The use of underground sites by bats in the Yorkshire Dales

ANITA GLOVER AND JOHN ALTRINGHAM
Institute of Integrative and Comparative Biology
Faculty of Biological Sciences
University of Leeds
Leeds LS2 9JT
bgymg@leeds.ac.uk and j.d.altringham@leeds.ac.uk
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INTRODUCTION

Bats in the Yorkshire Dales Biodiversity Action Plan: *Nature in the Dales*

In 2000, the Yorkshire Dales National Park Authority (YDNPA) launched its Biodiversity Action Plan, *Nature in the Dales* (2000). Bats feature in several of the habitat action plans and a grouped species action plan (SAP) for bats was later developed. One major aim of this SAP is to identify those underground sites in the Park that are used by bats and determine their relative importance.

Eight of the UKs 16 species of bat are known to be resident in the Park. Three of them, *Pipistrellus pipistrellus*, *P. pygmaeus* (45 and 55 pipistrelles) and *Nyctalus noctula* (noctule) do not make significant use of caves. The remaining five species, *Myotis nattereri* (Natterer’s bat), *M. daubentonii* (Daubenton’s bat), *M. brandii* (Brandt’s bat), *M. mystacinus* (whiskered bat) and *Plecotus auritus* (brown long-eared bat) are all known to hibernate in underground sites. Prior to this study, a few of the caves and mines of the Yorkshire Dales had been surveyed on a casual basis by bat workers making visual counts of hibernating bats. Few bats were recorded, probably because they were out of sight in crevices, and therefore these sites have previously been given low conservation priority with regards to bats.

The Yorkshire Dales contains the UK’s largest area of karst landscape. In addition to almost 2,000 cave entrances and the longest cave system in the UK, the area has a huge number of old and abandoned lead mines. These underground sites could hold nationally important populations of all five species of cave-hibernating bat and a systematic and comprehensive survey was long overdue. Given the difficulty of finding bats underground, is there a suitable survey method? A possible method was identified during ongoing studies in the North York Moors National Park, which showed that monitoring autumn mating activity could be relatively easy and reliable.

In the North York Moors National Park we have shown that that all five of the above cave-hibernating species gather at caves in the late summer and autumn to mate, during an event called swarming (Rivers et al. 2005, 2006). Some of these caves attract thousands of bats from a catchment area over 60 km in radius. Swarming bats are potentially easy to monitor using automatic loggers that count the echolocation calls of passing bats. Swarming bats are also relatively easy to catch and identify as they pass in and out of caves. By monitoring swarming we may also be identifying hibernation sites: there is a net movement into caves throughout the autumn and a net movement out in the spring. This suggests that towards the end of the swarming season, swarming bats are staying to hibernate in their swarming caves. Monitoring swarming can therefore identify sites critical to bats for mating, and potentially for hibernation, since in many cases the same sites are probably used for both purposes.
Study species

*M. nattereri* and *M. daubentonii* are relatively widespread and common in the Yorkshire Dales. *M. nattereri* forage in woodland and on the woodland edge. Nursery colonies are primarily in buildings and in tree holes and the species hibernates in caves and tunnels, where they are typically found in crevices, singly or in small groups. *M. daubentonii* feed predominantly over water. Large nursery colonies are found in bridges and similar structures close to water, while smaller groups of males may be found in riverside tree roosts. They also hibernate in underground sites, again singly or in small groups. Little is known about the ecology of *M. brandtii* and *M. mystacinus*, which were only separated as two species 30 years ago. In Yorkshire, they are close to the northern limits of their range and populations may be more fragmented than those of *M. nattereri* and *M. daubentonii*. Both species forage and roost in or close to woodland. Both are found hibernating in caves, mines and tunnels. *P. auritus* is also a woodland bat, but may be less dependent than *Myotis* species on underground sites for hibernation, sometimes making use of buildings and trees. Differences in the distribution and ecology of these species could have important implications for population structure and the role of underground sites.
PROJECT AIMS

The broad aims of this PhD project were to investigate the ecology of those bat species using underground sites in the Yorkshire Dales, to develop methods for surveying and monitoring bat activity at caves and to identify those sites of particular importance to bats. The results would be prepared for addition to the appropriate national park databases and recommendations made for safeguarding important bat sites.

Methodological objectives

To develop methods for automatically surveying and monitoring underground sites based on the detection and logging of the echolocation calls of passing bats.

To investigate the potential of a new echolocation call analysis method (Time Domain Signal Coding, TDSC) in automatic logging systems. TDSC analysis may allow us to identify bats to species without the need for intensive and intrusive capture.

Primary conservation aims

To identify underground sites in the Yorkshire Dales important to bats and answer the questions:

- At what time of year are they used?
- For what purpose?
- By which species?
- What factors influence the use of caves and mines by bats?

To prepare the data collected during this project for addition to the park’s Geographical Information System (GIS) database.

To produce guidelines for the conservation of bats at underground sites, and draw up a code of practise for cavers.

