
Greater horseshoe	1	0	0.6
Daubenton's	2	0	1.3
Unknown species	24	12	-

Source: *The Bats In Churches Project*, Sargent (1995).

3.4.2 Evening/dawn bat detector back-tracking

A technique of locating roosts using bat detectors has been developed in the Netherlands and a full description of the method can be found in Kapteyn (1993). The technique is based on four principles:

1 The earlier a bat is seen at sunset or the later it is seen at sunrise, then the closer it is likely to be to its roost (the exact time depends on the species under study).
2 Bats fly away from their roost at sunset and surveyors should move towards flying bats to locate the roost.
3 At sunrise bats fly towards their roost and surveyors should move in the same direction as the bats to locate the roost.
4 At sunrise some bat species 'swarm' at roost entrances before entering for between 10 and 90 minutes. Surveyors should look for swarming bats at sunrise.

Surveyors search for bats at emergence time, noting down the time bats were encountered and the direction and style of their flight, e.g. west, commuting. This information is pooled on a map to identify potential commuting routes and possible roost sites. Close to dawn surveyors search again, this time for returning bats. Potential routes identified earlier at emergence time are surveyed for bats swarming at roost entrances. Although the technique is biased towards early emerging species with loud echolocation calls and which form large roosts, it is possible to locate roosts of any species using this method.

3.4.3 Identifying and counting bats in roosts

Identification

Bats roost in a wide variety of sites within buildings, so the ease with which the bats can be seen is very variable. The horseshoe bats are probably the easiest to identify because they generally hang in accessible locations and are readily distinguished by size difference. Long-eared bats sometimes hang in obvious locations, often clinging on to timbers near the apex of the roof. However, many of the vespertilionid bats tend to roost in cracks and crevices, often using narrow spaces under soffits or between roofing felt and slates or weather boarding, and so can be much more difficult to see. Always try to keep disturbance of bats to a minimum and spend as little time inside the roost as possible, especially when females are at the end of pregnancy.

Some species are very similar and need to be examined in the hand to be certain of the identification. Bats can be caught by hand during the day or by static nets placed outside the exit holes at sunset. When catching at sunset, it is important that a sample of bats is caught at different times because where mixed species are present they can emerge at different times. For example if noctules and Daubenton's bats roost together the noctules will emerge at least 30 mins before the Daubenton's.

Although identifying live bats is the most accurate way of determining the species present, it can be disturbing and for some species other methods may be satisfactory, particularly when the bats are absent or inaccessible. Bat detectors in combination with visual clues can be used to identify species leaving the roost, although confidence in identification is restricted to certain species. Where two or more species are present, species can often be distinguished by size, but there is room for confusion between whiskered and pipistrelle bats and between Daubenton's and Natterer's bats. A well-used roost may contain mummified corpses or skeletons in the guano pile and these can be identified from a key such as that of Yalden (1985). Other clues to the identity of the bats come from the size, shape and texture of the droppings and the presence of host-specific ectoparasites. Further information about the use of droppings for identification can be found in Stebbings (1993).

Counting

By far the most common and least disruptive way of estimating bat numbers in summer roosts is to count the bats leaving the roost at sunset. The most successful period over which to make counts so that yearly comparisons can be made is when the colony is at its most stable. Maternity colonies continue to grow into early June as pregnant females arrive from pre-maternity roosts. Later in the summer young bats begin flying and counts at this time will include both adults and young. Just prior to birth of the young, a peak in adult female numbers is reached and many or all of the adult females emerge every night. In general, young are born between mid- to late June in most species, although there is variation from year to year. Counts in late May to mid-June are likely to reflect the most

stable numbers. This is the time that is recommended by the National Bat Monitoring Programme (see Walsh *et al*., 2001; Appendix 4).

When attempting to count a colony for the first time, it is important to establish the number and location of access holes and this may require several people surrounding the roost. Once all access point have been discovered then fewer surveyors may be required for future counts. Assign observers to a specific exit or field of view because often two exits close together may be counted simultaneously. Be in position at the roost about 15 minutes before sunset (earlier on overcast evenings) and listen for the sound of bats moving at access holes or for squeaks as bats jostle for position. Poor weather conditions with overcast skies and rain may delay emergence and particularly bad conditions should be avoided in case bats choose to abandon foraging and remain inside the roost. Remain counting until at least 10 minutes after the 'last' bat has emerged.

As a general guide, bats may begin emerging from just before sunset onwards. The noctule is an early emerging species, whilst Natterer's and long-eared bats are late emerging (up to 40 minutes after sunset).

Do not shine white lights directly on the roost exit because this can often delay or prevent emergence. Excess noise, particularly ultrasound from keys, coins or nylon jackets, may disturb bats and inhibit or delay emergence. Emergence counts are most effective when departing bats are silhouetted against a light background (normally a clear sky or sometimes a light coloured wall). It is best to observe from the side of the emergence point(s), rather than from in front. Sometimes the structure of the roost and behaviour of the bats means this is not possible and the additional use of a bat detector is always recommended.

The behaviour of bats at emergence varies between species. Some, such as noctules, tend to fly off fast and direct to foraging grounds while others, such as the horseshoe and Natterer's bats, may exit and re-enter the roost several times before departing for foraging grounds (called 'light sampling' behaviour), which makes counting more difficult. In all cases, a running total of both exits and entries should be recorded so that a final net emergence figure can be calculated. This is essential when several exits are being counted simultaneously, so that bats that emerge from one and subsequently re-enter at another may be properly accounted for. A small tally counter is useful for 'clicking up' bats as they emerge.

Automatic counting equipment or video equipment at roost exits can be a useful substitute for observers, although even the most sophisticated systems have their problems. Most automatic counting systems are based on one or more infrared light beams that are broken as a bat emerges from the roost. A single beam is unable to distinguish between emerging and returning bats but beam breaks should be proportional to the number of bats emerging/returning and so could be calibrated by combining beam counts with observer counts. More sophisticated systems use two sets of beams so that emerging and re-entering bats can be counted separately. Both types of system are unable to cope with bats that emerge without breaking the beams or when two bats break the beam simultaneously. Problems also arise when two or more species are using the same roost or if insects fly close to roost access points. When using automatic systems results must be cross-checked with simultaneous visual checks to identify errors or consistent biases.

Counts of bats within summer roosts are generally more difficult, cause more disturbance and are less accurate than emergence counts. One or two visits to a breeding roost in a season would probably be acceptable provided that every care was taken to keep the disturbance to the minimum. The exception to this is for counts of non-flying young, which may be counted on a weekly basis once all the adults have left to forage. This method is mainly applicable to horseshoe bats.

3.4.4 Finding hibernation sites

Bats use a very wide range of sites for hibernation, including trees, caves, mines, ice-houses, grottoes, lime-kilns and tunnels of every description. In some parts of the country such sites are plentiful but in others they are a scarce resource for bats and are therefore well worth preserving.

Hibernation sites can be located in a number of ways. Examination of maps can reveal the location of old quarry workings, disused tunnels (railway, canal etc) and, sometimes, old lime-kilns. Most large old country houses will have an ice-house, usually not too far from a lake, and many also have extensive cellars that may be accessible to bats. Old

mining and local history books can be a valuable source of information about workings that may not appear on maps, because many small mines and trial workings are not recorded. Local sources of information may be important; for example, farmers may know of old workings on their land. Similarly cavers, mining research/history groups, industrial archaeology groups and others with interests in underground structures may be able to help.

If extensive underground sites, such as caves or mines, are to be explored for bats, safety must be a prime consideration. Simple rules for safety underground are given in Chapter 2 and a model risk assessment for entry into disused mines may be found in Appendix 8. Even relatively small structures such as ice-houses or lime-kilns can be dangerous places if they are in bad condition so always proceed with caution and be prepared to abandon the visit if the structure looks dangerous.

Always observe common courtesies when searching for new sites. Seek permission from landowners before going on their land and check that entering a site is not going to interfere with other people's interests. Some sites are used for storage, dumping of rubbish, mushroom-growing or water supplies and their owners are naturally sensitive about allowing others access.

3.4.5 Identifying and counting bats in hibernation sites

Ideally, hibernating bats should be counted when outside temperatures are both low and most stable. This is when the numbers of bats visible in underground sites will be highest and also most stable. In Britain, January and February are generally the months with the most stable cold temperatures. Because of the negative relationship between temperature and the number of visible bats, it is recommended that temperature be recorded when making a count and notes made about the previous night's weather conditions. As the size and complexity of the hibernation site increase, the probability that all bats will be observed and counted decreases, thus it is also good practice to record some details about the site.

Horseshoe bats hang in the open from ceilings or walls but vespertilionid species often tuck themselves away in cracks and crevices and may not be immediately obvious. Horseshoe bats can also hang from rocks and boulders close to the floor and other species may hibernate in loose rubble on the floor so tread carefully. Careful searching with a light suited to the circumstance is essential. Bats select a variety of places to roost but most vespertilionid bats are found within a few 100 m of entrances, which are associated with the lowest temperatures. Lesser horseshoe bats can also be found in such places but are commonly found much deeper underground where temperatures are warmer and more stable.

In all survey work great care must be taken to avoid disturbing bats unnecessarily. Do not make excess noise or stay near bats longer than is necessary and do not shine bright lights on bats for longer than is required to identify them. Arousing hibernating bats can affect their ability to survive through to the spring, so the aim of surveyors should be to count and identify bats without handling them. If identification is difficult, as with whiskered and Brandt's bats for example, make a note of the uncertainty rather than arousing the bat. Identification of the Myotis species without handling them takes practice and experience and the best way of learning is to accompany an experienced bat surveyor. Further guidance is given by Greenaway & Hutson (1990). No licence is required to search sites where bats have not previously been found, but unlicensed surveyors must withdraw if bats are found so that bats are not intentionally disturbed.

