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EUROBATS

European bats are a species-rich group widely distributed through the range of agricultural and non-agricultural landscapes and habitats that form the wider countryside. The landscape of Europe has been and continues to be affected by intensive and varied human influences that have had widespread and sometimes devastating effects on bat populations. In addition, there is continued misunderstanding and prejudice arising from ignorance about bats and their lives and habits.

As a result of these effects many species are considered endangered, some have even become extinct in certain countries, and all are considered sufficiently threatened to be protected by legislation. The threatened status of bats in Europe means that information on changes in the distribution and abundance of bat species over time is urgently required. Monitoring and surveillance programmes are needed across Europe at varying levels: country, region and Europe wide.

In this publication, general information about surveillance and monitoring schemes is provided; surveillance methods are described and illustrated by examples; species accounts for all bat species occurring in the EUROBATS range have been compiled; and national bat monitoring programmes give practical advice.

The information collected will assist government and non-government organisations in Europe to: detect changes in distribution, range and abundance and provide long-term population trends; influence national and international policy/setting of conservation priorities; assess the effects of conservation and other types of wildlife management; and educate people about conserving and managing mammal populations.

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Guidelines for Surveillance and Monitoring of European Bats

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Bat detecting at sunset in Perth, Scotland.
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Foreword

Figure 1. Counting a cluster of 3,895 individuals of Rhinolophus ferrumequinum/mehelyi/euryale in Orlova Chuka cave (N Bulgaria). © B. Petrov

This document provides guidance on methods for surveillance and monitoring of European bat species. It is recognised that methods may need to be amended to take account of regional variations and in the light of new information.

Some examples of monitoring schemes used in different countries are provided for illustrative purposes only (chapter 3). These are not intended to be representative for every species or every region. Distribution maps are shown with the species accounts (chapter 4).

Case studies of national monitoring schemes are also provided for illustrative purposes only (chapter 5). It is important to note that the guidelines are likely to require revision and update in the future as new methods are developed and incorporated. Updates will appear in the pdf version of the guidelines which can be found on the EUROBATS website.

These guidelines were developed by an Intersessional Working Group of EUROBATS and other advisors listed in chapter 7. The completed text was examined by a small editorial group comprising Dr. Stéphane Aulagnier, Dr. Jessamy Battersby, Dr. Zoltán Biharí, Dr. Ferdia Marnell and Mr. Tony Hutson. A final edit was carried out by Dr. Stéphane Aulagnier and Mr. Tony Hutson. The distribution maps were formatted by Dr. Tony Mitchell-Jones.

1 Surveillance and monitoring of bats across Europe

1.1 The importance of surveillance and monitoring

European bats are a species-rich group widely distributed through the range of agricultural and non-agricultural landscapes and habitats that form the wider countryside. The landscape of Europe has been and continues to be affected by intensive and varied human influences that have had widespread and sometimes devastating effects on bat populations. These include: ***loss of roost sites*** through fragmentation and loss of woodland areas, destruction and development of old buildings often used by bats, and disturbance and loss of structures used as hibernacula or maternity roosts; ***loss of foraging areas and reduction in insect prey*** through habitat destruction and fragmentation and increased use of pesticides; and ***poisoning*** by timber treatment chemicals when old buildings are renovated (Jefferies 1972, Clark 1981, Leeuwangh & Voûte 1985, Racey & Swift 1986). In addition, there is continued misunderstanding and prejudice arising from ignorance about bats and their lives and habits.

As a result of these effects many species are considered endangered, some have even become extinct in certain countries, and all are considered sufficiently threatened to be protected by legislation (Hutson *et al.* 2001). The threatened status of bats in Europe means that information on changes in the distribution and abundance of bat species over time is urgently required. Monitoring and surveillance programmes are needed across Europe at varying levels: country, region and Europe wide.

The information collected will assist government and non-government organisations in Europe to:

- **Detect changes in distribution, range and abundance and provide long-term population trends** in order to have an informed understanding of what is happening to European bat populations. Many bat species travel long distances at certain times of the year to maternity roost sites, mating sites or hibernation sites and in doing so often cross country boundaries (Fleming & Eby 2003, Hutterer *et al.* 2005). Data collected in European monitoring programmes will facilitate effective targeting of conservation action (including the selection of species of conservation concern, key sites and priority habitats) by a wide range of organisations and individuals.
- **Influence national and international policy/setting of conservation priorities.** National governments and the European Community as a whole require good quality information on the status and changing fortunes of different elements of biodiversity in order to produce effective conservation and wildlife management policy. Bats are important elements of that biodiversity and the reliance of bats on insect prey and their specialised feeding behaviour and habitat requirements suggest that bats are potentially valuable indicators of the general health of the environment.
- **Assess the effects of conservation and other types of wildlife management.** There is a great deal of habitat and species management in operation and being recommended across the European Union for conservation and sustainable use. It is extremely important to know whether such management is achieving the intended goals. The main ways of assessing this are through monitoring changes in habitat structure, species abundance and distribution.
- **Educate people about conserving and managing mammal populations.** Education is an important part of any conservation or wildlife management initiative. Informing the general public about issues affecting wildlife in urban environments and in the wider countryside as well as obtaining public support and involvement in these areas are the keys to success. In some countries monitoring schemes have been initiated, using volunteers to collect the data, and indeed they are an extremely important part of many surveillance schemes. Many volunteers attend training courses to improve their survey and identification skills; later they receive newsletters about the results of the work they have done and thereby improve their knowledge and understanding. It is also important to inform and engage the general public more widely through mass participation surveys, easy-to-access websites and annual reports and newsletters. Surveillance and monitoring schemes are ideal for achieving these interactions and information dissemination process.

1.2 International monitoring obligations

The threats to bats have been recognised in a number of international Conventions, Agreements under those Conventions, and European Directives.

- **The Convention on the Conservation of Migratory Species of Wild Animals, Bonn Convention (UNEP/CMS)** which recognises that endangered migratory species can be properly protected only if activities are carried out over the entire migratory range of the species. All European bat species are listed on Appendix II. Under Article IV of the Convention, Range States for Appendix II species are required to conclude legally binding Agreements for their conservation.
- **The Agreement on the Conservation of Populations of European Bats (UNEP/EUROBATS)** came into force in 1994. It is one of the Agreements under Article IV of the Bonn Convention and the first international Agreement devoted to the conservation of bats. Out of the 48 Range States, more than thirty European states are Parties to the Agreement.

The EUROBATS Agreement aims to protect all European bat species, through legislation, education conservation measures and international co-operation with Agreement members and with those who have not yet joined. In 1995, the First Session of the Meeting of Parties to the Agreement formed an Action Plan, which was to be translated into international action. An Advisory Committee was established to carry forward this Plan between the Meetings of Parties.

The most significant items for the Advisory Committee are monitoring and international activities. International protection measures for bats have, above all, to concentrate on those species that migrate the furthest across Europe, in order to identify and address possible dangers caused by conservation risks encountered along their migration routes. The results of these studies are intended to lead to a comprehensive international programme for the conservation of the most endangered bat species in Europe.

- **The Convention on the Conservation of European Wildlife and Natural Habitats, Bern Convention** is another important international treaty. It imposes a legal obligation on Parties to protect all breeding and resting sites of the strictly protected species on Appendix II, including all European bat species apart from *Pipistrellus pipistrellus*, which is listed on Appendix III.
- **The Convention on Biological Diversity (CBD)** also has relevance to European bat populations. Two of the main objectives are the conservation of biological diversity and the sustainable use of its components. Article 7 of the Convention requires that contracting Parties should "monitor, through sampling and other techniques, the components of biological diversity, paying particular attention to those requiring urgent conservation measures and those with the greatest potential for sustainable use." It notes that regard should be given to species that are threatened, of social, scientific or cultural importance, indicator species and alien species.
- **The European Community's Directive 92/43/EEC on the Conservation of Natural and Semi-natural Habitats and of Wild Flora and Fauna (The Habitats Directive)** was notified with the fundamental purpose of establishing a network of protected areas (Natura 2000) throughout the European Community, designed to maintain the distribution and abundance of threatened species and habitats. Several European bat species are listed in Annex II and all are listed in Annex IV of the Directive, requiring Member States to maintain and restore "favourable conservation status" of the species. Article 11 of the Directive states that "Member States shall undertake surveillance of the conservation status of the natural habitats and species referred to in Article 2 with particular regard to priority natural habitat types and priority species."

Finally, a new Red List for European mammals has been completed through the European Mammal Assessment (Temple & Terry 2007). Monitoring mechanisms to provide data on bat populations are required to continue measurement of conservation status in the future.

1.3 Surveillance and monitoring of bats at a European level

The EUROBATS Agreement aims to assist in establishing pan-European surveillance programmes to identify population trends and then to facilitate the timely introduction of measures to address any problems highlighted by the results of the programmes.

The purpose of this manual is to recommend best practice in surveillance and monitoring methods so that consistent methods can be developed within and between Range States, allowing comparison of results obtained and eventually the production of European trends for bat populations.

It is recognised that methods may need to be amended to take account of regional variations and in the light of new information.

2 Developing surveillance and monitoring schemes

2.1 Introduction

There are many factors to consider when designing long-term surveillance and/or monitoring programmes. The terms "surveillance" and "monitoring" have been used somewhat interchangeably in the past, but in fact a distinction can be drawn between the two activities and this is quite important when considering the level of information required.

Figure 2. Three people counting on emergence. © J. van der Kooij

Surveillance, in the context of measuring populations, consists of repeated and standardised observations of abundance over time, using methods that enable changes in numbers to be detected (Hellawell 1991). Surveillance is a means of assessing what is happening to populations of a particular species over time.

Monitoring requires that targets are set, management recommendations made and carried out, the effectiveness of the management assessed and changes made to improve the process. Monitoring therefore involves surveillance, not only of the species in question but, so far as possible, also of the other factors likely to affect populations of that species.

The guidelines concentrate on standardised surveillance methods required to produce indices of population change. However, it is important to note that the recommended surveillance methods can be used in conjunction with the collection of other information, such as roost site condition, habitat extent and quality, climate, food availability, disturbance and other variables, to monitor possible causal factors of changes in bat populations. Some of this additional information will be particularly valuable in making assessments of conservation status for species listed in the Annexes of the European Habitats Directive.

An example of using surveillance data in conjunction with other data is provided by the UK, where research funded by the Environment Agency (EA) and carried out by the National Bat Monitoring Programme (NBMP, Walsh *et al.* 2001 and 2003) has demonstrated a significant, positive relationship between foraging activity of *Myotis daubentonii* and insect biodiversity, itself an indicator of water quality (Catto *et al.* 2003). This research showed that the status of waterway bat populations could also be an important indicator of waterway "health" and could contribute to wider conservation issues.

The main factors to consider when setting up a surveillance programme are listed below.

2.2 What is being measured?

2.2.1 Species occurrence

There are several steps to assessing changes in populations over time. If very little information is known about the occurrence of a particular species then the first step is to assess the presence or distribution of the species in certain areas *e.g.* habitat types, administrative units or geographical grid squares. The methods used should focus on having a high probability of detecting and recognising all bat species occurring in a distinct area (Limpens & Kapteyn 1991, Limpens & Roschen 1996 and 2002, Flaquer *et al.* 2007).

The results of such surveys are usually displayed as simple distribution maps showing where species are known to occur and can be repeated at regular (say 5 or 10 yearly) intervals to provide some indication of change in species distribution.

2.2.2 Species abundance

A more rigorous approach involves making some assessment of species abundance in a given area and assessing trends in abundance over time. This could involve carrying out a full census of all individuals and then repeating the census at regular intervals. However, a full census of a population is likely to be time-consuming, costly and to have very wide confidence limits.

Sampling a subset of the population to provide an estimate of relative abundance and to use this as an index of the true population is an easier and probably more reliable approach. With repeated, standardised surveys, changes in the index can be assessed over time, providing population trends. If total population size has been estimated at any point in time, then the index trend can be used to reassess the population estimate at regular intervals. The collection of standardised time-series data in this way provides an opportunity to apply a variety of sophisticated analyses or to develop models.

2.3 Survey frequency and standardisation

Surveillance schemes should collect data at frequent and regular intervals. For the majority of purposes data should be collected at least annually, because population trends (up or down) will be detected more quickly and with greater certainty. However, for some species less frequent surveillance may be effective.

The value of surveillance data increases with the length of time over which they have been collected. Surveillance projects should be long-term, *i.e.* for decades, which will require long-term commitment. It is only through the collection of data over long periods of time that real declines or increases in bat populations can be detected separately from the natural fluctuations that are often observed from year to year.

When the survey method has been selected, it is important to ensure that the application of the method is standardised as much as possible, so that it is repeatable between sites within one survey year and between years, to allow comparisons to be made across years and over long periods of

time. Creating standard survey forms with clear instructions is one very effective way of standardising the methods and effort used for data collection (Walsh *et al.* 2001 and 2003).

2.4 Area coverage, stratification and sample sizes

When setting up a surveillance scheme it is important to consider the size of area to be surveyed and the sample size required to generate statistically significant trend information. Generally, the finest scale at which information is required will be the scale that determines the overall sample size. It may be that information on population trends is required at a country level, but that it is also desirable to have trend information for regions within the country or for particular habitat or environmental areas. The number of sample sites required to provide trend information at a country level will also be required at each of the regional levels, so it is important to consider this when initially planning the surveillance effort. For example, a sample of 40 sites, surveyed each year for a number of years, might be considered sufficient to deliver country-level trends. However, if there are five regions in the country and trends are required for each of those regions, then 40 sites will need to be surveyed in each region, giving a total of 200 sites overall. The situation becomes more complex as additional stratifications are included.

Selection of survey sites should be completely random or randomly selected within a designed stratification, although it is possible to stratify the sample at the data analysis stage. Randomly selected sites provide more statistically robust results and are also more likely to be representative of the total population than survey sites that have been specifically chosen. This may mean including sites in the survey sample where bats are seldom or never seen.

Random survey requires a relatively large number of sites and is particularly useful for widespread species and those that are relatively easy to detect. If resources are available only for *e.g.* five or ten sites in a country then the monitoring sites can be specifically selected and counts repeated at the same sites and under the same conditions to reveal population trends in those locations.

2.5 Species coverage

It is best, if possible, to carry out multi-species surveillance because it is easier to manage and more cost effective. Multi-species bat detector surveys are possible even where species echolocate at very different frequencies, especially with the use of frequency-division or time-expansion detectors. If resources are limited and only a selected proportion of species occurring in a particular area can be surveyed, then consideration of priorities at country, regional and European level may help in deciding which species to include in the survey. Another consideration is the ease with which the species can be surveyed, because good data on slightly lower priority species may be more informative than poor quality data on high priority but less tractable species.

2.6 Assessing the surveillance scheme — the pilot phase

2.6.1 Survey sensitivity and power

Establishing a long-term surveillance scheme involves piloting the design of the scheme to test ability to deliver the required level of information. The benchmark for monitoring sensitivity needs to be set when setting up the scheme. One measure used for UK birds is that sufficient sites are monitored to detect a population change of 50% over 25 years, equivalent to the Red Alert declines for UK birds (Walsh *et al.* 2001 and 2003, Gregory *et al.* 2002) and hopefully the more sensitive measure of 25% over 25 years, equivalent to the Amber Alert decline for UK birds.

The power of a surveillance scheme is the ability of the scheme to correctly identify an ongoing population trend and is expressed as the percentage chance that a particular survey design will detect a trend of the specified magnitude. Power is influenced by many factors, including the magnitude of population change over time, between year population variation, the number of years of data, frequency of surveillance, the number of sites surveyed, proportion of samples with the species present and sampling error.

The power of surveillance schemes should be analysed in the pilot phase to assess the level of information and degree of certainty that a scheme can deliver. Sample sizes and, therefore, the level of certainty of the results may vary for different species in the same surveillance scheme (because of differences in detectability). The power of a scheme will be increased if the design includes repeating data collection at sample sites within and across years, and this should be a priority.

2.6.2 Survey bias

Bats are difficult to count, and even using the best available sampling methods, there will be uncertainties inherent in population estimates and estimates of trend. In trend estimation, however, repeatable counts do not have to be accurate in the sense that the population estimate is close to the actual population figure. If the counts are consistently wrong for any reason the changes from year to year can still be measured accurately using repeatable methods to achieve high precision.

Thus the ability to count bats with the same detectability each year remains an essential attribute of a successful bat population monitoring scheme. However, the effects of small sources of bias are often over-emphasised in comparison with a lack of precision (Toms *et al.* 1999). For this reason, it is important to measure or justifiably estimate the magnitude of bias and to take this into consideration when balancing bias and precision in monitoring schemes.

There are a number of factors that influence the encounter rate of bats on field surveys or numbers of bats counted from summer roosts. These can be divided into two categories:

1. Factors that influence bat encounters and are likely to change over time resulting in potentially erroneous trends;
2. Factors that influence bat encounters but are likely to remain stable over time.

Detailed analyses of the potential biases in the data can be conducted using a Residual Maximum Likelihood model (REML) to explore the effects of covariates, in order to allow for the complex structure of the data. Factors evaluated can include the influence of bat detector model, survey duration and temperature (BCT 2006).

2.7 Data collection, management and validation

Managing surveillance data is probably one of the most difficult and time consuming aspects of running a surveillance scheme. It is essential to have a database of survey results that can be easily accessed and analysed. If volunteers have collected the data then it is also important to have a database for the volunteers, including names and addresses, which survey they are participating in, which site they are surveying *etc.* The nature of the database should be decided before commencing the project so that resources, both in time and money, are used most efficiently. Some of the main issues to consider are listed below.

2.7.1 Database requirements

What will be the present and future requirements of the database? What information will need to be stored and in what format? The format may be determined by the type of analysis that will be carried out on the data and so these factors need to be considered when designing the database. As a minimum, the information collected should include: species (sightings or signs), number of individuals, method (survey technique and bat habitat type), site and spatial reference (*e.g.* grid reference at 1 km^2 level or more detailed if possible), date, a measure of survey effort and the recorder's name.

2.7.2 Database compatibility

It may be that exchange of data with others is not a consideration. However, it is likely that pan-European information exchange and sharing of data will have much greater conservation potential than keeping datasets in isolation. Building a database that allows for easy information exchange, *i.e.* is compatible and compliant with databases held by other organisations, will save time and money in the long run.

2.7.3 Quality control of data

There may be some concerns over the accuracy of raw data provided; a process of data validation should be put in place when entering the data electronically, so that the accuracy can be checked. Generally, surveillance data can be collected by relatively inexperienced surveyors, including volunteers, because the data collection process can be fairly simple. However, it is important to have some way of verifying the data they provide. It is also important that schemes include some form of training and feedback of results to surveyors.

2.7.4 Data entry and storage

A decision should be taken on how to enter the data. There are several options, including manual entry by the survey organiser, scanning information using Optical Mark Recognition (OMR), paying for professional data entry or asking the volunteers to enter the data through a website. All the methods have their advantages and disadvantages in terms of cost, time required and accuracy.

In the UK, the National Biodiversity Network Trust has devoted a great deal of time and thought to all the issues to do with data management. All the information can be found on their website www.nbn.org.uk.

Data should be stored in a format that is accessible and can be maintained in perpetuity and made available to as wide an audience as possible. Long-term (*i.e.* over decades) organisational, financial, data archiving and data supply structures should be put in place. In particular procedures should exist to safeguard the foregoing irrespective of changes in personnel.

2.7.5 Data analysis

The purpose of analysis is to draw correct conclusions on population trends occurring in species of interest. Many factors can influence the appearance of trends (apart from true changes in population size) and the magnitude of their effect should be estimated and methods for reducing their influence put into place to reduce the possibility of data misinterpretation.

The models used for analysis of species trends are usually General Additive Models (GAM) or General Linear Models (GLM) with Poisson error distribution (appropriate for count data). Annual means can be calculated from survey data using GLMs, which will show the variations between years. For easier interpretation the means can then be converted to an Index that starts at 100 for the first reliable year of data.

General Additive Models (GAM) calculate individual trends over time for each site surveyed. They then amalgamate trends from all sites to produce an overall estimation of trend direction with confidence limits. GAMs can be used to fit a smooth line to each dataset (ter Braak *et al.* 1994, Fewster *et al.* 2000) in order to produce a clear picture of the long-term trend for individual species. These smoothed curves are quite robust against random variation between years.

