Romptickle Viaduct and Thurgoland Tunnel: survey and designation of a site for bats.

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Background Information

This document details bat survey work undertaken on a site in South Yorkshire that has highlighted the presence of a range of summer and winter bat roosts used by a number of widely occurring bat species. The bat interest of the site is considered sufficient grounds to designate it as Local Wildlife Site (LWS) with the justifications for this decision and the designation process explained. It is hoped this document may act as a spur to other bat workers to pursue designation of the best bat sites.

Our site (Central OS Grid Ref. SE280008) is located along the Trans-Pennine Trail on the boundary of Thurgoland village, Barnsley adjacent to the River Don within an upland river valley on an area with coal measures geology in the Yorkshire Southern Pennine Fringe National Character Area (Natural England, 2013). The main land uses in the local area comprise woodland and pastoral farmland with a sewage works located a short distance to the north-west. The site is located at the northern end of an extended tract of mixed-woodland, which at approximately 14km^2 comprises the largest area of continuous woodland within South Yorkshire, encompassing several Local Nature Reserves.

The site itself comprises three built structures: a former rail viaduct (Romptickle Viaduct) crossing the River Don, a disused railway tunnel (Thurgoland Tunnel) located 400m south-east of the river and a single span stone bridge (Drystone Bridge), located approximately 10m south of the viaduct. Romptickle Viaduct and Thurgoland Tunnel are both owned by Barnsley Metropolitan Borough Council (BMBC) with ownership of Drystone Bridge unknown.

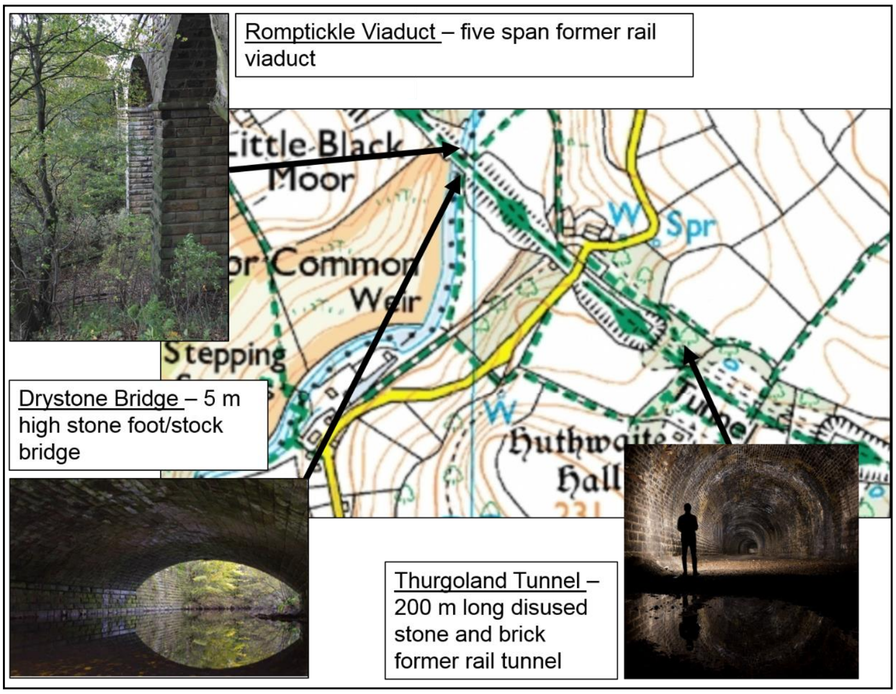

Figure 1 Site layout

Romptickle Viaduct comprises a five span stone-built viaduct built in 1844. The viaduct is approximately 25m high at its tallest point with a total span of approximately 30m. The underside of the arches is generally well pointed however the piers have numerous openings between stone blocks leading to deeper voids.

Thurgoland Tunnel comprises a pair of tunnels with an older double bore tunnel to the north and a more recently built tunnel, now used as a bridleway, to the south. The older stone block built tunnel is approximately 6m high and supports all the bat interest, with a variety of cracks between blockwork and beneath rough sawn wooden planks which have been nailed in place at head height more than ten years ago. All further mention of Thurgoland Tunnel refers to the northern tunnel. The south-eastern portal of this tunnel is largely blocked by a spoil pile leaving a narrow access of approximately 0.5m between the upper edge of the portal and the spoil. The north-western portal is part blocked by a breezeblock wall with a grill across the top half. In March 2014, with input from South Yorkshire Bat Group (SYBG), Barnsley Council modified the north-western portal of Thurgoland Tunnel through the addition of welded galvanised steel plate across the majority of the metal grill to reduce airflow. In October 2015, twelve 0.5m^2 panels of clear corrugated plastic were attached to walls within the tunnel to increase roosting space for bats.

Drystone Bridge is a single-span bridge approximately 20m deep, 8m wide and 5m high. There is no evidence of pointing between component stone blocks and consequently abundant crevices and voids are present between stones. The top of the bridge is earth filled, grass covered and is used for grazing.

Prior to the involvement of SYBG, use of Thurgoland Tunnel by two hibernating brown long-eared bats had been recorded in 1996. Roosting bats were not known to use Romptickle Viaduct or Drystone Bridge. Potential for the viaduct and bridge to be used by roosting bats came to light as a result of the 'Daub's on't Don' project, the objective of which was to locate one or more Daubenton's bat *Myotis daubentonii* maternity roosts on the River Don. The initial visual inspection of these structures by SYBG members took place in December 2012.

Methods

Between 2012 and 2015 members of SYBG undertook 21 survey visits to the site using a range of survey techniques targeted at locating different types of bat roost.

Romptickle Viaduct has been subject to visual inspections, nocturnal survey and survey using an Anabat SD1 static monitoring device. Visual inspections of the viaduct have been conducted from ground level using a one million candlepower torch to illuminate crevices between stone blocks, which are then inspected using binoculars. In order to allow comparison of survey results between occasions this visual inspection has targeted two piers to the east of the river which are surveyed to a set height, with the location of each roosting bat precisely recorded. Twelve visual inspections were undertaken following this system at regular intervals over a period of approximately one year from winter 2013/2014 to winter 2014/2015.

The viaduct has been subject to nocturnal survey on five occasions comprising four dusk-emergence and one dawn-return survey. One dusk emergence (19/05/2013) and one dawn return survey (17/08/2013) covered the majority of Romptickle Viaduct in addition to Drystone Bridge, with the further three dusk emergence surveys focused on an identified

Daubenton's bat maternity roost and adjacent areas (18/08/2013, 18/05/2014 and 23/07/2014). It should be noted that due to volunteer surveyor availability on no occasion have the viaduct or bridge been subject to survey with the number of surveyors that would be necessary to comply with the accepted bat survey guidance (Hundt, 2012). On 31/08/2015 an Anabat SD1 was installed for five nights at the base of the viaduct's eastern pier.

Thurgoland Tunnel has been subject to visual inspection using a one million candlepower torch and binoculars on two occasions (15/12/2013 and 21/02/2015) with an Anabat SD1 installed within the centre of the tunnel for a period of one week from 15/12/2013.

In addition to being included in one dusk emergence and one dawn return survey, Drystone Bridge has also been subject to full visual inspection, using a torch and waders on one occasion (29/06/2013).

Results

Romptickle Viaduct has been shown to support a large Daubenton's bat summer roost (maximum count = 124 bats), a large *Pipistrellus* species hibernation roost (maximum count = 30 bats), together with day and/or transitional roosts of brown long-eared bats *Plecotus auritus*, common *Pipistrellus pipistrellus* or soprano pipistrelle *P. pygmaeus* and an as yet unidentified *Nyctalus* species bat.

The large Daubenton's bat roost recorded from the viaduct is considered likely to comprise a Daubenton's bat maternity roost. Whilst Daubenton's bats are also known to form large male only bat roosts (Senior et al., 2005) the roost within the viaduct is located in close proximity to high quality bat foraging habitat within a lowland setting, both factors associated with Daubenton's bat maternity roosts (Encarnacao et al., 2005; Angell et al., 2013). In addition maternity roosts are typically located in warm settings; the observed roost is located in the southern elevation of the viaduct, possibly beneath the heat absorbing tarmac surface of the bridleway.

Visual inspections have shown the viaduct is used during the hibernation period by a large number of roosting *Pipistrellus* species bats. Both common and soprano pipistrelle bats are known to roost in the viaduct however the breakdown between these two species is difficult to gauge. Given that fewer than half the bat-accessible crevices between stonework can be inspected during ground based visual inspections, the actual number of *Pipistrellus* species bats over wintering within the viaduct is likely to be at least double the total peak number recorded during inspections. Repeated visual inspection of a set range of external crevices on Romptickle Viaduct, undertaken throughout the year, has shown the structure supports a large *Pipistrellus* species hibernation roost, occupied by the peak number of bats during the coldest period of winter. The number of *Pipistrellus* species bats roosting within the viaduct drops off sharply in spring and rises sharply in late autumn with no bats recorded from the surveyed range of crevices during some periods in mid-summer.

Preliminary static monitoring survey work also suggests that Romptickle Viaduct may be used by autumn swarming *Pipistrellus* species bats, in accordance with observations collected from Holland by Erik Korsten (pers. comm).

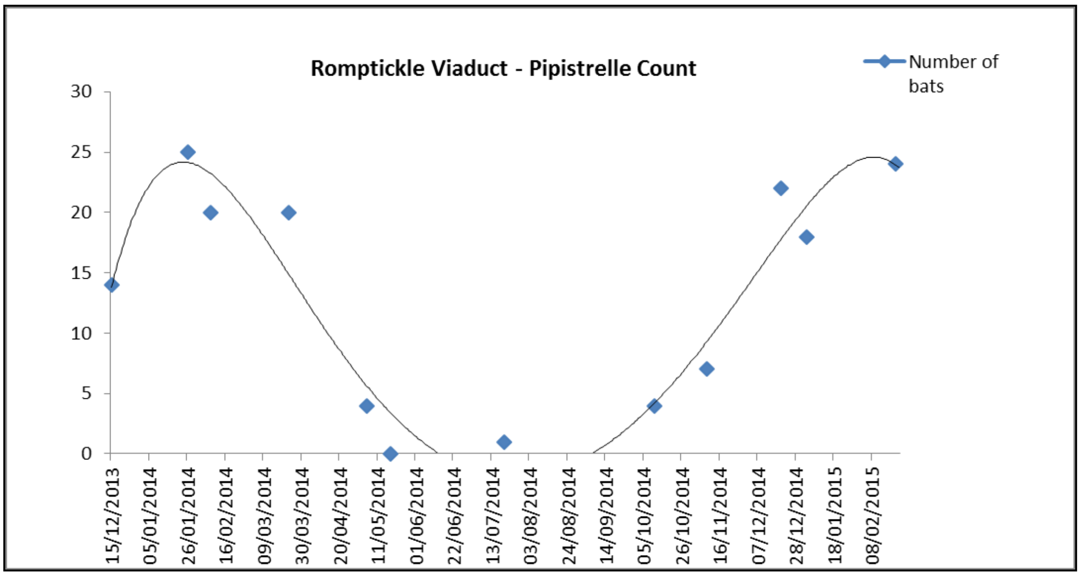

Figure 2 Annual change in roosting pipistrelle numbers at Romptickle Viaduct

Thurgoland Tunnel supports hibernating Daubenton's bats and brown long-eared bats with SYBG surveys recording a maximum count of one bat of each species using the tunnel. Drystone Bridge has been shown to support a Daubenton's bat day or satellite roost used by a maximum count of one bat.

Plates

Top left image – underside of Drystone Bridge. *Top centre image* - west portal of Thurgoland Tunnel *Top right image* – thermal image of Thurgoland Tunnel interior taken in February 2015. *Central image* – panorama of Romptickle Viaduct from top of Drystone Bridge. *Bottom left image* – red circle shows the location of the large Daubenton's bat maternity roost. *Bottom central image* – four pipistrelle bats hibernating in crevice in Romptickle Viaduct. *Bottom right image* – single hibernating brown long-eared bat behind sawn timber section in Thurgoland Tunnel.

Site Designation

The decision was made to pursue LWS designation in order to formally recognise the site's significance to bats, increase the likelihood of protection from development/during maintenance, spread knowledge of bat presence in the area and promote further survey. If successful, this designation would comprise the second designation of an LWS solely or partially for bats within Barnsley and only the fourth such designation within South Yorkshire.

The LWS designation criteria adopted by BMBC were consulted. The bat section of the 'Barnsley Natural Heritage Sites: Species Designation Criteria' document (BMBC, 2011) states:

> "Sites qualifying for consideration will include one or more of the following:
>
> (a) Any breeding roost site that regularly supports a significant colony of bats (100 or more soprano pipistrelle bats *Pipistrellus pygmaeus*, 60 or more common pipistrelle *Pipistrellus pipistrellus* bats or 30 or more of any other bat species);
> (b) Any hibernation site which regularly supports at least 10 bats or 2 or more species of bat;
> (c) Any series of smaller hibernation sites which individually may not qualify as at (b) but together are considered of significance;
> (d) Any roost site which regularly supports at least 3 bat species;
> (e) Any habitat area (e.g. woodlands, river corridors, lakes/lodges/ponds) which regularly support 4 or more foraging bat species;
>
> Where breeding sites are considered for selection, the selection may include vital flight and commuting routes to and from the roost and vital foraging areas around the roost."

The Romptickle Viaduct site can be considered to satisfy all potential qualification criteria based on survey results obtained and consequently a 'Case for Designation' document was written by SYBG and sent to the BMBC Ecologist for his consideration. In February 2014 two members of SYBG were invited to a meeting of the Barnsley LWS Panel to present the case for designation in person. The proposal met with broad approval at the meeting and the Romptickle Viaduct site was accepted as a candidate LWS (cLWS). An obligatory Phase 1 survey of the potential site area was undertaken in July 2015. It remains for the boundaries of the site to be fully defined, after which stage there should be no further barriers to full adoption of the site as a LWS.

Further Work

Romptickle Viaduct has been registered as National Bat Monitoring Programme hibernation site and both this structure and Thurgoland Tunnel will be subject to two visual inspections a year for the foreseeable future, with single survey visits in January and February.

Initial survey findings suggest that Romptickle Viaduct is used by autumn swarming pipistrelle bats. Further survey targeted at confirming this use will be undertaken in autumn 2016. In order to understand the activity and arrival of hibernating *Pipistrellus* speices bats at the viaduct during the peak winter months, a static monitoring and temperature survey is ongoing, with one Anabat SD1 and a Tinytag temperature logger deployed near the base of the eastern pier to enable continuous recording between December 2015 and February 2016 inclusive. Comparisons of bat activity with temperature and date will be undertaken to try and determine patterns in activity.

In order to spread knowledge of bat usage of the area and bat conservation in general, it would be desirable to install an interpretation panel on Trans Pennine Trail railings along the deck of the viaduct. Coupled with one or more bat walks this measure would help spread knowledge of bats amongst recreational users of the trail and these options will be pursued upon formal designation of the site in order to mark this event.

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Tottergill lime kiln, RSPB Geltsdale, Cumbria.

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Introduction

Interest in Tottergill began as a mature sycamore tree was growing on top of the lime kiln and had been identified by RSPB site staff as having potential for damaging the structure. The tree was rooted in the top edge of the kiln and branches were overhanging the entrances to the draw arches. Due to the location of the kiln, at the head of a wooded valley, it was anticipated that the kiln may be used by bats at certain times of the year.

To ascertain bat use of the site prior to any work being carried out to fell the tree, an SM2+ bat detector was placed on the retaining wall immediately east of the kiln in October 2012. Over 4,900 bat call files were recorded during the night of 09-10/10/2012. Sound analysis identified *Myotis* species bats, common pipistrelle *Pipistrellus pipistrellus* and soprano pipistrelle *P. pygmaeus* flying around the kiln. Subsequently, *Myotis* species bats were observed flying within the lime kiln on 13/10/2012. Time expansion calls identified some of the *Myotis* species calls as Natterer's bat *M. nattereri*.

Due to the high level of bat activity in and around the kiln in October 2012 it was thought that this kiln may be a significant swarming site and potential hibernacula. A Natural England bat project licence was applied for and approval was sought from the RSPB Reserves Ecology Team to allow research to be undertaken in the swarming period using mist nets to catch and ring any *Myotis* species bats caught at the kiln. This short report summarises the bat research that has been undertaken at Tottergill lime kiln between 2013 and 2015.

Site description

Tottergill lime kiln is a small double arched kiln beside the Totter Gill towards the head of an open wooded valley on the western slope of Castle Carrock Fell, Cumbria. The valley contains secondary woodland with a diverse mix of semi-mature and mature conifers and broad leaved trees. Castle Carrock reservoir lies 500m to the west. The immediate surrounding area is un-improved limestone grassland and heather moorland, grazed by sheep.