Many bat hibernacula or potential hibernacula can be improved for bats by appropriate management such as grilling or altering the air flow (see Chapter 11). The scientific evaluation of the effects of such practices is an important part of these projects and as much information as possible should be collected both before and after any changes have been made. The value of such work is greatly increased if numbers of bats at the site can be monitored for one or two winters before any works take place or if a comparable 'control' site can be monitored at the same time. Examples of such studies are given by Stebbings (1965, 1992) and Voûte & Lina (1986).

3.4.6 Bats in flight

Field surveys of flying bats can incorporate one or more of four basic techniques. Direct observations of bats may be made in the early evening or later by using spotlights or infra-red night-vision scopes.

Captured bats may be fitted with chemiluminescent tags so that individuals can be observed readily in the dark (Racey & Swift, 1985). Mist-nets or harp traps for capturing bats in flight can be useful in certain circumstances for survey work, but they are not recommended for general purpose use (see Chapter 4). Mist-nets are particularly useful in intensive small-scale studies when verification of species difficult to identify in flight is necessary. If mist-netting is to be used, the survey project must be designed carefully to obtain the maximum benefit from the results obtained. Simply erecting nets on a casual or random basis rarely produces worthwhile results.

Recent advances in portable ultrasonic detectors have led to bat detectors becoming invaluable tools with which to study bats. Their use to identify bats in flight is now widespread, although it is important to realise that the technique has its limitations.

Bats and echolocation

Bats emit rapid, ultrasonic pulses and, by processing the information contained in the returned signals (echoes), are able both to orientate themselves and to detect prey in their environment. Bats have to use ultrasound because the wavelengths of lower frequencies are longer than most insects. However, the disadvantage of using high frequencies is that they are strongly attenuated in air, which limits the distance they can travel. The varied ultrasonic repertoires of bats are related both to the species of bat and type of environment in which they are flying.

There are two broad types of ultrasonic signals: constant frequency (CF) and frequency modulated (FM). Echolocation pulses are generally composed of various combinations of the two.

CF is a sound produced at one frequency. There are two distinct types of CF calls, of short and long duration, which are used in different situations and by different families of bats.

FM is a pulse that sweeps through a range of frequencies. These pulses are less suitable for long-range detection than CF pulses but can give other types of information such as distance to the target and texture discrimination.

The number of pulses a second emitted by a bat is related to:

- the wing-beat frequency;
- the environment in which the bat is found;
- the bat's behaviour at the time, e.g. searching for or approaching insects.

The pulse repetition rate of any species is not fixed. It is slowest and most characteristic in open environments but increases in cluttered situations when more information needs to be processed. This reaches a peak rate as a bat attempts to capture a prey item, when frequent updating of the distance to the target is required. The term 'feeding buzz' aptly describes a very fast pulse repetition rate.

Source: Extract from *The Bat Detector Manual* (Catto, 1994).

Species identification

Some species can be identified reliably from their echolocation calls using a bat detector; others can be identified only in favourable situations, with considerable experience or by computer analysis. Echolocation calls are made to perceive the environment and the nature of the environment dictates the type of calls that are produced. This is in contrast to bird song, which is a repetitive series of notes sung irrespective of the environment the bird is found in. For example, bats in open areas produce loud sounds, which travel far, whereas the same bat in cluttered areas produces quieter sounds so as not to be deafened by the echoes.

Horseshoe bats can be identified from their unique echolocation calls, and the frequency of the call identifies the species. Pipistrelle bats have a unique echolocation call, which distinguishes them from other bat genera in the UK and the species of pipistrelle can be distinguished, although only under certain conditions. Identification of other species in the UK requires a combination of visual observation and listening to the sounds heard through the detector. There is some overlap in the echolocation calls of noctules, serotines and Leisler's bat (although their calls are distinct from other UK species) but their size and wing shape can separate these species from each other. The identification of most *Myotis* species rests least with echolocation calls and comes mostly from the foraging style and environment in which the bat is found. The level of confidence of identification depends on the experience of the surveyor and the type of equipment used. The topic of identification of flying bats is complex and is covered in detail by Briggs & King, 1998. The use of time expansion techniques can help verify field identification of bats made with tuneable bat detectors. A detailed analysis of the echolocation calls of British bat species has been made by Vaughan *et al*. (1997).

Conducting bat detector surveys

Bats have distinct activity patterns both seasonally and nightly. Their activity is strongly influenced by time of night and prevailing weather conditions. Most species appear to follow bimodal nightly activity patterns with a large peak at dusk and a smaller peak at dawn. Thus conducting surveys for around 2 hours after dusk is likely to produce the maximum encounter rate. The most widely employed methods have been to use a detector to record the number of bat passes at particular spots or to walk a set route or transect and record the number of bats heard in each habitat type. An important aspect of such surveys is to ensure that the route taken visits cross-sections of available habitats and is not biased by visiting only the best habitats for bats. The NBMP carries out monitoring of free-flying bats with ultrasonic detectors and has standard protocols and recording sheets. To collect useful data, it is generally better to survey more shorter transects only a few times than to re-survey the same long transect many times. An example of such a study at a national scale is given by Walsh *et al*. (1993), Walsh & Harris (1996a, b). A general finding of such work has been that, not surprisingly, bats tend to forage most in the habitats with the greatest concentration of flying insects. For many species this is very often close to woodland or over open water.

Bat detectors

In recent years a wide range of bat detectors has become available both for the amateur bat worker and professional bat researcher. The transformation of ultrasound into audible sound can be made using one of three main techniques:

- Heterodyning
- Frequency division
- Time expansion

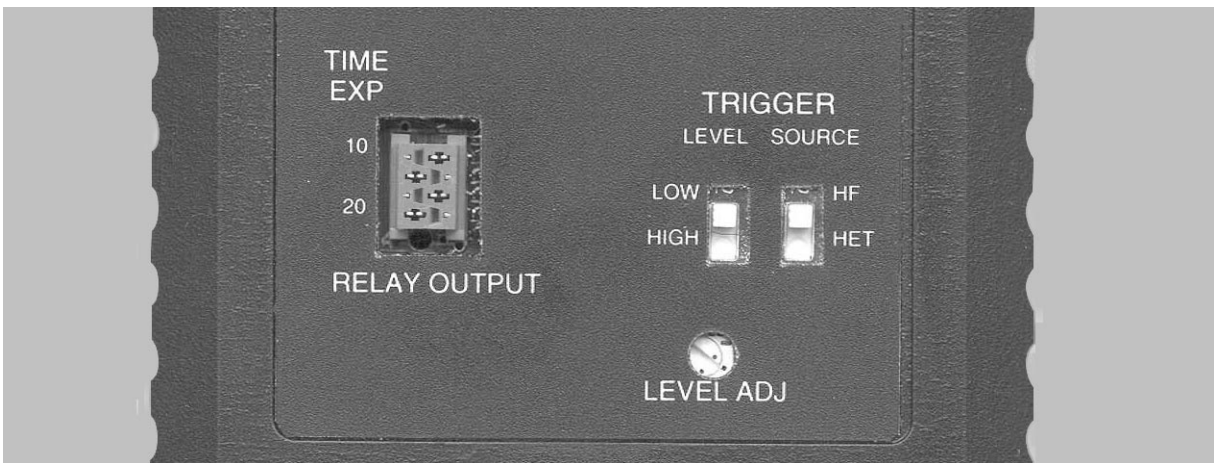
Heterodyning and frequency division are real-time methods so you will hear the sound from the detector at the same time as it is emitted by the bat. Heterodyning is sensitive and the detector can be tuned to specific frequencies. The resultant sound from the detector can have tonal qualities such as 'ticks' and 'smacks', which are important because they are related to the type of ultrasound the bat is producing and hence form the basis for identification. Frequency-division detectors can also be used for the laboratory analysis of sounds.

Recently, low cost frequency division/time expansion detectors have entered the market. Recordings made via these detectors can be played through a computer with suitable software to produce sonograms.

When purchasing a detector a number of points should be considered in addition to cost:

- accuracy – detectors with digital frequency displays can be read more accurately;
- bandwidth – this refers to the range of frequencies to which the detector is sensitive when set to a given frequency – the bandwidth will affect the number of species that can be heard when the detector is tuned to any frequency;
- frequency range – in the UK a detector should be sensitive to frequencies within the range 19 kHz to 118 kHz; some types of detector are more sensitive at certain frequencies, which is an important consideration when carrying out surveys because an element of bias can be introduced if a number of different types of detector are being used.

Source: Based on extracts from *The Bat Detector Manual* (Catto, 1994).



Pettersson D240x Bat Detector. © Alana Ecology.

Sonogram analysis

Producing sonograms of bat echolocation and social calls is a useful aid to identification. Sonogram analysis is most appropriate for identifying open/edge species with reasonable confidence such as *Pipistrellus, Eptesicus, Nyctalus* but *Rhinolophus* and *Barbastella* species can also be identified. However, separation of *Myotis* species remains problematic due to the large overlap in call structure of this group.

The process of making recordings and producing sonograms is complex and requires some specialised equipment and reasonable computer skills. Mastering the whole process requires a basic understanding of sound theory.