Scientific and long term conservation aims

An understanding of the ecology of cave use by bats and the consequences to population structure are

To look at genetic diversity in the bats of the Yorkshire Dales:

- Does each species comprise a single, homogeneous genetic population or is there geographic differentiation?
- Does the population structure vary according to species and if so, can this be related to differences in their ecology or rarity?
- Is there any evidence to suggest that physical features, such as areas of high altitude, present a barrier to gene flow?
- What role do swarming sites play in determining population structure?
WORK COMPLETED AND PRELIMINARY FINDINGS

All fieldwork was completed in the autumn of 2005 and laboratory work in January 2006. Analysis of all aspects of the work is ongoing and will be completed and written up by the summer of 2006. The conclusions presented in this report are therefore preliminary.

METHODOLOGY

Automatic loggers

We assembled and tested an automatic echolocation call logger based on commercially available components stored in a rugged, shock- and waterproof box. They are programmed to count the number of bats passing per minute, 24 hours per day for 11 days, when the batteries must be replaced and the data downloaded. Their accuracy was confirmed using artificially generated bat calls and by comparing their output with observations of bats from night video recordings. Eleven loggers were then made and have been successfully deployed throughout the Dales, inside and outside caves over the last three years. All are still in service and will continue to be used beyond the end of the park-supported project for long-term survey and monitoring. We hope soon to have six new loggers capable of operating unattended for up to three months.

Species identification using time domain signal coding of echolocation calls

Spectral analysis characterises an echolocation call on the basis of its component frequencies and how they change over time. This is the most widely used sound analysis method for species identification but it will not reliably separate *Myotis* species. Time domain signal coding (TDSC) characterises the call by the shape of its amplitude envelope and has been used successfully in insect identification.

An ability to identify the four *Myotis* species found in Dales caves from echolocation recordings would greatly reduce the need for capture, saving valuable survey time and reducing disturbance.

In collaboration with David Chesmore and Kate Haydock in the Intelligent Systems Engineering Group at the University of York, we have developed an analysis system in *MATLAB* which uses artificial neural network programmes and TDSC to identify bat calls. A pilot study using calls recorded in the Dales from the four *Myotis* species and *Plecotus auritus* suggested that the technique could perform significantly better than spectral analysis. We have since recorded a very substantial library of calls and are currently refining the neural network training regimes to further enhance its performance.

SUMMARY

A reliable method of monitoring bat activity at cave entrances has been developed, with the prospect in the near future of developing an automatic system that will be able to identify the bat species present.
PRIMARY CONSERVATION AIMS

- We have logged about 60 entrances to caves and other underground sites during the swarming seasons (August-October) of 2003-5. Data were collected for a minimum of three nights of good weather at each site. Repeat logging was carried out within and between seasons at a number of sites. The data were used to determine the characteristics of a cave and its surrounding environment that correlate with swarming activity.

- Loggers were placed in major chambers in six caves for continuous logging through the winter (November-March) of 2003/4 to assess their ability to detect bats during periodic winter arousal.

- Six cave entrances known to be important swarming sites from early work were monitored throughout the year during 2004/5 to assess cave use outside the swarming and hibernation seasons.
• Logging has been followed up catching at over 20 caves. All captured bats have been ringed to follow movements and to estimate population sizes by mark-recapture analysis, since many caves have been visited several times each season. By the end of 2005, over 2000 bats had been ringed.

The principle findings and outcomes are:

• Virtually all the caves surveyed are used by bats during the swarming season. However, major swarming activity is concentrated at a relatively small number of sites. The principle caves identified to date include entrances to the large Gaping Gill (Ingleborough) and Easegill (Casterton Fell) systems, and smaller caves such as Dow Cave (Wharfedale) and Cherry Tree Hole (Fountains Fell).

• At most caves 3-5 species have been caught, with Natterer’s bat generally being the most abundant species. Whiskered and Brandt’s bats are usually the least abundant. There is frequently a more even spread of the number of bats caught of each species in August, with Natterer’s bat becoming dominant in September and October.

• Bats are usually recaptured at the cave at which they were ringed. Only two bats have been caught at more two caves, in each case less than 10 km apart in a direct line.

• Ringing has also shown that bats may fly over 65 km from summer roost to autumn swarming site: e.g. from Addingham and Middleham to Dow Cave near Kettlewell and from Lancaster to Yordas Cave in Kingsdale. The caves of the Dales are therefore important mating sites for bats that spend their summer far outside the boundaries of the national park.

• Mark-recapture analysis is not complete, but initial estimates suggest from hundreds to several thousand bats visit the most important sites in a season.

• Initial analysis (data from the 2005 season have yet to be included in the calculations) suggests that the most important predictors of swarming activity are cave length and the degree of internal chamber development: bats appear to be attracted to long systems which contain large chambers. These may provide suitable ‘arenas’ for mating behaviour as well as a wide variety of secure hibernation sites, reinforcing the suggestion that important swarming sites are often major hibernation sites too. Many other features, such as cave entrance size, surrounding habitat and remoteness appear to have little or no influence on swarming activity.
We have also shown that sites important for swarming are used throughout the year, by small numbers of bats, probably males and non-breeding females.