Tottergill lime kiln is constructed from random stone blocks with an assumed rubble fill. The kiln has an unusual construction in that each draw arch has two draw eyes and the two draw tunnels go to the same pot. Each draw arch of the kiln is relatively small, with width of 2.1m, depth of 2.7m and a maximum height of 2.7m (www.solwaypast.co.uk).

The kiln is at 235m above sea level (asl) and is located within Ordnance Survey grid reference NY550544. The kiln is within the RSPB Geltsdale nature reserve and is owned and managed by the RSPB (see Figure 1).

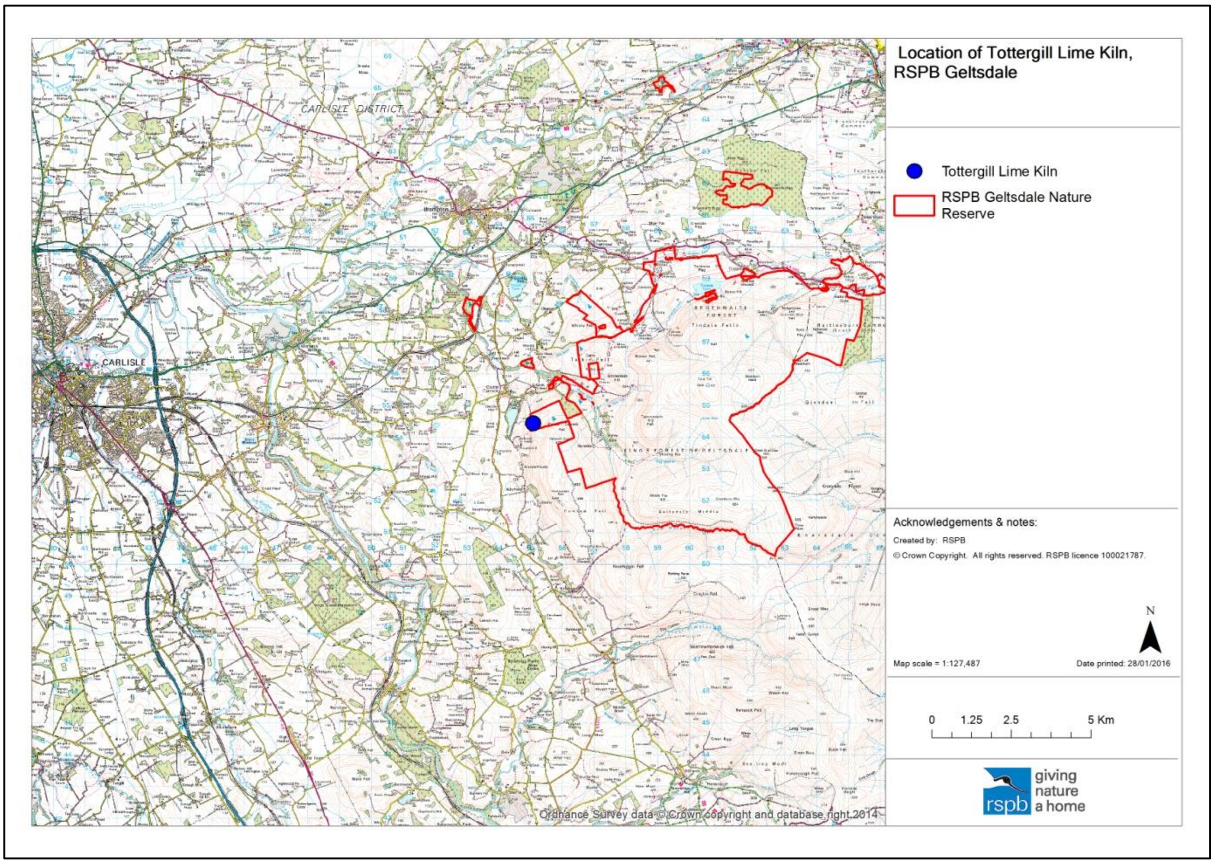

Figure 1 Location of Tottergill lime kiln, RSPB Geltsdale.

Methodology

As the mature sycamore needed to be removed to limit future structural damage to the kiln and due to the bat interest at the site, works have been phased to maintain the microclimate around the kiln during and after the works. The majority of the sycamore was removed in September 2013; the lower limb that hangs down over the draw arches was preserved to help maintain some climatic stability at the site. An SM2+ bat detector was placed at the kiln before, during and after the works to monitor the bat activity levels around the kiln during the tree works.

Subsequently, eleven swarming surveys have been undertaken at the site between 2013 and 2015, in August, September and October (see Table 1). The nets were set before sunset and remained in place until bat activity had effectively stopped. Over the three years of the project, the earliest catching survey was on 16th August and the latest was on 4th October. Previous studies have shown that swarming occurs between August and October with a peak in activity between mid-August to mid-September (Parsons et. al., 2003a, b). As mist nets were used to catch bats, trapping could only take place on still nights, and as Tottergill is at 235m asl, finding suitable nights for trapping proved challenging.

Date	Sunset	Start time	End time	Trapping hours	Minimum temperature
14/09/2013	19:27	19:00	01:30	6.5	-
20/09/2013	19:11	19:00	00:00	5	-
04/10/2013	18:36	18:00	23:00	5	-
31/08/2014	20:02	19:30	01:00	5.5	13.25°C
04/09/2014	19:52	19:30	03:30	8	14.5°C
17/09/2014	19:19	19:00	04:00	9	16.25°C
29/09/2014	18:48	18:30	03:00	8.5	12.0°C
16/08/2015	20:38	20:30	03:30	7	9.0°C
31/08/2015	20:02	19:45	03:15	7.5	9.75°C
08/09/2015	19:42	19:30	01:00	5.5	10.0°C
26/09/2015	18:56	18:15	00:45	6.5	8.25°C

Table 1 Swarming survey dates.

All bats caught were identified and their biometrics taken. The data recorded were the species, sex, age, reproductive status, forearm length and weight of each individual. All *Myotis* species bats were ringed on the right forearm with individually numbered rings as supplied by the Bat Conservation Trust. Fur clippings were taken, under licence, from selected small *Myotis* species to allow DNA analysis for species confirmation.

During 2015 an Anabat Express detector has been left by the kiln at intervals during the bat activity season. The detector was first deployed on 15/05/2015 and was brought in for winter after the heavy rains on 05/12/2015. On each occasion, when the detector batteries were changed the kiln was inspected visually for the presence of roosting bats.

Results

The majority of the mature sycamore was removed in heavy rain on 05/09/2013, the branch that hangs down to the south west over the south face of the kiln was retained. Heavy rain started to fall before dawn on 05/09/2013 and continued until during the night of 06-07/09/2013; the minimum night time temperature also fell more than 6°C during this period.

The remote detector at the kiln recorded Daubenton’s bat *Myotis daubentonii*, Natterer's bat, *Myotis* species bat, noctule *Nyctalus noctula*, common pipistrelle, soprano pipistrelle and brown long-eared bat *Plecotus auritus* around the kiln. The number of bat calls fell after the tree works with the lowest number of bat sound files recorded the second night after the tree was removed but bat activity recovered to above previous levels within three nights (see Figure 2). The fall in bat activity is likely to be related to both the disturbance caused by the tree works and the wet and cool weather.

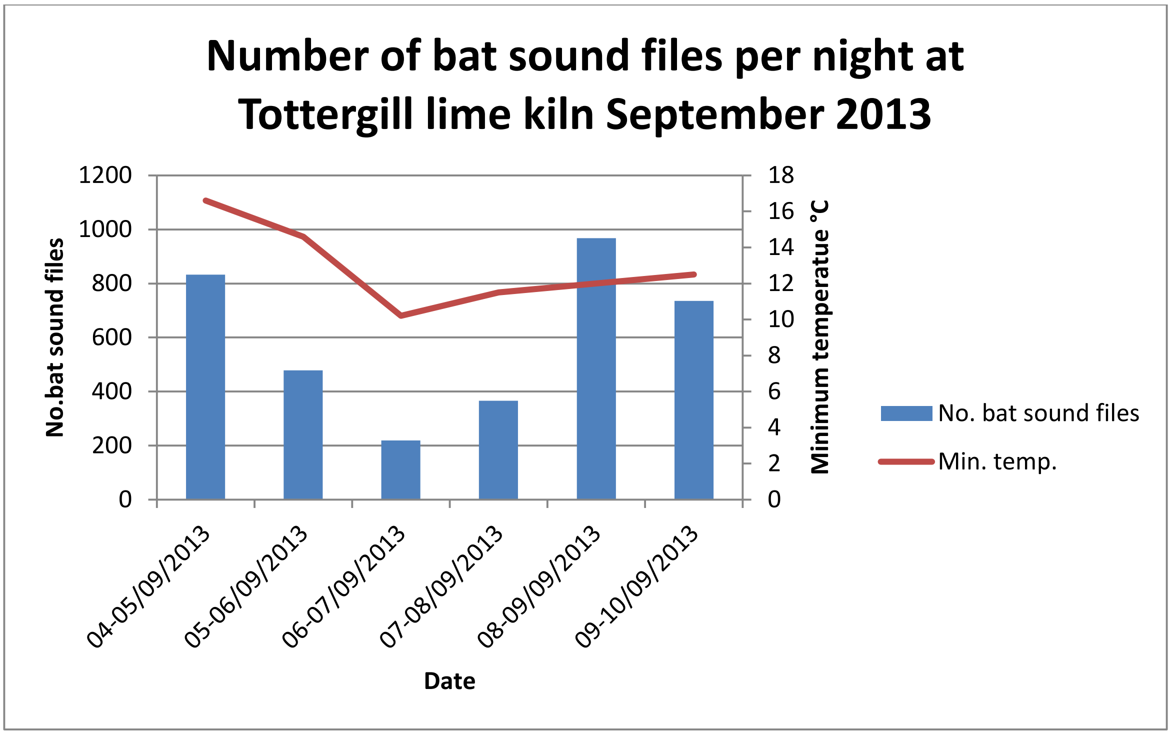

Figure 2 Number of bat sound files per night at Tottergill lime kiln September 2013.

Eleven swarming surveys have been undertaken at the kiln and 105 bats of seven species have been caught under licence between 2013 and 2015 (see Figure 3).

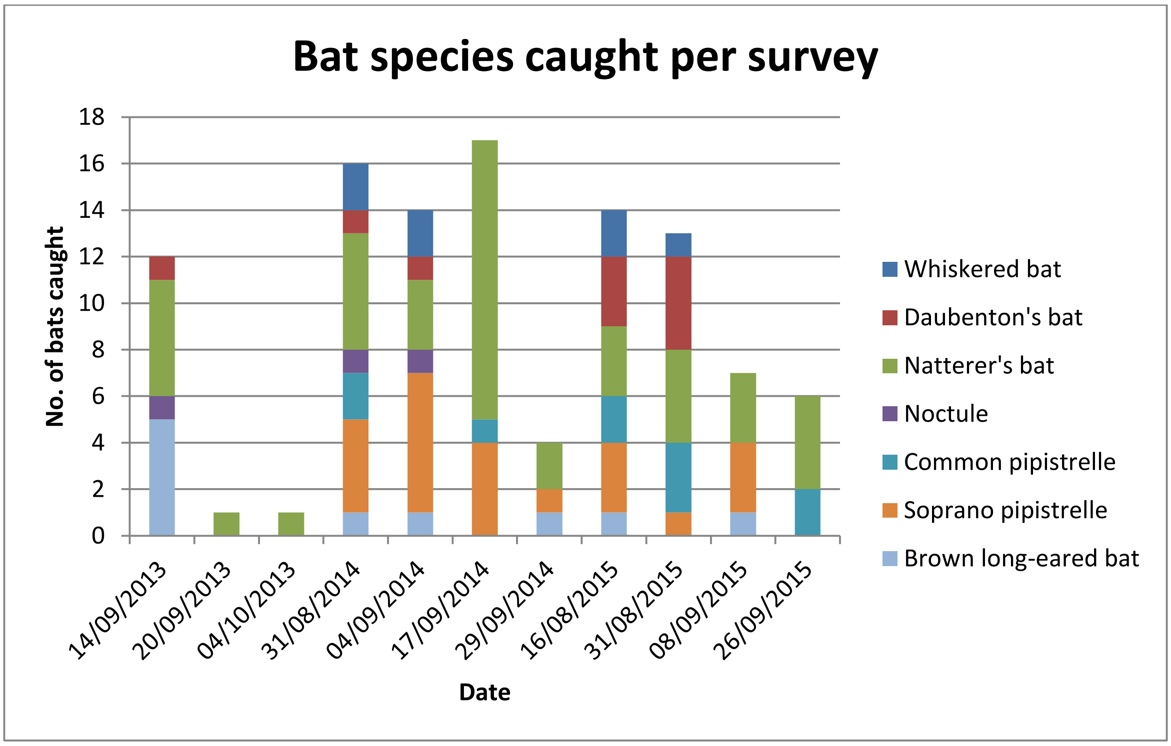

Figure 3 Bat species caught per survey.

Four of the five resident swarming species have been caught at the kiln. Noctule, common pipistrelle and soprano pipistrelle have also been caught at this site, with both common and soprano pipistrelle caught whilst trying to enter the kiln.

Natterer's bats were the most numerous bats encountered, with 43 bats caught, accounting for 41% of bats caught. Thirty six Natterer's bats have been ringed, four individuals have been recaptured and two bats were not ringed due to old injuries along their forearms. Soprano pipistrelle was the next most frequently caught bat at 22, 21% of all bats caught. Ten Daubenton's bats, ten common pipistrelle and ten brown long-eared bats have been trapped (9% each), seven whiskered bats *M. mystacinus* and three noctules have been caught, 7% and 3% respectively. Whiskered bats were first caught in 2014; three of these bats were fur clipped for DNA analysis, the results confirming the species identification in the field. Two more individuals were subject to DNA analysis in 2015, again confirming whiskered bat.

Previous studies have shown that during the swarming period the species composition changes from relative species evenness to a greater proportion of Natterer's bat in the catch (Glover and Altringham, 2008). The pattern of bats caught at Tottergill fits within this trend (see Figure 4).

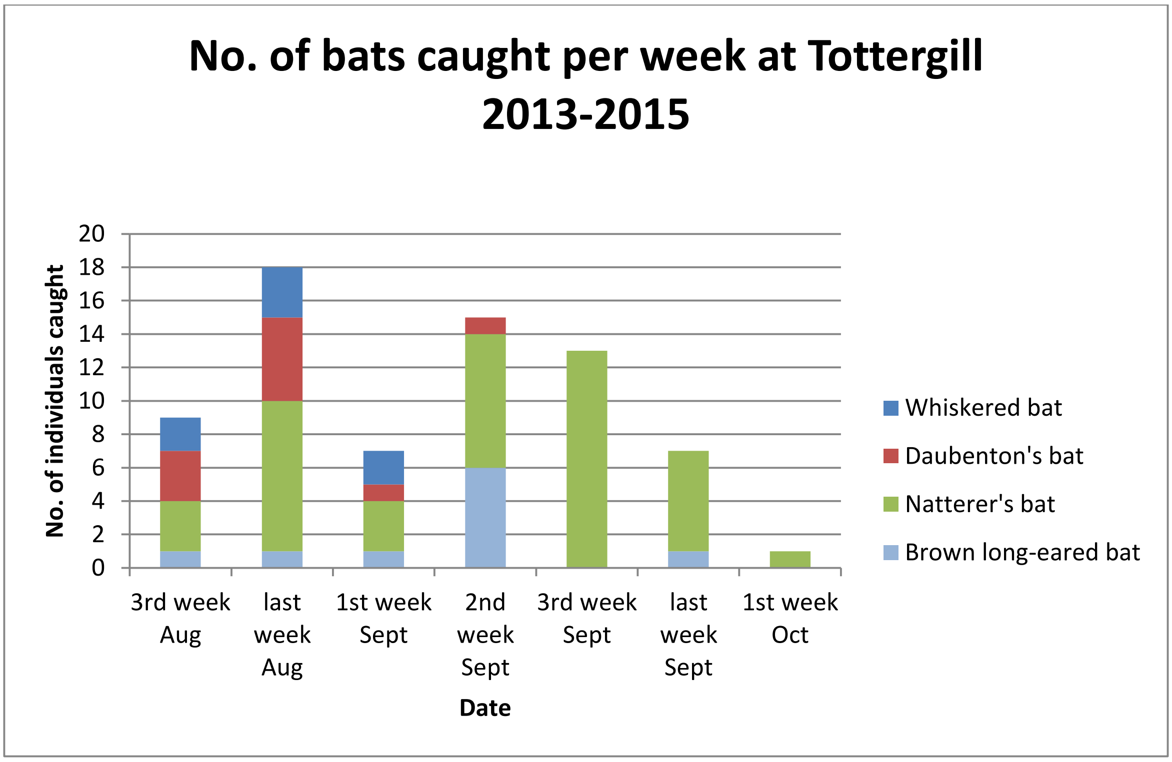

Figure 4 Number of bats caught per week at Tottergill 2013-2015.