Basic equipment required:

Detector systems
Time expansion or frequency division detector – both these systems retain frequency information. Although time expansion detectors are more expensive, they produce better quality sonograms, but the advantage of frequency division is that it works in real time thus making it a better survey tool. Although sonograms derived from both systems are of sufficient quality to identify many bat species, analysis is generally easier with recordings derived from time expansion systems.

Recording devices
At the time of writing recording systems are undergoing a revolution, with tape cassette recorders being phased out and replaced with digital recorders such as mini discs, MP3 systems, .WAV recorders etc. Due to this fluid environment, recommendations for particular equipment can become outdated quickly so up-to-date specialist advice should be sought before purchasing expensive recorders. At present mini-disc recorders offer the cheapest recording system and resultant sonograms are suitable for analysis. There are many models available but for sonogram production it is important that they have both LINE IN and LINE OUT sockets. A date/time stamp is a useful addition for keeping track of recordings. Mini-disc recorders are not particularly robust so should be handled with care in the field.

Devices that record directly as .WAV files and can be attached to the computer via the USB port have started to appear and these are useful because sound files can be copied across directly to the hard disk of the computer. This approach saves considerable time because recordings will no longer require to be played into the computer via the sound card.

Computer sound card
No special card is required because standard cards sample at 44 kHz. However it is important that they offer a LINE IN port because there is a growing trend, especially with laptops, for the LINE IN port to be dropped. The user should be able to access the sound card settings to optimise its performance.

Appropriate software
Software is required to convert sounds into sonograms. As the ultrasound has been converted to audible sound via the detector, sonogram software developed for bird/cetacean sonogram analysis is suitable for bat sonogram analysis. There are many suitable software packages available and some can be downloaded for free from the internet – search for 'bird sound analysis' for suitable sites.
Useful sonogram analysis tools include a Power spectra function (this identifies which frequency contains the most energy) – filters for 'cleaning' the sonogram and a measuring cursor. 'BatSound' is the only sonogram software designed specifically for bat analysis and has all the relevant tools (available from Alana Ecology).

Turning a laptop computer into a bat detector with appropriate software, hardware and an ultrasonic microphone it is possible to convert a laptop computer into a bat detector. Although an expensive option the advantage of this system is that high quality sonograms can be produced in the field.

Suggested reading: Russ (1999).

Source: C Catto, National Bat Monitoring Programme.

3.4.7 Bat boxes

The primary function of bat boxes is to provide artificial roost sites for bats, particularly in areas such as coniferous plantations where there is a shortage of natural sites. However, the provision of boxes also makes the bats easier to find, so that surveys of bats in woodland become possible. In continental Europe this has proved to be a particularly valuable technique for Bechstein's bats, for which other survey techniques are inappropriate. Guidance on the setting-up of bat box schemes, including construction, siting and inspection, is given by Stebbings & Walsh (1991).

The frequency with which the boxes are inspected will depend both on the need to check that the boxes are well sited and available to the bats, and the requirements of any research project.

There is still much scope for experimentation with new designs. However, such projects are only useful if they produce results that allow comparison between different types of boxes or different situations. It is essential, therefore, that careful thought is given to the experimental design before the boxes are erected and that the location, type and subsequent usage of each box are carefully recorded. Large projects involving more than 100 boxes are more likely to give statistically meaningful results than small projects with just 20 or 30 boxes and it may well be worthwhile for researchers to co-operate on projects.

3.5 Monitoring the status of sites and populations

Monitoring studies are designed to quantify change over some time period. Most monitoring is carried out by repeating counts of bats at maternity roost sites in the summer, counts of bats at hibernation sites in the winter and counts of bats along set transects at regular intervals (Walsh *et al*., 2001). Additionally, distribution studies of species can be repeated at regular intervals to provide valuable monitoring data. Often, changes to populations may be more obvious from range changes shown on a distribution map than from counts made at the centre of the species' range.

Monitoring objectives vary and can include annual checks on the status of the site, long-term studies of changes in bat numbers, investigations of the effects of management practices, scientific studies of hibernation and arousal mechanisms or the breeding biology of bats. Each of these purposes may require a different intensity of monitoring, although in each case the aim should be to minimise any disturbance to the bats.

Visits to sites for long-term monitoring or for checking on the condition of the site generally need be no more frequent than one or two visits annually, but it is important to keep the times of these visits the same and to use exactly the same methods each year. Standardisation is a key element if results are to be reliably compared over time. Although the number of bats will vary with the weather conditions at the time of the annual count, underlying long-term trends will show up once a number of years' data have been collected.

Brown long-eared bat roost site. © Frank Greenaway

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Lesser horseshoe bats. © Frank Greenaway

Catching bats

M. Finnemore & P. W. Richardson

Before attempting to catch bats, think carefully about the justification for catching in view of the potential for damage or disturbance to the bats. Bats may be caught by a variety of techniques both at the roost site and in free flight. Once bats are trapped, great care is needed to ensure that they are dealt with quickly and harmlessly. The welfare of the bat is of paramount importance and if any method of catching bats causes, or seems to cause, distress or harm, it should be stopped immediately and further advice sought. Several of the methods described below can injure bats if used carelessly and should be employed only when fully justified. Take particular care when heavily pregnant bats may be caught because these may give birth or abort their foetus while captive.

The bat roost visitor licence normally licences capture by hand or static hand held net at the roost. All other capture methods will require a special licence from the relevant SNCO (see Chapter 1).

Barbastelle bat. © Frank Greenaway

4.1 Hand-nets

4.1.1 Types

Round and kite-shaped frames and handles are available from entomological suppliers (Figure 4.1). Kite-shaped nets are often more useful, particularly when bats are in corners, but folding circular nets are convenient to carry. Fine meshed nets as used for butterfly or dragonfly nets should be used. Mist-netting material or other open mesh nets should not be used for hand-nets as the bats become entangled far too easily.

4.1.2 Methods

Static net

Outside roost sites, nets can be held just under the exit hole and will catch emerging bats at dusk (Figure 4.2). It is usually best to arrange ladders or any other equipment before dusk and wait until the first few bats have emerged. Then position the net around the hole as closely as possible. In some cases, it is advantageous to fix an extending handle on to the net because this avoids prolonged periods spent on a ladder outside a roost. Avoid noise of any kind because this delays emergence. Excessive delay will reduce the feeding time for bats, and too much disturbance can lead to the abandonment of roosts. Inside roost sites, such as attics, the hand-net should be carefully positioned around the bat before it flies. This may prevent it from flying so that it can be taken by hand, but if it flies it will be caught in the net. Angling the net at 45–90° from the pole can increase the catch rate. In high roofs a second thin stick may be used to touch the bat gently, causing it to fall into the net. Do not attempt to catch bats in flight. As soon as a bat is netted, the net frame should be rotated so that the bat is enclosed in loose netting and is unable to escape (Figure 4.3).

Moving net

Large kite-shaped hand-nets have been used for catching bats in flight. Unfortunately, bats are too easily killed or injured by this method for it to be recommended.

Extraction from hand-nets

When netting and extracting bats good lighting is essential. Head torches are recommended because these leave both hands free; the torch should not be switched on until the bat is netted.

If a suitably sized mesh is used, bats should not become entangled in the hand-net, so extraction can be achieved merely by sliding a gloved hand through the closed opening and getting a hold on the bat. Move one hand around the body of the bat, ensuring that the wings are folded carefully and that

thumb and toe claws are unhooked and not pulled. Often it is best to place the bat and net on a flat surface to achieve better control; this applies particularly to larger bats, when it is necessary to avoid being bitten.

4.2 Cone trap

This trap is used mostly for research projects where large numbers of bats must be caught. Bats can be damaged (for example by biting each other) and these traps should not be used when females are in late pregnancy.

The trap is simply a large cone made of plastic, nylon sheet or other suitable material, sometimes with a collecting bag at the narrow end. The open end is held in position over an exit hole and emerging bats slide down (Figure 4.4). Various sizes and shapes can be employed to suit individual roost sites and the method works best where the bats are emerging from a small hole, so it is not generally suitable for capturing horseshoe bats. This method is ideal for catching a large number of bats at a roost as quickly as possible. Captured bats should be quickly transferred to holding bags.

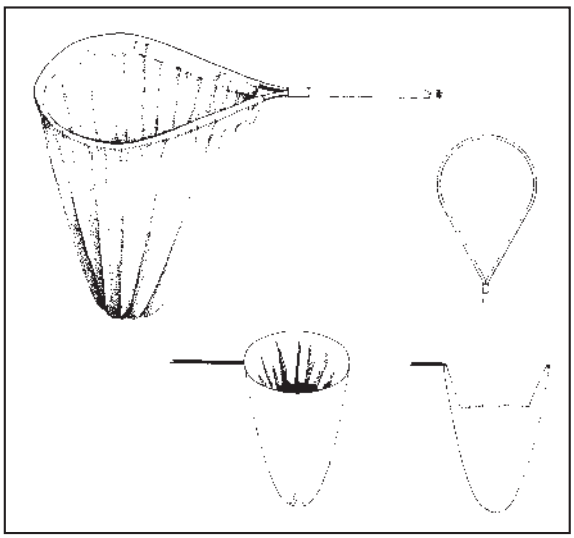


Figure 4.1
Hand-nets. Polythene around the lip prevents bats climbing out.

