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Barbastelle, one of the species recorded in the Norfolk Bat Survey. Hugo Willcox/FN/Minden/FLPA

Bat-monitoring: a novel approach

Stuart Newson, Viola Ross-Smith, Ieuan Evans, Rachel Harold, Ryan Miller, Martin Horlock and Kate Barlow

Thanks to recent advances in technology, even the most inexperienced enthusiasts can now provide reliable bat-monitoring data, enhancing community involvement and engagement.

In the UK, the monitoring of bats is undertaken on a large scale through the National Bat Monitoring Programme (NBMP) run by the Bat Conservation Trust (www.bats.org.uk). Established in 1996, this long-term monitoring programme relies upon trained volunteers to help provide robust population trends for 11 of the UK's 17 breeding bat species. These volunteers take part in various types of survey, including bat counts at winter and summer roosts, as well as standardised bat-detector surveys using simple, tuneable detectors that allow identification in the field. The bat-detector surveys focus on specific, relatively easily identifiable species and the survey methods are designed to be as inclusive as possible, using affordable bat-detectors to maximise participation and geographical coverage.

There are, however, limitations to this bat-detector approach, as not all bat species are easily monitored through these methods. There are a number of reasons for this, including the difficulty of distinguishing the calls of some species, the expertise that is required to do so, the expense of sophisticated bat-detecting equipment that can make high-quality sound recordings, and the time-consuming process of analysing sound files containing bat calls.

With recent advances in bat-detector technology and digital-signal processing, however, more can now be done. The technology now means it is possible to collect large volumes of high-quality acoustic data through remote monitoring and then analyse these by using automated computer classification algorithms that push acoustic identi-

Box 1 'Bat Monitoring Centres' in Norfolk

The aim was to set up a system that minimised the amount of work required of volunteers and which was simple and accessible enough to allow anyone who was interested to become involved in the project. As Norfolk is the fifth largest county in the UK (5,371 km²), we needed a system that distributed limited equipment (19 detectors) across the area. We wanted centres that were open and widely used by the public, and that were easily accessible and geographically well spaced across the county. In addition, we wanted the opportunity to work with a range of communities and organisations that had their own network of volunteers or members.

In 2013, Bat Monitoring Centres were set up at two National Trust properties (Oxburgh Hall and Sheringham Park), Toad Hole Cottage (Broads Authority), Titchwell Marsh (Royal Society for the Protection of Birds), Welney (Wildfowl & Wetlands Trust), Sculthorpe Moor (Hawk & Owl Trust), BTO headquarters in Thetford, the Ted Ellis reserve at Wheatfen, Dinosaur Adventure in Lenwade, and the Local Records Centre (Norfolk Biodiversity Information Services NBIS) in Norwich, and at nine local libraries (Attleborough, Caister-on-sea, Dereham, Gaywood, Hethersett, Long Stratton, Swaffham, Watton and Wells next-the-sea).

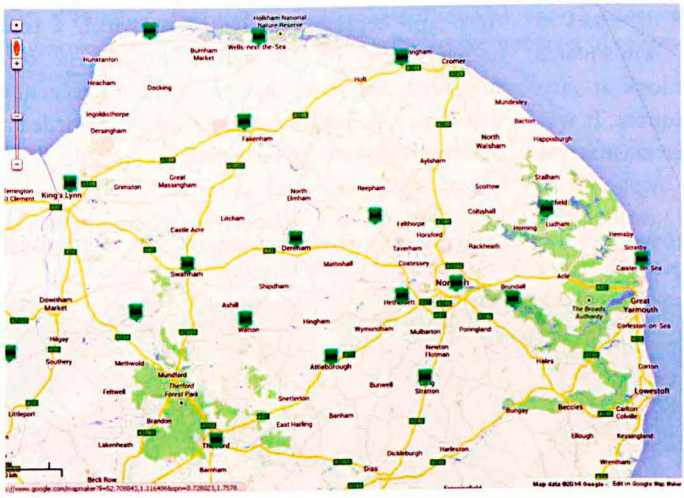

Figure 1 The 19 Bat Monitoring Centres set up across Norfolk.

fication further than would otherwise be possible. Used within a well-designed structured monitoring programme, this has the potential to provide robust and representative assessments of species for which the UK has legislative or reporting requirements. Information on species' distribution, status and population trends underpins local decision-making and the targeting of conservation action, as well as providing evidence for biodiversity-reporting and supporting policy-relevant research. Unfortunately, the equipment required for these purposes is prohibitively expensive, so is largely restricted to use by environmental consultants and university research groups.

In April 2013, we trialled a novel approach to this problem at county-level through the Norfolk Bat Survey. The project, which was largely funded by the People's Trust for Endangered Species (PTES UK Mammal Grant) and Defra (Defra Fund for Biodiversity Recording in the Voluntary Sector), aimed to enable anyone in Norfolk to take advantage of recent developments in bat-detecting technology (see www.batsurvey.org).