The sex ratio of all bat species caught is strongly biased towards males, 84 males caught compared to 21 females. This is true, not only of the *Myotis* species and brown long-eared bats, the species that are known to visit swarming sites, but also of noctule and the *Pipistrellus* species bats caught at the kiln (see Figure 5). This skewed sex ratio corresponds to data from previous studies (Rivers et. al., 2006). Male bats are thought to visit swarming sites on several occasions during the swarming period to increase their chance of fathering offspring whereas a female bat only needs to mate on a single occasion.

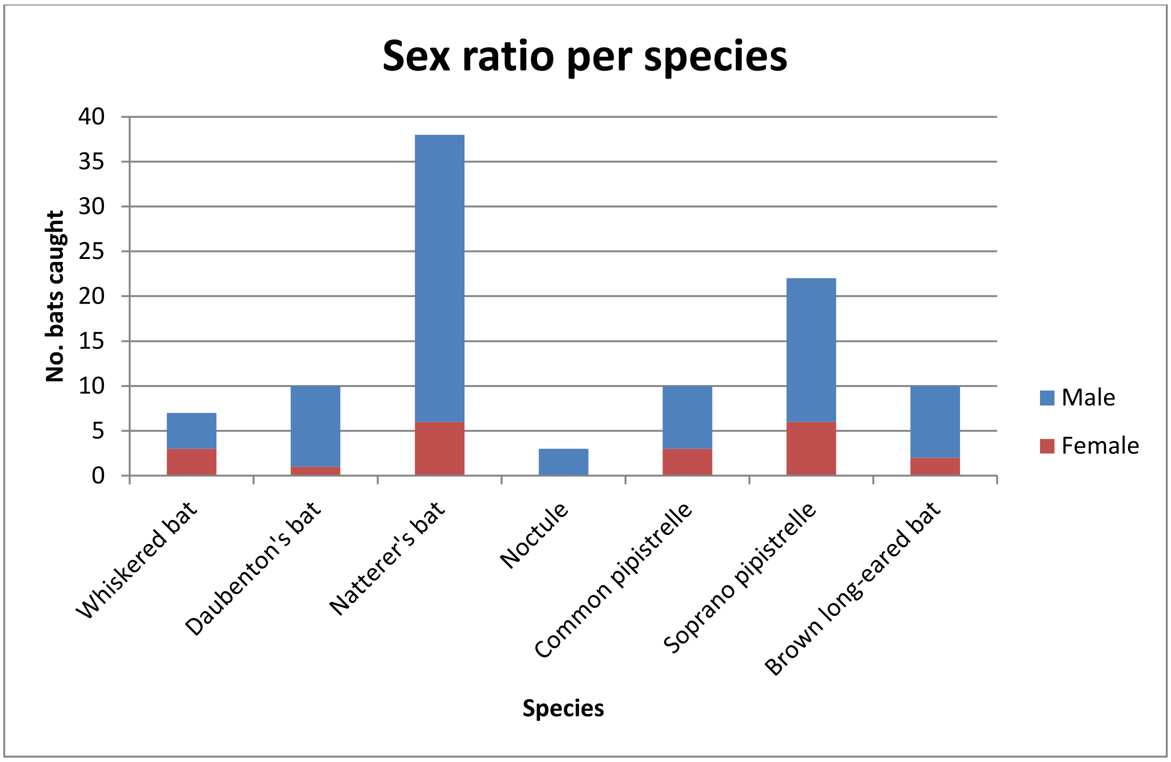

Figure 5 Sex ratio per species.

Glover and Altringham (2008) found that for Natterer's bat the ratio of females caught increases two to three-fold during the peak swarming season. The data for Tottergill fits this pattern although the sample size is small; six female Natterer's bats were caught during this study, all during September; one in the first week, two in the second and three in the third week.

Studies by Glover and Altringham (2008) have found that bats show high fidelity to single swarming sites with only two of 239 retrapped bats in their study moving between swarming sites.

At Tottergill lime kiln four individual ringed Natterer's bats have been retrapped, one twice. All four bats that have been retrapped were adult males. Y4927 was ringed on 14/09/2013 and then caught roosting in the kiln on 29/09/2014 and caught again on 26/09/2015, pictured right. Y4948 was ringed on 04/10/2013 and retrapped in the kiln on 31/08/2015. The two other recaptures have been same year retraps, Y4962 was caught on 31/08/2014 and again on 17/09/2014, roosting in the kiln on both occasions and H4970 was caught on 08/09/2015 and retrapped on 26/09/2015.

Retrapping bats that have been caught in the kiln, for example catching two bats within 17 and 18 days of original capture, illustrates that the disturbance does not cause them to leave the site. Y4927 has been seen in all three years and Y4948 was not seen in 2014, this research will allow us to study these bats through many years.

Natterer's bats use the kiln as a roost in autumn; ten Natterer's bats have been recorded roosting within the kiln on survey nights, with three bats present in the kiln on 17/09/2014.

Swarming sites are usually associated with hibernation sites. At Tottergill there are no known underground structures although a ringed bat was found deep in a crevice in the kiln on 10/11/2015. The last digit of the ring could be read, narrowing this bat down to one of three individuals, all male, two first caught in September 2014 and one in August 2015. This is the first bat that has been seen in daytime roosting within the kiln structure.

An Anabat Express detector has been deployed at the kiln at intervals during 2015. As yet this data has not been analysed, it is hoped that this data will provide an insight into the bat use of the kiln at other times of the year. In May 2013, an SM2+ bat detector recorded Natterer's bat, *Myotis* species bat, common pipistrelle, soprano pipistrelle and brown long-eared around the kiln on three nights, although the number of bat files was low, with 15, 53 and 180 bat files recorded respectively.

Discussion

Tottergill lime kiln is an important site for bats. All the resident swarming bat species have been caught at the kiln with the exception of Brandt's bat *M. brandtii*. As it is unclear if the study has over looked this species or if the species is locally absent, a request was made to the Cumbria Biodiversity Data Centre (CBDC) for records of Brandt's bat. The closest record was for a female Brandt's bat found roosting in a bat box in Gelt Woods in May 1992; this is 4.9km north west of the site. As a result of the CBDC verification process this record has been reclassified as a whiskered/Brandt's bat. This is due to the greater understanding of species identification techniques within the twenty eight years since this bat was first recorded. This is the only Brandt's bat record within 20km of Tottergill.

The level of bat activity in autumn correlates with swarming studies undertaken elsewhere, however this site is not typical of other swarming sites as there are no underground chambers that bats could be investigating in terms of hibernation sites (Glover and Altringham, 2008). Typical swarming sites allow bats to fly freely both inside and outside of the cave/mine entrance and lead directly into the underground chambers where bats can hibernate. It is possible that there could be a void within the pot of this kiln, although bat access would involve the bat landing and crawling through rubble in the draw eyes. The draw arches themselves are small, again not typical of the structures used for swarming in other studies.

This study is a long term project and it is hoped that we will continue to retrap ringed bats at this site. Similar work at castle sites in the Scottish Borders has provided data on individual bats using the same sites over a number of years with Natterer's bats being recaptured at the same site up to 11 years after they were first ringed (Stuart Smith, pers. comm.).

Acknowledgements

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Seasonal variation in activity by common pipistrelle bats *Pipistrellus pipistrellus* at Durham Cathedral cloister.

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Abstract

1. Observations of activity throughout the yearly cycle by common pipistrelle bats at Durham Cathedral cloister are compared with the results of an intensive study of a hibernaculum and swarming site at Marburg Castle, Germany.

2. The general phenology of activity at Durham is very similar to that at Marburg, with a late summer/early autumn swarming period, late autumn immigration, and evidence of emigration during mild spells from mid-winter onwards.

3. Estimates of numbers of bats visiting the cloister are necessarily speculative, but observations of numbers of grounded bats and of peak numbers of bats flying simultaneously during the swarming period are consistent with an estimate as high as 12000 for swarming and 2600 hibernating.

4. If accurate, such figures indicate that the Cathedral provides a resource for up to 0.5% of the UK population of common pipistrelle, distributed over an area with a 13.8km radius, and may be the largest recorded concentration of the species in the UK.

5. Further investigations are required to test the assumptions on which these estimates of numbers are based, as the site may be of national significance and therefore a candidate for designation as a protected wildlife site.

Introduction

Seasonal swarming by bats during late summer and autumn, in which up to several hundred individuals gather at cave hibernation sites, is associated mainly with the genera *Myotis* and *Plecotus* in the British Isles (Glover and Altringham, 2008), and is thought to be related to mating activity (Parsons et al., 2003). However, similar behaviour also occurs in common pipistrelle, which frequently enters hibernation sites in buildings as well as caves, a phenomenon often referred to as pipistrelle 'invasions' (Sachteleben, 1991, Sachteleben and von Helverson, 2006, Kanuch et al., 2010). Mark-recapture studies indicate that very large numbers may be involved in such invasions over the course of a swarming season, with an estimated 23,000 individual common pipistrelle visiting a hibernaculum in a cellar at Marburg Castle, Germany (Sendor, 2002a).

A common pipistrelle swarming and hibernation site in the 12th Century cloister at Durham Cathedral shares many characteristics with the Marburg site, and is notable for the large number of grounded bats that occur in a typical swarming season. In recent years this has prompted a regular patrol from July to September by members of the Durham Bat Group (DBG), with the purpose of rehabilitating grounded bats. During the 2013 swarming period late opening of the Cathedral during an exhibition of the Lindisfarne Gospels provided an opportunity to monitor the numbers of bats flying in the cloister after sunset, and this was extended into 2014 to provide a picture of year round use of the site. Here I compare the seasonal pattern of occurrence of common pipistrelle at Durham to that recorded at Marburg, and consider whether any evidence can be adduced regarding numbers of bats visiting the cloister during a typical year.

The cloister at Durham Cathedral comprises an outer wall which is square in plan with sides approximately 44m long, comprising the sandstone block walls of the buildings surrounding the cloister, which vary between 8 and 20m in height. An inner wall with empty stone tracery windows surrounds a central lawned garth approximately 34m square. Between the two walls are flag-stoned walkways or ranges, approximately 4m wide and 4m high, and with 15th century wooden beamed ceilings. Above the ceilings are enclosed roof-spaces approximately 0.5m in height where the mono-pitched roof abuts the outer wall. When bats are present they are frequently seen entering and exiting gaps between the ceiling timbers and the stone walling either side, and are assumed to roost and hibernate either within the gaps or in the enclosed roof space.

Method

During the swarming period, and to some extent at other times of year, bats can be observed flying in circuits within the covered walkway surrounding the garth. The overall level of activity was therefore estimated by counting the number of passes with the aid of a heterodyne bat detector. Five minute point counts were performed during the period shortly before and after sunset, during which activity would generally be gradually increasing, if bats were present, due to emergence from roosting sites around the edges of the wooden-beamed ceiling.

During the swarming period, from late July to early October 2013, three point counts were taken separated by two periods of 15 minutes. At other times three consecutive five minute point counts were carried out, often supplemented by several further five minute counts if bats were present. The timing of point counts was varied in relation to sunset to facilitate statistical modelling (see Figure 1). Altogether a total of 300 point counts were performed during 65 visits carried out between June 2013 and June 2014.

Pass frequency was analysed using a generalised linear model with Poisson errors and a log link function, with date and time in relation to sunset as explanatory variables. Date was treated as categorical variable with 65 levels, and time as a continuous variable with a quadratic term.

Results

Bat activity at the cloister generally began somewhat before sunset and continued to build up until around an hour after sunset (see Figure 2). Since point counts taken at different times in relation to sunset are not strictly comparable, assessment of seasonal trends is based on estimates derived from the statistical model of the number of passes at 50 minutes after sunset for each date on which observations were made. This is likely to give the most reliable comparative estimates since it coincides with the modal time period (in relation to sunset) for point counts across the entire year of data recording (see Figure 1).

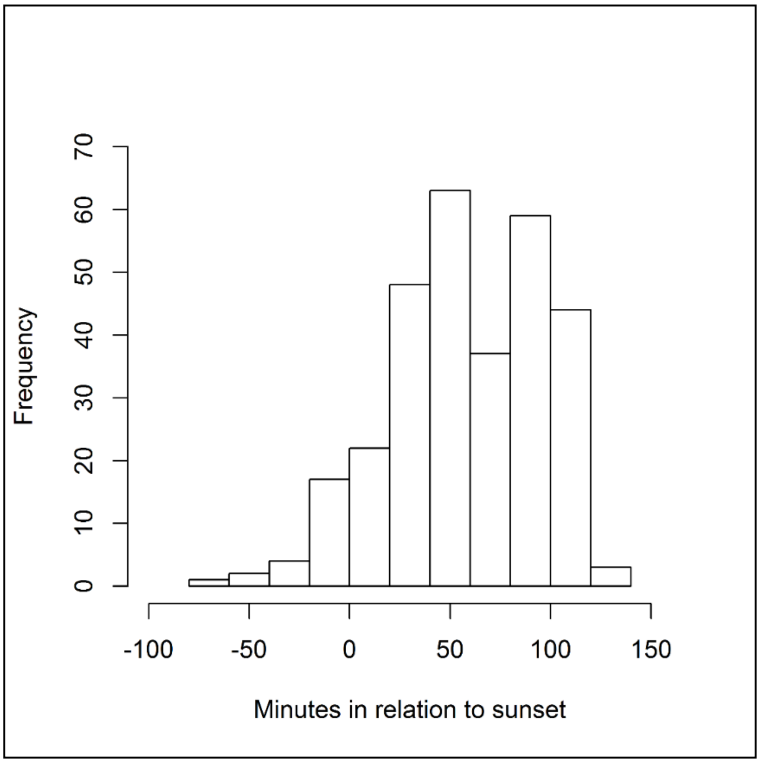

Figure 1 Distribution of five minute point counts in relation to sunset over the entire recording period.

Notable features of the seasonal pattern were the very rapid increase in the numbers of bats in the cloister during July, reaching a peak at the end of the month, followed by a drop in numbers and a second peak at the end of August, then a rapid decline through September (see Figure 3). Bats then appeared to be absent from the cloister until around the time of the first frosts in mid-late November (see Figure 4). Activity from this point onwards was at a very low level compared to the swarming period, but continued intermittently until 11th January. Activity then ceased until 6th February, and again until 19th February, after which intermittent activity continued until 25th March. From this point activity was continuous, either within the cloister ranges or garth, though recording of flight within the ranges was intermittent (see Figure 3).

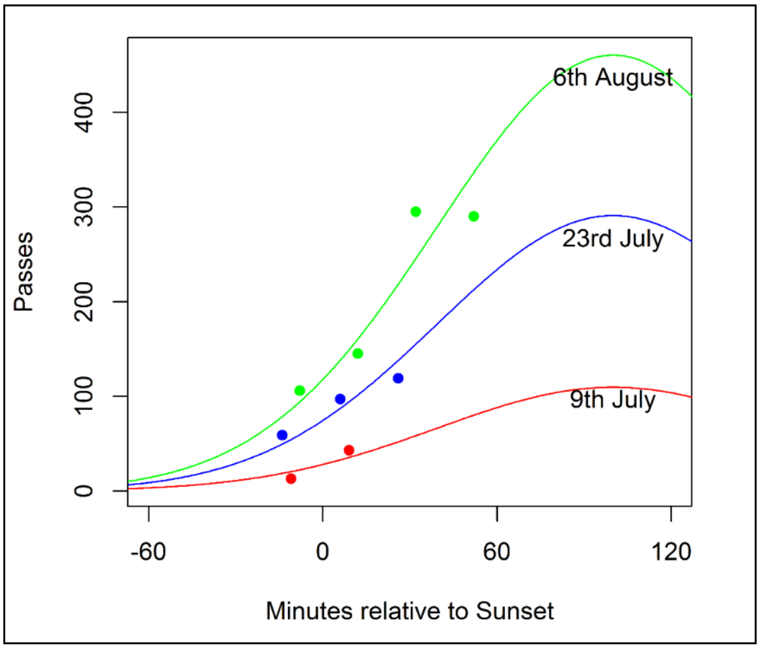

Figure 2 Number of passes per five minute period for three dates during the early part of the 2013 swarming period, along with best-fit lines derived from the GLM.

Bats take approximately 30 seconds to do a circuit of the cloister ranges, and so the number of bats flying at any one time can be estimated from five minute point counts by dividing by 10 (see Figure 4), which indicates that up to 30 bats at least were circling the cloister simultaneously during the peak swarming period. Seasonal variation in this figure can be compared with the number of bats found grounded by DBG over the same period (see Figure 5). Bats were clearly present during mid-June, as several groundings occurred then, but on both observational and grounding evidence they appeared to be absent through late June and early July, reappearing again during the second week of July. Swarming bats then increased rapidly, as assessed by point counts, but this was not reflected by groundings since there was a two week lag before these resumed in the third week of July. Groundings then increased rapidly until the beginning of August and remaining at a relatively high level until the beginning of September, from which both flying and grounded bats decreased rapidly.