GAM models can include covariates for factors that could influence the means (*e.g.* bat detector make, temperature). Generalised Linear Mixed Models (GLMMs) can be used to investigate these factors, and any variables that are statistically significant and that have a biologically plausible relationship can be included in subsequent GAMs.

It is not uncommon for the first year's results in a survey to be atypical because:

- the methodology is not yet well established (teething problems);
- observers are learning the ropes;
- fieldwork may start late because of the difficulties in getting funding and recruitment sorted out in time.

To counteract this problem, it is best not to use the first year of a survey as the baseline year, where the index equals 100. The first year's results can be discarded and this is often done in analyses once a scheme is well established. Another possibility is to keep the first year's data, but use the second or even the third year as the "base year" on which to base the 100 index against which all other estimates are shown (BCT 2007).

If data analysis by computer is intended in order to extract trends and statistic indices from a series of survey results the application of the Dutch PC-programme TRIM is recommended. It is available free of charge (see www.cbs.nl) and widely used by European ornithologists from many countries as well as international institutions for bird research, *e.g.* European Bird Census Council (EBCC).

2.8 Recruiting surveyors

2.8.1 Volunteers or professionals?

When designing a monitoring scheme it is important to decide whether it will be better to use professional surveyors or recruit volunteers to collect the data. There are some major advantages to using volunteers. A large network of volunteers will be able to cover a large number of sites over a short period of time and give a level of coverage that would be prohibitively expensive if professional surveyors were employed. Volunteers also tend to be highly motivated and often have local knowledge of the area they are surveying and have contact with local landowners and naturalists. Generally it is very cost effective to ask volunteers to collect data rather than pay professionals to do the job. This means that organisations are able to run surveys that would otherwise not be possible and to ensure effective use of available funds.

There are, however, some disadvantages to engaging volunteers. Levels of uncertainty increase because there is no control over whether volunteers return data or not.

Volunteers expect more information and more feedback than professionals and, because of time constraints and level of expertise, they may have more problems in carrying out surveys. The level of knowledge of some volunteers can be extremely high, but the majority of volunteers will have lower field craft abilities than professionals. This can be rectified somewhat through good training courses. Volunteers are also likely to have more constraints on their time if they are giving it freely and not being paid to do the work. If volunteers are asked to survey randomly selected poor quality sites where they seldom see anything, they can become disillusioned with the survey work.

Many European countries do not have a culture of using volunteers to collect natural history information and so do not have a source of volunteer surveyors to call on. An alternative is to have a combination of volunteer and professional surveyors or only professionals to carry out the work.

In the UK the Tracking Mammals Partnership (TMP) and the National Biodiversity Network Trust (NBN) have produced a manual on engaging volunteers in survey work and managing volunteer networks (TMP & NBN 2004). This could provide useful information for organisations considering using volunteer surveyors.

2.8.2 Health and safety issues for surveyors

Fieldwork on bats is always accompanied by special risks for the surveyor, and all people and institutions being involved in a bat monitoring programme should take the utmost care to minimise these risks. For this reason survey work has to be planned carefully and all appropriate measures for safety of the surveyors should be taken. Institutions which are involved in the coordination and implementation of surveillance schemes are urged to inform surveyors about health and safety issues and offer appropriate education and training for them.

Surveys at night should be preceded by an inspection of the sites during daylight in order to be aware of rough or even dangerous areas. If a particular place is to be occupied for a longer period at night, *e.g.* to observe emerging bats at a roost or to attend a mist net, it should be cleared of obstacles like branches or large stones, so the risk of being hurt or stumbling in the dark is low. Surveyors must have enough lights with them to detect at any time during their fieldwork all features which might be of danger, *e.g.* ditches, burrows in the ground, wire fences, or inconvenient animals such as cattle or wild boar. Reserve lighting equipment is recommended. Speleologist advice should be sought when entering caves or mines, and it is recommended that surveyors are accompanied by speleologists in complex cave systems.

Bats may be hosts of diseases which can also infect humans. In particular viruses (rabies and others) may be a risk for human health if bats are caught and handled or dust from bat faeces in a roost site is inhaled. When access to a bat roost or catching bats is necessary a safe approach is important to minimise disease and accident risks. Secure measures and special training is of greatest importance if underground sites or roosts in higher trees are inspected. At any stage of their fieldwork bat surveyors must take effective measures to protect their personal health conditions.

2.9 Resource issues

When setting-up a surveillance scheme the long-term viability of the scheme is one of the most important factors to consider. Bat fieldwork is normally labour intensive, requiring highly trained surveyors with often one person-night fieldwork generating one data point. Bat detector surveys are mainly restricted to the summer months and in most cases the three hour period post sunset on each survey evening. Thus, to generate 100 independent data points may require 100 nights of fieldwork and a large number of surveyors. Therefore, availability of personnel and finances, accessibility of terrain, transport issues, habitat features and other aspects all have to be taken into account and their importance weighed against the preferred survey methods.

For example, bat detector surveys covering transects in the wider countryside is the recommended method for many species, but if surveyors are in short supply or the terrain makes such surveys difficult or dangerous then another option might have to be considered. A relatively new method involving attaching ultrasonic detectors and recording equipment to moving vehicles is one option where fewer people may be required.

3 Surveillance methods

3.1 Introduction

The surveillance methods listed here are based on those agreed at the Second Meeting of Parties of the EUROBATS Agreement and outlined in Resolution 2.2 (Doc.EUROBATS.MOP2.5.AnnexBfin Resolution No. 2), but include other methods that have been developed in recent years. It is recognised that methods may need to be amended to take account of regional variations and in the light of new information.

The surveillance method or methods selected for a particular species or scheme will depend on the life-style of the bat species concerned, local circumstances and seasonal changes in bat occurrence. A surveillance scheme should always aim to obtain high quality data, which will be appropriate for robust forms of data analyses. However, the methods used should be as simple as possible, allowing surveyors with minimum skills and training to participate, thus increasing the possibility of obtaining a sufficiently large sample over the long-term. They should also cause the minimum disturbance possible to the bats, because of the long-term, repeated nature of the activity.

Surveillance of bat populations can generally be carried out in two main ways:

- Bat detector transects of foraging bats. This could be walked transects or transects along roads using moving vehicles.
- Records of roosting bats. This could be at maternity roosts or other summer roosts, at hibernation sites and at mating roosts.

Figure 3. Counting Miniopterus schreibersii in Huda luknja pri Gornjem Doliču cave, Slovenia. © P. Presetnik

3.2 Site Species Richness

Measurement of Site Species Richness can be used whenever it is considered necessary to register all bat species in an area, including rare or only locally occurring species. Some European bat species are difficult to identify and often need a period of observation to secure a safe species identification. In such cases the bat researcher has to remain at the spot of first encounter for a variable amount of time to secure a good recording of the species, or to move around to find the species again.

Methods that are based on line transects or listening points generally do not include prolonged stops at a given point. This means the occurrence of rare species is often underestimated or missed altogether and samples of rarer species will often be insufficient for statistical analyses.

It is not possible to actually count numbers of bats using this method. However, repeated surveys over the years, in the same selected areas and using a standardised method will reveal changes in species occurrence and distribution and gives the earliest indications of disappearance as well as expansion to new sites. High species richness can be an indicator of habitat quality so this method could be useful for general monitoring of the environment.

3.2.1 Species suitability

Potentially all European species can be detected using this method, particularly where there is relatively low species richness.

3.2.2 Technical requirements

The method requires the use of high quality bat detectors (heterodyne combined with time expansion or high speed recording) and good quality recordings of long sequences of bat calls. For some species visual clues about behaviour and appearance are also needed, sometimes with a strong handheld lamp (Ahlén & Baagøe 1999). In some cases field work also involves the use of other methods such as searches inside buildings or other structures, netting and automatic registration.

Automatic Recording Devices (ARDs) or "autoboxes" can also be used. These act as a complement to detectors, especially in species rich sites. The boxes collect time-expansion or high speed recordings of high technical quality and most species can be identified. The efficiency of finding all species is likely to be improved by adding this method. Instructions should be given on the best positions for the boxes and appropriate use of netting or visual observations.

3.2.3 Sampling

Specific geographical units are selected for survey, *e.g.* 10 x 10 km square grid or small administrative units. Within each area select one or more main sites (known from atlases or inventories) should be selected to have the highest possible bat species richness for the region (*i.e.* by drawing a polygon with coordinates on the map). If necessary, smaller satellite sites with supplementary biotopes are included to ensure registration of bat species missed in the main site(s). Main sites are usually between 1-10 hectares depending on diversity and configuration of biotopes. Satellite sites are often smaller.

Sites are surveyed on foot, with detectors, under optimal weather conditions, during "prime time", *i.e.* the first four hours after sunset. The different habitats and localities within the site are visited several times during this period to cover differences between species in time of emergence, commuting and foraging. This may include visits inside large barns or other buildings (*e.g.* for *Plecotus*). Satellite sites can be visited later the same night, but still within the "prime time".

ARDs can be used especially in areas with high species richness, or in one or more of the satellite sites. If any species remain unidentified, the same site, or a satellite site, is visited the following night, using netting or other supplementary activities.

3.2.4 Timing

Most often surveys are carried out during one night in the breeding season in the first four hours after sunset, when females remain in an area and generally forage short distances from maternity roosts. Roosts are often found during surveys with bat detectors. There are also periods between hibernation and breeding, both in spring and autumn, when bats use insect rich habitats which are restricted to small areas. It is necessary to find and protect these key habitats because the bats may depend on them for their survival at certain times of the year.

3.2.5 Number of counts

Surveys can be repeated at regular intervals, *i.e.* every six years (to coincide with frequency of Habitats Directive reporting). Repeated survey in each of the selected areas reveals changes in presence or absence of species. The number of encounters or number of bats hunting together or swarming can give a rough estimate of bat abundance.

3.2.6 Skills

Bat detector researchers need high quality training to attain the capability necessary for finding all species and for recording and analysing bat sounds. Those with a good ear quickly learn to distinguish the easy bat species by sound, and over time they can build up great skill in distinguishing also small differences in sound quality, rhythm and frequency. Most people have initial difficulties and need a couple of seasons of intensive field experience to build up enough skill to be able to work professionally with detector-based surveys or monitoring.

Individual human beings have quite different abilities to learn to use sound, and there is no doubt that some people will never learn to use this technique, in spite of great effort, especially if their sound memory is not good enough. This is a problem, especially since this lack of "ear" cannot be fully compensated for by recording the sounds and visualizing them on the computer screen. But it should not prevent those who can from using the technique.

3.2.7 Data management, analysis and quality control

Quantification and analysis is based on presence/absence data at a number of sites in each surveyed region. Sound recordings must be stored and made available. Subsequent control is sometimes useful for verification when dealing with species records in new areas and in difficult identification cases.

3.2.8 Example: The Danish bat surveillance programme 2005-2010

This surveillance method has been commonly used with great success for many years in Sweden and Denmark (Ahlén & Baagøe 1999). The current programme has been running for four years. Main sites and satellite sites in 26 selected 10 km UTM squares are surveyed each year during the

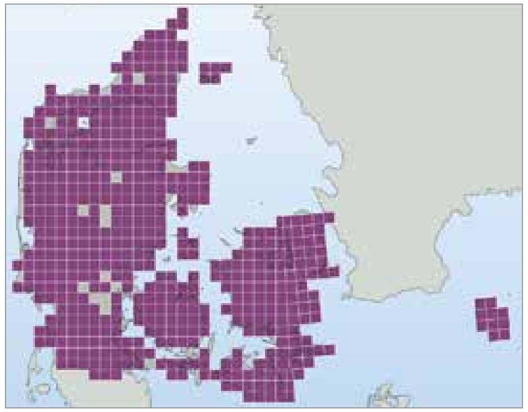

Figure 4. "Standard Bat"- All Danish 10 km UTM squares visited at least one night with high quality bat detectors under optimal conditions in 1981-2004 (provided by H. Baagøe).

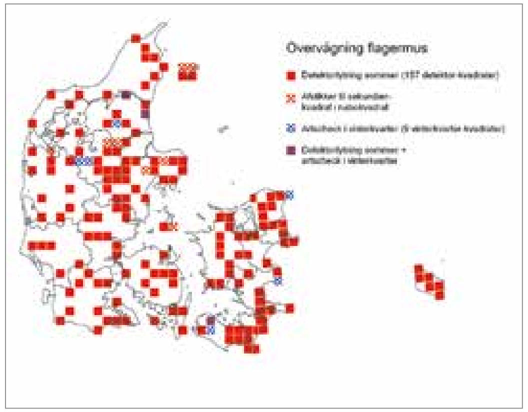

Figure 5. Based on knowledge about bat species occurrence in each of the squares in Figure 1, 157 squares of special interest were selected (red squares). In these squares main sites and sometimes satellite sites were selected for surveillance for bat species richness (provided by H. Baagøe).

Red rasters: satellite sites in neighbouring squares.

Blue rasters: surveillance in well known winter roosts.

Figure 6. Polygon showing one of the surveillance sites in one of the selected squares (provided by H. Baagøe; map source: the National Survey and Cadastre, Denmark).

breeding season (Figures 4, 5, 6). Results are entered into a database.

3.3 Walked bat detector transects for foraging bats

Ultrasonic-detector surveys using pre-defined sampling methods provide the most statistically-robust and repeatable surveillance, although they provide an index of abundance rather than absolute density. Standardisation of bat detector surveys is possible using line-transects and point-counts. Line-transect surveys require the observer to follow a pre-determined path of known length; point-counts require the observer to listen at a fixed point for a known time. The two methods can be combined to give estimates of relative abundance of species being surveyed.

Some bat species forage preferentially or even exclusively over water bodies such as rivers and lakes; the standard field survey methods can be adapted for use at waterways to collect data on population trends for those species.

Remote automatic recording of bats can replace surveyors in certain circumstances to record bat presence in a particular habitat.

3.3.1 Species suitability

Counts away from roosts using bat detectors are most suitable for any species which has a loud and distinctive echolocation call. At water bodies the method is most suitable for *Myotis daubentonii* and *Myotis dasycneme*. The method can also be applied to *Myotis capaccinii* in areas where *M. daubentonii* and *M. capaccinii* are not sympatric.

3.3.2 Sampling

Sampling areas may be chosen in a variety of ways, provided these do not violate the need for a repeatable sampling method and a random, or stratified-random, selection of areas if at all possible. Sampling should cover a wide range of habitat types (these may be the strata) rather than just selecting the habitats most likely to contain bats. For a survey of waterways, data are collected in a simple, repeatable fashion at a random selection of water bodies.

Suitable sampling may be based on selecting squares from the national mapping system (non-stratified) or selecting areas from a national land-classification scheme (stratified). Within these areas, line-transects, point-counts or a combination of both can then be set up according to a standard methodology. Suitable line-transects may involve a walk across or around the square, or a random 1 km stretch of water body (Walsh & Harris 1996a and 1996b, Masing *et al.* 2004).

3.3.3 Timing

Sampling effort should be well-defined, either by setting the length of transect to be followed (at a constant speed) or by pre-defining the time to be spent at each sampling point. Similarly, the time of day when sampling is to be carried out should be standardised. Sampling should commence at a given time related to sunset and continue for at least one hour and up to three hours. The timing of survey of a given transect will depend on whether early or late flying species are being detected.

Surveying waterways should be carried out during the months of peak bat activity (May-August).

3.3.4 Number of counts

Surveyors should make a day visit to each site to secure landowner permission and to assess the site for safety and familiarisation. The number of counts that should be carried out during the active season will depend on resources available. Generally, the more counts that are completed at each sampling point the lower the associated sampling variation. However, it is statistically preferable to sample more areas (use more replicates) than to sample areas more intensively (repeated measures at fewer sites). Two to three counts per area is probably a good number, but if bat activity in a certain area has to be evaluated carefully, up to five surveys per year could be made.

For surveying waterways, surveyors should mark out ten points, approximately 100 m apart, along a 1 km stretch. On two evenings during the survey months, surveyors should stand at each of the ten points for four minutes, recording bat activity with a heterodyne detector. A torch should be used to confirm the bat is flying close to the water surface, a behavioural characteristic of *Myotis daubentonii* (dry ultrasounds with maximum at 45 kHz, flight 5-15 cm above water surface) and *Myotis dasycneme* (dry or wet ultrasounds at 60-25 kHz with maximum at 35 kHz, flight 15-60 cm above water surface). If it is difficult to estimate height then flying speed can be used. See species account for how this method might also apply to *M. capaccinii*.

3.3.5 Data management and analysis

All separate bat passes (a "bat pass" can be defined as a sequence of two or more echolocation calls registered as a bat passes within the range of a microphone (Fenton 1988 and 2001, Walsh & Harris 1996) should be recorded on a map (for transects) or associated with a sampling point (for point-counts). For analysis, the classification of habitat along a transect or around each point should be completed during a day-time visit.

3.3.6 Example: Bat detector surveys in Germany

In Germany a proposal was made for standardising bat detector surveys in order to fulfil the EC Habitats Directive reporting requirements (Dietz & Simon 2005). Recommendations were as follows:

- In each survey area at least one line-transect should be allocated per 500 ha. Line-transects should include several habitat types.
- Each line-transect should be 1.5 to 2 km long with surveyors taking about 8 minutes to walk each 100 m section.
- Line-transects should be surveyed five times per year, between the end of April and mid-September. All surveys should be carried out under good weather conditions.
- If particular species need to be recorded (*e.g. Myotis myotis*) additional 100 m line-transects could be selected in the most promising habitats. These specific transects should be surveyed five times per year, taking 15 minutes to walk the transect.

3.4 Bat detector transects along roads using moving vehicles

At a minimum, vehicle-based projects deliver high quality distributional data for common species and will identify distributional changes in common species with good sensitivity. Through annual monitoring, they will also provide statistically robust conclusions on population trends of common species along roadsides.

Annual vehicle-based surveillance should have high year to year precision, provided the following factors are recorded: 1) start time; 2) survey date; 3) route taken; 4) roadside habitats noted; 5) same bat detector system is used. Roads are easy features to follow and normally well identified on maps.

3.4.1 Species suitability

This method is generally restricted to open/edge species such as *Pipistrellus* spp., *Nyctalus* spp., *Eptesicus* spp. and *Vespertilio murinus* as they are loud echolocators that are found foraging in open habitats along roadsides. *Miniopterus schreibersii* might be suitable, because although it forages in closed habitats, or high in the air, it is also found at street lamps, but not where it is sympatric with *Pipistrellus pygmaeus*.

3.4.2 Sampling

The protocol should be designed to minimise variation between repeat visits. Any detector system could be used, but once a system has been selected then the same system should be used on each survey.

Survey transects should be representative of landscape types (not forgetting the inherent bias in following roads). The landscape to be surveyed can be divided into 30 km blocks and a selection of these blocks chosen at random. This provides a structure and target number of blocks to be surveyed.

3.4.3 Timing

Ideally surveillance should coincide with the pre-parturition period (April to June depending on latitude) to avoid annual "noise" from numbers of volant young and does not have to coincide with the highest period of activity. The annual survey date, start time and starting point should be consistent between years and repeat surveys should take place under similar environmental conditions.

3.4.4 Number of counts

Surveyors drive each route, with each survey transect driven no faster than 25 km/h. The route should be driven (preferably twice) annually within a four-week period. More transects can be driven if resources allow, to increase survey sensitivity. As surveillance is likely to be long-term, costs should be minimised.

3.4.5 Count method

Surveyors can design a route within each 30 km block that is roughly circular and of approximately 100 km length, which can be driven within a four-hour period.

The route can be divided into transects of *e.g.* 1.6 km length, 3.2 km apart. Each transect can then be defined as an independent sampling unit. Thus for each route driven, 20 independent sampling units are surveyed, providing a large sample size from a few nights of survey. The distance between each survey transect, combined with the driving speed, makes it highly unlikely that the same bat could be recorded on more than one survey transect.

Adding stopping points or sections alongside rivers, canals or at other water bodies means that *Myotis cappacinii*, *M. daubentonii* and *M. dasycneme* could also be detected using this method.

Driving speed alters recorded peak frequencies due to Doppler Shift and this can result in misidentification of species. For this reason vehicles should be driven at a constant slow speed where possible (no more than 25 km/h).

3.4.6 Data management and analysis

The main advantage of the vehicle-based survey is that few surveyors are required to deliver a large number of sites. For example, based on power analysis, a single surveyor could collect sufficient data with ten nights of fieldwork to provide a statistically defensible surveillance project.