We collaborated with a range of other organisations and local libraries across Norfolk to set up 19 'Bat Monitoring Centres' at existing sites used by the public (see Fig. 1) from which anyone could borrow a static bat-detector for a few days (Wildlife Acoustics SM2Bat+ detector recording in full-spectrum; see Waters & Barlow 2013). With the appropriate guidance, we believe that static detectors can be deployed in the field by anyone interested in getting involved in monitoring his or her local wildlife. The detectors are left outside all night and are automatically triggered to record upon a memory card every time a bat passes. In return for collecting and returning data from their local patch, participants are sent a summary of the bats they recorded within a few days of taking part. As a result of this approach, members of the public are given an opportunity to participate in bat surveys and take advantage of bat-recording technology that would not normally be available to them.

Site choice

Ideally, survey sites (the 1-km square was chosen in order to be comparable with the NBMP and standardised monitoring of other taxonomic groups in the UK) would normally be selected and allocated at random to people wanting to take part in the project, so as to ensure representative coverage across the county. However, we felt that this would reduce participant uptake, so we allowed a free choice of 1-km squares to survey,

although we appreciated that this approach might incur costs in terms of any subsequent analysis to control for biases in coverage. We provided written and video tutorials on how to set up the detectors, and guidance was given on how and where to place the detector within the selected square in order to maximise the chance of recording bats. The survey was run from mid-April until the end of September, to cover the core activity period of bats, and to maximise use of the equipment during the year.

Intensive small-scale field trials were carried out during the previous September at five sites, the idea being to discover the effort required to provide a reliable representation of species present within a 1-km square. While we considered that each Bat Monitoring Centre would have only a single detector, we placed several detectors at different points across a number of 1-km squares over multiple nights, enabling us to look at variation in species recorded within a square. It was clear that not only was there a big increase in the number of species logged when two complete nights of recording were carried out compared with one, but this number continued to increase with three and four visits. There was also considerable variation in the number of species recorded at different points within a 1-km square on the same night (between one and six species), suggesting that bats were using particular micro-habitats within a square for foraging or commuting.

To identify the number of visits that would be required to detect all species present over a season, we looked at the species-accumulation curve for a single rural site in Hapton, Norfolk (OS grid TM1797), where a detector was put out on consecutive nights when the temperature was predicted not to fall below 7°C. We focused on data collected across 131 nights between mid-April and September 2012, over which a total of ten species of bat were recorded. The data suggested that more than 60 nights of recording would be required to detect all species recorded at that single point over the season.

A microphone is connected to the SM2Bat+ detector box and raised to a height of about 9 feet, and then left out on a pole to be automatically triggered to record every time a bat passes close by. Stuart Newson

Species	Number of Recordings	1-km squares (% total)	% decline detectable (8% coverage)	% decline detectable (20% coverage)
Common Pipistrelle *Pipistrellus pipistrellus*	153,580	419 (94%)	10	5
Soprano Pipistrelle *Pipistrellus pygmaeus*	81,894	399 (89%)	10	5
Nathusius' Pipistrelle *Pipistrellus nathusii*	230	92 (21%)	35	25
Daubenton's Bat *Myotis daubentonii*	1,246	82 (18%)	40	25
Natterer's Bat *Myotis nattereri*	355	104 (23%)	35	25
Whiskered/Brandt's Bat *Myotis mystacinus/brandtii*	129	45 (10%)	50	35
Noctule *Nyctalus noctula*	2,899	235 (53%)	20	15
Serotine *Eptesicus serotinus*	537	100 (22%)	35	25
Leisler's Bat *Nyctalus leisleri*	101	37 (8%)	55	40
Brown Long-eared Bat *Plecotus auritus*	1,191	208 (46%)	20	15
Barbastelle *Barbastella barbastellus*	1,019	162 (36%)	25	20
Unidentified pipistrelle	11,891			
Unidentified *Myotis* species	2,358			
Unidentified big bat: Noctule, Serotine or Leisler's Bat	1,398			

Table 1 Number of recordings, percentage of squares reporting species, and percentage decline in species presence detectable at a Norfolk level, with the current level of coverage (8% of Norfolk) and increasing coverage to 20%.

Clearly, a compromise was needed between trying to detect as many species as possible and yet not restricting coverage to a small number of sites, so we decided to ask participants to undertake three complete nights of recording within each 1-km square. By doing this we accepted that species with a low detection probability, either because they occur at low density or because they produce very quiet echolocation calls, such as Brown Long-eared Bat, or species that rarely pass through a 1-km square, may be missed by this approach. With almost as much variation in species recorded within squares as between different squares, we decided that the three nights of recording should be made at three different points within each square.