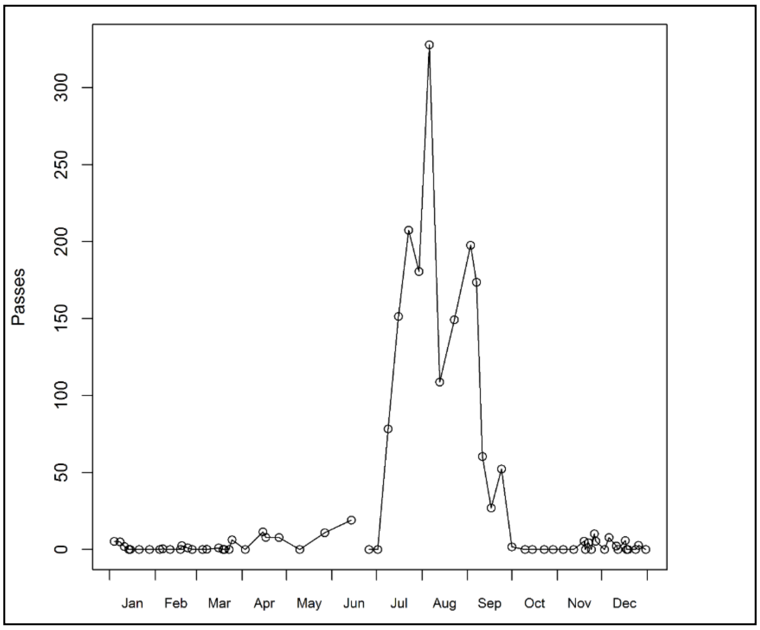

Figure 3 Seasonal variation in estimated number of passes within cloister ranges per five minute period starting 50 minutes after sunset.

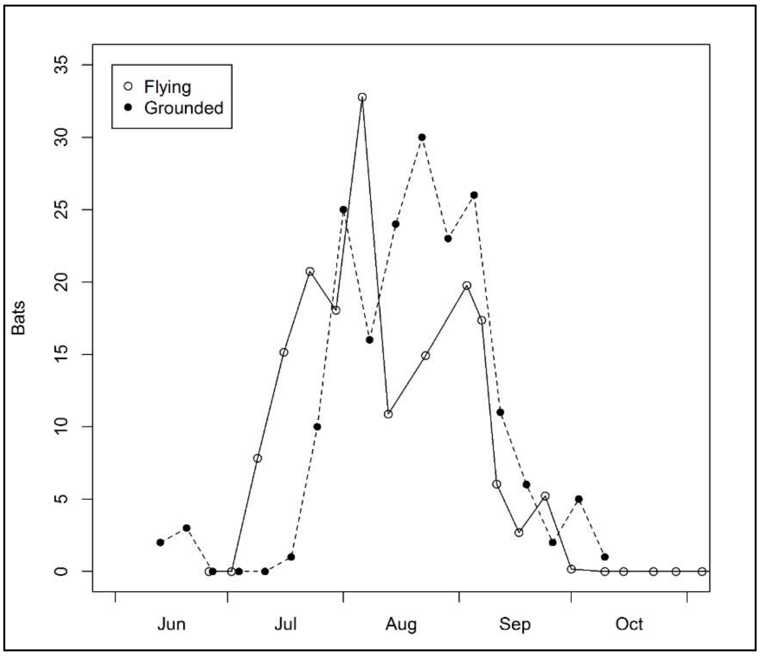

Figure 4 Estimated numbers of bats flying on survey nights, and weekly totals of grounded bats during 2013 swarming period.

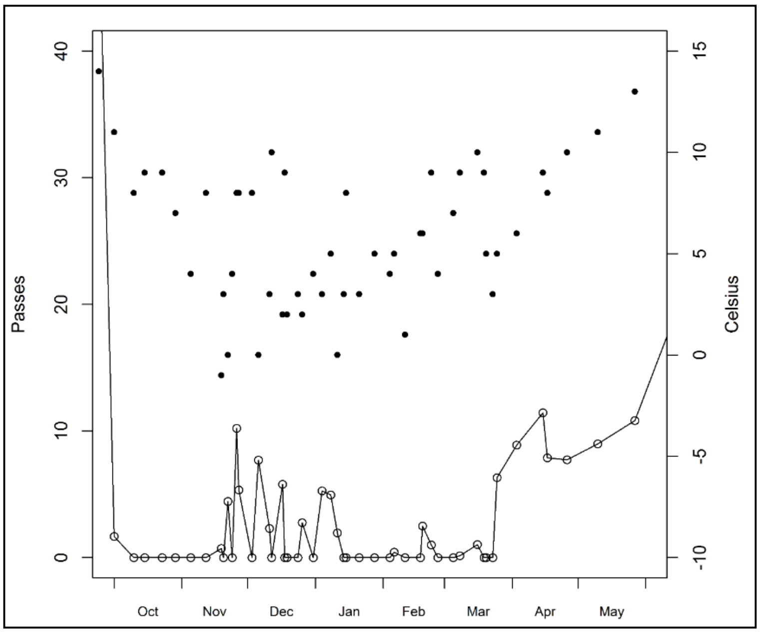

Figure 5 Bat passes per five minute period (open circles) in relation to temperature at 2100 GMT (black dots). Activity from late March includes foraging in the cloister garth.

Discussion

Additional data on bat activity at the Durham Cathedral cloister is available from a consultancy study carried out in 2010-11 (Barrett Environmental 2011 – see appendix A), and the results presented above will be discussed in relation both to this and the study at Marburg.

The purpose of swarming

Sendor (2002b) describes three main theories regarding seasonal swarming by bats: the feeding theory, the mating theory, and the parental guidance theory. The feeding theory explains swarming as concentration of bats responding to local food abundance. Sendor dismisses this as an explanation of the Marburg site where there are few insects available, and this also applies to the Durham Cathedral cloister, since although bats can be seen performing occasional foraging actions within the cloister ranges, the density of insects there is relatively low, and certainly much lower than in the extensive wooded habitat that exists a few tens of metres away in the River Wear gorge at Durham.

The mating theory states that bats gather in swarms in order to mate promiscuously and opportunistically, an idea that is widely accepted for species in the genus *Myotis*. However, Sendor dismisses the possibility that this could explain swarming in *Pipistrellus* species on two main grounds. Firstly, the mating system of *Pipistrellus* species involves resource-based polygyny, with defence of territories by males. Secondly, the late summer/autumn swarming bats at Marburg are mainly females and juveniles. The latter is precisely what is predicted by the parental guidance theory (attributed to Sachteleben 1991), in which swarming reflects maternally-guided visits to potential hibernacula by young of the year, which would otherwise struggle to find suitable hibernation sites.

Sendor relates the difference in swarming behaviour to the relative length of the mating season, which is substantially longer in *Pipistrellus* species due to their shorter hibernation period. Resource-based polygyny therefore maximises fitness in *Pipistrellus* species and comprises an evolutionarily stable mating strategy, whereas in *Myotis* species fitness is maximised during the relatively brief breeding season by promiscuity and opportunistic mating, which is best achieved during autumn gatherings.

The phenology of swarming behaviour

Sendor (2002c) found that the temporal pattern of swarming activity within nights varied according to season. During the summer/autumn swarming period the highest numbers occurred in the middle of the night, following a roughly symmetrical or right skewed pattern of overnight increase and decrease, while a left-skewed pattern occurred during the hibernation period, with most activity immediately after sunset. Observations in the Durham cloister in summer/autumn 2010 indicate a similar pattern, with low numbers immediately after sunset (see Figure A1, Appendix A) and large numbers seen between three and six hours after sunset on 18th August and 7th September (see Figure A2).

The rapid increase in activity seen immediately after sunset at the cloister during the 2013 swarming period almost certainly relates to bats roosting on site, since they could be seen emerging from various points either side of the timber ceiling during the survey. However this also suggests that the increase in numbers later in the night observed in 2010 relates to an influx of bats that have been roosting elsewhere, and this was certainly the case at Marburg as no roosting takes place at the study site during the swarming period. Clearly, therefore, fewer bats were roosting at the cloister during the 2010 swarming season than in 2013, and this raises the question as to whether the numbers roosting reflect the numbers visiting. If so, the mid-night peak of numbers in 2013 may have been even higher than the figures recorded in 2010.

The seasonal pattern of early evening activity supports the idea that this reflects variation in overall numbers, as the pattern of post-sunset variation recorded in 2013 is very similar to the seasonal pattern of numbers visiting Marburg Castle (see Figure 6). Bats present at Marburg during May and early June were exclusively males, and of the five grounded bats at Durham in June 2013 the only two that were sexed were immature males. At Marburg the rapid increase from the beginning of July resulted from an influx of adult females, reaching a peak at the end of July and then beginning to decline around the time that juveniles began to appear. Females then rapidly declined while juvenile numbers continued to increase, resulting in a second peak in overall numbers in late August. At Durham the two-week lag period between the increase in the numbers of swarming bats at the beginning of July, and the beginning of groundings in mid-July, suggests a similar pattern since grounded bats are almost exclusively juvenile. The lag may therefore be explained by the fact that the initial influx involves adult females that are unlikely to become grounded. Additionally, if the increasing trend in numbers of flying bats between mid and late-August is projected backwards, it reaches zero at about the time groundings begin in mid-July, again suggesting that the second peak may be mainly juveniles, and that the mid-August dip reflects an exodus of adult females.

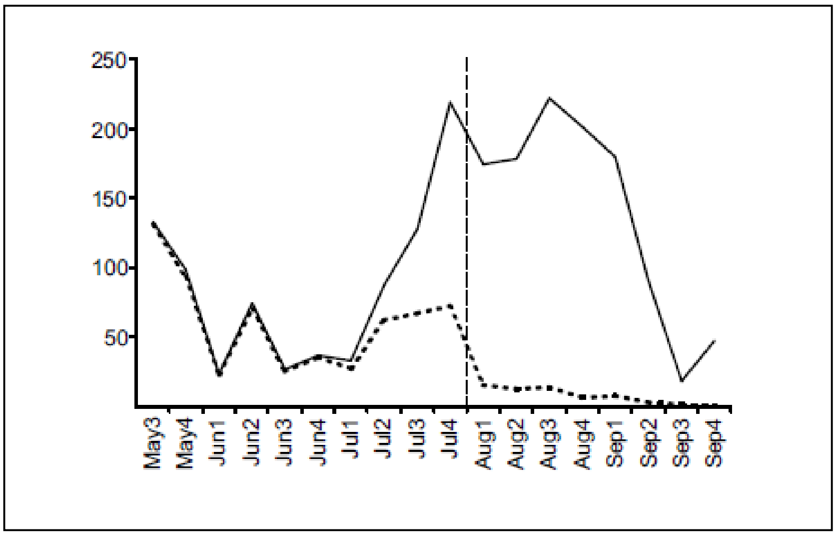

Figure 6 Copy of figure 4.2 in Sendor (2002b). Estimated mean number of bats captured during mist-netting sessions. Solid line represents all bats, dashed line males only, and vertical dashed line the appearance of juveniles at the swarming site.

As at Marburg (Sendor et al., 2000), bats were absent from the cloister for a period of several weeks through October and into November before a resumption of activity coinciding with the first frosts of the year. Habitual foraging by common pipistrelle generally ceases around mid-October at Durham (pers. obs.) after which only small numbers can be detected foraging, even in high quality feeding areas. The majority must therefore enter torpor around this time, despite not appearing in the cloister hibernaculum until late November. Sendor (2002d) recorded a general pattern over several winters of immigration to the hibernaculum during cold weather in the early part of the winter, followed by emigration during mild weather in mid-late winter, and interpreted this as evidence of roost-switching in response to temperature fluctuation. Mass winter hibernacula in common pipistrelle may therefore be frost-free refuges that are used only when cooler hibernation sites are abandoned due to the risk of frost damage.

Sendor attributes such behaviour to an inability of *Pipistrellus* species to accumulate sufficient fat to survive the winter in a thermally stable hibernaculum because of their small size. Instead they resort to colder sites until these become threatened by frost, at which point they transfer to a frost-free location such, putatively, as the Cathedral cloister. The evidence obtained from Durham is consistent with this interpretation. Survey using Anabats placed within the enclosed roof spaces during winter 2010-11 indicated that hibernating bats concentrate in the south-east corner which is presumably the coolest and most thermally stable area on average since it receives the least insolation. Observations in 2013 indicate an influx of bats to the cloister from mid-late November as night-time temperatures drop towards zero (see Figure 4), but the pattern over the rest of the winter is more difficult to interpret, which may be related to the fact that the 2013-14 winter was exceptionally mild.

The winter of 2010-11 was relatively severe, by contrast, and the pattern of activity in relation to variation in temperature was therefore much clearer (see Figure A3). Remote recording by bat detectors positioned within the cloister range indicated some activity during

October, but never exceeding 20 passes over the entire night. This could possibly reflect foraging activity in the garth, but in any case is commensurate with recorded absence on the basis of post-sunset point counts in October 2013. A peak in late November parallels the pattern seen at Durham in 2013, but over the 2010-11 winter both weather conditions and activity patterns diverge from those in 2013-14. Temperatures in 2010-11 were generally between 5 and 10 celsius lower than in 2013-14 (see Figure 5, Figure A3), and there are three striking peaks of activity in January and February 2011 which coincide with the three occasions during that two month period when daily minimum temperature exceeded 5 celsius. These clearly represent emigration events during relatively warm winter periods when the threat of frost recedes, consistent with the view of *Pipistrellus* species hibernation as highly dynamic, with continual transfer between hibernacula throughout the hibernation period.

Interpretation of seasonal activity at Durham Cathedral cloister

On the basis of observations made at Durham in 2010-11 and 2013-14, it is reasonable to conclude that the seasonal pattern of activity by common pipistrelle is essentially the same as that documented by Sendor at Marburg Castle. The relatively low numbers of bats observed in the cloister ranges during spring and early summer are very likely to be males engaged in exploratory investigation of potential hibernacula. From the end of June onwards numbers visiting the cloister build up rapidly as a result of maternally guided juvenile exploration of the hibernaculum, which lasts until the end of September. Apart from occasional foraging in the garth, bats are then absent from the cloister until the first frosts, generally towards the end of November, which prompts immigration to hibernating sites within and above the timber roof beams, particularly above the south range. Numbers then decline from the turn of the year via progressive emigration, which occurs particularly during spells of warmer winter weather.

One of the most striking aspects of bat behaviour at Durham Cathedral cloister is the repeated circling of the ranges by bats, which is particularly evident during the swarming period. This has no obvious function, since the ranges contain few insects and much more profitable foraging locations can be found within a short distance. A clue to the function of this behaviour may come from Sendor's (2002b) observation of a difference in behaviour between adult and juvenile bats affixed with light tags during swarming within the cellar hibernaculum at Marburg. Prior to exiting the cellar via an arrow-slit, adult bats circled several times in front of the point of egress before emerging. Juveniles behaved quite differently however, approaching the exit point 20-25 times and each time flying back into the interior of the 30m long cellar. Sendor remarked that it appeared the juveniles were attempting to assess the dimensions of the cellar, and a similar process might be occurring with the repeated circling of the cloister by bats at Durham, involving a process of familiarization and memory fixing by juvenile bats encountering the hibernaculum for the first time.

Numbers of bats visiting Durham Cathedral cloister

Another aspect of swarming at Durham Cathedral that requires explanation is the large number of groundings that occur each year during the swarming period (see Table 1).

The numbers of bats recovered by DBG are not necessarily comparable across years, due to variation in effort both by the group and independently by Cathedral staff. Caution is also required in assessing totals since repeated groundings of individuals are known to occur. It is certain, however, that up to 90 juvenile bats die in the cloister during the swarming season, the demographic significance of which depends on the number of bats visiting the cloister. At one extreme this may be a catastrophic mortality suffered by a relatively small population, in which case it would be appropriate to search for a causal factor or factors, and at the other it may be simply be an outcome of the normal high level of juvenile mortality in a very large population (see Appendix B).

Year	Deaths	Other grounded	Total
2004	90	64	154
2009	78	95	173
2012	58	126	184
2013	81	157	238
2014	34	49	83

Table 1 Number of grounded bats handled by DBG during the swarming season.

No obvious factor that would cause a high level of mortality to bats is apparent within the cloister. Bats occasionally get trapped within light fittings, but most of the moribund bats that are discovered during the swarming season are simply found on the flooring of the ranges, with a smaller number on the paved area around the edges of the garth. A proportion carry a significant load of external parasites in the form of mites or fleas, but in the majority this is not excessive, and very few show any sign of external injuries, so groundings are unlikely to be caused by collisions with obstacles in the cloister. Furthermore, it would seem unlikely on demographic grounds that this represents a catastrophic mortality to a relatively small population, since its regular occurrence would drive such a population rapidly to extinction, though the possibility remains that the cathedral hosts a 'sink' population that is constantly replenished by immigration.