Roadside habitats are unlikely to be in proportion to habitats available in the wider countryside and this introduces biased habitat sampling. There is potential for streetlights to attract certain species and give an over-estimate of species abundance along roads in relation to actual abundance in the wider countryside. There is also potential for roads to be developed at a different rate and in a different way to the general countryside, introducing other biases in data collection. It is important therefore to note bat encounter rates at streetlights and any changes in type and number of lights over time, and any road development activity.

With these biases in mind, great care must be exercised if attempting to extrapolate bat encounter rates from vehicle-based surveys to the wider countryside, because they could lead to erroneous conclusions. If this is to be attempted then, at the very least, roadside habitat assessments should be made. For example, preliminary results from vehicle-based surveys in the UK suggest that pipistrelle bats are more likely to be encountered along roads with boundary features than featureless roads (see also Verboom 1998). Thus we assume that the vehicle-based survey is monitoring pipi-

Table 1. Results of the Republic of Ireland Car Survey power analysis.
The table shows the number of years required to detect Amber and Red Alert in relation to the number of squares surveyed.

Squares	*Pipistrellus pipistrellus*		*Pipistrellus pygmaeus*		*Nyctalus leisleri*	
	Amber	Red	Amber	Red	Amber	Red
10	>25	11	>25	11	>25	12
15	19	10	24	10	>25	11
20	16	9	20	9	24	10
25	15	7	17	8	19	9

strelle bats at boundary features (not the roads themselves) and if further research confirms this, then encounter rates of bats along roads with boundaries can be extrapolated to include boundary features away from roads.

3.4.7 Example: Republic of Ireland Car Survey

A pilot survey using this method was carried out in the Republic of Ireland in 2004 (Roche *et al.* 2005). Table 1 shows the results of power analyses, indicating the number of years of surveying required to achieve 90% power to detect Amber Alert (25% decline in 25 years) and Red Alert (50% decline over 25 years) for each species. All results using two repeat surveys of each square per year (each square with 20 transects of 1.6 km).

3.5 Counts at maternity roosts

Counts of bats at maternity roosts are a traditional method for monitoring the status of roosts. Information can be used to make an assessment of the importance of the roost at local, regional, national and international levels through collation and analysis of data. Counts of bats in, or emerging from, maternity roosts have also often been used as a way of monitoring the status of a species.

External counts of bats emerging from roosts are preferred to counts inside roosts to minimise disturbance, but may not always be possible. In some cases it is better to carry out counts inside the roost, usually when colonies are very large, or where bats roost in mixed species groups and identification with a bat detector on emergence is very difficult.

Internal counting is the method most widely used in central and eastern Europe where buildings, such as churches and castles, have very large attic spaces, allowing surveyors to go in and survey without disturbing the bats. Colonies are usually highly philopatric and faithful to their roosts throughout the breeding season. In southern countries and in central Europe, maternity colonies of some species such as *M. schreibersii*, *R. euryale*, *M. myotis* and *M. capaccinii* are often found in mixed groups in warmer mines and caves throughout the summer and internal counts are required to estimate numbers of the separate species. One advantage of internal counts is that multiple species can be encountered at the same site. It is also possible for surveyors to survey multiple sites in a day and fewer surveyors are required than on field projects to collect the same data quantity.

Non-invasive counting for small colonies can also been performed using DNA analyses of bat droppings using specific markers (Puechmaille & Petit 2007, Puechmaille *et al.* 2007). Small samples of droppings collected from beneath the maternity colony at known intervals (weekly, fortnightly or monthly) may be dried and stored in small, labelled canisters. If surveillance highlights population declines, samples can be analysed for diet content and contaminants.

3.5.1 Species suitability

The most suitable species for colony counts are those where:

- The bats appear to be relatively faithful to their maternity roosts, and return predictably to the same site each year;
- The establishment of a new colony is a rare event;
- The species tends to form large colonies;
- The bats can easily be distinguished from other species which may be present.

Examples of such species include *Rhinolophus euryale*, *R. ferrumequinum*, *R. hipposideros*, *R. mehelyi*, *Myotis blythii*, *M. capaccinii*, *M. dasycneme*, *M. emarginatus*, *M. myotis*, *M. nattereri*, *Miniopterus schreibersii*, *Plecotus* spp.

Colony counts are less appropriate for species that often use a network of roosts and where individuals frequently change between roosts. Internal counts are also generally not appropriate for crevice dwelling species, where only a proportion of the bats may be seen at any time. Such species include *Pipistrellus pipistrellus*, *Eptesicus serotinus* and *Barbastella barbastellus* (Simon *et al.* 2004). However, in the case of *Eptesicus* certain sites are suitable for internal counts (several cases in Slovenia and Serbia).

Species such as *M. myotis* and *M. dasycneme*, and to some extent *Rhinolophus* spp., also use networks of sites in some regions, and the numbers in the central roost might fluctuate. However, these species have a tendency toward the model of a "central important roost" with "satellites", so this surveillance method is considered appropriate.

3.5.2 Sampling

In countries or regions where the species is widespread, a sample of sites should be counted on a regular basis, with roosts selected to give a range of roost sizes (number of bats), geographic locations and land use types. Stratified random sampling of roosts, with strata selected for roost size and/or land use type probably provides the most statistically robust methodology. Where the species is rare, it may be possible to count all known sites.

3.5.3 Timing

Counts need to be timed to take account of the breeding season, which will vary with climate. Local research may be required to determine this before setting up a monitoring project. Counts should generally be timed to occur between the time when bats arrive in the maternity roost and the time that the earliest births occur, usually between late April and mid July depending on latitude. This will give an indication of the number of adult females in the population associated with the maternity site.

3.5.4 Number of counts

At least one count should be carried out annually, covering the period between the arrival of bats and the first possible date for parturition. The preferred method involves two counts during this period, but the logistics and cost of organising counts may mean that only one is possible. If data on reproductive success are required, another count should be carried out prior to colony dispersal. Statistical advice suggests that it is better to increase the sample of roosts than to increase the number of counts at each roost. However, it is also important that the agreed number of counts is carried out at each roost and that the same time period is used each year.

3.5.5 Count methods

Counts of emerging bats

• Observers should ensure that all entrances to the roost are known and be stationed outside each entrance, but not so close as to disturb the bats or obstruct their flight lines. The number of bats emerging in each five minute period should be recorded.

• Recording should begin when the first bat emerges and end when it is too dark to continue counting, or no bat has emerged for ten minutes.

• The roost entrances should not be illuminated with white light. It is recommended that no torch is used, though one fitted with a dark-red filter may be acceptable (Downs *et al.* 2003).

• Ultrasonic detectors can be used to give warning of the approach of a bat. They should be tuned to an appropriate frequency and used with headphones.

• Counts should not be made in bad weather conditions, or on nights with previous bad weather, as this is known to inhibit bats from emerging. Bad weather conditions include low temperature, rain or strong winds.

• In some cases, for instance when colonies are very large but it is not possible to do internal counts (see below), filming of bats emerging from the roosts using infrared videos connected to bat detectors is desirable. Several caves in southern Europe have very large colonies of bats that cannot be counted using internal counts due to difficulties in accessing all parts of the cave, large mixed clusters of bats or the height of the roosting places. In such caves several evenings are necessary to determine the emergence time and behaviour of different species and to assess species richness and numbers.

• Another method in cases of very large colonies (>5,000 ind.) where thousands of bats emerge within a few minutes can be to count or assess, respectively, emerging bats over a period of one minute and to repeat this one-minute-count every five minutes. The number of bats for the five-minutes-period then can be calculated by extrapolation of the numbers of the one-minute-counts, taking the middle of two consecutive one-minute-counts per minute (Rudolph *et al.* 2005). However, in such cases it is necessary to observe the roost and the bats behaviour in two consecutive nights and to conduct the monitoring with two observers.

Counts inside the roost

• In regions where mixed species groups occur, a photographic method of counting bats inside the roost may be appropriate. The main advantage of this method is minimising the time spent with the colony and, therefore, minimising disturbance, which is especially important for some shy (sensitive) species such as *R. ferrumequinum* and *R. hipposideros*. The least invasive methods involve the use of infrared camera techniques used in combination with a reflector with IR filter. For large colonies a stick of known length can be used to calibrate the subsequent estimation of surface area covered by individuals.

• This type of count should be carried out by two people, one taking photographs, the other holding the light, and should be completed as quickly as possible. It is best to take photos of separate groups of bats, but if groups are too large, then 2-3 photos of a group can be taken, shifting the focus of the camera each time. One of the main limitations of this method is the distance from counter to colony.

• One or two counts during the season should be sufficient. Surveyors should have some knowledge of identifying species and all crevices and timbers should be checked using a torch. Droppings located underneath timbers are a good indication of presence.

• Bats are less disturbed by red light; a red filter can be applied to the torches. Counts should be carried out in the morning and early afternoon because bats start to fly around in mid-afternoon. Strong torches are needed for high ceilings.

• Counts can be carried out in any kind of weather conditions, but colonies are less active and easier to count when temperatures are cooler.

Measuring colony productivity

Measuring the productivity of a maternity colony may be possible in some circumstances with some species. For some cave-dwelling bats and species that preferentially roost in buildings it may be possible to enter the roost after the adult evening emergence and to count the non-volant young. In cases where the adults remain with the young after the young are able to fly, such as some *Myotis* species, a recorded increase in the colony size post-weaning may indicate the number of young weaned. However, in some species such as *Eptesicus serotinus* and *Pipistrellus pipistrellus*, the adult females depart as soon as the young are capable of feeding themselves and the spread of weaning dates means that there may be no marked increase in the colony size, or any such increase may not reflect the full productivity of the colony.

3.5.6 Example: Measuring colony productivity of *Rhinolophus ferrumequinum* in the UK

To measure the productivity of *R. ferrumequinum* colonies three annual counts can be done:

1. Emergence count of females in the second or third week of June (A = number of females);
2. Emergence count of females in the first two weeks of July with a count in the colony when females have left (control of A; B = number of juveniles);
3. Emergence count in the last week of July or first week of August (control of A and B; C = number of dead juveniles in the colony) (Ransome 1998).

3.5.7 Data management and analysis

Counting roosting or swarming bats usually involves non-random selection of survey sites. The sites tend to be ones that are known about, often because they are visible sites with large numbers of bats. If the sample size of roosts is sufficiently large then any biases in the dataset introduced as a result of being non-random are probably not important, but it is a factor to consider.

Colony counts are not the most statistically robust method for assessing population trends, because of the non-random sampling method. However, for some species that predominantly dwell in buildings and are highly philopatric, it is a robust method for assessing population trends if the majority of potential buildings are surveyed.

The relationship between trends in species' colony size and population trends has not been established, but comparison of different survey methods over time may help to provide the required information.

3.5.8 Example: Estimating numbers of colonies of *Nyctalus noctula* within a roost network in Hungary and other central European countries

In Hungary, *Nyctalus noctula* is a very common species in the housing estates of large towns, where it roosts in the crevices of prefabricated panels of tall ten-storey houses (Bihari 2004). *N. noctula* is very active before sunset, and can be heard squeaking very loudly. The monitoring method described below has been used in 19 towns and 3 housing estates in Budapest to estimate population size for the species.

Method:

In the housing estates a transect is chosen which passes 40 houses. Surveyors walk the transect twice, first along one side and then on the other side of the houses, listening for the sound of bats. The aim is to locate the position of bat roosts and mark the location on a map.

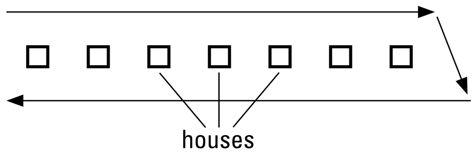

Figure 7. Scheme of walked transects along houses.

Two counts are carried out at least seven days apart, the first count between 1-15 September, and the second count between 16-30 September. Counts are carried out on calm, clear days with no rain, starting half an hour before sunset. The number of colonies along a transect and the number of buildings on each housing estate are counted to provide an estimate of the number of colonies in a town.

3.5.9 Colony counts in bat boxes

Counts of colonies using bat boxes has been suggested as a surveillance method. However, bat boxes only occasionally hold an entire colony and counts are unlikely to be representative of the general population or to produce a comparative national or even regional picture, because breeding success in boxes is likely to be different from natural sites. There are additional issues of potential disruption to bat communities through placing large numbers of bat boxes in semi-natural woodland and disturbance to bats because boxes might need to be invasively checked for occupancy and numbers. Therefore, the effect of introducing bat boxes to woodlands needs to be thoroughly investigated before bat box occupancy can be considered as a surveillance strategy.

Counts in bat boxes may, however, be the only suitable method for some woodland species whose natural roosts are seldom found and which often use a roost network (for example *Myotis bechsteinii*, *M. daubentonii* and *M. nattereri*, *Barbastella barbastellus*, *Plecotus auritus*). Furthermore, these species often live in locations where species cannot easily be surveyed using other methods, or where species seldom use buildings as roosts. In these cases the sampling unit is the area of woodland and not the individual bat-box. Bat boxes are especially useful in artificial (mainly non-native coniferous) forests where natural roosts are lacking or rare. In such forests real population trends can be measured (*e.g.* Schmidt 2000, Blohm 2003, Heise & Blohm 2003; see also overview in Meschede & Heller 2000). In semi-natural forests this method can at least contribute to determining the occurring species spectrum and status of bats.

3.6 Counts at hibernation sites

Some bat species aggregate at hibernation sites during the winter months and it is possible to make annual counts of the number of bats encountered. Hibernation counts are particularly useful in assessing the importance of a site for conservation purposes; site data collected by monitoring programmes can be used to inform decisions when considering site protection under national and international designations.

One advantage of hibernation site monitoring is that multiple species can be encountered at the same site. It is also possible for surveyors to survey multiple sites in a day and fewer surveyors are required than on field projects to collect the same data quantity.

One problem with hibernation site surveys is that the relationship between the number of bats seen and the number of bats present is not always clear. In complex sites bats can hide away in cracks and crevices and it is not always possible for surveyors to see all of them. As an example: Bad Segeberg cave in northern Germany is a cave with lots of fissures. About 300 individual bats are visible upon normal visual inspection. About 15,000 (mostly *M. nattereri* and *M. daubentonii*) are present when counted with infrared detection (Kugelschafter *et al.* 1995). For complex sites like this an assumption for population trend analysis is that the proportion of bats seen to the number of bats actually present remains constant over time.

In roost sites with large spaces species identification can be problematic because of poor visibility or low light and because the bats could be a long distance away from the surveyor. In such cases the reliability of collected data must be evaluated in order to avoid biases.

Bats are vulnerable to disturbance when hibernating and strict protocols should be observed before and during hibernation site surveys. Some species can be hard to identify unless they are handled, but handling is not recommended as it is considered too disturbing and could affect the survival of the bat.

3.6.1 Species suitability

Counts of bats in hibernation sites are most suitable for species where:

- The species is faithful to the site;
- The species can be identified accurately without disturbance;

- The species hibernates in large numbers at one site;
- A high proportion of the population regularly hibernates underground.

3.6.2 Sampling

In countries or regions where the species is widespread, a sample of underground sites should be counted on a regular basis, with sites selected to give a range of sizes (number of bats), geographic conditions and land-use types. Stratified-random sampling, with strata selected for roost size and/or land-use type probably provides the most statistically-robust methodology, though the accessibility of sites is likely to influence the sampling methods. Where the species is rare, it may be possible to count all known sites.

Areas where only small numbers of individuals are found, spread across many sites, present great difficulties for hibernation site monitoring and it is probably better to attempt to find maternity sites.

3.6.3 Timing

The extent to which bats occupy hibernation sites depends on the local climate; in some parts of Europe bats may be active throughout most of the year. This makes the method more reliable in the northern part of species' ranges, where the bats will remain in hibernation sites for longer periods. Counts are probably best done in January or February, but local research may be required to check this before setting up a monitoring project.

The weather conditions can influence the hibernation behaviour of bat species that are tolerant of low temperatures: in Germany, for example, a strong dependence between the number of hibernating barbastelle and Natterer's bats and the temperatures the days before a count has been observed, leading to low numbers of these bats in hibernacula if the temperatures are several (5-10) degrees above 0° C and to much higher numbers if temperatures are just around or below zero (*e.g.* Meschede & Rudolph 2004). Therefore, cold weather conditions should be preferred within the time period of winter counts.

3.6.4 Number of counts

The logistics and cost of organising counts and the danger of disturbance to bats means that the number of counts at each site should be limited to a maximum of two per winter (preferably one count), carried out at least two weeks apart. To reduce disturbance to a minimum and following statistical advice, it is better to organise counts at more sites than to increase the number of counts at each site. However, it is also important that the agreed number of counts is carried out at each roost and that the same time period is used each year.

3.6.5 Count method

When large numbers are present, it may be better to estimate the area the bats cover through the use of photography or video camera. Strong torches are needed for high ceilings. In some cases binoculars are very helpful. Notes should be kept annually for each site indicating which areas were searched and the main areas in which bats were found. This provides useful information for future surveyors.

It is preferable to adopt the same counting method each year, so that valid comparisons can be drawn. If the count method is changed, any differences should be recorded. Ideally, the extension of counting to new parts of a site should be recorded separately. Data should be recorded separately for each site, or each sub-site, particularly if parts of the site are liable to flooding or other climatic factors that may make it impossible to count all parts of the site each year.

3.7 Surveys of mating roosts

Tree roosts, including bat boxes, are often occupied by advertising males displaying territorial behaviour. Such roosts can be found by following the advertising calls, which can be heard without technical aid in some species. It is most efficient to survey along edges of forests and water, especially near larger rivers and lakes, because such places are preferred by males of some species.

3.7.1 Species suitability

This method is most suitable for species where the males display territorial mating behaviour and generally have loud display behaviour, notably *Nyctalus noctula*, *N. leisleri* and *Pipistrellus nathusii* (in trees and houses), but also *Myotis dasycneme* (found in mating roosts, but without loud display behaviour). *P. pygmaeus* and *P. pipistrellus* do not advertise from a stationary site but in a territory. As with breeding birds this behaviour can be used to assess territories and numbers of advertising males.

3.7.2 Sampling

Surveys of mating roosts in tree holes or bat boxes follow the same procedures as surveys of maternity colonies at such places, counting the number of emerging bats. However, one could also use the advertisement calls of the species and take the number of advertising males as the parameter for monitoring. The whole area can be surveyed and a cluster analysis performed, or transect and relative numbers from year to year can be used.

3.7.3 Timing

The best time to survey mating roosts is during peak migration in the region, and this will vary across Europe. For *e.g. Nyctalus noctula* and *Pipistrellus nathusii* the peak in advertisement behaviour seems to coincide with the peak in migrating females passing by.

In the region of Bonn, Germany, some bat boxes are occupied by *P. nathusii* from August to September and then by *N. noctula* throughout the winter.

3.7.4 Number of counts

During migration the number of females in the mating roost of a territorial male changes from day to day. For this reason roost surveys should be carried out every week until there are no longer any bats present.

3.8 Surveys at swarming sites

In late summer and autumn some species begin to migrate to sites where mating and/or hibernation take place. During this period, large numbers of bats can be encountered at some sites, swarming inside and outside the site. This is primarily a mating event, since it occurs long before hibernation, but probably also serves to check hibernation sites and guide inexperienced juveniles to them.

Swarming sites attract very large populations of bats (thousands) from large catchment areas (~100 km radius or more), with many hundreds visiting a site each night at the peak of the season. The number of species present varies from five in the north of England to ten or more in other parts of Europe. Two hundred or more individuals may be caught per night at the "best" sites, representing an estimated 5-20% of the bats present each night. Individual bats are faithful to one or a small number of sites. Every late summer/autumn a very high proportion of these bats will visit their swarming site(s) on one or more occasions. Surveillance of swarming sites can therefore provide a useful index of the status of a number of species over a very large area.

Swarming populations are dominated by males (60-90%), but it is not known if this is a real sex bias or an artifact of differences in behaviour that make them easier to catch (Kerth *et al.* 2003, Rivers *et al*. 2006).

3.8.1 Species suitability

The method is suited for those species that appear to use a mating strategy that involves extensive chasing flights in large bat assemblages (hence the term swarming), these include *Myotis bechsteinii*, *M. brandtii*, *M. dasycneme*, *M. daubentonii*, *M. myotis*, *M. nattereri*, *M. mystacinus*, almost certainly other *Myotis* species, *Eptesicus nilssonii*, *Barbastella barbastellus*, *Plecotus auritus* and *P. austriacus* and possibly other species (see Meschede & Rudolph 2004). Some of these bats cannot be surveyed easily using other methods.