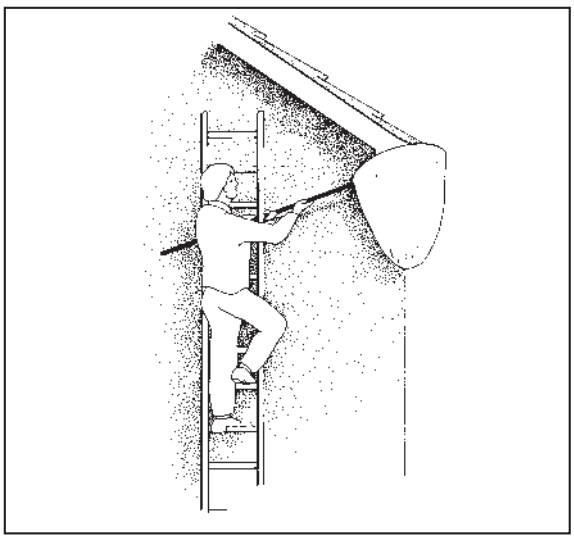


Figure 4.2
Use of hand-net to catch bats at the roost entrance. Always follow the safety code when using ladders.

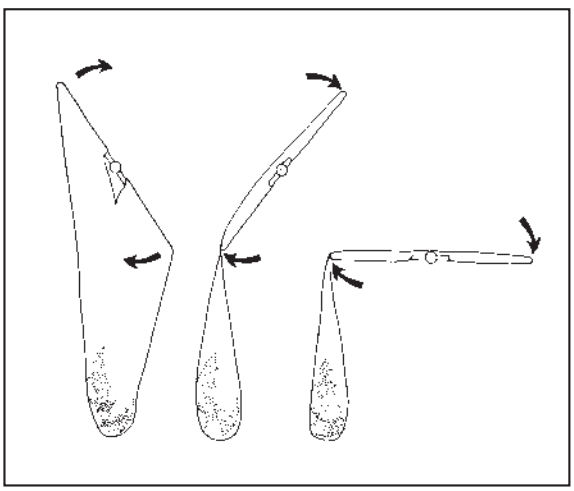


Figure 4.3
Rotate the hand-net frame to ensure the bat cannot climb out.

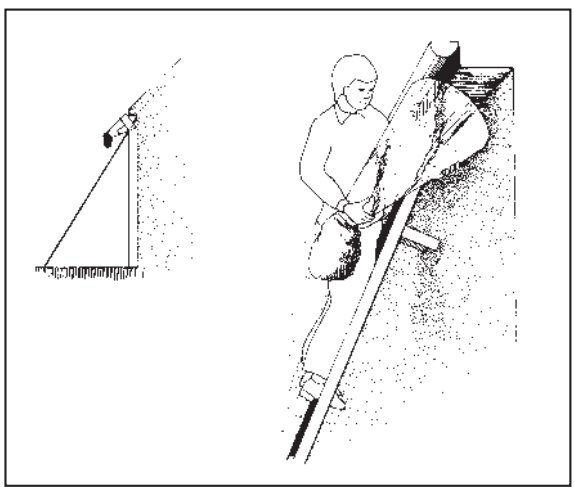


Figure 4.4
Cone trap. These can be constructed from a variety of smooth materials, such as acetate sheet. The collecting bag must be securely tied on.

4.3 Harp trap

This trapping method works best where bats are at a high density or are concentrated in narrow flyways. They have been used successfully in the UK outside cave and mine entrances, particularly in the autumn.

4.3.1 Design and operation

The trap consists of a frame supporting two banks of vertical strung nylon or wire lines (Figure 4.5). The trapping area is generally much smaller in size (2 m x 2 m) than a mist net. When set up in the flight path of bats this trap can be very successful. Bats fly into the lines, slide down them and land in the collecting bag underneath. The lines are carefully arranged and tensioned so that the risk of damage to the bat is minimised. The traps are especially suitable for catching bats that weigh less than 30 g. Detailed information on the use of harp traps may be found in Kunz (1988).

4.3.2 Extraction

The advantage of this system is the ease of extraction. The bats are not tangled and can be removed from the collecting bag when required.

4.4 Mist-nets

4.4.1 Description

These nets consist of fine nylon or terylene netting, which is usually held in tension between two poles (Figure 4.6). Mist-nets are supplied to responsible licence-holders through the British Trust for Ornithology (BTO), in standard lengths of 6 m (18'), 12 m (42') and 18 m (60'). Loose netting can also be purchased to make up nets of any length. The height of the nets is divided into ‘shelves’, each with a loose pocket of netting that holds the trapped animals. Nets can have between one and four shelves, but four are most usually used for catching bats. The nets have a mesh size of 13" or 12", the latter being preferable as it is apparently less easily detected by bats.

The main problems with mist-nets are entangling bats, risk of damaging them during extraction and potential predation. Mist-netting should be avoided between mid-June and mid-July because adult females may be heavily pregnant, lactating or carrying youngsters, which may become dislodged. They should not generally be used outside roost entrances, where large numbers of bats are likely to emerge/enter.

The use of mist-nets will be licensed only following adequate training in setting of nets and extraction of bats.

4.4.2 Static nets

Static nets are usually detected by bats and avoided. Some skill is required, therefore, to use them effectively. Bats have good memories and it is best only to attempt to catch them in one place on one occasion. Nets must be attended continuously. Cats and other predators can easily kill bats caught in mist-nets.

Setting a net, which must be well supported and firmly guyed, needs training and experience if the net is to be operated successfully. The length of net that can be safely operated will vary from site to site and the net must be set at an appropriate height for the target species. Set nets with the minimum amount of ‘bag’ required to enclose the size of bats likely to be caught. Over water, nets must always be set with the bottom pocket well clear to ensure that trapped bats do not become immersed. The operator should stand quietly beside the net with no light or bat detector, as both these can frighten away bats. The net must be closely supervised at all times and, if more animals are caught than can be safely dealt with, it should be taken down or temporarily furled as soon as all bats are removed.

There are a number of ways of increasing the probability of catching bats.

Concealment

If the net is set in front of a background (e.g. vegetation) it is less likely to be detected. It is most effective when placed in vegetation. Stand beside the net with a long-handled hand-net ready to place over any bat which lands on the mist-net. Great care needs to be exercised and if the bat flies before the hand-net arrives do not swipe at it.

Surprise

Bats often fly along the same flight paths and may fly into a net that is set up in this path, merely

through lack of attention. This method works particularly well when the net is set up just round a corner where the bat always makes a sharp turn or where it is funnelled through encroaching vegetation.

Confusion

Setting nets in a funnel arrangement may guide the bat from its usual flight path into the net at the end. Such methods work best where the bat has a regular flight path, such as around the edge of water, or where the flying area is limited, as in narrow woodland rides. A well tried method of luring bats to the net is by flicking a small pebble upwards as the bat flies overhead: it will swoop down to investigate and, if the pebble is well directed, will be netted. Do not throw the stone so that it hits the bat or so that the bat catches it!

Nets should not normally be set until most birds have settled to roost, but occasionally they may be caught. Some guidance on removing birds from nets is given by Redfern & Clark (2001) but again there is no substitute for experience. Always be prepared to cut the net with scissors or a quickunpik, but avoid cutting where possible as it may result in increased entanglement of bats caught subsequently.

4.4.3 Moving nets

Single-pole flicking

This method, which requires two people in normal use, can be employed in any area with some success, including from bridges over canals and rivers (Figure 4.7). In this case, a 6-m or 9-m net is lowered over the bridge, being fixed to the parapet at one end by the top shelf string and having a weight tied to the bottom shelf string. The other end has a pole, to which the net is firmly fixed by elastic bands on both top and bottom shelf strings. This stops the net sliding off the pole. The pole is held vertically down by one operator, and approaching bats can be caught by moving the pole quickly upwards through an arc so as to encircle them. Once a bat is netted, the tension on the netting should not be altered, especially by stretching it, and the second person should retrieve any bats gently. Illuminating the catching area from the side with a strong spotlight makes catching easier. Bats may soon be frightened away, so periodically remove the net or move to another bridge.

Two-pole flicking

In this method, which requires three people, a net is supported on poles at each end and held horizontally and taut by two people (Figure 4.8). Approaching bats can be detected visually by careful positioning of the workers or audibly by setting a bat detector on the ground in front of the net. Often, bats can be attracted by throwing a small pebble in the air. Once a bat is in range, the net is flicked up, following the flight of the bat and ensnaring it. It is important not to increase the tension of the net, or the bat may be damaged by wings or legs being pulled apart. The third person can extract the bat. This method is very difficult, partly because of the synchronisation required between two people.

4.4.4 Extraction from mist-nets

This can be a difficult and time-consuming operation, which requires patience, skill and training. However, any bat which cannot be removed in about 2 minutes should be cut free with a quickunpik or scissors. When doing this, be most careful to ensure that no netting remains embedded in the fur or in the bat's mouth.

First, ascertain the direction from which the bat entered the net (see Figure 4.9 for general guidance) and start from that side. If the bat is above normal working height, lower the net to bring the bat within reach and open the pocket so as to expose it. The extraction of a bat must follow in reverse the stages by which it became entangled. Wearing suitable gloves, clear the netting away from the feet; this will require gentle teasing of the net from the toes by a stroking movement of one's fingers. Gently raise the bat by its legs, which should now be free, and slowly work the net down and away from the body of the bat. Wings need to be extracted one at a time and each wing may need to be partly opened to remove the netting. When one wing is clear, firmly hold the bat by the forearm, allowing its feet to grip the fingers of one's hand. Finally, check that the net is not caught in the teeth.

Occasionally, bats may be so badly entangled that they cannot be freed quickly. In these situations the net should be cut free, using scissors or a sharp quickunpik (available from BTO), before the bat begins to show signs of distress. Badly holed nets should be destroyed safely, as they entangle animals too easily. Always check nets carefully when they are being dismantled just in case a bat has been caught and not noticed.