It is therefore more likely that the groundings are explained by a normal level of juvenile mortality in a large population that visits the cloister during the swarming season, and given the limited information available, a figure of 12,000 bats would appear to be a reasonable, if speculative estimate of the number of individual bats visiting the cloister during the year (see Appendix B). The numbers hibernating at the site will be smaller, since not all bats visiting the site will choose to hibernate there, and at Marburg a population of 5,000 hibernating bats compares to an estimated 23,000 visiting the site. A similar proportion at Durham results in an estimate of 2,600 hibernating bats.

Given these figures it is possible to estimate the catchment area from which the swarming population is derived. Harris et al. (1995) give estimates of up to 0.2 'Pipistrelles' per hectare in areas of suitable habitat. This was prior to the split between common and soprano pipistrelle *Pipistrellus pygmaeus*, so may include some of the latter, but given the high quality of habitat and availability of roost sites in the Durham area it may be reasonable to use this as a basis for an estimate. Thus, if 12,000 bats visit the cloister this represents the population from the surrounding 60,000 hectares, which is the equivalent of a circular area with a radius of 13.8km (see Figure 7). The only other known *Pipistrellus* species swarming sites in the area are Auckland Castle 13km to the south-west, where groundings also occur regularly during the swarming season, though on a much smaller scale, and a site near Piercebridge, west of Darlington (Barrett Environmental 2011).

Significance of the Durham Cathedral swarming and hibernation site

The estimates of numbers of bats are necessarily speculative, but are the best estimate achievable with the limited information available. It should therefore be a working assumption that the cathedral cloister provides a significant resource for 0.5% of the estimated 2.4 million UK common pipistrelle population (Battersby, 2005), spread over an area comprising around half of lowland County Durham. The number using the cloister for hibernation in any one year is likely to be significantly smaller than this, but is also likely to vary considerably with the severity of the winter, with larger numbers resorting to the cloister during winters with significant spells of cold weather. It is a commonplace observation that hibernation sites are the major limiting resource determining the overall density of bat populations, and so the availability of the cathedral cloister may be supporting a significantly higher density of common pipistrelle bats within the catchment area than would otherwise occur. Equally, should any changes occur that render the cloister unsuitable as a hibernation site, the density of common pipistrelle within a wide area around the Cathedral is likely to be significantly reduced.

If the estimates of numbers are of the right order, the population using the cloister will undoubtedly exceed the 1% threshold for the population of the north-east region, so that the site can be regarded as being of at least regional significance for common pipistrelle. However the scale of the annual swarming event at Durham would appear to exceed anything so far recorded elsewhere in the UK, so there is a case to be made that the site should be regarded as nationally significant, and therefore worthy of SSSI designation.

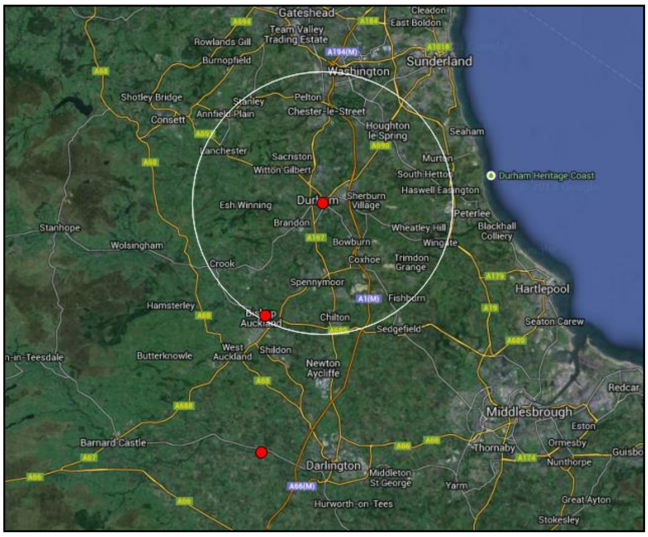

Figure 7 Estimated catchment area for bats visiting the Durham Cathedral cloister, with location of other known swarming sites.

Scope for further studies

Given the potential significance of the site, there is an urgent need to place the estimates of bat numbers using the cloister on a firmer footing. The best solution would involve a mark-recapture survey carried out during the swarming season, but this would be extremely onerous and require a considerable investment of resource. A cheaper and easier alternative might involve vantage point surveys during the swarming period designed to count the number of bats entering and exiting the cloister over the course of a night. If this were practicable it would be possible to test the hypothesis regarding the rapid turnover of swarming bats, and therefore the estimate of the overall numbers involved.

Barrett Environmental (2011) conducted some vantage point surveys using bat detectors around the periphery of the cloister. However most of these were conducted at ground level and appeared unable to pick up incoming bats, since observations of sudden influxes of bats within the garth and cloister ranges were not matched by simultaneous recording of incoming bats by observers outside. This is not surprising given the height of the walls surrounding the cloister, and the limited range within which bat detectors will register bat ultrasound.

A more productive approach may involve bat detector vantage point surveys at the roof level of the buildings around the cloister. Deployment of eight or more observers evenly distributed around the periphery may be sufficient to pick up a high proportion of the bats entering and exiting the cloister. Alternatively, remote recording devices could be deployed at roof level to record bat passes overhead. Such a device or devices could be deployed at a variety of different sites to determine where entry and exit is occurring and would enable continuous recording during the hours of darkness, simplifying the task of estimating the overall number of movements.

It would also be useful to carry out some investigations of the roof void above the cloister ranges to determine exactly how this is used by the bats. A scoping inspection might be performed during October when bats are essentially absent from the cloister. The distribution of bat corpses at this time might indicate the areas used by roosting/hibernating bats, and suggest a protocol for any subsequent inspections intended to estimate numbers when bats are present. In addition it would be useful to record variation in temperature and humidity, particularly over the winter period, to determine whether conditions are indeed relatively stable relative to the exterior, as suggested by the phenology of bat activity.

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Appendix A

Data collected in the Cathedral cloister in 2010-11 (re-analysis from Barrett Environmental 2011).

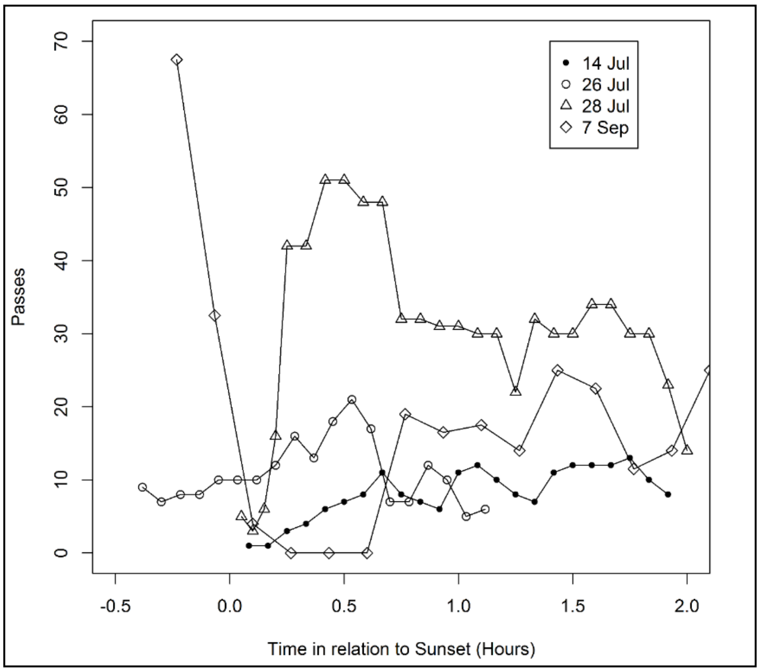


Figure A1 Early-night counts of bat passes in Durham Cathedral cloister per five minute period during the 2010 swarming season.

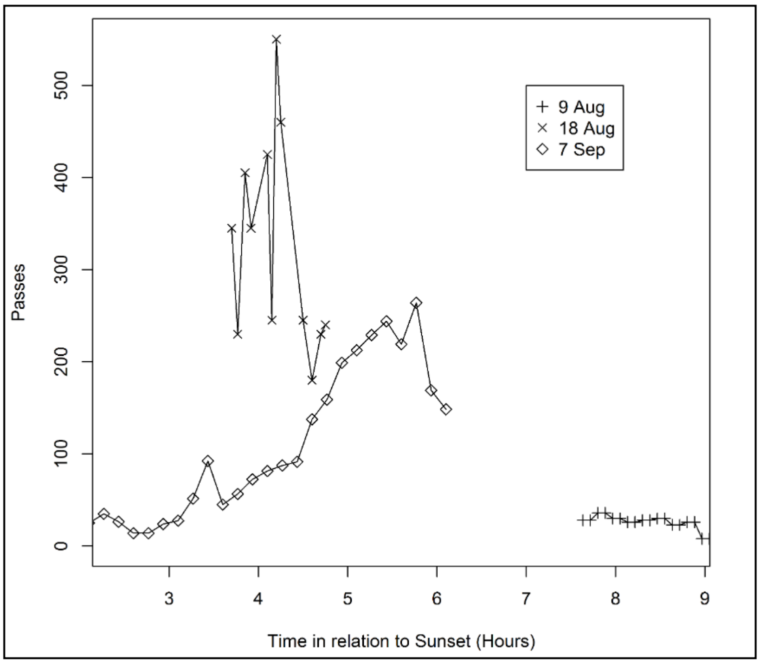


Figure A2 Midnight counts of bat passes in Durham Cathedral cloister per five minute period during the 2010 swarming season.

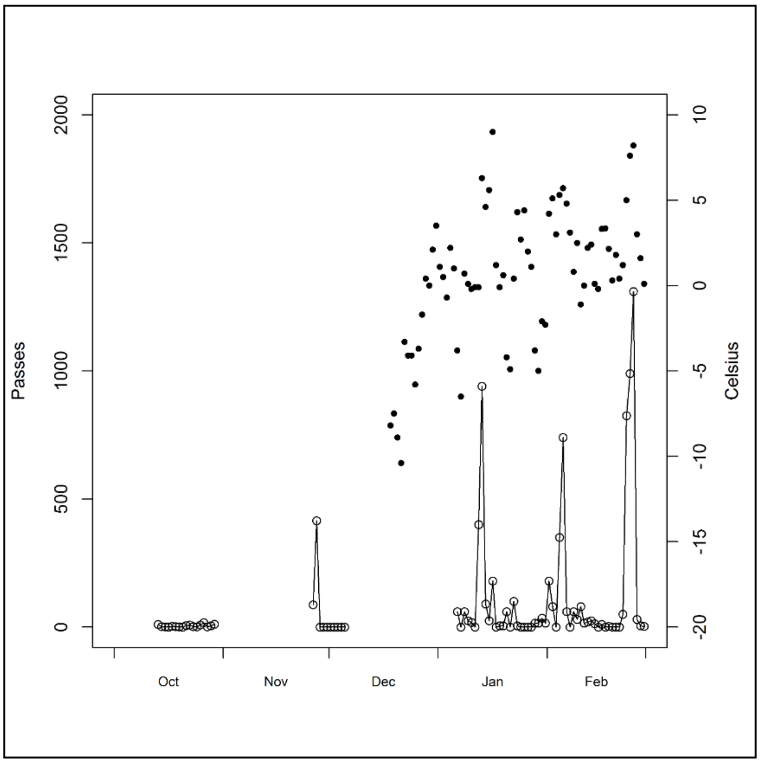


Figure A3 Number of overnight bat passes in Durham Cathedral cloister recorded by Anabat during autumn/winter 2010-11, in relation to daily minimum temperature.

Appendix B

Assessment of numbers of bats visiting the Cathedral cloister during the swarming season

Estimates of the number of bats visiting the cloister can be obtained by two independent methods.

Estimation Method One

It is known that a minimum of 90 juveniles visit the cloister in a good year. Since their mothers also visit, this number can be doubled, and assuming an equal sex ratio and equal likelihood that male bats will swarm/hibernate, it can be tripled, giving a rock-bottom estimate of 270 bats. However this assumes that (i) all juveniles die (ii) all deaths occur in the cloister (iii) all dead juveniles are found. By relaxing these assumptions a more realistic estimate of numbers can be made.

Sendor & Simon (2003) estimate that first year survival in their study population of common pipistrelle is 0.53. Mortality is likely to be 'front-loaded' – i.e. most will occur immediately after the young bats begin to fly or become independent. On the conservative assumption that 50% of young bats die during the swarming period, the estimate of juveniles visiting the cloister can be doubled to 180, and the overall estimate to 540.

However this still assumes that all juveniles die in the cloister and that all are found. If it is assumed that only half die in the cloister, the estimate doubles again to 1080. If only half are found it doubles again to 2160. Even this can be regarded as a conservative figure, particularly if individual bats spend only a short time at the swarming site (see below). If proportions are reduced to one third (deaths, deaths in cloister, discovered deaths) the overall estimate rises to 7290. If it drops to one quarter, the estimate is 12960.

Estimation Method Two

The second method is based on Sendor's (2002b) observation that individual bats spent an average of only 10 minutes at the swarming site. Observations both in 2010-11 and in 2013-14 indicate that 30 is a reasonable estimate of the maximum numbers of bats in the cloister at any one time. Assuming 10 minute visits, if there are 30 bats at time t and no further bats enter, there will be no bats in the cloister at t + 10 minutes, so another 30 bats must enter to maintain equilibrium, i.e. 3 per minute.

Assuming a ten hour night, and on the conservative assumption that the rate of entry increases linearly from 0 to 3 per minute over the first five hours, and decreases from 3 to 0 over the last five, an estimate can be made of the number of bats visiting per night around the seasonal peak.

(i) Over the first five hours bat entry rate accelerates at 3/300 =0.01 per minute, so..
(ii) $dn/dt = 0.01t$, and..
(iii) $n = 0.005t^2$

To get the number of bats that have entered the cloister by the mid-point of the night t is set to 300 (minutes), so $n = 0.005*300^2 = 450$. Since the decline is symmetrical this can be doubled to find the number visiting over the whole night, i.e. 900.

The number for the whole season can be estimated by a similar process. Assuming a 60 day swarming period, if the number visiting per night increases linearly from 0 to 900 over a 30 day period, then declines from 900 to zero for the next 30 days:

(i) Over the first 30 days visit rate accelerates at 900/30 = 30 per day, so..
(ii) $dn/dt = 30t$
(iii) $n = 15t^2$

By mid-season therefore, when $t = 30$, $n = 15*30^2 = 13500$ visits will have occurred, so 27000 visits over the whole season. Sendor's maximum estimate for probability of capture of a marked bat during a trapping session was 0.05, suggesting that the chance of a bat visiting a swarming site in any one night is as high as 1 in 20, i.e. 3 visits per season, which suggests that 27000 visits represent 9000 individuals, the majority of which will be adult females and juveniles. Assuming 4000 of each, this indicates a total of 12,000 bats visiting cloister year round, including spring swarming of males.

South Yorkshire Mine – Hibernation and Swarming Study Findings.

Robert Bell robert.andrew.bell@gmail.com

Background Information

Shortly before the onset of the 2012/2013 winter an abandoned mine, not previously known to be used by bats, was located in the South Yorkshire area. Following discussions with the site owners it was agreed that bat survey work could be undertaken on the understanding that the mine location was not disclosed. This report documents results of 2012/2013 hibernation survey work, a winter 2013/2014 visual inspection/ temperature study and bat swarming survey work carried out in autumn 2015.

Image 1 This image shows main tunnel intersection located approximately 7m in from the mine entrance. An Anabat recording device is shown in the top left of the image. A thermometer was installed on the dry stone support in the top right of the image.

The mine is located within mixed woodland on an area of Sandstone within the Millstone Grit Geology Series. The true purpose of the mine is unknown, however it is likely to comprise a source of gannister or pot clay, with these substances used in the steel making process and mined extensively from the wider area, during the 19th and early 20th Century (Battye, 2004). The mine is not marked on OS Survey Maps and consequently is taken to be at least 150 years old. The passages vary in height and construction but are typically approximately 1.5m in height and the same width, with dry stone supports in some areas and solid stone walls in others. The mine lacks standing or running water but has high humidity and has been subject to historic collapses which have cut off access to much of the mine's previous extent. An approximate plan of the current accessible mine layout is shown in Image 2. Previous inspections undertaken by site owners or their agents, during the last 30 years, showed that this mine previously extended across a number of vertical levels.