3.8.2 Sampling

One possible surveillance method would be to place automatic loggers at the entrance to swarming sites to log bat passes per minute for a period of at least a week, ideally several, in early September. Although species identification would be difficult or impossible, it would give an index of the bats visiting the site to mate (and perhaps later hibernate) from the large catchment. It could be repeated with ease each year.

It should be noted that species composition can vary considerably through August and September, so some initial investigation is needed to determine patterns of activity of different species. Harp-trapping / mist-netting can be used to determine the species present and their relative abundance. Following the initial assessment of species numbers, catching bats at intervals can be used to keep track of species present and their relative abundance.

Because of the often large numbers of bats, harp traps are preferred to mist nets and should be used whenever possible. The number of traps and/or nets used will depend on the size and number of entrances to the site. However, the numbers and positions should be identical each year. Traps and nets should not prevent bats from entering or leaving the site, to minimise disturbance.

3.8.3 Timing

Catching should be carried out on dry nights with little wind. Do not catch on more than three consecutive nights: although there is considerable turnover of individuals each night, some bats will learn the position of traps and nets. Swarming activity peaks vary between species and depending on latitude. In southern Germany it starts with *Eptesicus nilssonii* in mid-July, followed by *Myotis brandtii* and *Barbastella barbastellus* at the end of July. The swarming activity of other species peaks between mid-August and mid-September, but can continue until mid-October (*e.g. M. nattereri*, see Meschede & Rudolph 2004). In the UK, swarming activity peaks between mid-August and mid-September. Peak activity is 4-5 hours after sunset but again may vary across Europe.

3.9 Remote automatic recording

This method can be used to record bats where it is not possible to use surveyors. Recent developments in technology allow a range of bat species to be recorded and their calls identified with sonogram analysis. Remote automatic recording can be carried out using a heterodyne detector connected to a device that allows recording of full spectra or time-expanded calls. The method is generally restricted to single species surveys *e.g.* surveying *M. daubentonii* over a water body or at potential sites for wind turbine construction.

3.9.1 Sampling

Sampling can be done at different sites and for different purposes. Placed at the entrance of roosts *e.g.* of caves, it can give an indication of the onset of activities either in spring at a hibernation site, or in summer for the timing of emergence activities. Due to possible swarming activities at such sites, numbers of emerging bats cannot be counted reliably.

Placing bat boxes or other automatic recording units at cave entrances or other roosts can make species identification difficult because bats often change their typical sounds inside or close to roosts. Other possible positions to use automatic recorders may be along linear landscape features, such as waterways, hedgerows or forest edges, to monitor the use of flightpaths by a species.

3.9.2 Timing and number of counts

The device has to be used in accordance with the needed monitoring data. Surveys for wind turbine installations should start early in the season, shortly after hibernation, to identify possible migration routes *e.g.* of *Nyctalus noctula* through an area. Surveys at cave entrances to monitor post-hibernation activities should be done at least twice during the six-week early spring period *e.g.* after the last nights of severe frost.

Recordings during the main bat activity period should include at least two settings of the recording device, with the detector placed at the same spot each time and tuned to the same frequency.

3.9.3 Data management

All separate bat passes have to be identified clearly. Care should be taken to identify other bat species using similar echolocation frequencies to the chosen one. Misidentification could occur due to the skewed tonal quality of the registered calls.

3.10 Catching bats

Invasive methods involving catching and handling of bats, including the use of bat attractors, harp traps and mist nets, are not generally recommended for the purposes of surveillance because of the potentially high levels of disturbance to bats. However, they are extremely useful for initial research prior to setting up surveillance schemes, for periodic assessments of bat abundance and when identification of emerging bats must partly be verified by netting of some specimens. Netting can also be the only method to determine the ratio of some species in mixed groups. Furthermore, they may be appropriate when the two main surveillance options, bat detector transects or roost counts, cannot be employed effectively and there are no other current alternatives.

Catching can be used to identify bat species that cannot be recognised with a bat detector, to confirm the sex and the reproductive status of abundant bats, or to obtain specimens for radio tagging, or in the case of swarming sites, periodically to assess changes in species relative abundance (as described in 3.8.2).

Catching generally requires a license. Rigorous training is required in both putting up nets correctly and in removing bats from them to minimise distress to the bats. Harp traps are preferred to mist nets since they are more efficient (bats are less able to detect them), cause less distress and require minimal training in use. However, their small catching area means they are only useful at roost entrances or where the bats are moving along natural flyways such as woodland paths or small streams. They are also heavy and expensive. Mist nets are more versatile (available in 2.6 to >18 m lengths), light and easy to carry but it is possible to be overwhelmed by bats if care is not taken. Mist nets and harp traps should never be left unattended and should be checked every few minutes.

3.10.1 Sampling

Bats are capable of detecting and avoiding both harp traps and mist nets, but careful positioning and the element of surprise allows both to be used with considerable success. Capture success declines rapidly if the bats are given time to learn the positions of nets and traps, so it is best to move them every night if catching is to be carried out on consecutive nights (with some exceptions, *e.g.* at swarming sites). The fine mist nets designed for catching birds or those specifically designed for bats are equally successful, but their efficiency declines rapidly under even moderately windy conditions since bats are better able to detect moving objects. Harp traps can be used very successfully in conjunction with nets, the latter steering the more alert bats towards a trap.

Netting is especially successful in forests and across rivers.

3.10.2 Example: Netting study in Germany

A study in Germany (Dietz & Simon 2005) showed that the optimum number of netting sites is related to the area being surveyed.

Most efficient is the period from May to August. Netting should start shortly before sunset and last for six to eight hours, although the first three to four hours may be the most productive since bat activity is often concentrated in the first half of the night and whole-night observations make the monitoring very expensive.

Table 2. Optimum number of netting sites related to the size of area being surveyed.

area size	number of netting sites
<30 ha	1
30-250 ha	2
251-500 ha	3
501-1,000 ha	4
>10 km²	6
>100 km²	8

3.11 Ringing

Ringing of bats is not recommended as a surveillance method. Ringing can be used for particular research projects, often those that extend over many years, and can provide very useful information on population structure and migration behaviour. However, ringing bats to assess population trends is inappropriate because of the invasive nature of the method and because it is unlikely to provide any useful information for surveillance purposes. Ringing generally requires a license and best practice guidance on ringing and catching bats has been produced by the EUROBATS Advisory Committee (EUROBATS Resolution 4.6: Guidelines for the Issue of Permits for the Capture and Study of Captured Wild Bats, adopted in 2003; Hutterer *et al.* 2005).

3.12 Best practice to be adopted when carrying out bat surveys

Surveillance of bats and their roosts is a long-term activity, over many years if robust population trends are to be derived. The methods generally involve repeated counts and visits to the same sites at least annually and may involve entry into the roost site or catching and tracking of bats. It is therefore very important to follow a strict code of practice to ensure that all the surveillance activity does not have detrimental effects on the populations of bats that are to be conserved. The recommendations listed below address the main factors to consider when surveying bats and their roosts and follow the best practice guidance on ringing and catching bats (see chapter 3.11).

3.12.1 Surveys of winter and summer bat roost sites

- Any survey should be carried out with the approval of the owner or administrator of the roost site (excluding roost sites both located on public land and with open access).
- During hibernation, counting and identification of bats should be done without waking or catching them.
- Only electrical light should be used during counting. Use of light sources with a flame (torches, candles) is unacceptable. Using modern conventional or LED-based lighting systems, specifically designed for use in caves, it is possible to survey even the longest and most technically difficult caves. Strong torches can be used for high ceilings and red lights should be used in maternity roosts to minimise disturbance.
- The survey (counting) duration as well as the identification of each animal should be kept to the minimum necessary.
- During surveys of summer colonies, counting and identification of bats in the roost should be done without catching them if at all possible. Single individuals may be caught only if there is no other way to identify the species, but this should not be done while non-flying young are in the colony.
- It is important to be as quiet as possible when carrying out the survey so as not to disturb the bats. The number of people in a survey group (summer and winter) should also be kept to a minimum.
- Survey of roost sites at any time of year should not be carried out more than twice a year with at least one month between visits, and in the event that research on seasonal

population dynamics is justified, not more than once every two weeks.

• Any damage to the bat roost structure is unacceptable (*e.g.* making holes in walls, removing rubble blocking corridors, draining water, removal of parts of the roof or bark sheets) even where these activities would increase the effectiveness of the survey.

3.12.2 Catching bats

• Catching bats around breeding colonies when non-flying young are present should only be carried out if there is no other way to identify the species reliably using less invasive methods (*e.g.* daytime surveys, ultrasound detection). If catching bats is necessary then the number of individuals caught should be kept to a minimum.

• No catching should be carried out during the expected time of parturition.

• Where nets and other traps are used, they should not be left unattended and should be checked every 3-10 minutes, depending on numbers of bats present.

• When removing bats from the net, check first if the netting is caught in the bat's teeth, and if so, it should be removed very carefully (this particularly concerns small species). Disentanglement should proceed as quickly as possible. The animal should be held softly with one hand and the other hand used to take the bat out the same way it entered the net (*e.g.* Kunz 1988, Barlow 1999).

• When the bat is disentangled it should be placed in a fabric bag to minimise stress for the animal.

• The time the individual is captured must be kept to the minimum necessary – ideally not exceeding ten minutes. Visibly pregnant and nursing females should be released immediately after removal from the net. If many bats are captured at the same time then additional catches should be stopped until all animals have been disentangled.

• In the event that a large number of bats are caught at the same time, preferably individuals should be placed in separate bags. Individuals of *Rhinolophus* spp. should always be in separate bags. Pregnant and nursing females should be dealt with immediately.

• After examination, bats should be released immediately. If a bat does not fly from the hand it should be placed on a tree trunk or a branch. Captured bats may lower their body temperature for energetic purposes and then need some time to heat up before departure. For this reason bats must not be thrown in the air for release.

4 Species accounts

EUROBATS Resolution 2.2 originally recommended methods for a selected group of species that could be surveyed in many countries to represent the range of bat behaviour and habitat patterns found in European bat species. This group included: *Rhinolophus hipposideros*, *Myotis myotis* / *M. blythii*, *M. bechsteinii*, *M. capaccinii*, *Eptesicus serotinus* / *E. nilssonii*, *Nyctalus noctula*, *Miniopterus schreibersii*. However, recommendations are provided here for all European species, taking into account the variety of factors affecting species in individual countries.

Species nomenclature follows the Annex of species occurring in Europe to which the EUROBATS Agreement applies as adopted in Resolution 5.3 (2006).

Methods are listed for each species in order of preference, but this order can be different according to the number of bats, the size of the sites, and the region of Europe. The accounts and methods will need to be periodically updated in the light of new information and regional variations.

Although not specifically included as a method, DNA analysis of droppings, wing punch and hair follicle samples, gathered under licence, can help in the identification of species which is particularly useful where bats occur in mixed groups.

The maps provided were compiled by the IUCN/SSC Chiroptera Specialist Group and its collaborators in 2005 for the IUCN Global Mammal Assessment (IUCN 2008). For updated maps readers are advised to consult the IUCN database and more recent literature.

4.1 Pteropodidae

4.1.1 *Rousettus aegyptiacus* (Geoffroy, 1810)

Figure 8. Distribution of Rousettus aegyptiacus.

Recommended methods

1. Counts at maternity roosts, internal, if access is possible, or emergence.

Other information

Colonies can be hard to find and access depends on circumstances *e.g.* by sea canoe for remote colonies. The species emerges very late and flies very low so emergence counts may not be applicable. However, they are faithful to sites.

This species is considered a pest by local fruit farmers and is often persecuted. These bats can be conspicuous in car headlights as they fly low across roads from tree to tree. It may be possible to carry out car headlight surveys but at present this method requires testing and development of a protocol.

4.2 Emballonuridae

4.2.1 *Taphozous nudiventris* Cretzschmar, 1830

Figure 9. Distribution of Taphozous nudiventris.

Recommended methods

1. Colony counts, internal or emergence.

Other information

There is only one recorded site in the EUROBATS Agreement area (in eastern Turkey). The species needs further survey and status assessment before any monitoring can be entertained (using mist nets and bat detectors). The known site is a bit remote, but should be checked as and when possible (*e.g.* counting at the roost).

4.3 Rhinolophidae

4.3.1 *Rhinolophus blasii* Peters, 1866

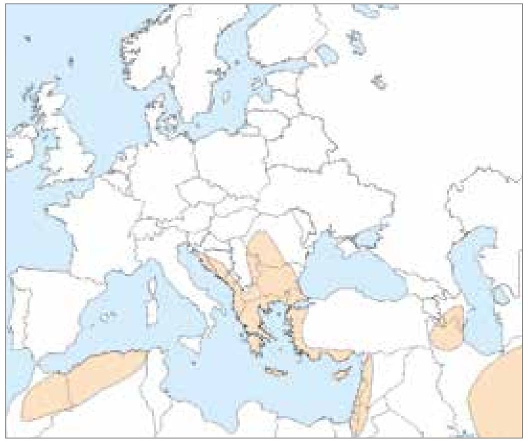

Figure 10. Distribution of Rhinolophus blasii.

Recommended methods

1. Counts at maternity roots.
2. Counts at hibernation sites.

Other information

The species has a relatively quiet and highly directional echolocation call; the use of ultrasonic detectors is usually inappropriate but possible in some sites. It is considered to be an exclusively cave-dwelling species, natural or man-made, and appears to be faithful to its underground roosts.

The general problem for surveillance of all "middle" sized horseshoe bats – *R. euryale*, *R. mehelyi* and *R. blasii* – is that they often form mixed colonies in which the visual separation of each species is impossible in south-eastern Europe. Preliminary research, involving catching bats for species identification and assessment of the proportion of each species, is required for each site. This could be repeated at five yearly intervals to assess any changes in relative proportions of each species.

4.3.2 *Rhinolophus euryale* Blasius, 1853

Figure 11. Distribution of Rhinolophus euryale.

Recommended methods

1. Counts at hibernation sites.
2. Counts at maternity roosts, internal or emergence, if colonies are known to be faithful to their roost sites.

Other information

The species has quiet and highly directional echolocation calls, and the use of ultrasonic detectors is therefore usually inappropriate but possible in some sites. The species is particularly faithful to its hibernation roosts, while some maternity colonies move between roosts.

The species is susceptible to disturbance. Roost fidelity can be increased through protection of the site. The general problem for surveillance of all "middle" sized horseshoe bats – *R. euryale*, *R. mehelyi* and *R. blasii* – is that they often form mixed colonies in which the visual separation of each species is impossible in south-eastern Europe. Preliminary research, involving catching bats for species identification and assessment of the proportion of each species, is required for each site.

4.3.3 *Rhinolophus ferrumequinum* (Schreber, 1774)

Figure 12. Distribution of Rhinolophus ferrumequinum.

Recommended methods

1. Counts at maternity roosts, emergence if possible, from late June to mid-July (if not mixed with other species and colony size <400 individuals), possibly using digital photography for large groups inside roosts.
2. Counts at hibernation sites by visual determination with one winter census between 15 December and late February (when not mixed with other Rhinolophid species), again using photographic methods for large groups.

Other information

Echolocation calls are intense but highly directional and observer held detectors rarely pick up bats unless they are detected moving along commuting routes. However, static detector systems can be used successfully to confirm suspected commuting routes and foraging areas within suitable foraging habitats near linear features.

R. ferrumequinum often lives during summer and winter in colonies mixed with other Rhinolophid species or with *Myotis emarginatus* (Pir *et al.* 2004). This sometimes makes monitoring difficult.

4.3.4 *Rhinolophus hipposideros* (Bechstein, 1800)

Figure 13. Distribution of Rhinolophus hipposideros.

Recommended methods

1. Counts at maternity roosts, emergence or internal.
2. Counts at hibernation sites.

Other information

The species has a quiet and highly directional echolocation call; the use of ultrasonic detectors is therefore inappropriate. It appears to be faithful to its maternity roosts and depends completely on underground sites for hibernation.

In western Europe, summer emergence counts are favoured over hibernation counts because populations are more aggregated during the breeding season than during hibernation. In central Europe counts at hibernation sites are preferred.

4.3.5 *Rhinolophus mehelyi* Matschie, 1901

Figure 14. Distribution of Rhinolophus mehelyi.

Recommended methods

1. Counts at maternity roosts, emergence or internal.
2. Counts at hibernation sites.

Other information

The species has a relatively quiet and highly directional echolocation call; the use of ultrasonic detectors is therefore inappropriate. It appears to be faithful to its underground roosts.

A general problem for the monitoring of all „middle" sized horseshoe bats in the Balkans – *R. euryale*, *R. mehelyi* and *R. blasii* – is that they often form mixed colonies in which the visual separation of each species is impossible. Preliminary research involving catching of bats for species identification and assessment of the proportion of each species is required for each site, which can be repeated at five yearly intervals.

4.4 Vespertilionidae

4.4.1 *Barbastella barbastellus* (Schreber, 1774)

Figure 15. Distribution of Barbastella barbastellus.

Recommended methods

1. Bat detector surveys in woodlands.
2. Counts at maternity roosts, emergence.
3. Counts at hibernation sites.

Other information

It is possible to identify *B. barbastellus* from echolocation calls with reasonable confidence and this opens possibilities for carrying out field surveys. The species tends to be scarce in the landscape so is difficult to encounter, but commutes long distances along regular flight lines to foraging areas, which aids detection. Colony counts are difficult because colonies constantly divide and move locations.

Accurate population estimates for each colony will rely on the invasive techniques of a radio-tracked individual coupled with infrared camcorder roost exit counts. This procedure is best undertaken during early August when the colonies are at their largest and most stable. Although invasive, radio-tracking is the only method consistently reliable enough at revealing roost locations to ensure at least partly accurate emergence counts.

Occasionally individuals will utilise open buildings or barns in very cold weather, but normally they are active in all milder spells throughout the winter. In the more continental climate of central Europe *B. barbastellus* widely hibernates in colder underground sites. In these areas there are possibilities for winter surveillance.

Long-term roost surveillance and monitoring should cover both an estimate of the number of breeding females in a colony and the quality of the habitat. Foraging habitat quality can be assessed by species richness, particularly botanical and insect diversity.

4.4.2 *Barbastella darjelingensis* (Hodgson, 1855)

Figure 16. Distribution of Barbastella darjelingensis.

Recommended methods

1. Bat detector surveys along water courses and scattered trees and shrubs.

4.4.3 *Eptesicus bottae* (Peters, 1869)

Figure 17. Distribution of Eptesicus bottae.

Recommended methods

1. Bat detector surveys.

Other information

This species has a distinctive echolocation call (Holderied *et al.* 2005).

4.4.4 *Eptesicus nilssonii* (Keyserling & Blasius, 1839)

Figure 18. Distribution of Eptesicus nilssonii.

Recommended methods

1. Bat detector surveys, including car surveys.
2. Counts at hibernation sites in parts of central and eastern Europe and higher altitudes in the southern part of its distribution.
3. Counts at maternity roosts, emergence (but may have low site fidelity in some places).

Other information

The species has loud calls which are distinctive from all other species.

4.4.5 *Eptesicus serotinus* (Schreber, 1774)

Figure 19. Distribution of Eptesicus serotinus.

Recommended methods

1. Bat detector surveys, including car surveys.
2. Counts at maternity roosts, emergence (or internal in suitable roosts).
3. Remote automatic recording.

Other information

The species has loud echolocation calls which are distinctive from all other species (however in cluttered habitats there is risk of confusion with *Nyctalus leisleri* and *Vespertilio murinus*). Hibernation sites for the species are not generally known.

The species is synanthropic throughout most of its range. It is therefore highly dependent on conservation measures and the attitude of private house owners. For roof-inhabiting serotines, at least two counts are recommended: one in mid-May after the establishment of colonies, and one in mid-/end-June before young become volant. Crevice-inhabiting colonies differ almost daily in numbers and all known roosts of the colony have to be followed to get accurate numbers. Radio transmitters can be fitted to individuals caught at drinking/foraging sites to locate roosts, *e.g.* in countries where there are no known roosts.

4.4.6 *Hypsugo savii* (Bonaparte, 1837)

Figure 20. Distribution of Hypsugo savii.