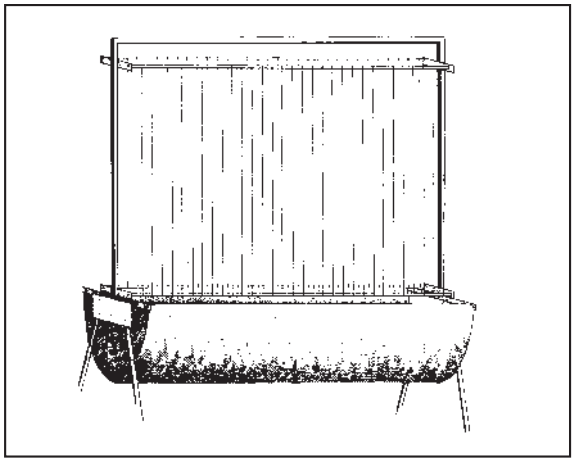


Figure 4.5
Harp trap. Bats fly into the rows of vertical lines and slide into the collecting bag below. Traps are usually collapsible.

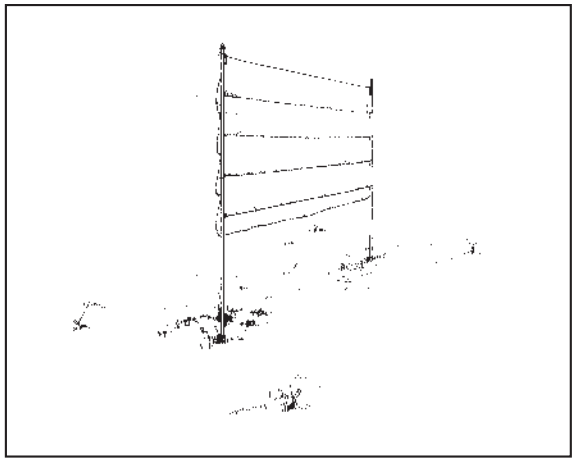


Figure 4.6
Mist-net correctly set and guyed.

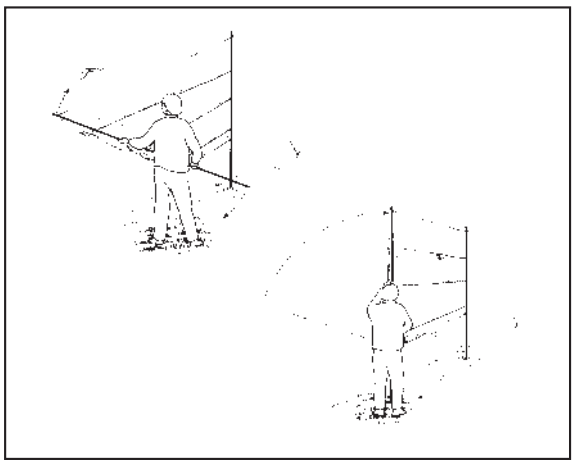


Figure 4.7a
Single-pole flicking. The pole should be held slightly above horizontal so the net can be accelerated fast enough to catch the bat.

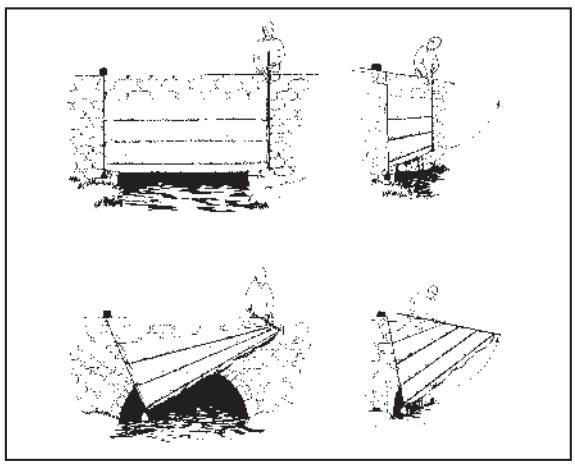


Figure 4.7b
Single-pole flicking from a bridge. Great care must be taken not to pull on the net once the bat has been caught. An assistant at the water's edge is needed to remove the bat safely.

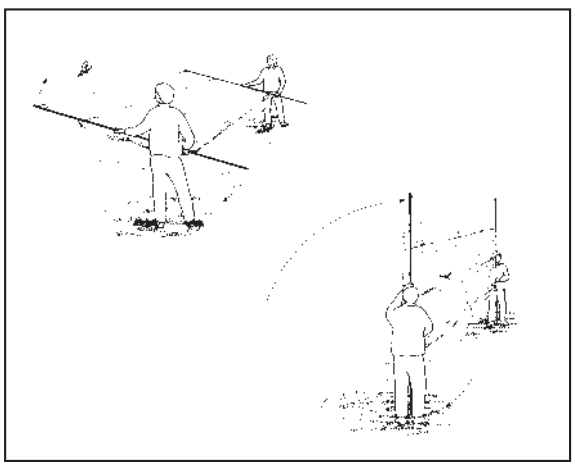
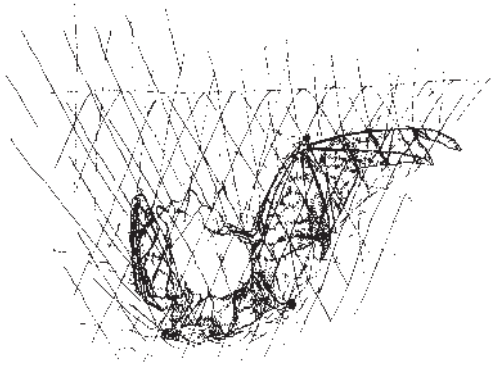
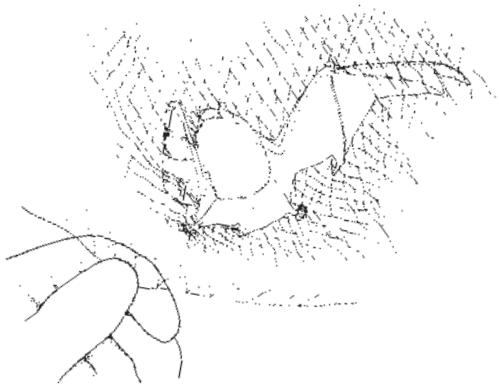


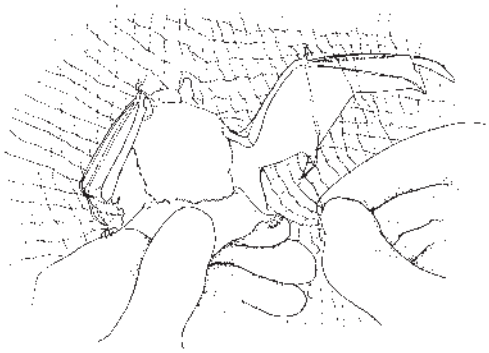
Figure 4.8
Two-pole flicking. Practice is required to ensure that the two poles move in synchrony.



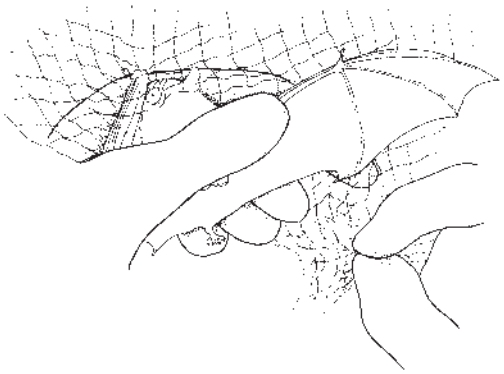
1 In the net.



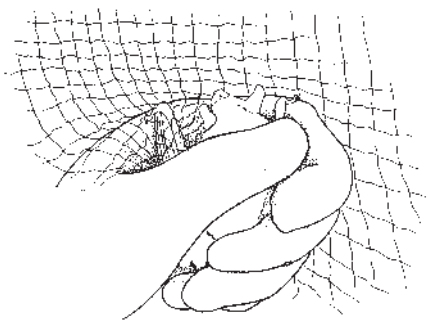
2 Opening the bag.



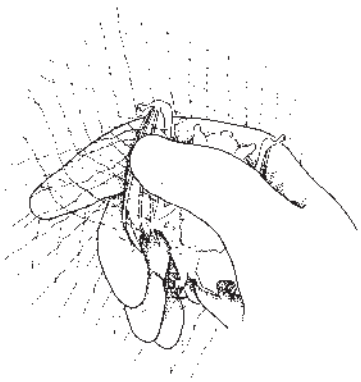
3 First clear the feet and tail.



4 Hold the body firmly and free the extended or less-tangled wing.



5 Next free the head. At this stage the bat must be held firmly to avoid re-entanglement. Once the head is free, change the grip to restrain the movement of the head and prevent the bat biting.



6 Wings may need to be opened to disentangle them.

Figure 4.9
Removing a bat from a mist-net. Many variations on this method are possible and training and experience are essential.

4.5 Additional equipment

It is important to have suitable equipment to help with the swift removal of a bat from a trap and to hold it safely until released.

4.5.1 Head-torch

Ample illumination is essential when removing bats from traps and especially from mist-nets. A head-torch leaves both hands free for the extraction of bats. A floodlight is also useful to illuminate the whole area when dismantling equipment.

4.5.2 Scissors or quickunpiks

A pair of fine scissors can quickly cut a bat from a net in an emergency. Some bird-netters favour using a quickunpik, but this must be sharp or it will pull the net, causing damage to the bat.