Encouraging broad survey coverage

Publicity before and during the project directed people to an online tool that allowed volunteers to sign up for the survey (www.batsurvey.org/sign-up/). This website showed up-to-date coverage of sites and indicated which 1-km squares were available for survey. This simple approach to survey coordination was extremely useful in encouraging volunteer uptake, and permitted a focus on areas of poor coverage at different times during the season. Clicking on a 1-km square sent the participant's e-mail address and chosen 1-km square grid reference to a dedicated e-mail account for the project, and the online map was then updated. On the selection of a 1-km square, a web link was given to the volunteer for a detector-booking system, through which a detector could be reserved at a Bat Monitoring Centre of the volunteer's choice for the duration of his or her participation. People were encouraged to book a four-day slot where possible, in order to put the detector out at three different points over three consecutive nights and return the detector on the fourth day. Twitter and Facebook were used to promote and seek feedback, views and experiences from members of the public who took part.

Recording bat calls in full-spectrum produces many large *.wav files that it would not be easy to transfer electronically; it is possible to generate over 10 GB of files over a few nights at a good site. The most efficient way in which to collect participants' data was, therefore, to supply all participants with a freepost envelope in which to return their detector's memory card along with a completed recording form at the end of their survey. Along with the SM2Bat+ detectors, we used SonoChiro to provide a first analysis of the recordings.

Extensive coverage

The response was extraordinary. Thanks to an enthusiastic public, the project was able to survey no fewer than 448 1-km squares (about 8% of Norfolk) during 2013, and we received over a

quarter of a million high-quality recordings of bats (Table 1, page 267). To the best of our knowledge, this is the largest county-level project of its type.

In the short term, this has allowed us to determine the distribution and relative abundance of Norfolk's bats, including several scarce or localised species for which previously there was only a handful of records for the county. This compares with about 1,000 bat records of all species which are normally submitted to the Local Records Centre (NBIS) for the county each year.

Power to detect change

By making repeat visits to the same sites in different years, we have the potential to monitor change in bat populations in Norfolk. Currently, the Norfolk Bat Survey should be able to detect a contraction in range of 25% or less for five species of bat in Norfolk (Common Pipistrelle *Pipistrellus pipistrellus*, Soprano Pipistrelle *P. pygmaeus*, Noctule *Nyctalus noctula*, Brown Long-eared *Plecotus auritus* and Barbastelle *Barbastella barbastellus*) (Table 1). If we were able to increase survey coverage in the future from the current 8% to 20% of Norfolk (1,074 1-km squares), however, we would be able to detect a 25% decline or less in presence for nine of 11 species considered here.

Acoustic identification still has some way to go before we can confidently discriminate some of the cryptic *Myotis* species in particular, although work by Kate Jones and colleagues at the University College London and John Altringham and his team at Leeds University are making significant progress in this respect. There are clear opportunities to maximise the use of acoustic data here to identify sites, where more intensive site-based work, potentially using an acoustic lure with mist-netting, could usefully be carried out to confirm presence of individual species that are difficult to detect or currently cannot be confidently identified from calls.

Where next?

In all, 352 people took part in the 2013 Norfolk Bat Survey. From the Twitter and e-mail feedback that we received from volunteers taking part, it is clear that the project worked with a new pool of volunteers (largely non-bat specialists), and involved a broad range of communities and individuals, including schools, church groups, local businesses, the farming community, wildlife groups, reserve-managers, families and university students.

The enthusiasm of these volunteers is hugely encouraging, and suggests that the project could be developed more widely in future years. Ideally, given funding, we would like to set up, promote and support an additional ten Bat Monitoring Centres across Norfolk, with additional 'floating detectors' which could be used by participants who are interested in surveying larger areas.

After reviewing feedback from participants and centres hosting equipment, we shall be making a number of changes to the project in 2014, to simplify the experience of taking part, and to give a greater reward in terms of the feedback that volunteers receive through their participation. In addition, we plan to work with some additional communities and wildlife groups who took part in the project in 2013, and are keen now to purchase their own equipment. This benefits the project by increasing survey coverage of particular areas, and in return groups or communities are able to take advantage of the system that we have set up for analysing and providing feedback to them on species recorded. Through this trial we have shown what can be achieved with a limited budget, but, as with any long-term volunteer-based monitoring, continued investment is essential.

Thanks to a further UK Mammal Grant from the PTES in 2014, we are carrying out a critical evaluation of the Norfolk Bat Survey approach and what the data can tell us about bat species' distribution, relative abundance and fine-scale habitat requirements, which we hope to publish later this year. More generally, while this project directly improves our understanding of bats in Norfolk, it has important implications for building on and improving bat conservation and monitoring strategies more widely, and we hope that this project stimulates enthusiasm and is able to feed into and help to inform future projects in the UK and overseas. While there are still a number of challenges to overcome, there is the potential in the future, with continuing development of these types of methods and technologies, to broaden this kind of approach to a larger scale and potentially expand the species coverage of bat-monitoring with bat-detectors at a national scale, thus boosting the essential information gathered through the existing programme.

Importantly, this project is a partnership that brings national and local groups together, which we hope to build on further in the future.

Volunteers of all ages took part in the project. Stuart Newson

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