Recommended methods

1. Bat detector surveys.

Other information

Survey can possibly be carried out using balloons with remote recording equipment attached.

The roosts of *H. savii* are difficult to find, although some roosts can be found in buildings. They can be located by fitting transmitters on individuals caught at foraging/drinking sites.

The species has calls that are distinctive from all other species (except in cluttered habitats, where there is a risk of confusion with *Pipistrellus* species). It is important to take account of the vertical distribution of this species when foraging as it is often found flying above the tree canopy at relatively high altitudes compared with other species. *H. savii,* like several other species, seems to roam widely to different foraging areas (Russo & Jones 2003) to feed on swarming insects, so counts could vary a lot within a short period and should be repeated many times during summer.

4.4.7 *Myotis alcathoe* von Helversen & Heller, 2001

Figure 21. Distribution of Myotis alcathoe.

Recommended methods

1. Mist-netting and identification in the hand is the only known option at present and can provide some useful information.

Other information

The echolocation calls of this species cannot be separated for identification purposes from those of other *Myotis* species.

Molecular analyses are required to confirm species occurrence in areas where this species has not yet been recorded.

4.4.8 *Myotis aurascens* Kuzyakin, 1935

Figure 22. Distribution of Myotis aurascens.

Recommended methods

1. Mist-netting and identification in the hand is the only known option at present and can provide some useful information.

Other information

Molecular analyses are required to confirm species occurrence in areas where this species has not yet been recorded.

4.4.9 *Myotis bechsteinii* (Kuhl, 1817)

Figure 23. Distribution of Myotis bechsteinii.

Recommended methods

1. Use artificially produced social calls to attract foraging specimens into mist nets or harp traps and follow up with radio-tracking to locate roosts. Use infrared camcorders to carry out emergence counts.
2. Surveys at swarming sites.

Other information

This species has a close association with semi-natural woodland. The bats habitually forage in tree crowns at some distance from the ground. This behaviour makes it particularly difficult to monitor their quiet echolocation calls with ultrasonic detectors.

The constant shifting and dividing of maternity colonies makes accurate counts difficult and the species rarely hibernates where it can be counted.

M. bechsteinii is caught in sufficient numbers at mating swarming sites in late summer and this could offer a potential for surveillance. These swarming animals are, however, predominantly male and too little is currently known about male/female birth proportions and survival rates to make population predictions based on male numbers alone. Counting juvenile bats at swarming sites may hold possibilities, but the bats need to be caught and handled to identify them. Swarming sites are not known across wide areas so how relevant the data would be from the few currently known swarming sites is unknown.

Echolocation calls are very quiet and often difficult to separate from some other *Myotis* species. For long-term population monitoring the numbers of breeding females in a selected number of maternity roosts should be assessed and estimated every five years. A habitat assessment should form part of this exercise.

4.4.10 *Myotis blythii* (Tomes, 1857)

Figure 24. Distribution of Myotis blythii.

Recommended methods

1. Counts at hibernation sites.
2. Counts at maternity roosts, internal. For separate colonies emergence counts are possible.

Other information

It is possible to use photographic methods to identify species (see also 4.4.17). Identification of the difference from *M. myotis* is difficult with ultrasonic detectors and also visually in mixed colonies. *M. blythii* may have a distinctive white patch on the top of its head, making it distinguishable from *M. myotis* while roosting, although identification remains difficult. In most cases it would be wise not to distinguish between *M. blythii* and *M. myotis* where they live in mixed colonies. These species are faithful to their summer and winter roosts.

Preliminary research, involving catching bats for species identification and assessment of the proportion of each species, is required for each site. This could be repeated at five yearly intervals to assess any changes in relative proportions of each species.

4.4.11 *Myotis brandtii* (Eversmann, 1845)

Figure 25. Distribution of Myotis brandtii.

Recommended methods

1. Counts at hibernation sites with mass occurrence of the species.
2. Surveys at swarming sites.

3. Netting over water bodies or in forest clearings could be useful if the other methods are not appropriate.

Other information

Ultrasonic detectors are not appropriate for this species because of the current impossibility of distinguishing it from other closely related *Myotis* species.

The species can be confused with *M. alcathoe* and *M. mystacinus* which are very similar. Punch samples of wing membrane can be gathered, under licence, for possible later confirmation of identification.

4.4.12 *Myotis capaccinii* (Bonaparte, 1837)

Figure 26. Distribution of Myotis capaccinii.

Recommended methods

1. Counts at hibernation sites (south-eastern Europe).
2. Counts at maternity roosts, internal (south-western and south-eastern Europe).
3. Bat detector surveys, except where the species is sympatric with *M. daubentonii*.

Other information

It is possible to use digital photography for large colonies (1 m^2 corresponding to about 2,000 specimens in Croatia). Ultrasonic detectors are inappropriate for this species where it is sympatric with *M. daubentonii*.

The species may form mixed colonies with *M. myotis* / *M. blythii* / *Miniopterus schreibersii.*

In some roosts in south-western Europe it is possible to count the young using photography after the adults have emerged, which could give a measure of colony productivity. This procedure may be inappropriate for large colonies in south-eastern Europe.

4.4.13 *Myotis dasycneme* (Boie, 1825)

Figure 27. Distribution of Myotis dasycneme.

Recommended methods

1. Bat detector surveys, using point count method around water bodies.
2. Counts at maternity roosts, emergence.
3. Counts at hibernation sites.
4. Surveys at swarming sites.

Other information

It is possible to distinguish this species from other trawling bats acoustically and visually (Britton *et al.* 1997).

4.4.14 *Myotis daubentonii* (Kuhl, 1817)

Figure 28. Distribution of Myotis daubentonii.

Recommended methods

1. Bat detector surveys where *Myotis capaccinii* does not occur, using point count method around water bodies using a torch to confirm identity from flight style.
2. Counts at hibernation sites, although the species can be hard to identify because it may use crevices during hibernation.
3. Surveys at swarming sites.
4. Remote automatic recording under bridges.

Other information

The foraging style means that the species can easily be identified foraging over water bodies, but there is a high risk of confusion where *M. capaccinii* and *M. dasycneme* are also present.

4.4.15 *Myotis emarginatus* (Geoffroy, 1806)

Figure 29. Distribution of Myotis emarginatus.

Recommended methods

1. Counts at hibernation sites.
   Counts at maternity roosts, internal. This is the preferred method in a large part of Europe.
2. Surveys at swarming sites.

Other information

Preferably one hibernation count should be carried out to avoid disturbance, but with a maximum of two, as the species is very sensitive.

There is a risk of confusion with other middle-sized *Myotis* species in hibernation sites when animals roost in deep crevices. The species uses several roosts and the number of individuals in maternity roosts changes from one year to another or even from the beginning to the end of the breeding season (Pir 2004), making surveillance using colony counts difficult. In Croatia, 1 m^2 corresponds to about 2,000 individuals. There is no evidence that bat detector transects are effective for this species.

4.4.16 *Myotis hajastanicus* Argyropulo, 1939

Figure 30. Distribution of Myotis hajastanicus.

Recommended methods

There are no known methods for this species, but the same methods as for other *Myotis* species can probably be used. Only known from Armenia, where internal counting is the only method possible at present.

Other information

There is only one locality known, in Armenia, with small groups of 1-5 individuals.

4.4.17 *Myotis myotis* (Borkhausen, 1797)

Figure 31. Distribution of Myotis myotis.

Recommended methods

1. Counts at maternity roosts; emergence counts are possible for monospecific colonies (particularly in the north). However, the species often uses many exit points so care needs to be taken when organising the count.
2. Counts at hibernation site, again using photographic methods.

Other information

Internal counts in large attic roosts or caves are possible using digital photography (1 m^2 corresponding to about 1,300 specimens in Croatia, 1,000 specimens in Portugal). Identification of the difference from *Myotis blythii* is difficult with ultrasonic detectors and also visually in mixed colonies. *M. blythii* may have a distinctive white patch on the back of its head, making it distinguishable from *M. myotis* while roosting, although identification remains difficult. In most cases it would be wise not to distinguish between *M. blythii* and *M. myotis* where they live in mixed colonies. These species are faithful to their summer and winter roosts.

4.4.18 *Myotis mystacinus* (Kuhl, 1817)

Figure 32. Distribution of Myotis mystacinus.

Recommended methods

1. Counts at hibernation sites with mass occurrence of the species.
2. Surveys at swarming sites.
3. Mist-netting in suitable habitats could be useful if no other methods are appropriate.

Other information

Ultrasonic detectors are inappropriate for this species because of the current impossibility of distinguishing it from other closely related *Myotis* species (see *M. alcathoe*). The species can be confused with *M. alcathoe* and *M. brandtii* (see under those species).

4.4.19 *Myotis nattereri* (Kuhl, 1817)

Figure 33. Distribution of Myotis nattereri.

Recommended methods

1. Counts at hibernation sites. The species is often found in underground sites and is easy to identify in central Europe; there is a risk of confusion with other middle-sized *Myotis* in southern Europe.
2. Counts at maternity roosts, internal.
3. Surveys at swarming sites.
4. If no other alternative is possible then mist-netting in forests provides some information.

Other information

Internal counts at maternity roosts can be very difficult because this is a crevice-dwelling species and its presence is often not obvious.

Surveillance using ultrasonic detectors is not recommended because of confusion with other foraging *Myotis* species. It may be recognised from time-expansion recordings of echolocation calls, especially in cluttered habitat, due to its broad frequency bandwidth signals (Russo & Jones 2002).

Emergence counts at maternity roosts are also not very reliable because of the unpredictable behaviour of emerging bats, frequently returning to the roost and re-emerging, causing confusion in the counts.

4.4.20 *Myotis nipalensis* (Dobson, 1871)

Figure 34. Distribution of Myotis nipalensis.

Recommended methods

1. Counts at hibernation sites with mass occurrence of the species.
2. Surveys at swarming sites.
3. Netting over water bodies or in forest clearings could be useful.

Other information

Ultrasonic detectors are inappropriate for this species because of the current impossibility of distinguishing it from other closely related *Myotis* species.

The species can be confused with *M. alcathoe* and *M. brandtii*. Punch samples of wing membrane can be gathered, under licence, for possible later confirmation of identification.

4.4.21 *Myotis punicus* Felten, 1977

Figure 35. Distribution of Myotis punicus.

Recommended methods

1. Counts at maternity roosts, internal. Emergence counts are also possible, but the large size of colonies can make counting quite difficult.

4.4.22 *Myotis schaubi* Kormos, 1934

Figure 36. Distribution of Myotis schaubi.

Recommended methods

No colonies are known, but the methods would be the same as for *M. nattereri*.

4.4.23 *Nyctalus lasiopterus* (Schreber, 1780)

Figure 37. Distribution of Nyctalus lasiopterus.

Recommended methods

1. Bat detector surveys.

Other information

The use of accoustic lures may be effective. The species can be confused with *N. noctula*, but also with *Tadarida teniotis*, and therefore computer analysis of echolocation recordings is the only way to identify the three species (Bec *et al.* 2008).

N. lasiopterus is a large heavy bat with less manoeuvrable flight than other smaller bats. It is also highly associated with water bodies as it seems to need a regular water supply (possibly connected with its rapid flight) so individuals visit drinking places regularly. This means that mist-netting can be a good method for survey.

Mist nets placed on the banks of small ponds or streams with calm surfaces where the species comes to drink can be used to provide information on sex ratio and reproductive condition. It is important to use the same locations for the mist net each time and mist nets must be of similar quality (denier and mesh size). In Hungary mist-netting at such localities has been very successful. Absolute acoustic separation from *N. noctula* may not be possible except in very open habitats.

4.4.24 *Nyctalus leisleri* (Kuhl, 1817)

Figure 38. Distribution of Nyctalus leisleri.

Recommended methods

1. Bat detector surveys, including car surveys.
2. Counts at maternity roosts, emergence, where species roosts in buildings.
3. Surveys at mating roosts.

Other information

The species echolocation calls overlap with *Vespertilio murinus* and *Eptesicus serotinus*, and can be confused with *N. noctula*, the exact type of call dependent on the environment where it is found. Identification with reasonable confidence requires surveyors who have some previous experience of this species.

Absolute acoustic separation from *N. noctula* may not be possible except in very open habitats.

The mating calls of the species can be easily identified using time-expansion detectors and may be useful for monitoring from August to early October.

4.4.25 *Nyctalus noctula* (Schreber, 1774)

Figure 39. Distribution of Nyctalus noctula.

Recommended methods

1. Bat detector surveys, including car surveys.
2. Surveys at mating roosts, of calling males during the mating season.
3. Counts at maternity roosts.
4. Counts at hibernation sites.

Other information

Counts at maternity and hibernation sites probably do not give a reliable index of *N. noctula* population density. However, the species can be identified easily with a bat detector, except where *N. lasiopterus* is present. It is possible to hear this species in roosts during the day time.

4.4.26 *Otonycteris hemprichii* Peters, 1859

Figure 40. Distribution of Otonycteris hemprichii.

Recommended methods

1. Counts at maternity roosts.
2. If no other methods are available then netting at water bodies can provide some information.

4.4.27 *Pipistrellus kuhlii* (Kuhl, 1817)

Figure 41. Distribution of Pipistrellus kuhlii.

Recommended methods

1. Bat detector surveys.
2. Counts at maternity roosts.

Other information

It is important to be aware of the overlap between calls of *P. kuhlii* and *P. nathusii*. Social calls may resolve all risk of confusion between the two species (Russo & Jones 1999). See Russo & Jones (2002) for *P. kuhlii* frequencies.

4.4.28 *Pipistrellus nathusii* (Keyserling & Blasius, 1839)

Figure 42. Distribution of Pipistrellus nathusii.

Recommended methods

1. Bat detector surveys.
2. Surveys at mating roosts.
3. Counts at maternity roosts, emergence.
4. Surveys at swarming sites.

Other information

Broadband detectors can be used on field surveys with post-survey species identification through sonogram analysis. But beware overlap with *P. kuhlii*. Social calls may resolve all risk of confusion between the two species (Russo & Jones 1999). *P. nathusii* is a highly migratory species (Hutterer *et al.* 2005).

4.4.29 *Pipistrellus pipistrellus* (Schreber, 1774)

Figure 43. Distribution of Pipistrellus pipistrellus.

Recommended methods

1. Bat detector surveys, including car surveys.
2. Counts at maternity colonies, emergence.
3. Surveys at mating roosts.

Other information

There is little overlap in dominant frequencies of *P. pipistrellus* and *P. pygmaeus* (< 5% overlap at maternity roosts, Jones & van Parijs 1993).

The species has very distinctive and loud echolocation calls mostly around 45 kHz and can readily be identified using a bat detector, except in some southern areas where the distinctive calls are at 49 kHz. Frequency partly overlaps with *Miniopterus schreibersii*, social calls are needed to resolve the risk of confusion. The use of buildings as maternity roosts by this species means that colony counts during the summer are also an appropriate method. However, it should be noted that this is a very mobile species, with colonies moving location within and between years. Colonies may also grow and shrink in size during the breeding season, making colony counts of questionable reliability.

4.4.30 *Pipistrellus pygmaeus* (Leach, 1825)

Figure 44. Distribution of Pipistrellus pygmaeus.

Recommended methods

1. Bat detector surveys, including car surveys.
2. Counts at maternity roosts, emergence.
3. Surveys at mating roosts might be useful as social calls of this species and *P. pipistrellus* are usually (but not always) straightforward to separate.
4. Surveys at swarming sites.

Other information

Beware of overlap of calls from *P. pygmaeus* with those of *M. schreibersii* where the two species are sympatric (Russo & Jones 2002). There is little overlap in dominant frequencies of *P. pygmaeus* and *P. pipistrellus* (< 5% overlap at maternity roosts, Jones & van Parijs 1993).

The species has very distinctive and loud echolocation calls at 55 kHz and can readily be identified using a bat detector. The use of buildings as maternity roosts by this species means that colony counts during the summer may be a good monitoring method. Colonies of *P. pygmaeus* are larger and more stable than those of *P. pipistrellus*, perhaps rendering them more suitable to this type of monitoring.

4.4.31 *Plecotus auritus* (Linnaeus, 1758)

Figure 45. Distribution of Plecotus auritus.

Recommended methods

1. Counts at maternity roosts, emergence.
2. Counts at hibernation sites.
3. Surveys at swarming sites.
4. If no other alternative is possible then mist-netting provides some information.

Other information

The species is predominantly a woodland species and has very quiet echolocation calls. It is not usually encountered in the open countryside, so it is not suitable for bat detector surveys. It forms fairly stable colonies and tends to be philopatric, especially when roosting in buildings.

This species tends to emerge late in the evening and have a pattern of emerging in groups of two or three with a few minutes between groups. The species can, therefore, take a long time to emerge from roosts, so visibility of bats may be an issue, particularly for larger colonies where the last bats will be emerging quite late.

4.4.32 *Plecotus austriacus* (Fischer, 1829)

Figure 46. Distribution of Plecotus austriacus.

Recommended methods

1. Counts at maternity roosts, both internal and emergence.
2. Counts at hibernation sites, but only in some parts of the species range.
3. If no other alternative is possible then mist-netting provides some information.

4.4.33 *Plecotus kolombatovici* Dulic, 1980

Figure 47. Distribution of Plecotus kolombatovici.

Recommended methods

1. Counts at maternity roosts would probably give a reliable index of *P. kolombatovici* population density. Possible problem could be identification of this species in areas of sympatry with other *Plecotus* species.
2. Locating new colonies using bat detectors during early morning swarming in front of summer roost sites.

4.4.34 *Plecotus macrobullaris* Kuzyakin, 1965

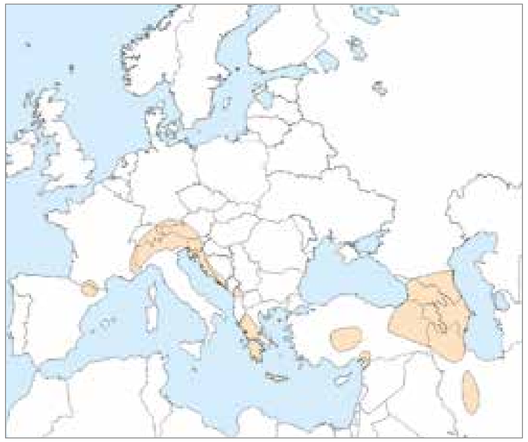

Figure 48. Distribution of Plecotus macrobullaris.

Recommended methods

1. Counts at maternity roosts should give reliable population density information.
2. If no other alternative is possible then mist-netting provides some information.

Other information

Bat detector surveillance is almost impossible and is not recommended. Preliminary mist-netting surveys may be required to determine true range and distribution.

4.4.35 *Plecotus sardus* Mucedda, Kiefer, Pidinchedda & Veith, 2002

Figure 49. Distribution of Plecotus sardus.

Recommended methods

Surveys are required to assess roost locations.

4.4.36 *Vespertilio murinus* Linnaeus, 1758

Figure 50. Distribution of Vespertilio murinus.

Recommended methods

1. Counts at maternity roosts, emergence; internal may sometimes be possible.
2. Bat detector surveys (line transects).
3. Surveys at mating sites.

Other information

The species has distinctive social calls, but echolocation calls can be confused with *Eptesicus serotinus* and *Nyctalus leisleri* (Schaub & Schnitzler 2007). *V. murinus* is a long-distance migrant in eastern and central Europe.

4.4.37 *Miniopterus schreibersii* (Kuhl, 1817)

Figure 51. Distribution of Miniopterus schreibersii.

Recommended methods

1. Counts at hibernation sites.
2. Counts at maternity roosts, internal.
3. Bat detector surveys.

Other information

A visual count should be undertaken as quickly as possible inside the cave or mine, assessing the size of the colony by estimating, through photography (stereoscopic if the roof is sloping), the square metre area which it covers (1 m² corresponding to about 2,000 individuals).

Beware of overlap of calls from *P. pygmaeus* / *P. pipistrellus* with those of *M. schreibersii* where the two/three species are sympatric (Russo & Jones 2002).

This species gathers in large numbers during winter. Colonies roosting above 15 m may be very difficult to count accurately. Females of one maternity colony can use several roosts in an area. Foraging areas of the species include edges of woodlands, hedgerows, orchards, and street lamps in some places.

4.5 Molossidae

4.5.1 *Tadarida teniotis* (Rafinesque, 1814)

Figure 52. Distribution of Tadarida teniotis.