4.5.3 Holding bags

Soft cloth bags with closure-strings and with seams on the outside are most suitable. They should be kept clean and dry. A clip (e.g. small carabiner) can be hung round the neck as a safe way of carrying bags at night. Suitable bags are available from the British Trust for Ornithology.

4.6 Captive bats

Bats should not be held for more than 2 hours and it is preferable to release them within a few minutes; they should be held in soft cloth bags until ready for processing. Bags should never be put on the ground but always hung up. Large bats, such as greater horseshoes, should be kept singly, especially if they are active, but small bats from the same roost may be kept in groups, which may help to calm them. Only keep one species in a bag, never mix species. Sometimes it is less stressful if bats are wrapped in a cloth (e.g. a holding bag) when they are being examined or worked on.

References

KUNZ, T.H. (ed.). 1988. *Ecological and Behavioral Methods for the Study of Bats*. Smithsonian Institution Press, Washington & London. 533 pp. ISBN 0 87474 411 3.

REDFERN, C.P.F. & CLARK, J.A. (comp./ed.). 2001. *Ringers' Manual*. 4th edition. British Trust for Ornithology, Thetford. 269 pp.

Bat workers erecting bat boxes. © Hugh Clark

Serotine bat. © Frank Greenaway

Examining bats

A. M. Hutson & P. A. Racey

5.1 Field identification

Bats are identified most easily in the hand, but practice allows identification by a variety of other means, such as bat detectors, droppings or flight pattern. Such methods have varying reliability and identifications may not be acceptable to recording authorities. A beginner will have to use an identification key (see Appendix 5) and, by looking at a number of characters, achieve a correct identification. It is essential, then, to be able to handle bats properly and confidently.

Bats are very vulnerable to disturbance, particularly in their nursery colonies, where excessive disturbance can cause them to desert their young, or during hibernation, where arousal uses up energy reserves. They should, therefore, be disturbed as little as possible. Similarly, if they are being handled, they should be confined for as short a time as possible; but a bat in the hand offers additional data that can be recorded for various personal or wider studies, e.g. sex, biometrics, physiology and parasites.

A museum specimen is no longer necessary to provide an acceptable record, and a preserved specimen often masks useful features. While a museum specimen is (or should be) available in perpetuity and will continue to provide research material, the live bat has many advantages. It allows both the opportunity to see pelage and skin in their natural colours and textures, and the monitoring of changes in certain physiological and morphological features.

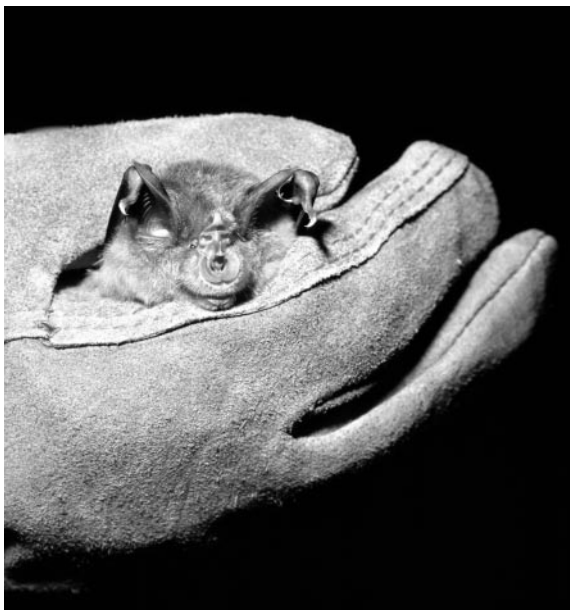
Complete familiarity with the topography of a bat is essential for successful identification and further studies. Features used in the identification and other aspects of the study of British bats are described on the generalised bats illustrated (Figure 5.1) and there are a number of guides available that give further details (see Appendix 5).

Callipers will be needed for any essential measurements. Almost all essential dental characteristics can be seen with a x10 hand lens – and a co-operative bat.

5.2 Sexing and ageing

5.2.1 Sex and reproductive assessment

Reliable assessment of the reproductive status of bats is important to field and laboratory studies.



Handling a greater horseshoe bat. © Frank Greenaway

However, it is often difficult to assess age and reproductive status accurately (see Kunz, 1988; Crighton & Krutzsch, 2000).

5.2.2 Sexing and sexual dimorphism

Males of all species have a conspicuous penis. Females have a single anterior pair of mammary glands and nipples. Pubic ‘false’ nipples are found in rhinolophids and are used by young bats to hang on to their mothers.

Although sexual dimorphism is well documented in bats, with females larger than males, it is seldom marked enough to be of use as a field characteristic. Males make characteristic social calls during the mating season, which may allow identification of sex in the future.

5.2.3 Reproductive status of males

Testicular descent

The position of the testes varies among the families of bats. In many Microchiroptera they are descended at birth and lie close to and on either side of the base of the penis, where they form bulges beneath the skin. Several authors have referred to seasonal testicular descent corresponding with seasonal spermatogenesis, but this has not been recorded in British bats.

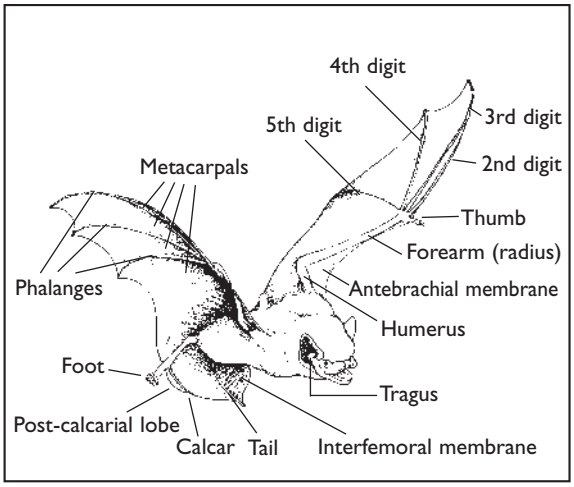


Figure 5.1
The features of a bat.

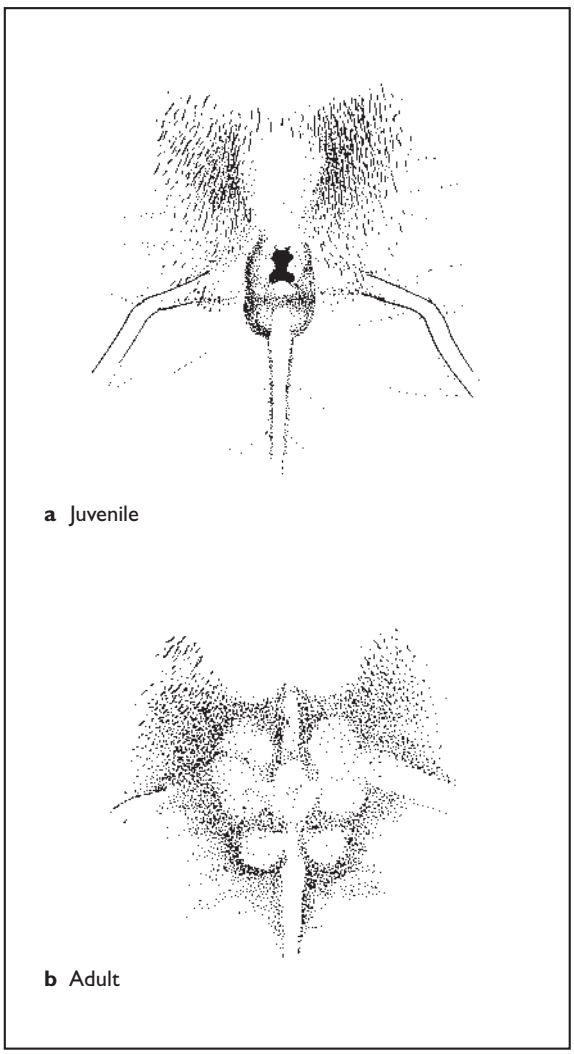


Figure 5.2
Sexual development in the male.

Puberty and spermatogenesis

Puberty is reached in most bats in the year following birth. However, in some vespertilionids some individuals achieve sexual maturity in their first autumn, while some horseshoe bats become sexually mature only after several years.

Both testes and epididymides are covered with a sheath of peritoneum - the tunica vaginalis. In juvenile and sexually immature male vespertilionids the tunica round the cauda epididymidis (= tail of the epididymis) can typically be seen through the skin as a densely pigmented sheath (figure 5.2a). Increase in the size of the testes, associated with growth of the seminiferous tubules and spermatogenesis, can be seen through the skin. After their release from the testes, spermatozoa pass through the epididymides to the caudae, which become distended between the layers of skin forming the interfemoral membrane. The rapid shrinkage of the testes at the end of spermatogenesis and the correspondingly rapid swelling of the caudae is very striking in captive bats. As a result of this swelling, the tunica vaginalis over the epididymis becomes stretched and the black pigment cells (melanocytes) separate so that the distended epididymal tubules appear white through the skin (figure 5.2b). After this initial separation has occurred, the melanocytes seldom return to their former density (in pipistrelles), so the apparent reduction in pigmentation, accompanied by varying degrees of distension of the epidydimis, can be used as a criterion of sexual maturity (although this is not proven in all genera). Where testicular swelling is apparent but the cauda is still heavily pigmented, the individual is probably undergoing its first spermatogenesis and is therefore described as pubertal.

Not only do immature bats have pigmented tunicae, but their testes are also smaller than those of individuals that have experienced spermatogenesis. This may be seen when the testes are examined through the skin.