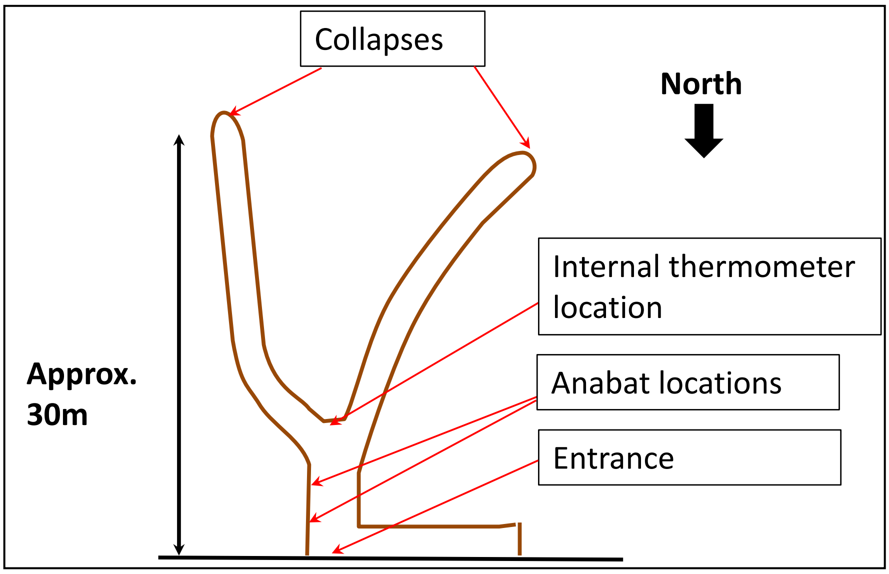


Image 2 Drawing shows an approximate aerial plan of the currently accessible section of the mine. The mine drops in height several meters from the entrance towards the southern end.

During the winter months, bats in northern England engage in hibernation. Hibernation in bats comprises a state of inactivity characterised by lower body temperature, slower breathing, and lower metabolic rates. The ability of bats to hibernate helps to preserve energy reserves at a time of year when weather conditions frequently prevent effective foraging. Different bat species select alternative microclimates for hibernation, with several bat species present in northern England known to make use of both natural (i.e. caves) and human made (i.e. mines and tunnels) underground sites. Underground hibernation roosts are typically characterised by limited airflow which results in low levels of micro-climatic variation (Altringham, 2011).

Autumn bat swarming is characterised by intense bat flight activity in and around the entrances of underground sites, often by multi-species groups of bats. Bats captured at swarming sites often display a strong male bias and autumn swarming has been shown to function as a promiscuous mating behaviour (van Schaik et al., 2015). The species present are usually limited to those that make use of the underground site for hibernation during the winter. Swarming is the major source of gene flow in many bat species (Rivers, Butlin and Altringham, 2005; Furmankiewicz and Atringham, 2007) and is also likely to allow bats the chance to assess hibernation sites ahead of roosting (van Schaik et al., 2015). Autumn swarming is potentially also a means of passing on knowledge of hibernacula locations from adults to young bats (Glover and Altringham, 2008). Internationally autumn swarming has been shown to be most frequently recorded amongst *Myotis* species bats (Parsons et al., 2002), with a range of species shown to display this behaviour in England.

Natterer's bats *Myotis nattereri* have comprised the most frequently recorded species during swarming studies in the Yorkshire Dales (Glover and Altringham, 2008) and North Yorkshire Moors (Rivers, Butlin and Altringham, 2006), whilst a combination of Natterer's bats and Daubenton's bats *M. daubentonii* were most frequently recorded across a number of swarming sites in southern England (Parsons et al., 2003a). The peak period for autumn swarming varies between sites and bat species (Glover and Altringham, 2008; van Schaik et al., 2015; Rivers, Butlin and Altringham, 2006) however this period extends from approximately mid-August to mid-October. Nightly peaks in bat swarming activity have been shown to vary with site and stage of the swarming season, with peak activity most often recorded 4-6 hours after sunset (Parsons, Jones and Greenaway, 2003b; Rivers, Butlin and Altingham, 2006).

Bats have been recorded migrating distances of up to 60km between summer roosts and major swarming sites (Rivers, Butlin and Altringham, 2006). Species composition and abundance during swarming has been shown to correlate with composition and abundance during hibernation at the same site (van Schaik et al., 2015). In addition, remotely logged bat activity has been shown to correlate with bat trapping levels during swarming surveys (Parsons, Jones and Greenaway, 2003b).

Methods

2012/2013 Hibernation/Anabat Survey

A single Anabat static monitoring device was installed within one of the two locations shown on the mine diagram for 115 days between 24/11/2012 and 06/05/2013. Unit sensitivity was set at 6.5 with no timers set. The Anabat batteries were changed when possible and consequently gaps are present between recording periods, particularly earlier in the winter and in the late autumn period, which was largely unrecorded. Recording periods are shown in Table 1.

Recording period	**Start date**	**End date**	**Recording period**	**Start date**	**End date**
1	24th November 2012	29th November	10	16th February	23rd February
2	29th November	6th December	11	23rd February	24th February
3	12th December	23rd December	12	4th March	11th March
4	31st December	5th January 2013	13	11th March	18th March
5	8th January	15th January	14	18th March	26th March
6	15th January	22nd January	15	26th March	3rd April
7	22nd January	24th January	16	3rd April	11th April
8	2nd February	6th February	17	11th April	21st April
9	6th February	8th February			

Table 1 Static monitoring periods: winter 2012-2013.

Bat calls recorded were analyed to species level, where possible, using AnalookW with reference to bat call parameters presented in Russ (2012). Mean daily air temperature over the survey period collected from a weather station at Leeds/Bradford Airport was downloaded from the Weather Underground website.

2014 Temperature Study

In order to obtain information on the microclimate in the mine and the level of temperature buffering it displays, a temperature study was undertaken. Two Tinytag thermometers were installed between 05-12/01/2014 with a thermometer inside the mine (see Image 2) and a second located approximately 10m north of the mine entrance. The thermometer installed within the mine also recorded relative humidity. Tinytag Explorer software was used to download themometers and draw the temperature comparison graph.

2015 Swarming Survey

A Pettersson d500x Mark 1 static monitoring device was installed 1m above the mine access for a five night period between 07-12/09/2015. This unit was set to turn on from 30 minutes prior to sunset until 30 minutes after sunrise with an Input Gain of 20 and a Trigger Level of 24. An interval of five seconds was used, resulting in a minimum five second delay between recorded five second long sound files, with this step taken to reduce data volume ensuring the detector remained operational for the full recording period.

Sound files were analysed using BatClassify auto-analysis software developed by Dr Chris Scott of Leeds University (Scott and Altringham, 2014). A positive identification was considered to comprise a stated probability of occurance of 0.8 or greater. Given the similiarity of echolocation calls emiited by Daubenton's bat with those of whiskered bat *M. mystacinus* and Brandt's bat *M. brandtii*, the decision was made to combine these three species within this study. A sample of recorded calls identified from each species were manually anlaysed to confirm species presence at the site.

Weather data during the swarming survey period was taken from recordings made at Leeds/Bradford Airport.

Limitations

During winter 2012/2013 the Anabat battery was changed as regularly as possible however there are significant gaps in coverage, particularly earlier in the winter and in the late Autumn period.

Leeds/Bradford Airport is the closest freely available external temperature data for the mine but is several tens of kilometers distance from the mine and cannot be considered to offer a very accurate refelection of external mine conditions, however this information is included in order to give a general impression of temperatures in northern England at the time.

Anabat or Pettersson sound files are taken as an indication of bat activity abundance, however it should be noted several sound files may be recorded from a single bat, or equally multiple bats may be recorded within a single Anabat sound file. Pettersson settings during the swarming survey ensured a minimum five second delay between sound files. Whilist this will have resulted in some bat activity going unreported it is considered unlikely to significant bias the analysis of sound file spread throughout the recording period.

Findings

2012/2013 Hibernation/Anabat Survey

Over the recording period 61 sound files originating from bats were recorded. Of these files, 59 were considered to have originated from an unidentified *Myotis* species bat, with a single Natterer's bat sound file recorded together with a single sound file originating from an unidentified bat species.

Figure 1 shows the number of sound files recorded by hour. Figure 2 shows the spread of recorded bat soundfiles throughout the recording period against external temperature, with Figure 2a showing temperature throughout the survey period and Figure 2b showing temperature only when the Anabat was operational.

Bat activity was recorded throughout most hours of the day with the low number of recorded sound files unable to provide sufficient resolution to show any clear temporal patterns in activity. Figure 1 does however suggest a slightly higher level of sustained bat activity in the evening, between 18:00 and 23:00 and possibly a spike in activity in the morning around 03:00.

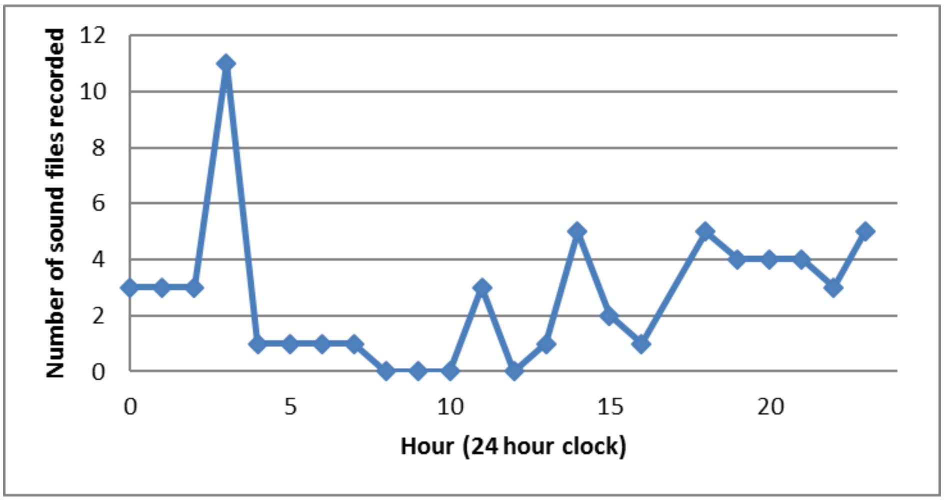


Figure 1 Bat activity against time.

Figure 2 suggests seasonal and weather related patterns in the bat activity. The first and clearest pattern is an increase in bat activity during spring from the beginning of March until mid-April.

The second weaker pattern that can be observed from Figure 2 is a clustering of recorded bat activity during periods of colder weather. An inspection of Figure 2a shows clusters of activity between 12-26/01/2013 and 09-16/03/2013 and occassional additional sound files recorded during periods of cold weather in December 2012 and February 2013. It should however be noted that Figure 2b shows the Anabat detector was frequently out of operation during the earlier part of the year and this appears to have occurred more frequently during periods of milder weather.

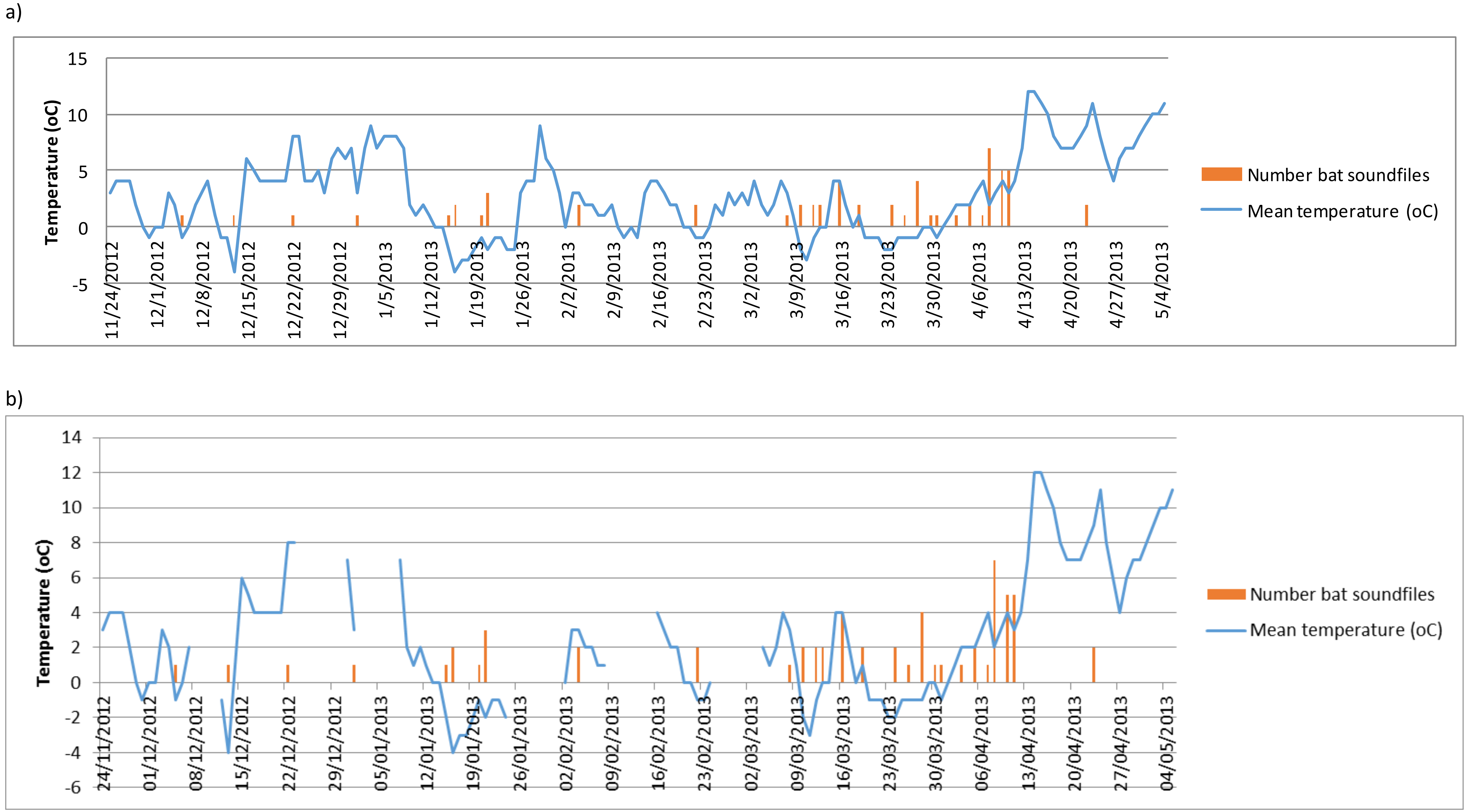


Figure 2 Recorded bat sound files shown against date and mean temperature; a) shows mean temperature throughout the entire survey period, b) shows mean temperature only on the days during which the Anabat recorder was operating.

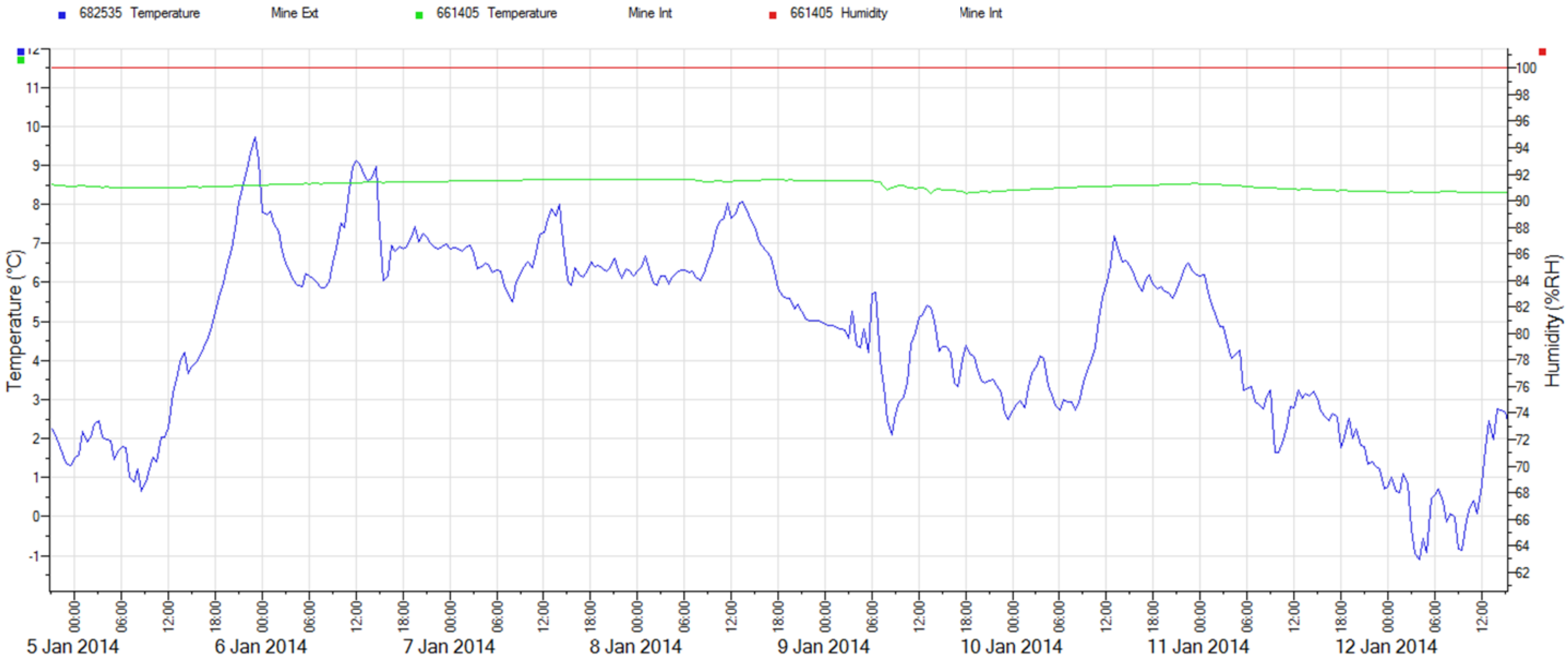


Figure 3 Comparison of temperature inside (green line) and outside the mine (blue line), with relative humidity inside the mine (red line).