Recommended methods

1. Bat detector surveys in foraging habitats. Echolocation calls are quite distinctive and can be heard at long range (Russo & Jones 2002).
2. Counts at maternity roosts, emergence, are possible, mainly for colonies roosting in buildings.

Other information

T. teniotis emits loud and audible echolocation calls, so sound surveys in summer are recommended for surveillance of the species for trained operators. The presence of *Nyctalus lasiopterus* with overlapping echolocation calls makes confirmation of identification with computer analysis necessary (Bec *et al.* 2008).

4.6 Summary table of species and methods

Table 3. Recommended methods for the monitoring and surveillance for European bat species. The numbers in columns indicate the order of preference of methods for each species. This order can change according to the number of bats, the size of the sites, and the region of Europe.

Table 3 (cont.)

Species	Methods									
	Bat detector survey			Colony counts		Hibernation survey	Mating roosts	Swarming sites	Remote recording	Catching bats
	Field	Car	Water	Internal	Emergence					
Pteropodidae										
Rousettus aegyptiacus				1						
Emballonuridae										
Taphozous nudiventris				1	1					
Rhinolophidae										
Rhinolophus blasii				1	1	2				
Rhinolophus euryale				2	2	1				
Rhinolophus ferrumequinum					1	2				
Rhinolophus hipposideros				1	1	2				
Rhinolophus mehelyi				1	1	2				
Vespertilionidae										
Barbastella barbastellus	1				2	3				
Barbastella darjelingensis			1							
Eptesicus bottae	1									
Eptesicus nilssonii	1	1			3	2				
Eptesicus serotinus	1	1			2				3	
Hypsugo savii	1									
Myotis alcathoe										1
Myotis aurascens										1
Myotis bechsteinii					1			2		1
Myotis blythii				2	2	1				
Myotis brandtii						1		2		3
Myotis capaccinii			3	2		1				
Myotis dasycneme			1		2	3		4		
Myotis daubentonii			1			2		3	4	
Myotis emarginatus				1		1		2		
Myotis hajastanicus				1						
Myotis myotis				1	1	2				
Myotis mystacinus						1		2		3
Myotis nattereri				2		1		3		
Myotis nipalensis						1		2		3
Myotis punicus				1	1					
Myotis schaubi				2		1		3		
Nyctalus lasiopterus	1									
Nyctalus leisleri	1	1			2		3			
Nyctalus noctula	1	1			3	4	2			
Otonycteris hemprichii					1					2
Pipistrellus kuhlii	1				2					
Pipistrellus nathusii	1				3		2	4		
Pipistrellus pipistrellus	1	1			2		3			
Pipistrellus pygmaeus	1	1			2		3	4		
Plecotus auritus					1	2		3		4
Plecotus austriacus				1	1	2				3
Plecotus kolombatovici					1					
Plecotus macrobullaris					1					2
Plecotus sardus										
Vespertilio murinus	2			1	1		3			
Miniopterus schreibersii	3			2		1				
Molossidae										
Tadarida teniotis	1				2					

5 National bat monitoring programmes

Some examples of bat monitoring programmes in European countries are provided here to show how the guidelines on survey methods can be applied in practice for a range of species.

5.1 Belgium

5.1.1 Introduction

Bat monitoring in Wallonia started in the 1940s and has been organised by Jacques Fairon (National Royal Institute for Natural Sciences, Brussels) from the 1960s. Since 1990 it has been part of the regional surveillance programme. Monitoring methods have been established for winter and summer surveys.

5.1.2 Surveying hibernacula

A number of representative underground sites per natural region of Wallonia have been identified (95 out of 712 underground sites have been selected). Timing and number of visits and use of equipment have been standardised (no carbid lamps!). Emphasis is on respect of conservation issues (no handling of bats, avoidance of disturbance to hibernating animals).

5.1.3 Surveying summer roosts

Estimating colony size and change in size is carried out through counts of droppings. Maternity roosts are located and species identified. Roosting places within the site are identified and plastic foil of standardised size is put under the main roosting places of the colony. The plastic sheeting is checked at regular time intervals, and the presence and size of the colony can be estimated according to the number (classified) of droppings. This method is especially useful if monitoring a large number of roosts and emergence counts are not possible. It minimises the disturbance caused by internal counting.

These long-term standardised surveys show country level population trends of all species and in relation to the natural regions where they occur.

5.2 France

5.2.1 Introduction

Bat surveillance has been ongoing in France for several decades, and has provided information on the dramatic decline of many bat species, particularly horseshoe bats (Brosset 1978, Brosset *et al.* 1988). However, surveys were restricted to a few main roosts and often carried out at a regional level (*e.g.* Faugier 1983, Ariagno & Salaün 1991, Faugier & Issartel 1993, Noël 2002).

In the 1990s a long-term surveillance programme for Annex II Habitats Directive species was initiated during the National Bat Meeting in Bourges. This surveillance was planned on an annual basis for wintering *Rhinolophus ferrumequinum* and was partly possible because of the dramatic increase in the number of bat workers. Later on, during the period 1999-2003, a five-year Action Plan for bats was implemented by the French mammal society (SFEPM). One aim of this first Action Plan was to survey annually some priority species and to test new methods.

Finally, in order to fill the gaps of the two previous surveys, regional surveillance was carried out mainly by counting rhinolophids in hibernacula and mapping the distribution of all species. All work has been carried out on a voluntary basis.

5.2.2 Long-term winter and summer surveys

In 1995 the first national survey attempted to estimate the populations of the twelve Habitats Directive Annex II species (Roué *et al.* 1997). The number of bats was recorded for both hibernation sites and nursery roosts selected by surveyors. In winter, bats were counted inside the roosts by volunteers. Disturbance of bats was kept to a minimum, with one visit only, no handling (excluding some for identification, and bats hidden deep in cracks), a small number of counters, and limiting the time spent in the hibernacula to an absolute minimum. Sites were surveyed preferably on the same day each year, usually from mid-January to mid-February. In summer, colony counts were traditionally carried out from late May to mid-July depending on the species. Counts were either inside the roost for a very short visit or during emergence with or without a bat detector.

This investigation highlighted a great disparity between regions, as the majority of the surveys were conducted in the northern half of the country and only localised information came from the southern part. A report was produced in 1995 to make the national and local authorities aware of the necessity to conserve these mammals and it gave the ministry in charge of the environment the incentive to start an Action Plan.

In 2004, a new assessment of bat populations was made, nearly ten years after the 1995 report. This assessment showed that the disparity between regions previously reported still exists, although systematic inventories have started in some regions, explaining the increase in numbers of sites and bats. However, some large areas of the country still need to be investigated.

As data from some areas or for some species had not been communicated at the time of the compilation, a full analysis could not be carried out. But some comment can be made for *Miniopterus schreibersii*.

After the exceptional mortality that affected *Miniopterus schreibersii* in France, Portugal and Spain in 2002, population decline on a national scale has been observed, but is still difficult to evaluate in the absence of national monitoring of all hibernation and maternity roosts. For this species, the absolute protection of its roosts seems to be the prerequisite that will allow its population to recover.

Table 4. Seasonal counting of French bat roosts at a nine-year interval, after Roué et al. (1997), Groupe Chiroptères SFEPM (2010).
Rhinolophus ferrumequinum was also surveyed in 1999 (Ros 2002). Myotis myotis and Myotis blythii are sympatric in the south of France and even form mixed maternity colonies; as they cannot always be identified separately, a total for the two species combined is presented in addition to the separate counts.

Species	Year	Winter		Summer	
		Bats	Sites	Bats	Sites
Rhinolophus ferrumequinum	1995	21,268	810	6,430	270
	1999	28,422	1,433	10,572	210
	2004	42,043	1,823	19,171	291
Rhinolophus hipposideros	1995	5,930	909	10,644	578
	2004	15,268	2,199	31,212	1,496
Rhinolophus euryale	1995	2,899	51	3,616	49
	2004	9,367	117	6,524	48
Rhinolophus mehelyi	1995	5	1	0	0
	2004	1	1	0	0
Myotis myotis	1995	13,035	681	37,126	252
	2004	15,520	1,363	52,449	311
Myotis blythii	1995	1,116	9	8,685	32
	2004	2,537	118	21,362	97
Myotis myotis/blythii	1995	14,151	690	45,011	284
	2004	18,057	1,481	73,811	408
Myotis capaccinii	1995	541	35	1,525	21
	2004	720	78	3,803	14
Myotis dasycneme	1995	18	5	0	0
	2004	23	6	0	0
Myotis emarginatus	1995	9,670	345	7,681	123
	2004	18,240	751	35,251	198
Myotis bechsteinii	1995	732	239	191	30
	2004	823	528	135	8
Barbastella barbastellus	1995	1,983	239	1,155	51
	2004	4,886	528	3,141	200
Miniopterus schreibersii	1995	211,109	45	114,056	95
	2004	74,786	52	57,515	50

Table 5. Extent of the five-year surveillance program in France.
** if possible all sites; ** only roosts >100 individuals.*

Species	Winter		Summer		Method	Regions	Total sites
	North	South	North	South			
Rhinolophus ferrumequinum	✓		✓		general	10	20
Rhinolophus hipposideros	✓		✓		general	10	20
Rhinolophus euryale *	✓	✓			general	12	28
Myotis capaccinii *				✓	specific	3	14
Myotis emarginatus	✓		✓		general	11	22
Myotis myotis			✓		general	8	16
Barbastella barbastellus **	✓				general	6	6
Miniopterus schreibersii *	✓	✓			specific	10	22

5.2.3 Five-year surveillance programme 1999-2003

The first national action plan for bats (SFEPM 1999), included a programme of roost surveys of eight Habitats Directive Annex II species in winter and/or summer (Arthur *et al.* 2000).

Due to the large number of roosts for six species, only the two most important ones for each region and for each study season were selected (Table 5). During the five-year period the surveillance of some roosts was abandoned due to the disappearance of the colony or of the roost itself or because there was no volunteer to continue the survey. Survey protocols for each species were similar (see long-term surveillance) except for *Miniopterus schreibersii* (a species that forms very large colonies, see 5.2.7.) and *Myotis capaccinii* (often found in mixed colonies, see 5.2.8.).

The information collected included site characteristics (location, type of roost, protection and disturbance), the date of survey, the number of bats as well as some other data (isolated individuals, clusters, corpses *etc.*). The winter survey was scheduled between 15 January and 10 February, and the summer survey between 1 June and 15 July, before the young start flying, in order to count them at night once the adults have left to forage.

5.2.4 Regional surveys

Regional surveillance mainly involves rhinolophids that are easy to count in hibernacula, and was initiated some decades ago in some localities (Ariagno & Salaün 1991, Lustrat 1994, Barataud & Jourde 1999, Lustrat 2001, Ariagno *et al.* 2002, Auboin 2002, Noël 2002, Lustrat & Jullien 2003, Boireau 2006). For example, in the Ardèche department (south-eastern France), winter and summer roosts (mainly caves) have been surveyed annually since 1953 (Faugier 1983, Faugier & Issartel 1993). This long-term surveillance deals with seven cave-dwelling species (*Rhinolophus ferrumequinum*, *R. hipposideros*, *R. euryale*, *Myotis myotis*, *M. blythii*, *M. emarginatus* and *Miniopterus schreibersii*) in a total of 238 sites. The data are particularly good for a comparison between decades 1953-1963 and 1981-1991 because there was similar recording effort in the field.

Results of various field surveys (roost counts, mist-netting, bat detector records) are usually stored on a regional basis. These databases are then used to map the distribution of the species and possibly identify trends in the evolution of their range. For example in the region Midi-Pyrénées, all bat contacts are recorded by volunteers, either on field sheets or stored directly in a local Access database. Once a year the local datasets are collected into a regional database for analysis and mapping. For each species, bat workers must give information on the site: name of the locality, map number (IGN 1/50,000) and quadrant (8 quadrants per map) or preferably geographic coordinates (altitude included), date, number of bats, type of contact (seen alive, corpses, droppings), bat activity (breeding, hibernating, transit *etc.*), age and breeding status, habitat. Standardised field sheets with codings are provided to bat workers. Maps of bat presence/absence are then easily obtained on any kind of information: breeding colonies, hibernating sites, mating roosts *etc.* Maps can also provide information on gaps in survey effort in order to plan future work.

5.2.5 Surveyors and volunteer training

In France the majority of bat surveys rely on volunteers because universities are not interested in bat research at present. Volunteers are members of the local bat groups, they do not require any licence for counting bats, including inside roosts. However they must have undergone training and/or be accompanied by a licensed bat worker. On average over 300 volunteers take part every year. Volunteer training is organised by local bat groups across the country during field surveys conducted by licensed bat workers.

5.2.6 Databases

Data are stored in regional databases and population trend information is made available through reports and sometimes publications. Data for national reports are then extracted and centralised by the programme coordinators of SFEPM. No national database is available.

5.2.7 Recommended surveillance methods for *Miniopterus schreibersii*

This survey concerned ten regions for a total of 25 hibernation sites which were visited between 15 and 25 January for the most important ones and, if necessary, until 10 February for the others.

Protocol

The aim is to estimate the size of the colony by counting the number of individuals and the surface area covered by the colony on a photograph (with an aliquot[1] area of 400 cm²). Two surveyors are necessary for this work.

General remark

In a cave the roof and the walls are rarely flat and their relief is more or less strongly marked. As the photograph does not take the third dimension into account, it is necessary to establish relief classes which correspond to a percentage of additional surface area according to the slope.

- Index 0 = 0% (nonexistent or insignificant relief: slope from the horizontal <20°)
- Index 1 = +10% (slope around 30°)
- Index 2 = +25% (slope around 50°)
- Index 3 = +35% (slope around 60°)
- Index 4 = +55% (slope around 70°)
- Index 5 = +75% (slope around 80°)

On a sketch showing the form of the group the appropriate index will be noted for the different relief areas.

In the field

a) Height of the colony <8 m

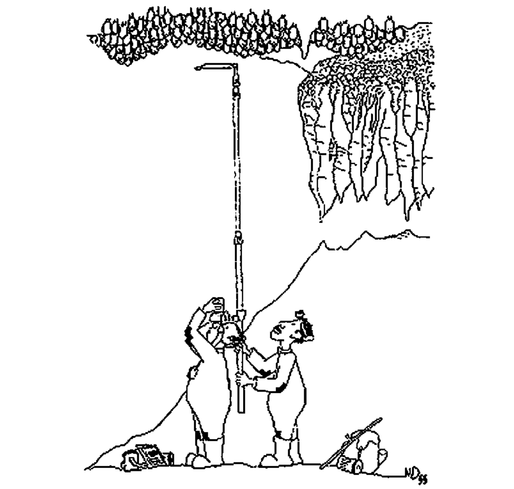

Figure 53. Calculating the density of and the area occupied by the bats.

- Use a light colour wooden square frame (internal size 20 cm x 20 cm) on top of a telescopic pole (3 m x 2). The camera will be a 24 mm x 36 mm reflex with changeable lens. You need to be able to change the focal length from 28 mm to 200 mm, so a zoom lens is useful. It is also essential to use a film for slides and a powerful flash gun.
- With the frame as close as possible under the colony take a picture. If the density of the group is not uniform or if spaces of a few cm² appear in between the bats, take one picture of each of the different zones.
- Attach a light colour wooden ruler (1 m long) at right angles to the end of the pole and place as close as possible to the colony. Take a picture focusing on the ruler (its light colour will help doing it even in low light). If you cannot get the whole colony on the same shot, take a picture of the different parts, noting the characteristic rocky features which surround the colony. Never use a focal length less than 28 mm because picture distortions will affect the results.

b) Height of the colony >8 m

If the colony is out of reach of the pole, the margin of error will vary and it will be necessary to mention the method used for the estimation. The most efficient way is the following:

- Using a torch with a narrow beam, first calculate the beam diameter at different distances (*e.g.* every meter from 8 to 25 m).
- Taking landmarks, evaluate as precisely as possible the distance observer-to-colony. Then measure approximately the size of the colony, using the projected beam of the torch, draw the form of the group and if necessary of the areas with different densities.
- With binoculars estimate the different densities of the colony and copy them out on the drawing.

Processing the data

a) Using photographs

- On a white sheet of paper show the slide of the 400 cm² frame. Count the number

[1] An aliquot is a part contained in another number and dividing it without a remainder, an integral factor, *e.g.* 2 is an aliquot part of 6.

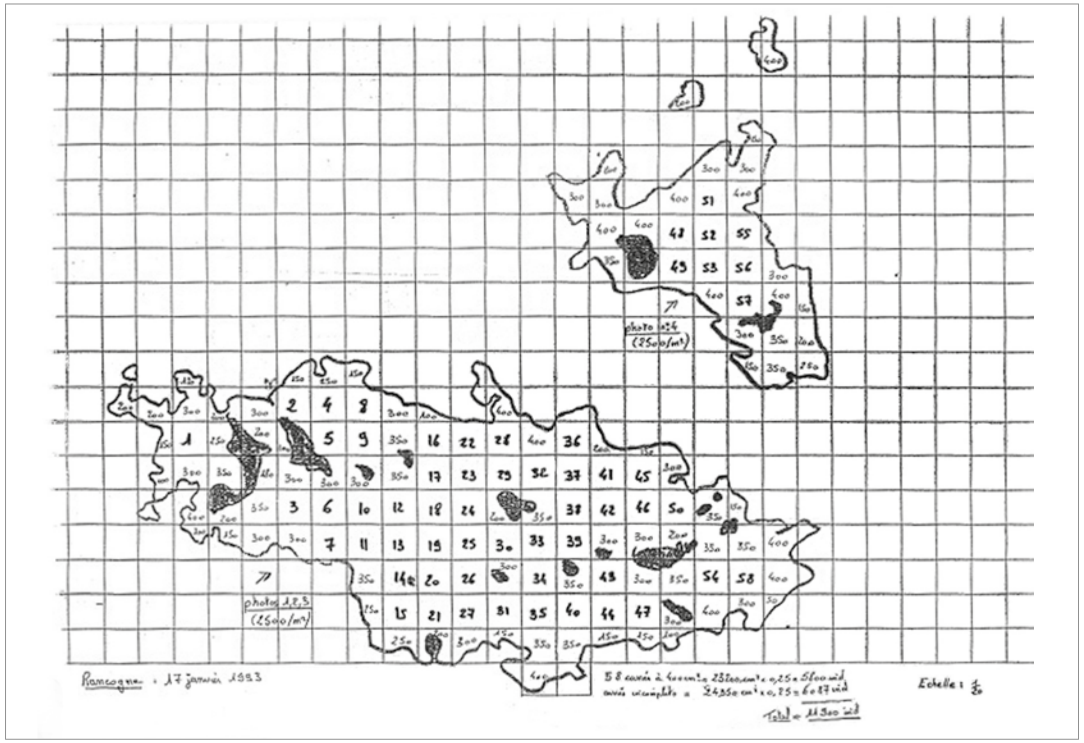

Figure 54. Example of count sketch with the area covered by the different groups of Miniopterus schreibersii (in black the areas without bats). The numbers in bold show the full squares with the same density as in the reference frame on photographs. The figures in the incomplete squares correspond to the calculated number of individuals (source: M. Barataud).

of individuals in the square ticking every counted nose with a felt-tip pen. Multiply the number by 25 to get the density of one m² or divide it by 400 for a density of one cm².

- On a vertical support, put a sheet of paper with a 1/10 grid (2 cm squares) or preferably 1/20 grid (1 cm squares) – or several sheets according to the size of the colony.
- Place the projector so that its beam is perpendicular to the sheet of paper and adjust the distance in order that on the projected slide the ruler in front of the colony measures 10 cm (1/10) or 5 cm (1/20). Each square on the sheet represents the aliquot area of 400 cm².
- Then draw on the sheet the outlines of the colony, showing if necessary the areas with a different density and from the field sketches the roof areas with a relief.
- Count the full squares and multiply their true area (400 cm²) by the density per cm² that they can have.
- Every incomplete square will be measured (according to the used scale) to determine the surface covered by the bats, this surface being simplified to show a triangle or a quadrilateral. The obtained surfaces will be multiplied by the corresponding densities and their total added to the full squares.
- All the information regarding the colony should appear in the caption (densities of individuals/m² and relief index for each zone). Each group is assigned a number that appears on the annual count form.

b) Using evaluation with torch beam

- With reference to the field sketch, draw the outlines of the colony on a squared sheet of paper, using the measures estimated with the torch beam to determine the scale.
- You might have to outline the areas of different densities or relief that have been observed in the field.
- Proceed as above to calculate the surface and the number of individuals.