The distinction between those males that have lost most of their epididymal spermatozoa and immature individuals is complicated when fat is deposited within the tunica vaginalis around the convoluted tubule of the epididymis and causes this membrane to appear stretched. In very fat hibernating bats, both testes and epididymis may be completely obscured from view.

The distinction between adult and immature individuals is further complicated by an autumnal moult when the dark pelage of immature individuals is replaced by the lighter one characteristic of adult animals, and a substantial error may occur in allocating males taken from hibernation into categories of sexually mature or immature.

These characteristics, which are the result of detailed study of pipistrelles and noctules, are not so clear in some other species such as long-eared bats.

5.2.4 Reproductive status of females

Oestrus

Oestrus is the time when females will allow males to mate with them, and the best criteria of its occurrence are behavioural, particularly in females soliciting copulation.

Copulation

A male mounts a female dorsally and often holds on by biting the neck of the female while curling its tail and penis underneath. Copulation is generally accompanied by much vocalisation, and some vespertilionids such as the serotine may remain in copula for several hours, without moving, giving the impression of one bat roosting on top of another.

Pregnancy

Early pregnancy is difficult to diagnose in bats. The nipples of nulliparous females (those that have never given birth or reached an advanced stage of pregnancy) remain tiny until around the time of first implantation of the egg in the wall of the uterus and so may be used as a criterion of nulliparity. Palpation can diagnose pregnancies that are between one-half and two-thirds progressed.

Parturition and lactation

The pubic ligament expands before parturition to allow the foetus to leave the birth canal. For a day or two after parturition, the vulva may appear blood-stained and swollen and the pubic symphysis is still separated. The mother encourages the baby to attach to a nipple immediately after birth and the mammary glands can be seen under her skin.

Milk may be extruded from the nipple by gentle finger pressure on the base of the nipple.

After lactation, the nipples retain (except in the case of Daubenton's bats) their enlarged, often darker, appearance and in most species of bat, as in other mammals, such nipples show that the bat has given birth. Bats that have had several young tend to have large nipples, but distinguishing between primiparous (having given birth once) and nulliparous females outside the breeding season often requires careful examination with the aid of a lens. The nipples of nulliparous females are rudimentary and often have tufts of hair on them. The nipples of parous animals show the expected characteristics of previous suckling: they are dark and cornified, either with no hair or with short, wavy hair.

5.2.5 Ageing

Juveniles

These are bats from the age of first flight until the loss of the characters described below. There is no widely accepted term other than 'baby' to describe the period from birth to first flight, although the use of the term 'pup' is becoming more widespread.

Ossification

At the time of first flight the bones are not completely ossified. This is most obvious in the joints of the digits (Figure 5.3). If held up to the light, the cartilaginous ends of the finger bones are apparent as pale bands either side of the joint. As cartilage is replaced by bone, the joint becomes more rounded or knuckle-like. The bones usually appear fully ossified by the autumn (60–75 days after birth).

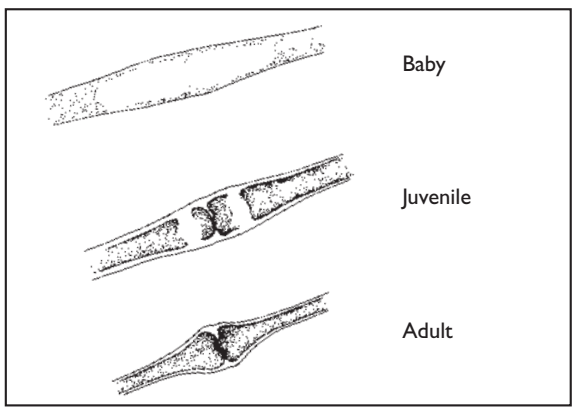


Figure 5.3
Development of the joints of the digits.

Size

Bats will fly before they are fully grown, so forearm lengths of early juveniles may be smaller than average for the species.

Fur colour and texture

Juvenile bats of all British species are darker and greyer than the adults. This is not always obvious, especially if the bats are born early in the year, when they may moult before hibernation. Fur of juveniles is often matt and frizzy rather than glossy or sleek.

Wing membrane colour/texture

Wing membranes of juvenile bats are often clean and unblemished and feel soft and tacky. The colour is generally darker than in adults. These juvenile characteristics may be detectable for up to a year.

Moult

Except for juveniles, bats have a single annual moult, usually in June and July. The moult usually starts from the back of the head and shoulders.

5.2.6 Abnormalities

It is worth noting unusual coloration, injuries or deformity to re-identify individual animals and monitor changes or healing processes. A number of bats are seen that have had serious tears to the wings, but which have healed. Bite marks are sometimes apparent.

5.3 Measurements

Measurements are generally only of value when taken as part of a larger project studying some aspect of bat morphology or for the field identification of certain species. Research projects may involve recording growth rates or assessing the normal and expected range of variation in size. If weight studies are being undertaken, it is useful to record at least forearm length to relate the weight to the size of each animal. All measurements should be in grams and millimetres.

Forearm measurements (by far the most useful), should ideally be taken with callipers, although a short steel ruler with a stop end can be used.

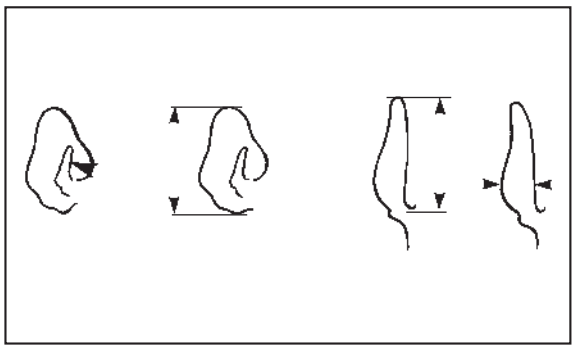
All other measurements should be taken with vernier or dial callipers. When measuring, rotate the callipers or animal slightly along the axis of the callipers to ensure that you have the maximum measurement. For right-handed people, it is best to control the bat in the left hand, leaving the right hand for the more delicate manoeuvring of the callipers.

Wing span, and head and body length

These are often quoted in books, but they are not useful field measurements because too much variation in measuring technique is possible. Their main use is in conveying the size of bats to the public.

Ear length

Take the longest measurement from the notch at the anterior base of the pinna to the tip. Ensure that the ears of Plecotus are fully extended.



Tragus width

Take the greatest width. In *Plecotus* it may be necessary to eliminate curvature by slightly bending the tragus at its widest point.

Tragus length

Record the maximum length from base to tip, ignoring curved edges.

Forearm

With the wing folded, take the maximum measurement from elbow to wrist. With the elbow of the bat resting on the movable jaw of the callipers, the callipers are adjusted to the correct maximum length when you can see or feel slight movement of the skin of the wrist against the fixed jaw as the forearm is rotated within the jaws of the callipers.

Fifth digit

Measure from the inside (posterior) of the wrist to the tip of the finger. This is best done on a flat surface. This measurement is needed to distinguish Pipistrellus pipistrellus from P. nathusii. This is a difficult measurement to take accurately and some authors use a measurement from outside the wrist to the finger tip as an easier and more reliable measurement.

Calcar

The length of the calcar compared with the total length of the edge of the uropatagium is an aid to identification of some species (e.g. whiskered and Daubenton's). The calcar will not be perfectly straight, but spread the tail membrane and measure the chord from the base of the calcar at the ankle to the tip and similarly from the tip of the calcar to where the membrane joins the tail.

5.4 Weight

The weight of an individual bat can vary by as much as 50% seasonally and by a considerable, although lesser, percentage over a 24-hour period. These factors must be borne in mind when comparing weights of individuals or population samples. Weights are of greatest value in long-term studies of growth and body condition, and there is little point in amassing data in a casual way.

Two convenient types of spring balance are available. A 50-g Pesola (long scale) balance can be used for all British species and can be read to an accuracy of 0.1 g. Other Pesola balances (including the 30-g) and the much cheaper Salter balances should only be read to an accuracy of 0.5 g. The balance should swing free from the ring at the top either from a fixed hook or from a well supported hand. Ensure that the balance and bat are free from obstruction and that weighing is carried out in a draught-free environment.

Torpid bats can be hung by the feet onto the clasp of the balance. Active bats should be enclosed in a small cloth bag and the difference between the weight of the empty bag and the weight of the bag plus bat recorded. The bat must be confined sufficiently to discourage movement without injury. Small cones of cloth open at both ends with the bat's head inserted down into the narrow end of the cone can also be used. If very light cones or bags are used, the balance can be adjusted to give a reading of zero when they are empty, but their weight should be regularly checked, as it will vary.

Remember that a bat's weight will vary greatly during the course of 24 hours when bats are active. This will put great limits on the use of weight data. Record the time of weighing, using the 24-hour system.

5.5 Rare bats

If a bat, which cannot be identified with a good key or which is clearly a rarity, is found seek expert advice immediately. Help can be obtained from an SNCO, The Bat Conservation Trust or through local bat group contacts. If it is not possible to arrange for a second opinion from a bat worker or an expert to see the bat within a reasonable time, take detailed notes before releasing the bat at the site of capture. Weigh the bat and measure the forearm and any other characters used in the identification of species of its genus. Note other non-measurable characters, such as colour, texture and extent of bare areas and of fur; the fur colour may change from the base of the hairs to the tip, and such colour banding should also be recorded. Take colour photographs and make sketches if possible. Make detailed notes of the circumstances in which the bat was found. These details will not only help your record to be accepted, but, by virtue of the fact that such bats are rare, the data will be useful to add to the limited amount of data available on the species.