2014 Temperature Study

Figure 3 shows that the internal temperature within the mine stays at a very consistent level of approximately 8.5^{o}C even when the external temperature drops below freezing. The level of relative humidity within the mine stayed at 100% throughout the study and this fits with the very humid conditions encountered within the mine during internal inspections.

2015 Swarming Survey

A total of 2942 sound files were recorded during the five night recording period. The spread of recorded sound files between species or species group is provided in Table 2. Table 2 shows that whilst the majority of calls were recorded from common pipistrelle *Pipistrellus pipistrellus*, numerous calls were attributable to either Natterer's bat or the whiskered/Brandt's/Daubenton's bat species group.

Species or species group	Recording night					Total number of sound files
	1	2	3	4	5	
Common pipistrelle	334	201	665	857	462	2519
Daubenton's/whiskered/Brandt's bat	21	10	30	40	114	215
Natterer's bat	57	24	50	26	28	185
Soprano pipistrelle	5	4	2	5	7	23

Table 2 Recorded sound files by species and recording night.

Weather during the survey period was dry and mild (mean temperature = 10-14^{o}C) with low winds; resulting in weather conducive to bat activity. Whilst bat activity levels varied, reasonably high levels of activity were recorded during each of the five nights.

Figure 4 shows the spread of *Myotis* species bat activity with time after sunset, whilst Figure 5 shows the mean and standard deviation of time after sunset recorded from all species or species groups. Common and soprano pipistrelle *Pipistrellus pygmaeus* were not included on Figure 4 given the number of common pipistrelle recorded greatly exceeds those of the *Myotis* species, *Pipistrellus* species are not traditionally associated with autumn swarming and the stone mine displays little potential for *Pipistrellus* species hibernation use.

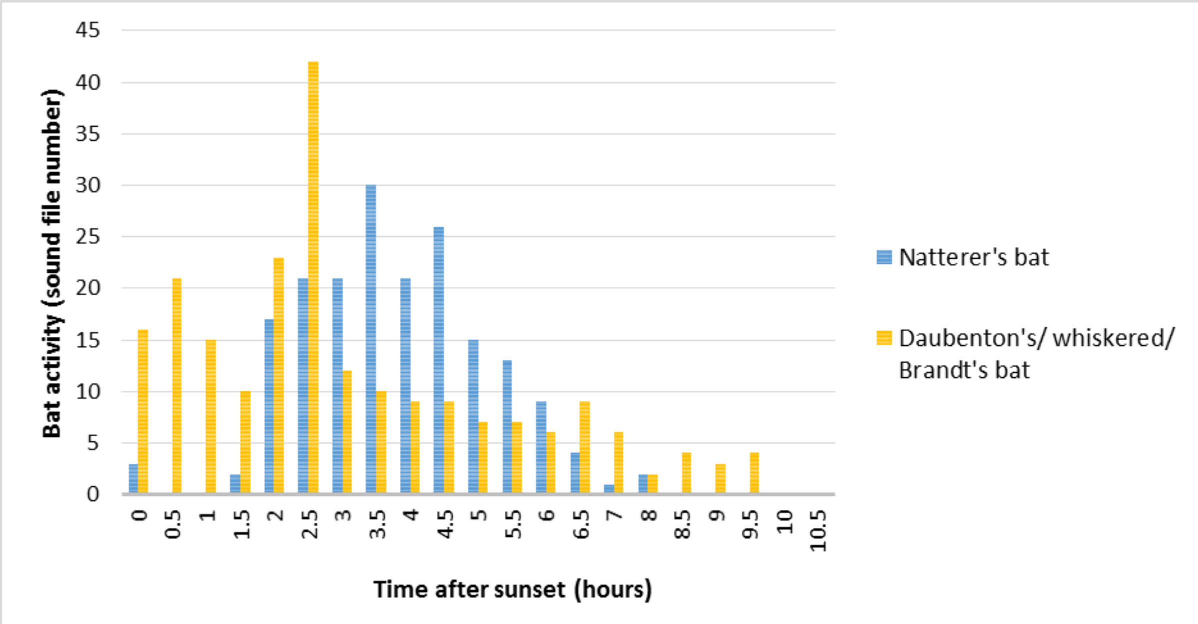


Figure 4 Distribution of *Myotis* species activity with time after sunset.

Natterer's bat activity peaked later in the night than activity by the whiskered/Brandt's/Daubenton's bat species group (see Figure 4), with the mean time of activity also later than recorded for common and soprano pipistrelle (see Figure 5). The spread of Natterer's bat recordings through the night is lower than recorded for other species (see Figure 5).This appears to be due to the lack of any peaks in activity early or late in the night.

It is notable that the Natterer's bat activity peaked 3.5 hours after sunset with the highest levels of recorded activity during each 30 minute period from 2 hours after sunset until 5.5 hours after sunset.

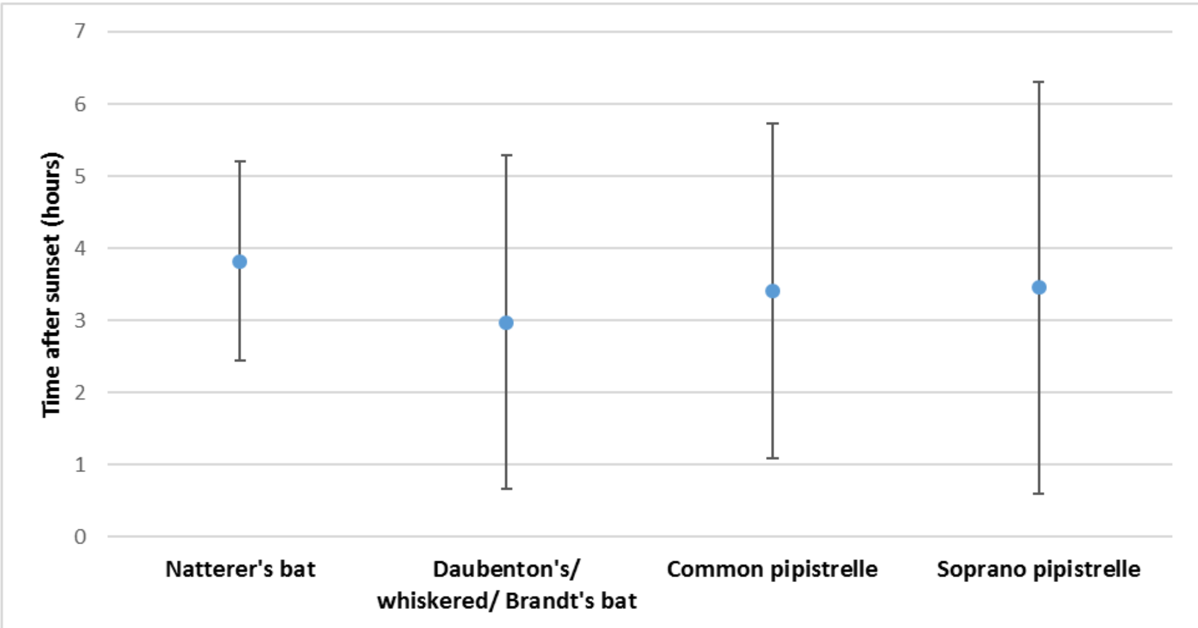
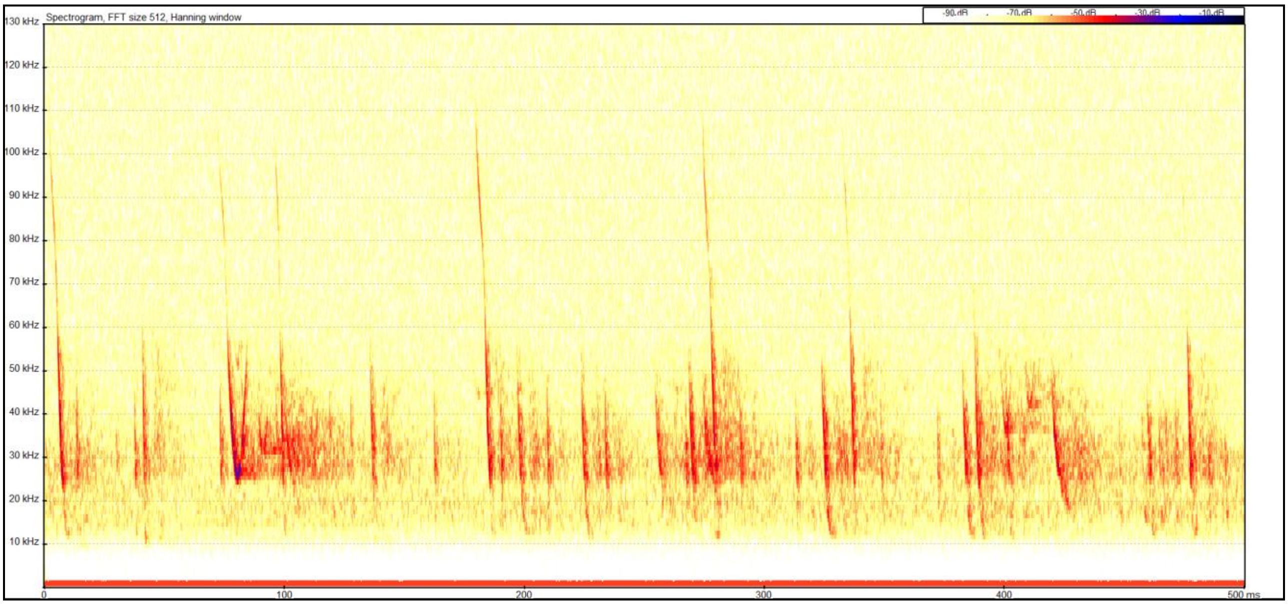


Figure 5 Graph showing the average (mean ±1 standard deviation) time after sunset of recordings by species/species group.

Numerous social calls were recorded during the survey period from species including Daubenton's bat, Natterer's bat and common pipistrelle. Social calls considered likely to have been emitted by Natterer's bat and Daubenton's bat are shown in Images 3a and 3b respectively.

a)



b)

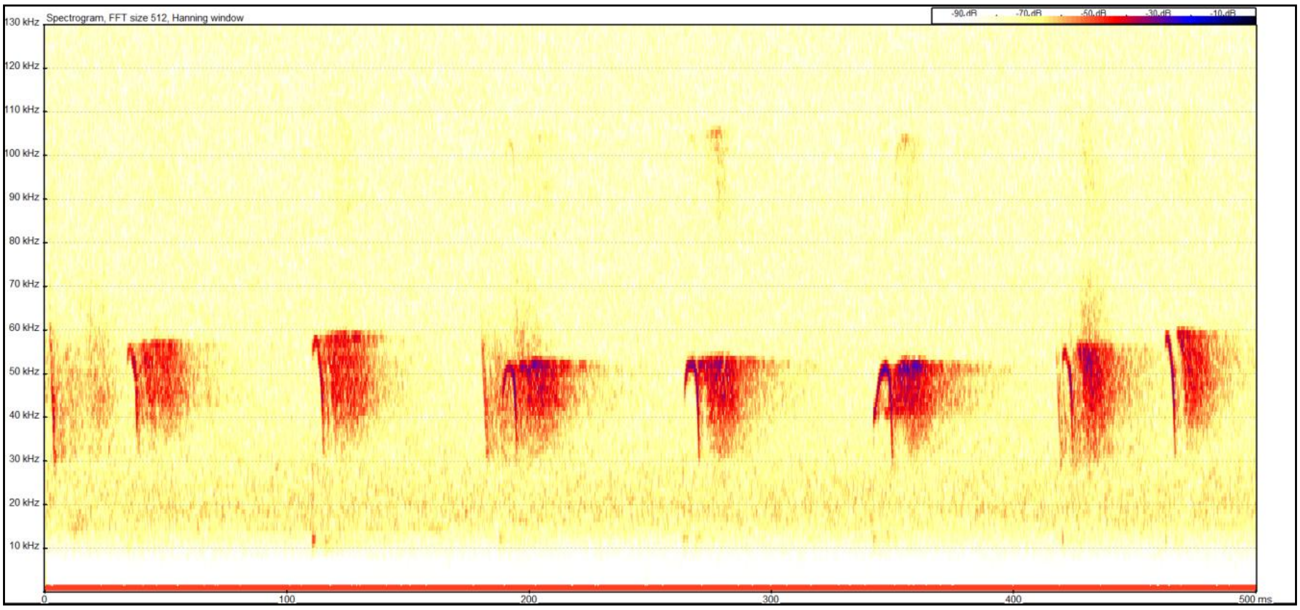


Image 3 Recorded social calls showing Natterer's bat (Image 3a) and Daubenton's bat (Image 3b).

Discussion

The study undertaken is considered to demonstrate usage of the mine as a hibernation roost and a probable autumn swarming site. A number of additional bat activity patterns were also suggested by the data. Although the low number of sound files collected during winter 2012/2013 and the short period of the 2015 swarming survey do not allow a high degree of confidence in survey findings, this study has provided considerable insight into bat usage of the mine.

Hibernation Roost Usage

The present study is taken as evidence that least one *Myotis* species uses the mine as a hibernation roost. Natterer's bat has been confirmed to fly within the mine, and is likely to also roost within it. Whilst survey findings suggest the mine is used by a relatively low number of bats, it is not considered that a study of this type can provide detailed insight into the number of bats using the mine during the hibernation period. Given bats typically rouse once every one to two weeks during hibernation (Altringham, 2011), it is apparent that a moderate to large number of bats would be likely to generate a higher number of sound files than was recorded during this study.

A consistent period of higher bat activity was recorded between early March and mid-April (see Figure 2) suggesting that bat activity within the mine increases in spring. This increase in activity is likely to be the result of bats beginning to emerge from the mine and move to transitional roost sites in other locations. Alternatively, activity at this period of the year may be linked to usage of the mine as a transitional roost. A particular spike in bat activity is evident towards the end of this period, from 06-13/04/2013 (see Figure 2). It should be noted that the air temperature remained cold throughout March 2013 and a late spring was observed, consequently it is likely that the spike in bat activity may have occurred later during winter 2012/2013 than during a typical year.

An additional pattern suggested by the data is that activity increases during periods of cold weather, when the temperature consistently drops below freezing. This suggests that bats most frequently use the mine when other, more marginal, and less insulated hibernation roost sites become too cold. It is possible that the relatively high level of bat activity recorded between early March and mid-April was a result of bats entering the mine due to cold weather at the beginning of this period and then most, if not all, bats exiting the mine at the end of this time.

As shown in Figure 3, the mine displays a remarkably consistent internal temperature of approximately 8.5^{o}C, as recorded only a short distance into the mine (approximately 7m). This temperature is within the range of the mean annual air temperature of the local area (between 8-10^{o}C) and together with the very high relative humidity (100%) indicates that the mine is a non-dynamic system with little airflow (Mitchell-Jones et al., 2010).

Research suggests the mine may actually be too warm to be ideal for hibernation use by locally common *Myotis* and *Plecotus* bat species, which display a preference for mean hibernation roosting temperatures between 4-5.5^{o}C (Nagel and Nagel, 1991). During hibernation, the energy costs of metabolism fall as temperatures approach 1-2^{o}C, although most bats choose to roost in temperatures slightly above this level (Webb et al., 1995). If it is true that the mine's internal temperature makes it sub-optimal for hibernation roosting by the bats that use it, then it would follow that it would be likely to be used mainly during very cold periods when other, more exposed, local roosts are unsuitable.

A comparison of the time of day from which bat activity was recorded highlights only weak patterns. This data would appear to suggest that whilst below ground, bats become active throughout the day, although a slight increase in activity appears to take place during the evening between approximately 18:00 – 23:00. The highest level of hourly activity was recorded at 03:00. This pattern fits with other research undertaken on bats, with studies showing that the circadian clocks within bats become free-running as winter progresses (Altringham, 2011).

Swarming

Myotis bat species recorded during the swarming survey have been classified as either Natterer's bats or bats within the whiskered/Brandt's/Daubenton's bat grouping, with all *Myotis* species present in the England known to exhibit swarming behaviour. The abundance of recordings is similar across both groupings however the mean time Natterer's bats were recorded was later, between 3.5-4 hours after sunset. Natterer's bat recordings also displayed a lower spread in activity times relative to other species, with the highest levels of activity recorded 2-5.5 hours after sunset.

Natterer's bat comprises the bat species most frequently recorded from other documented swarming sites in northern England (Glover and Altringham, 2008; Rivers, Butlin and Altringham, 2006). In addition, Natterer's bat activity recorded during this study peaked at a similar to time to that recorded from other northern England swarming sites (Glover and Altringham, 2008). Taking these considerations into account, it is considered that Natterer's bats are highly likely to engage in autumn swarming behaviour at the mine.