5.2.8 Recommended surveillance method for *Myotis capaccinii*

As part of the Action Plan for bats (Objective 3) twelve maternity colonies of *Myotis capaccinii* were surveyed for five years (1999-2003) in three regions. They were the most important roosts of the species.

The period of survey was preferably 30 May – 10 June, *i.e.* starting about ten days after the first births (around 20 May).

Survey method

a) Count of emerging bats

- At least two observers are necessary for the count. They have to sit in front of the cave entrance(s) before the emergence of the bats and note the time when the first and the last individual leaves the roost.
- As *Myotis capaccinii* forms mixed maternity colonies with *Miniopterus schreibersii* and/or *Myotis myotis/blythii* it is necessary to count the emerging bats with a bat detector (Bat Box III or Petterson D200) set on 35 kHz (peak frequency for *M. capaccinii*).
- If *Miniopterus schreibersii* is also present in the site there should be no problem as the peak frequency of its calls is on 50 kHz and no overlap of the two species is to be expected. The count of *M. capaccinii* will be fairly reliable (and is corroborated by the second surveyor).
- However, difficulties arise in presence of *M. myotis* or *M. blythii* (peak frequency 30 kHz and it is then necessary to separate visually *M. capaccinii* from the group *M. myotis/blythii*. In that case a subdued light will be used (a paraffin oil lamp or a weak head-lamp) to see which bat is which.
- This count will give the number of individuals in the cave during the parturition period.

b) Count of the young

A quick count of newborn young can be tried only if the presence of people in the cave does not disturb them, and once the adults have left the roost.

Some characteristics of *M. capaccinii* ecology allow this method, which had been previously tested without any mortality:

- Parturition starts very early, generally from 20 May to the end of the month in most cases.
- The young of *M. capaccinii* are present before the young of other species, which do not give birth before the end of May or the beginning of June.
- Although we have little knowledge of female behaviour during the first nights after giving birth, it seems that the females leave the young in the nursery when they are a few days old, under the supervision of one adult or more. However, the females go back and forth inside the cave network or even outside. But there is great variability in their behaviour which can be affected

by the prevailing weather and some nights they do not emerge at all. So caution is necessary.

This count is therefore performed at night, once the adults have left the cave. The counting can start only when most of the colony has departed. A maximum of two observers should be allowed in the cave to compare their numbers and to shorten their stay, as much as possible, as lactating females return rapidly to feed the young.

The counting method is as follows:

- Count the young as precisely as possible using binoculars (8x23) or a spotting scope or using the projected area of the torch beam (use a powerful torch with a focussing beam which should project a clear ring on a wall – if possible ring diameter of 1 m at 10 m distance).
- Observers should minimise the time spent in the roost.

This second count will reveal the number of births for the year and hence the breeding success (but not the flight success).

Comments

This survey method might possibly allow establishing a ratio between the number of emerging adults and the number of counted neonates. This ratio would give an estimate of newborn *M. capaccinii* (in normal parturition conditions) in sites with inaccessible spaces or where the cluster of newborns is not visible.

It shows that for regular parturition roosts of the species it is possible to perform precise counts of the maternity colony.

In Languedoc-Roussillon adults of both sexes gather at the end of winter (February) and are grouped together in the same roosting places without mixing with other species. A survey of these clustering sites could be done from 20 February to 10 March and would cast a new light on the annual cycle of *M. capaccinii*.

5.3 Germany

5.3.1 Introduction

In Germany several bat monitoring programmes are ongoing at a regional level with special reference to the Federal States of the country (*Länder*). However, in accordance with the EUROBATS Agreement a standardised monitoring programme for particular species was developed by bat specialists from nature conservation authorities and NGOs and has been implemented for the Greater mouse-eared bat (*Myotis myotis*). In 2007 the German Federal Government and the Federal States agreed upon a surveillance scheme for bats and other species and habitats of conservation concern to fulfil monitoring obligations of the EU Habitats Directive. It is worth highlighting this agreement as an extraordinary step forward to overcome the inconsistent diversity of nature conservation measures in Germany caused by the federal structure.

All bat surveillance and monitoring programmes in Germany are mainly based on voluntary fieldwork.

5.3.2 Regional bat monitoring programmes

Special regional data surveys have been conducted at maternity roosts of certain species and in winter roosts of certain areas of Federal States. As each state has set its own surveillance standards and methods, collation of data on a national level is usually inadequate. However, numbers and trends of many regional bat populations were well observed. Some of these regional bat monitoring results had been documented in the National Reports which Germany provided at the Sessions of the Meeting of the Parties of the EUROBATS Agreement in 2000, 2003 and 2006 (see http://www.EUROBATS.org/documents/national_reports.htm, section Germany).

5.3.3 Surveillance of Greater mouse-eared bats

Since 1996 the development of a standard procedure for the surveillance and monitoring of bats in Germany has been one of the main tasks of the advisory body which was established by the Federal States in accordance with Article III 5 of the EUROBATS Agreement. This body initiated a workshop on bat monitoring methods during the biannual conference of bat conservation and research in May 2001 in Prenzlau hosted by the NGO Naturschutzbund Deutschland (NABU). Basic ideas relevant for a bat monitoring programme were developed through various initiatives, including the research and development project "Model for an overall concept for monitoring of animal species populations, illustrated with the example of avian fauna" by the Federal Agency for Nature Conservation (BfN). In April 2002 the Federal Agency and the Society for Bat Conservation and Research in Thuringia (IFT) carried out another workshop on the Isle of Vilm, near Rügen, on "Steps toward nation-wide monitoring of bat populations". This workshop highlighted the fact that special coordination offices for bat conservation are needed in all Federal States to collect and evaluate survey data and maintain surveillance standards.

The efforts to develop a nation-wide system for monitoring bat populations were oriented to the species and methods previously recommended by the EUROBATS Agreement. For the Greater mouse-eared bat (*Myotis myotis*), an agreement of nature conservation authorities, NGOs and bat experts was reached calling for a nation-wide survey, using standardised methods, and beginning with volunteer workers in 2003 and 2004 (Biedermann *et al.* 2003).

Method

Each year all adult animals are counted in all suitable maternity roosts from mid-May to mid-June (before the young are born). In each case bats are counted either during the day in their roost or in the evening as they leave the roost. In addition, each year juvenile bats (alive or dead) are counted in all suitable roosts from the end of June until mid-July (before the young are able to fly). They should be counted either during the day in the roost (especially where colonies are small) or at night after the adults have left the roost. In cases in which roost and exit counts are especially difficult surveyors are urged to work in teams to improve data quality. Wherever possible a survey after a rainy night should be avoided, since such conditions can encourage adults to remain in alternative roosts away from the maternity colony. Additional population data from hibernation sites or other sources should also be taken into account.

In the two-year programme, 221 persons participated and surveyed *Myotis myotis* at 799 maternity roosts. They provided about 7,400 data sets on the species and gave a very good overview on the species' status in Germany. The survey also showed that successful bat surveillance can be based on volunteer contributions. However, it became clear that professional coordination, guidance, and reporting are necessary to keep things going. Many participants continued to survey maternity roosts annually in the standardised way and NABU took over the responsibility for further data compilation.

5.3.4 German federal surveillance and monitoring of bats under the Habitats Directive

In accordance with Articles 11 and 17 of the EU Habitats Directive each Member State of the European Union has to report on the conservation status of species listed in the Annexes of the Directive every six years. An appropriate surveillance and monitoring system has to be applied in all biogeographic regions within a Member State. In Germany, due to the federal structure of the state, implementation of the Habitats Directive is the responsibility of the 16 Federal States (*Länder*). As there was no standardised national surveillance and monitoring programme of species and habitats in practice, the Federal Government took the initiative to develop one which was appropriate for EU reporting procedures. This included the bat species occurring in Germany because all European bats are listed on Annex IV of the Directive, some are even listed on Annex II.

As a first step the Federal Agency for Nature Conservation (BfN) chaired a working group of representatives from nature conservation authorities of the Federal States, which elaborated detailed proposals for species surveillance and assessment procedures in accordance with the Habitats Directive (Schnitter *et al.* 2006). Then the Federal Agency commissioned two consultants (PAN and ILÖK) to develop a surveillance scheme based on the results of the administrative working group as well as the expertise of bat experts (*e.g.* Dense & Mayer 2001, Biedermann *et al.* 2003, Petersen *et al.* 2004, Dietz & Simon 2005). The targets of the consultants' proposals were to fulfil the legal requirements of the Habitats Directive at the national level and to minimise time efforts and expenses at the regional level of the Federal States. The recommended surveillance and monitoring schemes were finally evaluated by the federal and state ministries for nature conservation and their technical advisors. The Federal States adopted the proposal and promised to provide the data needed for a national conservation status assessment in the German part of the Atlantic and Continental biogeographic region. The German area of the Alpine biogeographic region is covered by the federal state of Bavaria.

A central idea of the consultants' proposal is that common species and habitats should be surveyed at sample sites of occurrence which should be chosen by the Federal States. To assure representativeness in a statistical sense it should be a random sample. Within the Directive's framework of a six-year reporting period and an overall assessment result within three categories (traffic light scheme: Favourable = green, Unfavourable – Inadequate = amber, Unfavourable – Bad = red) the consultants found a sample size of 63 per biogeographic region as the statistic threshold value to recognise ongoing population trends. Species with less than 63 areas of occurrence which can be sampled within a biogeographic region are classified as rare and should be exhaustively surveyed (total census). As an area of occurrence in bats a square of the German national topographic network 1:25,000 (TK25) was taken.

The agreed concept of the surveillance programme further outlines which parameters shall be used to indicate the trend of a population, its structure, the total population size of the species, and the occurrence of suitable habitats for the species (Table 6). For most species two recordings (every three years) are proposed per report period with two surveys in each recording year. For *Barbastellus barbastellus*, *Eptesicus nilssonii*, *Myotis emarginatus* and *Plecotus austriacus* the rhythm should be increased to three recordings (every two years) per period. *Rhinolophus ferrumequinum* should be recorded every year to watch carefully this critically endangered species.

The population trend of bats can be assessed either by counting the number of animals at a hibernation site, the number of females in maternity roosts or the assessed number of adult females in the surveyed area of occurrence. A declining population trend exceeding 1% per annum is automatically assessed as an unfavourable conservation status. However, in some bat species appropriate methods to survey population trends are still under discussion and may be modified (*e.g. Myotis bechsteinii*).

Information on population structure is not compulsory for assessing conservation status. Therefore, from the viewpoint of national reporting duties under the Habitats Directive, population structure should only be surveyed if it does not mean additional work, if it can be done without disturbance and if it is necessary from a scientific point of view. To assess the total population size direct and indirect measures can be applied to minimise efforts as far as possible. Methods vary from counting individuals, colonies, maternity roosts, areas of occurrence and TK25 grid squares where a certain species is present. All records from a report period are considered for this assessment.

To assure good data quality and detect changes in species' ranges nature conservation agencies of the Federal States are asked to continuously gather data on the occurrence of bats apart from the samples which are necessary to assess population size and trend. An estimation of the size of suitable habitat is important to report about the habitat provided for the species and the percentage actually occupied. As it is almost impossible to state habitat size exactly, it is only estimated from the number of TK25 grid squares where suitable habitats are present.

As the Federal States cover different parts of the three biogeographic regions, the 63 samples per region were shared in accordance with the distribution and occurrence of each species. Federal States that host a major part of the total population of a species have to take more survey samples than others (Table 7). However, the results of this federal surveillance scheme with 63 samples will only refer to the whole area of the particular biogeographic region in Germany. If a federal state wishes to assess a species' conservation status within its regional borders it should survey a total of 63 samples there to get consistent and reliable results. Apart from that, it should be kept in mind that monitoring under Article 11 of the Habitats Directive provides an overview. For management and planning purposes additional case-specific monitoring at the local scale is necessary or even a legal obligation.

For the 2007 report in accordance with Article 17 of the Habitats Directive, representatives from the federal and state ministries for nature conservation and their technical advisors agreed on a procedure to aggregate and evaluate relevant data in order to assess the conservation status of species and habitats following the traffic light scheme of the European Commission. Special rules and algorithms were developed and applied. Finally the status of all species and habitats of each biogeographic region were approved by a ministerial conference before the result was sent to the EU. A similar procedure will be implemented for the next report based on the data currently provided by the German federal surveillance and monitoring programme from the year 2008 onwards.

Table 6. Surveillance concept for bat species in the biogeographic regions of Germany (status: May 2008). Regions: ATL = Atlantic biogeographical region, CON = Continental biogeographic region, ALP = Alpine biogeographical region.
dd = data deficient

Species	Region	Areas of occurrence	Survey method	Population trend (number of)	Population structure	Total population size (number of)	Size of habitat
Barbastella barbastellus	ATL	9	exhaustive survey	animals per hibernation site		occurrences	number of occupied TK25 grid squares
	CON	561	sample				
	ALP	7	exhaustive survey				
Eptesicus nilsonii	ATL	1	exhaustive survey	adult females in maternity roosts		occurrences	
	CON	311	exhaustive survey				
	ALP	19	exhaustive survey				
Eptesicus serotinus	ATL	244	sample	adult females in maternity roosts		colonies	
	CON	1,081	sample				
	ALP	4	exhaustive survey				
Myotis alcathoe	CON	dd	exhaustive survey				
Myotis bechsteinii	ATL	24	exhaustive survey	adult females in a defined monitoring area		occupied TK25 grid squares	
	CON	717	sample				
	ALP	1	exhaustive survey				
Myotis brandtii	ATL	45	exhaustive survey	adult females in maternity roosts		maternity roosts	
	CON	565	exhaustive survey				
	ALP	11	exhaustive survey				
Myotis dasycneme	ATL	64	exhaustive survey	animals in hibernation sites		maternity roosts or hibernation sites	
	CON	153	exhaustive survey				
Myotis daubentonii	ATL	219	exhaustive survey	animals in hibernation sites		roost sites	
	CON	1,615	sample				
	ALP	18	exhaustive survey				
Myotis emarginatus	CON	dd	exhaustive survey	adult females in maternity roosts	proportion of reproductive females	adult females in maternity roosts	
	ALP	6	exhaustive survey				

Table 6 (cont.)

Species	Region	Areas of occurrence	Survey method	Population trend (number of)	Population structure	Total population size (number of)	Size of habitat
Myotis myotis	ATL	63	exhaustive survey	adult females in maternity roosts	proportion of reproductive females	maternity roosts	number of occupied TK25 grid squares
	CON	1,680	sample				
	ALP	22	exhaustive survey				
Myotis mystacinus	ATL	55	exhaustive survey	adult females in maternity roosts		maternity roosts	
	CON	956	sample				
	ALP	23	exhaustive survey				
Myotis nattereri	ATL	140	exhaustive survey	animals in hibernation sites		maternity roosts	
	CON	1,420	sample				
	ALP	7	exhaustive survey				
Nyctalus leisleri	ATL	85	exhaustive survey	adult females in maternity roosts		maternity roosts	
	CON	533	exhaustive survey				
Nyctalus noctula	ATL	227	exhaustive survey	adult females in maternity roosts	proportion of reproductive females	roost sites	
	CON	1,285	exhaustive survey				
	ALP	2	exhaustive survey				
Pipistrellus kuhlii	CON	10	exhaustive survey	adult females in maternity roosts	assessment procedure not yet defined	adult females in maternity roosts	occupied TK25 grid quarters
Pipistrellus nathusii	ATL	139	exhaustive survey	adult females in a defined monitoring area	proportion of reproductive females	roost sites	number of occupied TK25 grid squares
	CON	824	exhaustive survey				
	ALP	10	exhaustive survey				
Pipistrellus pipistrellus	ATL	286	sample	adult females in a defined monitoring area	proportion of reproductive females	maternity roosts	
	CON	1,554	sample				
	ALP	30	sample				
Pipistrellus pygmaeus	ATL	6	exhaustive survey	adult females in a defined monitoring area	assessment procedure not yet defined	roost sites	
	CON	243	exhaustive survey				
Plecotus auritus	ATL	200	sample	animals in hibernation sites		maternity roosts	
	CON	1,679	sample				
	ALP	15	exhaustive survey				
Plecotus austriacus	ATL	20	exhaustive survey	adult females in maternity roosts	proportion of reproductive females	maternity roosts	
	CON	776	sample				
Rhinolophus ferrumequinum	CON	31	exhaustive survey	adult females in maternity roosts	proportion of reproductive females	adult females in maternity roosts	number of occupied TK25 grid quarters
Rhinolophus hipposideros	CON	79	exhaustive survey	adult females in maternity roosts	proportion of reproductive females	adult females in maternity roosts	
Vespertilio murinus	ATL	33	exhaustive survey	average adult animals per roost	proportion of reproductive females	records	number of occupied TK25 grid squares
	CON	470	exhaustive survey				
	ALP	7	exhaustive survey				

Table 7. Number of bat survey samples per Federal State for the German federal surveillance and monitoring programme.

Regions: ATL = Atlantic biogeographical region, CON = Continental biogeographic region. All samples of the Alpine biogeographic (ALP) region lie within Bavaria and are therefore not separately listed in the table.

Federal States: BB = Brandenburg, BE = Berlin, BW = Baden-Württemberg, BY = Bavaria, HB = Bremen, HE = Hesse, HH = Hamburg, MV = Mecklenburg-Western Pomerania, NI = Lower Saxony, NW = North-rhine-Westphalia, RP = Rhineland-Palatinate, SH = Schleswig-Holstein, SL = Saarland, SN = Saxony, ST = Saxony-Anhalt, TH = Thuringia.

Species	Region	BB	BE	BW	BY	HB	HE	HH	MV	NI	NW	RP	SH	SL	SN	ST	TH
Barbastella barbastellus	CON	10		4	20		3		3	1		3			7	4	8
Eptesicus serotinus	ATL							1		34	16		10			2	
	CON	12		8	10		4		4	1	4	1	2	1	7	4	5
Myotis bechsteinii	CON	2		10	16		10			1	3	9	1		2	2	7
Myotis daubentonii	CON	6	2	8	14		5		6	2	3	4	2	1	4	2	4
Myotis myotis	CON	5		9	18		6		2	2	4	6		1	4	1	5
Myotis mystacinus	CON	5		9	17		5		1	3	5	3		1	5	3	6
Myotis natteri	CON	6	1	7	14		5		6	2	3	4	2		4	4	5
Pipistrellus pipistrellus	ATL							1		34	18		8			2	
	CON	6		8	15		5		6	2	3	4	1	1	4	4	4
Plecotus auritus	ATL							1		36	18		6			2	
	CON	7	2	8	13		5		5	2	3	4	2	1	4	4	3
Plecotus austriacus	CON	5		11	19		6				2				6	7	7

5.4 Netherlands

5.4.1 Introduction

Biodiversity in the Netherlands is monitored through the Network Ecological Monitoring (NEM) programme, which is funded by the Dutch Government. Partners in this programme are, amongst others, the NGOs that gather the data and CBS (Statistics Netherlands) which calculates indices and trends and checks the quality of the data. Analyses are done using TRIM, a loglinear GLM adapted and implemented for ecological time series (Van Strien *et al.* 2004; freely downloadable from www.cbs.nl).

For bats, there is one long-running scheme for hibernacula counts, and two summer schemes that have recently been started: car surveys and counts of colonies in attics. There are also a number of other initiatives underway including a new Dutch mammal atlas project, which will involve training and facilitating volunteers, and collation and validation of bat distribution data.

5.4.2 Hibernacula counts

Hibernacula counts in the Netherlands have been performed since the 1940s. In the early years, they were almost only done in the chalk mines in the south. In 1986, these counts were formed into a monitoring scheme, which is now coordinated by the Dutch Mammal Society (VZZ), and the number of counted sites increased. Mines are still counted, but now volunteers also visit bunkers, fortresses, ice cellars, old brick kilns, castle cellars and even bridge pillars. Currently about 1,100 sites are counted yearly.

Method

In October, the monitoring coordinator of VZZ sends site lists, forms, and a permit to visit the hibernacula to all volunteers. Volunteers visit their site once between 15 December and 15 February, counting all bats visible using LED torches. Forms are filled in and sent to the provincial coordinator. He or she checks the forms for errors and then sends them to the monitoring coordinator at VZZ. Here, data are entered into a database, a number of additional error checks are performed, and the data are sent to Statistics Netherlands (CBS). Indices are calculated, then placed on the CBS website http://statline.cbs.nl/statweb (in Dutch) and presented to the Dutch government. VZZ gives feedback of the results to volunteers.