5.6 Parasites

The word parasite is a loosely used term and here applies to any organism living in close association with a bat for at least part of its life cycle. Parasites fall into two groups – those that live within the bat's body or in the gut (endoparasites) and those that live on the surface or only very superficially below the skin (ectoparasites). The animal used by these organisms as a means of transport, for food or for shelter is called the host. Usually the bats live in harmony with these parasites, but occasionally (especially with the endoparasites) disease or debilitation may occur.

5.6.1 Endoparasites

Bats are hosts to a range of endoparasites but the only ones readily obtainable from a live bat are those that live in the blood. A drop of blood can be taken and spread as a thin (one cell thick) or thick

(several cells thick) smear on a glass slide. In Britain, blood smears have demonstrated the presence of trypanosomes, malarias and babesias.

The taking of and examination of blood smears is a specialist occupation and should not be attempted without training and except for specific projects. It will also require a Home Office licence.

Other parasites may be found by examining saliva or droppings (e.g. *Coccidia*), but little work has been done in this country and, again, studies should be attempted only by those with a special interest and adequate training.

5.6.2 Ectoparasites

Many arthropods live on bats for at least part of their lives. In Britain these include a variety of mites (Acari), species of flea (Siphonaptera), bat-flies (Diptera, Nycteribiidae) and bat-bugs (Hemiptera, Cimicidae). These parasites are in a very vulnerable position and so have become very specialised in their morphology, physiology, life cycle and ecology. For this reason they are of interest in themselves, although relatively little is known of the composition of the fauna occurring on British bats, or, for individual species, of their distribution, host-specificity, ecology and, in the case of mites, even their food. We also know little of the relationships between many of the parasites and their hosts and about any role they may play in the transmission of disease organisms. The study of these parasites can also provide additional information about the bats.

Some mites are so small that a hand lens is required to see them on the host; most are reasonably visible at least to the practised eye. Parasites can be found by inspecting the flight membrane, feet, ears and face and by blowing through the fur. They can be carefully removed with fine forceps or a fine paintbrush and are best stored in 70-80% alcohol. Some of the insects are very agile, but they can be immobilised with a dab of ethyl acetate. Some mites may be very firmly attached and there is the possibility of leaving mouthparts embedded in the host. Not only does this create problems of identification of the parasite, but there is a risk of the embedded parts causing an infection.

Specimens should be stored in small tubes of alcohol with full data of host, position on host, locality, date and collector. Some specimens will need to be mounted on slides. Full details of preparation and storage are given in some of the identification guides, or the advice of an expert should be sought.

A general guide to ectoparasites can be found in Hutson (1971). A detailed catalogue of the parasites recorded from bat species occurring in Italy (which includes all UK species) can be found in Lanza (1999).

Mites, including ticks (Acari)

Larval mites have six legs; nymphs and adults generally have eight legs. They can be flattened or globular, rounded or elongate, long- or short-legged, and they are not obviously segmented. In some species it is only the larva that is parasitic, in others only later stages; mites may feed on blood, glandular secretions or skin debris. They can occur anywhere on the bat. The star-like spinturnicids are most obvious on the wing membrane; other mites may also be found here. A great range of mites are found in the fur, and specialist mites can be found on facial whiskers, in sacs on the wings or feet, or in cones of dried plasma on the lips or feet. Some species, such as the ticks, spend more time off the host than on, but they or their cast skins can often be found around the roost. A good introduction to mites can be found in Evans *et al*. (1961) and a recent review of species found on British bats in Baker & Craven (2003).

Bat-bugs (Hemiptera, Cimicidae)

Sandy brown and flattened dorso-ventrally, these bugs are very closely related to our own bedbug and can bite humans. Eggs are laid around the roost, and the nymphs and adults venture on to the bats to feed on blood. They are not well adapted to travel with the bats and it is more likely that they or their cast skins will be found around the roost site or in the guano. One species is quite common on a variety of bats; a second species is doubtfully recorded. A monograph of the family was published by Usinger (1966) and Péricart (1971).

Fleas (Siphonaptera, Ischnopsyllidae)

Adult fleas are brown to yellow, laterally flattened, blood-feeding insects; the white, actively wriggling, legless larvae are found in the guano below the roost. Some species are host-specific and, if bats are not visible at a roost, collecting fleas from the guano can help to identify the bat species involved. *Pipistrellus pipistrellus* and *P. nathusii* can be difficult

species to separate, but they have quite different fleas. The larvae of some species are poorly known. Fleas can be identified from Smit (1957).

Bat-flies (Diptera, Nycteribiidae)

These blood-feeding flies are so highly modified that they are barely recognisable as true flies. Wings are absent and the thorax is so reduced and distorted that the head and long legs arise from its top. They do not lay eggs, but produce fully developed larvae, which are deposited near the bat roost site. A well-used traditional roost will be encrusted with the old puparia of these flies. Three species are recorded from Britain and all are virtually host-specific. They can be identified from Hutson (1984).

Guano dwellers

Apart from certain stages in the life cycle of some of the ectoparasites, the guano associated with a well established bat roost provides a habitat for a variety of mites and insects. In Britain the associated fauna is very limited, but it has been poorly documented. Some flies (Diptera) previously thought to be very rare have been found to be quite common in this habitat, and further investigation is worthwhile. If you collect guano samples, enclosure in an airtight container will kill any fauna through excess ammonia; it is better to keep the samples in a well-ventilated container, e.g. a cloth bag or an insect box with a fine-meshed gauze or muslin ventilation area. The guano should not be allowed to dry out completely. Different insects will require different methods of preparation and storage.

5.7 DNA analysis

A biopsy punch can be used to take 3-mm skin samples from the wing. This can be done only by scientists licensed to do so by the Home Office and SNCOs. The resulting hole heals within three weeks without impairment to flight or reproductive success.

5.8 Dead bats

Dead bats should never be discarded. Apart from being of value as voucher material for a species record, they may be of use for training, educational or more scientific purposes. Ensure that full details of locality, date and collector are attached to each specimen as soon after acquisition as possible. This information may also be required if you are questioned, under the Wildlife and Countryside Act, as to the provenance of any dead bats you hold.

5.8.1 Preservation and storage

Bats can be skinned or stuffed, but in British bats the body is so small that it can be easily dried out and will retain some of the body shape in a desiccated condition – as long as it is kept dry and free from pest beetle. A better way is to store it in 70-80% alcohol (industrial methylated spirit) with the abdomen opened to allow preserving fluid into the body cavity. A piece of matchstick can be cut to prop open the mouth so that the teeth can be examined. Specimens should be kept in the dark and alcohol levels should be kept topped up. Bats are also suitable for freeze drying if such facilities are available. Long-dead bats may be useful for skeletal material, particularly skulls. Such 'museum' specimens will have a variety of purposes, but there may be other useful purposes for a dead bat that require different forms of preservation. Some uses for dead bats are outlined below.

5.8.2 Uses

Rabies surveillance

Specimens can be submitted to the Veterinary Laboratories Agency as part of the programme to monitor for European Bat Lyssavirus. (see Chapters 2 and 9). All dead bats should be sent there unless they are needed for any other specific purpose.

Museums

National, county or local museums and other institutes may be very grateful for well-documented specimens, and such institutions will be best equipped to preserve specimens for posterity.

Exhibitions

Good, well preserved specimens may be useful for exhibition. Generally even the best-preserved specimens maintain little of the character of live bats and photographs are better, but an actual specimen can demonstrate size, fur texture and other features.

Demonstration

For the more seriously interested audience, even badly preserved specimens can be useful as aids to identification and the understanding of bat structure.

Ageing/sexing criteria

Some of the criteria for assessing age are based largely on external examination. Fresh material is always useful for confirming the accuracy of such characters, especially in ringed bats whose age is known.

Pesticide analysis

At present it is too expensive to do routine chemical analysis of bat tissues to check for pesticide residues and few laboratories can undertake the work. If specimens are ever required for a specific project (and it is obviously a very important subject for enquiry), requests will be made. Specimens will need to be very fresh and sent rapidly to the analyst.

If the illegal use of pesticides to poison bats is suspected, the relevant agriculture department should be informed. All the Agriculture Departments have laboratories, which are equipped for pesticide analysis and can investigate such incidents. Incidents in the United Kingdom can be reported on a free telephone line: 0800 321 600. The relevant SNCO should also be informed.

Parasites

Bats are subject to a variety of endoparasites (particularly parasitic worms) and some of the mites associated with bats occur almost internally (e.g. inside nostrils or mouth) and hence can only be collected by dissection of freshly dead or well-preserved specimens; others can be missed in searching a live animal. These mites can be treated as for other mites (see Section 5.6), but the endoparasites may need special preservation (e.g. a mixture of glacial acetic acid and alcohol for some worms) and the advice of experts should be sought.

Sending dead bats by post

Nobody likes smelly parcels: they are a problem for the recipient as much as for the postman. If you are sending unpreserved specimens by post, wrap them in absorbent tissue, put them in a sealed crush-proof package and try to ensure that the addressee wants and is expecting them. Packaging must comply with GPO regulations for pathological material (see Chapter 2). Send them by first class mail and preferably not on a Friday or just before a Bank Holiday. Full data should be included with each specimen. Unless a fresh specimen is particularly requested, the dead bat can be kept in alcohol for some time or have alcohol injected into the abdomen. It can then be sent sealed in a plastic bag in a crush-proof container. If sending specimens for rabies surveillance refer to the instructions in Chapter 2.

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Greater horseshoe bat in cave. © Frank Greenaway