Quantitative assessment of the importance of caves as hibernacula has proven to be very difficult. The majority of the caves surveyed showed some sign of occupation in the form of droppings on the floor and on ledges. A small number of hibernating bats were found in a significant minority of caves. However, attempts to measure activity through early and late winter monitoring of echolocation calls was not a success. We believe arousal frequency is too low and the bats are too thinly dispersed through the often extensive caves.

Measuring swarming activity is, at the moment, the single best method of assessing a cave’s importance to bats.

The most likely source of serious disturbance to bats would be evening caving activity, particularly by large groups, during August, September and October.

A variety of barriers have been placed over cave entrances to prevent livestock from falling in. To varying degrees these barriers obstruct bats, some excluding them completely. A programme of replacement with ‘bat-friendly’ barriers is planned.

All of the data are in a Microsoft Access database for transfer to the national park database when this phase of the work is complete. We expect to supply regular updates in future years.

Guidelines for the conservation of bats at underground sites are being drawn up and a code of practise for cavers written. The work has already been publicised in an article in the leading cavers’ magazine (see below).

**SUMMARY**

The brown long-eared bat and all four species of *Myotis* resident in the north of England use the Dales’ caves. Virtually all caves are used by bats to some extent, at all times of the year, but activity is concentrated at a minority of caves and in the late summer and autumn. Some caves may attract thousands of bats, many of which have spent the summer rearing young far outside the boundaries of the park. Caves important to bats are typically long and have sections with large dimensions. They may be both remote and in habitats unsuitable for foraging bats. Although we can to some extent predict the likely importance of a cave to bats from our studies, survey remains essential, since the principal predictors of activity do not explain all of the variation in activity seen.

The project has involved the survey of over 60 major caves and other underground sites in the Dales. Survey and monitoring will continue, with funding from new sources. A database of our findings will be made available to the Park Authority later in 2006, together with draft updates to the relevant sections of the Park BAP, and a revised code of practise for cavers in consultation with the British Caving Association.
SCIENTIFIC AND LONG TERM CONSERVATION AIMS

DNA extracted from wing biopsies is being used to look at the population structure of the bats caught at swarming sites using microsatellite markers. Population structure tells us much about the dispersal patterns and social structure of the bats and provides valuable information for conservation management on local and regional scales. Bats from isolated summer colonies move to underground sites to both mate and hibernate. We have shown that mating at these sites prevents inbreeding and maintains genetically healthy populations (Rivers et al. 2005a,b). It also determines the degree to which bats in different dales are dependent on populations in other dales for their long term viability. The population structure will be determined by the dispersal pattern and mobility of each species, and the location and density of swarming sites in relation to geographical corridors (the dales) and barriers (the hills).

We have collected a very extensive genetic library for Natterer’s bat from across the Dales and from sites in the North York Moors, Cumbria, Lincolnshire, Suffolk and Sussex for comparison. Less comprehensive but valuable libraries have been built for Daubenton’s, whiskered, Brandt’s and brown long-eared bats.

Analysis of these genetic libraries is in progress. Preliminary results suggest that we will find significant population differentiation across the Dales. We believe the resulting population structure is at least in part due to patterns of dispersal to swarming sites. We also have some evidence to suggest that differentiation, and therefore the risk of population fragmentation, is greater in species that are less mobile.

SUMMARY

Ongoing genetic analysis will show how behaviour, cave distribution and the unique geography of the Dales shape the genetic structure of bat populations. Seasonal migration from summer nursery roosts to mating sites in caves is probably a major determinant of the population structure of bats both in the Yorkshire Dales and in the surrounding lowlands.

PUBLICITY, SCIENCE COMMUNICATION

We have actively promoted our work and the role of the national park. All of the TV and radio programmes listed below involved on location recording in the Dales and in the case of Cave Capers and Michaela’s Wild Challenge, involved taking the crews into caves.

- BBC Radio 4, December 2003. We were the focus of a 30 min programme, Cave Capers, one of three in the Wild Underground series. Still available on the BBC website.
- BBC Radio 4, July 2004. JDA wrote and presented a programme in the regular natural history series, Nature, which included a discussion of some of the cave research. Still available on the BBC website.
• BBC 2, September 2005. We featured in Bill Oddie’s programme Wild Autumn.
• *Michaela’s Wild Challenge*, Channel 5, to be aired spring/summer 2006.
• Descent Magazine, December 2005. UK and international magazine for cavers. Article (colour centrespread), Bats in the North.

• British Cave Research Association Conference, Manchester, March 2004
• 13th International Bat Research Conference, Poland, August 2004

The work also been featured on local BBC TV, in national newspapers, and we have written articles for Yorkshire Wildlife magazine and the Craven Pothole Club Journal. Some preliminary findings from the important Easegill system are described on the Red Rose Caving and Pothole Club website (one of the most visited caving sites in the UK). We have given lectures to several local natural history societies and we make regular informal contact with cavers.

**REFERENCES**