Volunteers are actively stimulated to keep visiting "disappointing" sites. Training is organised by VZZ, which involves training of new volunteers during counts and provision of identification workshops by a number of workgroups.

5.4.3 Attic colony counts

For a number of years, bat workers have counted bats in attics of churches and abbeys. In 2007 a pilot study was carried out by VZZ and CBS to see if these counts could be combined and standardised to form a new monitoring scheme. The pilot was successful: the data already gathered were of good quality, and the volunteers were willing to add the data already gathered in past years to the scheme. 2008 was the first "official" counting year. A handbook and identification guide were printed, forms and a database were designed. A course on the method and on species identification was developed and is given to new volunteers.

The scheme focuses on *Plecotus austriacus* and *Myotis emarginatus*. Of the latter, all known breeding females (*i.e.* the two known breeding colonies) are counted. For this reason, the scheme now focuses on the counties of Zeeland, Noord-Brabant and Limburg, where these species occur. In the next three years, the scheme will be expanded to include the whole of the Netherlands, so that data on other species living in attics can be gathered.

5.4.4 Car transect monitoring

In 2007 a car transect monitoring scheme was piloted (Dekker *et al.* 2007). This pilot consisted of driving ten transects, testing the method and technique and finding the detection frequencies of target species. The pilot was repeated in 2008 with aims to increase the number of transects, test a number of improvements in the setup used in 2007, and calculate inter-transect variation in number of bats encountered.

Method

Transects are driven at 20-30 km/hour with an Anabat detector on the roof of the car, and with a hand held computer (PDA) with a Global Positioning System (GPS) logging the route. Sounds are analysed by a professional of VZZ. As Anabat timestamps the recordings, the record of bats and position of the car can be pinpointed to create maps. The resulting database of information is sent to CBS for analysis.

5.4.5 Species coverage

The three schemes aim to cover all Dutch bat species (see Table 8). *Myotis mystacinus* and *M. brandtii* can only be distinguished in the hand, and VZZ considers it unethical to disturb animals during hibernation, so these species are included together. However, a study in which a number of animals were identified in the hand during mistnet counts, and examination of dead or awake animals in hibernacula showed that *M. brandtii* is rare: only 1.7% of the *M. mystacinus/brandtii* that were checked were in fact *M. brandtii* (Mosterd *et al.* 2005).

The car transects and attic counts will be planned so that they also provide summer distribution maps, on a 10 x 10 km grid precision.

A newsletter is published twice a year for all VZZ volunteers on the results of the monitoring programme.

5.4.6 Other initiatives

Apart from these schemes, there are a number of initiatives that are not (yet) part of the NEM programme: a study focused on *Myotis dasycneme*, counts of bats in bat boxes, and swarming studies.

A large study on *Myotis dasycneme* is underway to provide detailed information on roost counts, capture-mark-recapture control of pond bats in summer, spring and autumn and control of marked animals in winter.

Table 8. Coverage of the National Ecological Monitoring programme's bat monitoring scheme.

[1] Only 350 individuals counted, population estimated to be ~10,000 individuals.

[2] Only a few individuals counted.

Species	Hibernacula	Car transects	Attics
Plecotus auritus	X		
Plecotus austriacus			X
Myotis mystacinus/brandtii	X		
Myotis nattereri	X		
Myotis emarginatus	X		X
Myotis dasycneme	(X)[1]	X	?
Myotis myotis	X		
Myotis daubentonii	(X)	X	
Myotis bechsteinii	(X)[2]		
Nyctalus noctula		X	
Eptesicus serotinus		X	
Pipistrellus nathusii		X	
Pipistrellus pipistrellus		X	

Annual counts of bats in bat boxes have been carried out, in some cases over long time periods. This yields mostly information on *P. nathusii*. No trend analyses have yet been performed with these data.

There has been much swarming research in the past few years. In 2001 a first workshop was held to train people in mist-netting (Spoelstra 2006), as there was little experience with mist-netting in the Netherlands. In 2006 and 2007, workshops were again given, resulting in a pool of experienced volunteers (Dekker & Limpens 2007). At these workshops, a number of species, such as *Myotis bechsteinii* and *Myotis brandtii* were caught in numbers higher than are found at hibernacula counts.

Following these surveys, a monitoring study has been set up under the umbrella of VZZ with the support of a large pool of volunteers. In this study, swarming animals are identified by mist-netting one night at six selected chalk mines every three weeks. The aim is to learn more about the temporal and spatial dynamics of the number of individuals and species that are swarming at such sites. This data will be compared with counts of hibernating species at these sites.

5.5 Portugal

5.5.1 Introduction

In Portugal, a monitoring programme of cave-dwelling species has been in progress since 1987, coordinated by the "Instituto da Conservação da Natureza e da Biodiversidade" (ICNB). The programme involves the annual estimation of bat numbers present in the most important wintering and maternity roosts. Data are collected by ICNB, "Faculdade de Ciências de Lisboa" and speleology associations. An evaluation of the development of the programme since its inception was published by Rodrigues *et al.* (2003).

Cave-dwelling species are considered to be those that regularly hibernate and/or breed in underground roosts: *Miniopterus schreibersii*, *Myotis myotis*, *M. blythii*, *M. nattereri*, *M. emarginatus*, *Rhinolophus ferrumequinum*, *R. hipposideros*, *R. euryale* and *R. mehelyi*. In addition, seven other species are occasionally found in this type of roost: *Myotis bechsteinii*, *M. mystacinus*, *M. daubentonii*, *Eptesicus serotinus*, *Plecotus auritus*, *P. austriacus* and *Barbastella barbastellus*.

5.5.2 Surveying hibernacula

Monitoring of 43 roosts known to be of national importance (criteria defined by Palmeirim & Rodrigues 1993, under revision) is carried out annually between the beginning of January and 15 February. Observations are made inside the roosts, counting the individuals or estimating the area of the colonies (visually and with photographs). Temperature and relative humidity are measured.

5.5.3 Surveying summer roosts

There are two maternity seasons: April/May for *M. myotis* and June/July for the other cave-dwelling species. As a result, 52 visits to roosts considered of national importance (17 for *M. myotis* and 35 for other species) are carried out annually. This number includes underground roosts and some buildings that harbour important colonies of *R. ferrumequinum* and *R. hipposideros*. Observations are made inside the roosts, counting the individuals or estimating the area of the colonies (visually and with photographs). Temperature and relative humidity are measured. Methods described for *Myotis myotis / blythii* and *Miniopterus schreibersii* in the EUROBATS Resolution 2.2 are used. It is believed that these methods can be successfully applied to *R. euryale*, *R. mehelyi*, *M. myotis*, *M. blythii* and *M. schreibersii* that are very faithful to their roosts and hang from the ceiling, making the observations very reliable. More problems occur in the case of *R. ferrumequinum* and *R. hipposideros* since they use many roosts to breed in small numbers. In the case of *M. nattereri* and *M. emarginatus*, only maternity colonies in underground roosts are known, but since they normally use hidden places (especially *M. nattereri*) very often the colonies cannot be observed. Frequently, only the capture of flying juveniles enables the identification of maternity sites.

5.6 Romania

The National Bat Monitoring Programme in Romania (NBMPR) commenced in 2002. This Programme is modelled on the UK's National Bat Monitoring Programme (NBMPUK). Two principal methods have been applied in Romania: observations at summer maternity roost sites and winter hibernation sites in underground habitats. Surveys occur twice in the hibernation period (December-February) and twice in the summer period (May-July). The data are collated in a standard datasheet.

Selected key species and categories for monitoring include:

- Cave dwelling bats: *Rhinolophus ferrumequinum*, *Rhinolophus hipposideros*, *Myotis myotis / blythii*, *Miniopterus schreibersii*;
- Non-cave dwelling bats: *Myotis daubentonii*, *Eptesicus serotinus*, *Pipistrellus pipistrellus / pygmaeus*, *Nyctalus noctula*;
- Species that have priority for further observations and research: *Pipistrellus nathusii*, *Barbastella barbastellus*, *Myotis dasycneme*.

Monitoring is carried out throughout Romania in 35 underground sites (Eastern Carpathians 3 caves, Western Carpathians 15 caves, Southern Carpathians 17 caves).

To implement the NBMPR it has been necessary to develop and maintain a network of volunteers covering all regions of Romania. Volunteers have been recruited through talks to university students, speleological clubs, environmental protection agencies, environmental NGOs and National Parks. Bat identification skills have been increased through training, workshops and field work participation.

5.7 Slovenia

In 2006, the Ministry of the Environment and Spatial Planning of the Republic of Slovenia commissioned a study on monitoring all bats species present in Slovenia. The Centre for Cartography of Fauna and Flora (Presetnik *et al.* 2007) judged that based on field data eight bat species were suitable for monitoring by hibernation counts and 63 sites (mostly caves) were chosen. The monitoring of 371 selected maternity roosts (mostly churches) is expected to give a good insight into the conservation status of twelve bat species. 13 bat species could be monitored by 24 ultrasound detector transect counts. Mist-netting at 20 proposed sites could provide information on 14 bat species. In total, 467 detailed field protocols which also deal with an estimation of the quality of bat habitat were made.

A lack of suitable data prevented an estimation of population size at the start of the monitoring for the majority of proposed sites and consequently for the whole scheme for particular species. An additional problem is that some areas of Slovenia still lack the data required to propose an adequate grid of monitoring sites covering particular species distribution. Therefore, intensive continuous monitoring of proposed sites and additional bat surveys are necessary.

The Ministry has approved the proposal for a monitoring scheme and the work is progressing.

5.8 United Kingdom

5.8.1 Introduction

The UK National Bat Monitoring Programme (NBMP) is designed to collect population trend information for bat species resident in the UK. It is run by the Bat Conservation Trust (BCT), a non-governmental organisation (NGO), in partnership with the Joint Nature Conservation Committee (Walsh *et al.* 2001, Battersby 2005). The NBMP was established in 1996 as a pilot programme to test the methods being used and continued as a pilot until 2000, when it became an established long-term surveillance programme.

A sampling approach is used on all surveys with the assumption that trends occurring in sample sites reflect trends occurring in the general population. Theoretically, this assumption is strongest when sample sites are chosen at random; random surveys are considered to be more robust and representative of the total population than surveys using self-selected samples.

The NBMP datasets offer a unique opportunity to examine the quality of data collected in different surveys, because some species are surveyed using more than one method. However, at present there are no long-term datasets (> 20 years) that allow a comparison of population trends between different surveillance methods for the same bat species. Longer time-series are required before robust analyses can be initiated.

Based on the theoretical grounds discussed above, where species are covered in more than one survey, priority is given to population trend results in the following order:

1. Waterways survey and Field survey
2. Hibernation survey
3. Colony counts

5.8.2 Waterway survey

The waterway survey began in 1997 with a successful pilot and surveys have continued annually. It focuses on *Myotis daubentonii* along water courses (such as rivers and streams, but excluding lakes and ponds) as this species has a high dependence on water bodies for foraging and the ease of identifying this species fits in well with mass participation surveys.

The Environment Agency (EA), through its River Habitat Survey (RHS), has surveyed over 10,000 random stretches of waterway for a variety of habitat features including flow rate and bankside vegetation. The BCT has worked closely with the EA since 1998 and, where possible, surveyed existing RHS sites for *M. daubentonii*. This approach adds value to the dataset because it enables cross analysis of both datasets.

Method

Data are collected in a simple, repeatable fashion at a random selection of courses throughout the UK. Where possible, surveyors are assigned a random 1 km stretch of water body that lies on an existing RHS site and that is within 10 km of the surveyor's home address.

Surveyors make a day visit to secure landowner permission and to assess the site for safety. They mark out ten points along the 1 km stretch, approximately 100 m apart. On two evenings in August they stand at each of the ten points for four minutes, recording *M. daubentonii* activity with a heterodyne detector, using a torch to confirm the bat is flying close to the water surface (behaviour characteristic of *M. daubentonii*).

5.8.3 Field survey

This survey began in 1998 and provides data on four species – *Pipistrellus pipistrellus*, *Pipistrellus pygmaeus*, *Nyctalus noctula* and *Eptesicus serotinus*.

Method

Data are collected in a simple, repeatable fashion in 1 km squares, drawn from a pool of 5,000 randomly generated 1 km² distributed throughout the UK using National Grid References. Volunteers are assigned a square at random within 10 km of their home address. Within each square a triangular "ideal" transect containing twelve marked stopping points is overlaid. Surveyors make a day visit to secure landowner permission and assess the site for safety. On two evenings in July they walk the transect with heterodyne ultrasonic detectors. At each of the twelve stopping points they listen for *P. pipistrellus* and *P. pygmaeus* for two minutes, then re-tune their detector and listen for *N. noctula* and *E. serotinus* bats whilst walking to the next stopping point. The survey starts at twenty minutes post sunset.

Trends derived from field surveys are considered to provide the most robust trend data. Volunteers are assigned random sites across the UK and the random selection process includes sites where the species of interest may not occur at present but has the potential to do so in the future. This provides a means of assessing change in distribution as a result of population expansion as well as change in relative abundance. There are potential problems with volunteers using different types of electronic equipment over time, volunteer turnover and volunteer experience, but these can be included as covariates in the data analysis to assess effects on the results.

5.8.4 Hibernation survey

A range of bat species aggregate at a variety of hibernation sites during the winter months and it is possible to make annual counts of the number of bats encountered. Bats are vulnerable to disturbance when hibernating and surveyors require training and a licence from the relevant UK Statutory Nature Conservation Organisations (SNCO) before entering sites. However, unlicensed surveyors can accompany licensed surveyors into sites.

Method

Sites are self-selected by volunteers who make two counts, one in January and one in February. Counts are made of all species encountered and site details are also recorded.

Unlike colony counts, the hibernation survey monitors potential sites as species can move into almost any existing site where they have never been recorded previously.

5.8.5 Colony counts

Colony counts are a traditional method for monitoring the status of roosts. For each species, information can be used to make an assessment of the importance of the roost at the national, regional and local level through collation and analysis of data.

The relationship between trends in species' colony size and population trends has not been established but, over time, comparison of field and colony trends may provide an answer. For the present, where trend direction conflicts between field and colony counts for the same species, the trend derived from field surveys will be considered most robust.

Method

Survey protocols for each species are similar although there are some minor inter-species differences (related to differences in emergence times of species). Roosts are self-selected by volunteers who make two counts of bats emerging from the roost between late May and the end of June. A summary of species surveyed on the project is shown in Table 9.

Colony counts are restricted to where the species of interest is known to occur: no potential sites are monitored (*i.e.* sites where a colony is not present but could be in future). Colony counts are likely to be effective for monitoring population change only if it is rare for new colonies to be established. This is because sampling only known roosts and not all potential roosts means there is no measure of the rate that new colonies are established or their effect on population trends. Little is known about the extent of new colony establishment so it is difficult to assess the magnitude of the issue.

One way of assessing the potential importance of new colony formation or colony mobility in general on species population trends would be to look at roost site age. For example, if a species is recorded using new buildings (new roosts) then this would provide evidence of colonies (or parts of colonies) switching from existing roosts. If new sites are often used by a species then it could indicate that interpreting population trends from counts at existing roosts only is not robust. Species such as *R. hipposideros* are assumed to form new roosts only occasionally (because they have very specific roost requirements); therefore the chances of possible erroneous trends derived from colony counts may not be as high as other species with less stringent roost requirements such as *Pipistrellus* species.

5.8.6 Survey coverage

The total site network for the NBMP was 3,906 sites in 2006 and continues to grow annually. Statistical analysis of past survey data has shown that a sample size of at least 40 sites with presence of bats is required to provide robust population trends for the UK (BCT 2001). Where species have been encountered on less than 40 sites trend analysis confidence is reduced due to low precision associated with small samples. For 11 of the 16 UK resident species there is sufficient coverage to carry out robust statistical analysis and this is shown below in Table 9.

Table 9. Coverage of UK bat species with each monitoring method.
A = encountered on >40 sites; B = encountered on 10-40 sites; C = encountered on <10 sites.

Species	Colony Counts	Field & Waterway Survey	Hibernation Survey
Barbastella barbastellus			C
Eptesicus serotinus	A	A	
Myotis bechsteinii			C
Myotis brandtii			B
M. brandtii/mystacinus			A
Myotis daubentonii		A	A
Myotis mystacinus			B
Myotis nattereri	A		A
Pipistrellus nathusii			
Pipistrellus pipistrellus	A	A	
Pipistrellus pygmaeus	A	A	
Nyctalus leisleri			
Nyctalus noctula		A	
Plecotus auritus	A		
Plecotus austriacus			
Rhinolophus ferrumequinum			A
Rhinolophus hipposideros	A		A

The difficulty in differentiating the two closely related *Myotis* species, *M. mystacinus* and *M. brandtii*, means that the data for these two species has been pooled for trend analysis and the trends assumed to be the same for both species.

5.8.7 The surveyors

One of the most important aspects of the NBMP is the participation of the general public as volunteer surveyors. Volunteers are the bedrock of the NBMP and come from a variety of backgrounds. Many colony counters are householders who happen to play host to "their" colony. Participation requires little previous bat experience and the project enables them to learn more about, and value, "their" colony.

Field volunteers tend to be more experienced local bat group members as some skill with a bat detector is required. For the Hibernation Survey volunteers require a licence from the relevant UK Statutory Nature Conservation Organisation before they can survey sites and undergo extensive training before being awarded such a licence. Unlicensed volunteers can enter hibernation sites if accompanied by a licensed bat worker.

Volunteers invest a tremendous amount of time and effort in the NBMP. Over 2,000 volunteers have surveyed over 3,000 roost and field sites since the programme began. On average over 730 volunteers take part every year with over 1,400 sites being surveyed. Data are stored in a centralised database and population trend data and information about the monitoring programme are made available through the NBMP annual reports, published on the BCT website.

5.8.8 Volunteer training

Volunteer training has always been a key feature of the NBMP. Each year a series of detector workshops is organised across the UK. At workshops volunteers learn about the basic elements of bat sounds, how to use their own hearing in order to discriminate between the various species and how to use bat detectors as tools to help identify bat sounds in the field. The workshops also teach volunteers how to take part in various surveys with an opportunity to go on a field session to polish up existing or practice new found skills. They also ensure there is standardisation for field surveys and recruit new volunteers to the programme. On average 15 workshops are held annually across the UK with over 300 participants receiving training.

5.8.9 Data analysis

The purpose of analysis is to draw correct conclusions on trends occurring in populations of interest. There are many factors that can influence trends (outside the population trends themselves) and the magnitude of their effect should be estimated and methods for reducing their influence put into place.

Annual means for each project are calculated from a log-linear generalised model. The model includes terms for factors that could influence the means *e.g.* bat detector make, temperature *etc.*, so their effect can be measured. For easier interpretation the means are then converted to an Index that starts at 100 for the first reliable year of data. General Additive Models (GAM) calculate individual trends over time for each site surveyed. They then amalgamate trends from all sites to produce an overall estimation of trend direction with confidence limits. On the graphs in each survey description, crosses represent the calculated means (converted to Index) and the line represents the estimated trend from the GAM. Dotted lines represent confidence limits. The actual trend occurring can be described from either the GAM (line) or the log-linear generalised model (crosses) although in many cases the interpretation is similar.

The annual percentage change assumes the annual trend direction is constant. It is estimated by calculating the annual percentage change that would take the population from 100 in the base year to the index value in 2003.

The benchmark for monitoring sensitivity is that sufficient sites are monitored to detect as a minimum population change of 50% over 25 years, equivalent to the Red Alert declines for UK birds (Gregory *et al.* 2002) and hopefully the more sensitive measure of 25% over 25 years, equivalent to the Amber Alert decline for UK birds.

Power analyses carried out in 2002 showed that if a minimum of 20 sites is monitored annually (in the pattern of returned data from previous years, *i.e.* a mixture of new sites and sites surveyed in previous years) then monitoring sensitivity is sufficient to identify UK declines of Red Alert magnitude for all surveys and Amber alert declines for the hibernation survey. A minimum of just under 100 sites would be sufficient to identify UK declines of Amber Alert magnitude for the field surveys. Power analysis has not been carried out on the Colony Counts.

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