Whilst bats of the whiskered/Brandt's/Daubenton's bat grouping may also swarm at the mine, the evidence demonstrating this use is less compelling than for Natterer's bat. This species group recorded an earlier peak activity time, which fell close to that recorded from common and soprano pipistrelle at the same site. The wider spread of activity through the night, including early evening activity, suggests that whiskered/Brandt's/Daubenton's bats also forage on site. It is considered probable that the activity recorded from this species group was a combination of commuting, foraging and some swarming activity.

The presence of Daubenton's bat at the mine has been shown with a high degree of confidence through the recording of a diagnostic social call during the swarming survey. The area surrounding the mine entrance is dry with the closest water feature, a minor brook, located approximately 400m from the site. Such habitat would not comprise typical Daubenton's bat foraging habitat and consequently the presence of a social calling Daubenton's bat in this situation supports the assertion that bats of this species engage in some level of autumn swarming at mine.

Further Survey

Whilst the mine is unlikely to be used by large numbers of bats for swarming or hibernation it presents a site that is easily accessed for further study. Static monitoring devices and other equipment is safe from theft given the secluded nature of the site. It would be appealing to repeat the hibernation study using a bat detector recording continuously over the whole hibernation period season. This bat detector would be coupled with two temperature loggers, one inside the mine and the other outside the main entrance. Such a study would help confirm the findings of the 2012/2013 survey, whilst also being enabling a more robust consideration of bat activity against temperature.

Further investigation of swarming could comprise static monitoring survey undertaken for one or more weeks per month during the swarming period. Static monitoring survey could be coupled with the use of a night video camera system to observe the mine entrance during peak swarming times, in order to record bats entering or leaving the mine. Direct evidence of stone mine entry/exit by bats would demonstrate that bats recorded during this period were engaged in autumn swarming, as oppose to other activities such as foraging. Consideration could also be given to harp trapping at the site, with bat capture enabling more definite species identification and potentially providing a gauge to bat numbers using the site.

Further Considerations

Local geology has not resulted in the production of natural caves and consequently the mine is likely to comprise one of the few subterranean bat hibernation sites available in the surrounding area. It is clear that this mine is suffering from collapses, reducing its extent and possibly resulting in changes to air movement inside. There is considered to be a relatively high risk that this mine may be lost completely to bats in the medium term due to a future collapse close to the mine entrance. It is not clear that any safe management action could be taken to secure this structure and recommendations of this kind are outside the scope of this report.

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Adit Surveys 2014-2016, the story so far.

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Introduction

Hibernation surveys within lead mine adits in Cumbria began in January 2014.

The surveys are based around Nenthead in Cumbria. This area was a centre for lead mining and there are many remaining adits that are open and safe to access. Adits, or levels, were the main horse access routes into the lead mines, used to bring the ore to the surface for processing. The adits are level tunnels between 1-2m wide and from 1.5-2.5m high with small stone blocks used to construct the walls and arched roof. The arching provides many crevices for bats to hide within, and no doubt there are many more crevices behind these which we cannot see. There are some short sections of rock cut and shale cut tunnel between sections of arching that are included within the survey area. The majority of the adits we survey still lead into extensive mine systems.

Bats have been found in some, but not all, of the adits checked and several of the sites are now registered with the Bat Conservation Trust's National Bat Monitoring Programme. The surveys are undertaken by members of Northumberland and Cumberland bat groups.

Methodology

The adits are searched systematically working inwards, until either the end of the stone arching is reached, the adit is blocked or fallen or it looks too unsafe to continue.

The temperature and humidity at each adit entrance is recorded. When a bat is found, the species is identified (if possible) and the temperature and humidity recorded from a spot below where the bat is roosting. The distance the bat is from the adit entrance is also measured to the nearest 50mm. Each team is led by a licenced surveyor and the recording of the bat and its location are done quickly and efficiently to prevent any undue disturbance to the bat.

The temperature in the adits is variable; however further in the mines maintain a steady temperature of 11°C. The mines themselves are not searched for hibernating bats as it is assumed (possibly in error) that the internal temperature is too high for bats to maintain themselves in torpor.

Results

This data has been collected for twenty three bats found between January 2014 and February 2015. The species found hibernating in the adits are whiskered/Brandt's' bat *Myotis mystacinus/brandtii*, Daubenton's bat *M. daubentonii*, Natterer's bat *M. nattereri* and brown long-eared bat *Plecotus auritus*.

Our results have shown that the temperature at which the bats have been found is variable, ranging from 0.5°C to 8.7°C. Dietz and Kiefer (2016) describe *Plecotus* species bats as cold hardy, tolerant of hibernation temperatures as low as 0°C and the small *Myotis* species, defined as whiskered bats, Daubenton's bats and Natterer's bats, as requiring temperatures between 4-8°C.

The data show a strong correlation between the external temperature and the internal temperature within the adit. The lower the temperature outside, the lower the temperature it is within the adit (see Figure 1).

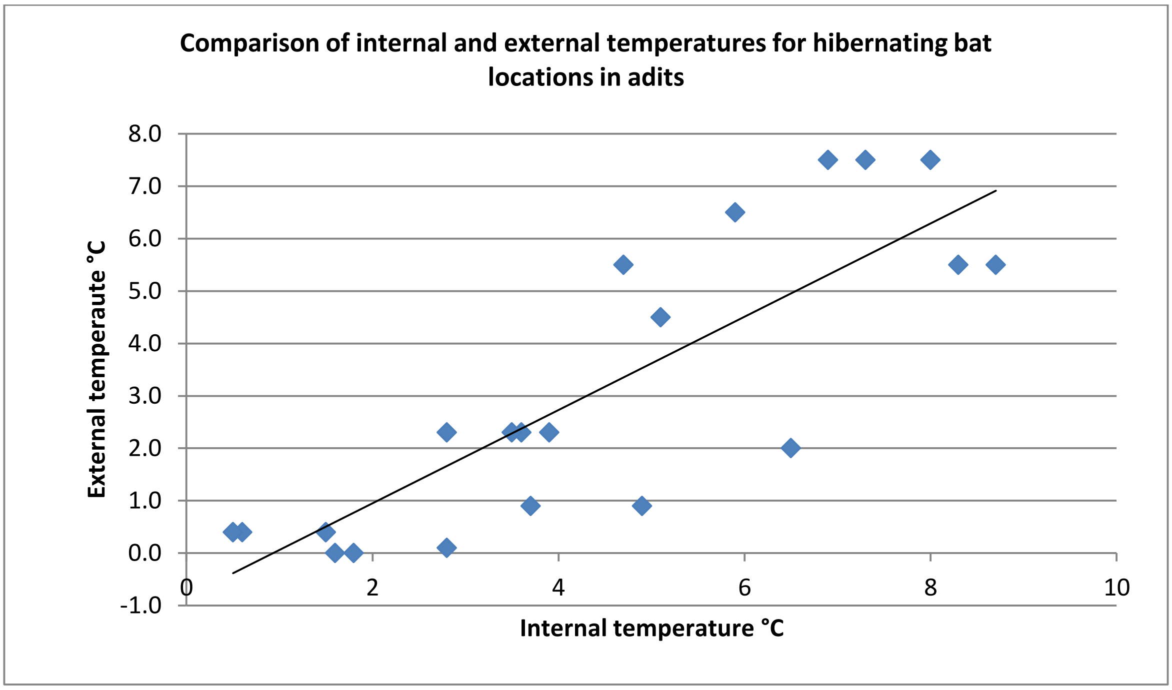

Figure 1 Comparison of internal and external temperatures for hibernating bat locations in adits.

There is also a direct relationship between the internal temperature and the distance from the entrance of the adit, the further the bat was in the adit the higher the temperature (see Figure 2).

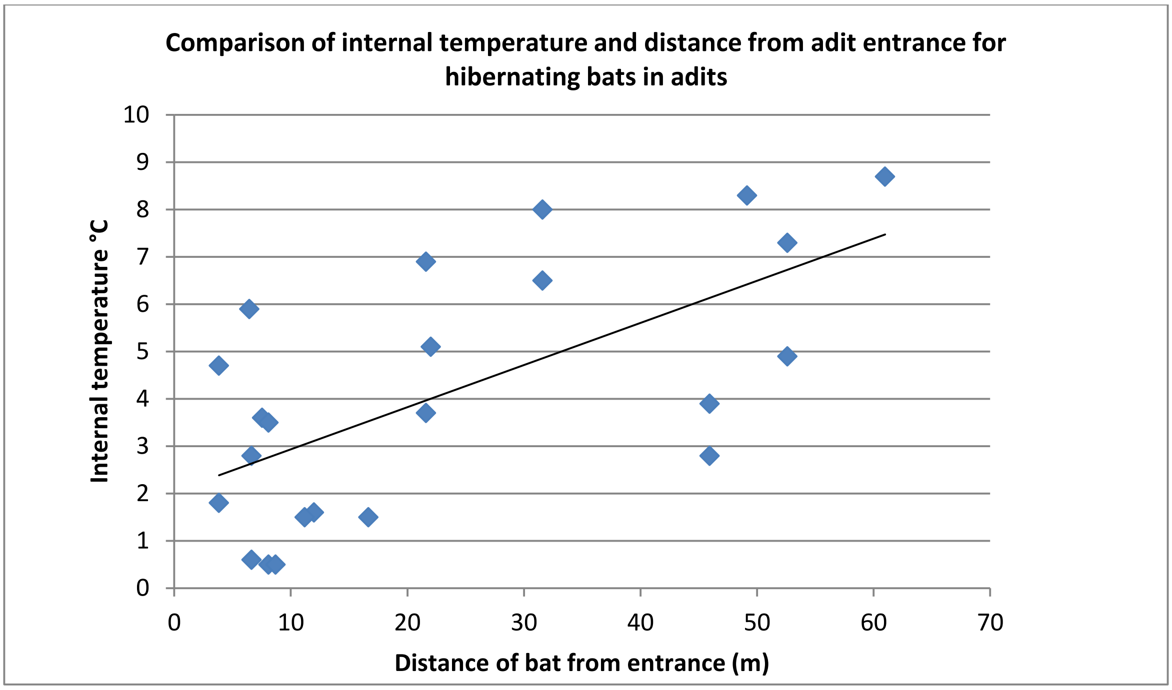

Figure 2 Comparison of internal temperature and distance from adit entrance for hibernating bats in adits.

Combining this data for all 23 bats shows the relationship between the internal and external temperature for each recording point and also shows the variation in temperature with distance into the adit (see Figure 3).

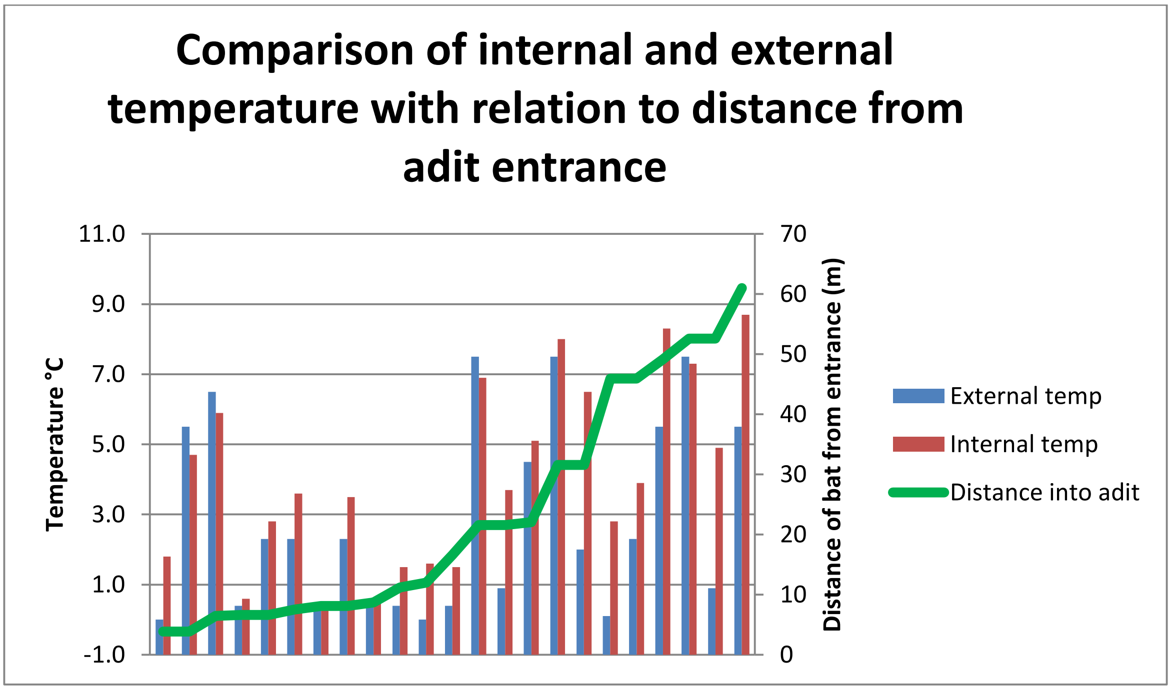

Figure 3 Comparison of internal and external temperature with relation to distance from adit entrance.

During the survey period seven individual bats have been refound in consecutive months. These bats have not changed their hibernation position and yet the internal and external temperatures have changed around them. This temperature change does not seem to have influenced the bat enough to have aroused and changed roost location (see Figure 4).

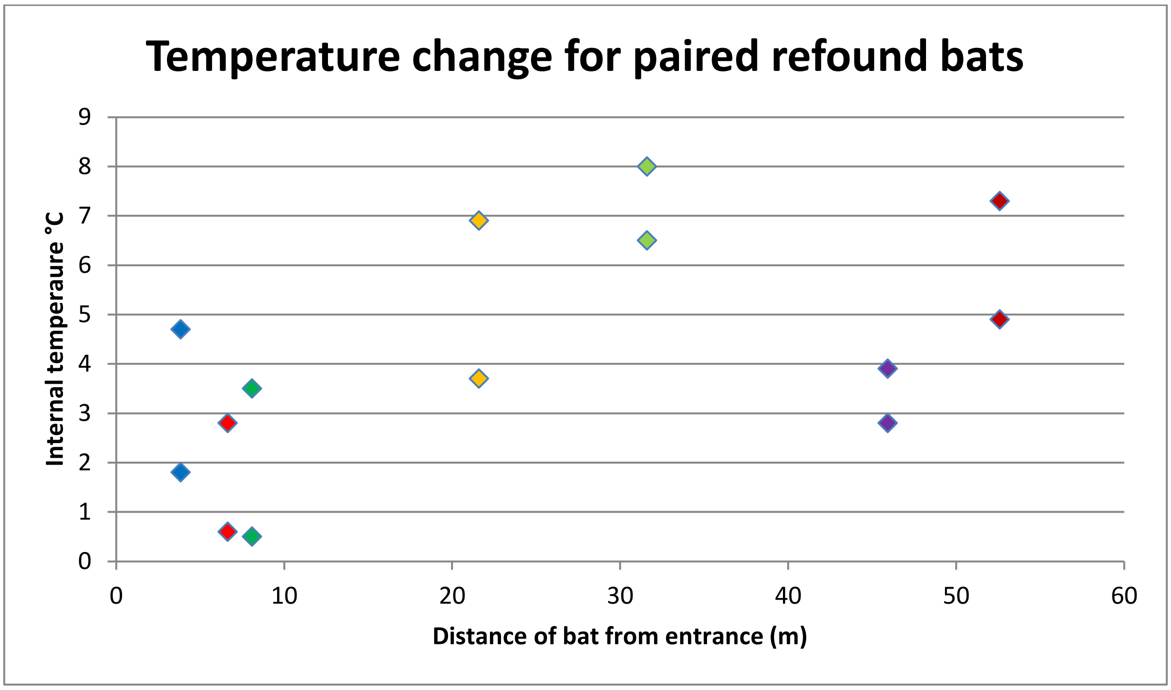

Figure 4 Temperature change for paired refound bats.

The temperature at which each bat is hibernating has varied between surveys. This is to be expected as the external temperature has changed between surveys and the internal temperature in the adit has changed as a result of the relationships shown in Figures 1 and 2.

Of the seven refound bats, three were first recorded on 17/12/2014 and were refound on 31/01/2015. The remaining four were found on 31/01/2015 and refound on 21/02/2015. None of the bats refound on 31/01/2015 were recorded again on 21/02/2015.

The temperature at which the three bats, two Daubenton's bats and a brown long-eared bat, recorded in December 2014 were hibernating at fell by an average of 2.4°C by January 2015. On this survey visit snow was lying up to 1m deep in places.

The remaining four bats, a Daubenton's bat and three Natterer's bats, all experienced a temperature rise of an average of 2.3°C between the surveys in January and February 2015. The second visit was undertaken in milder conditions, some pockets of snow remained but the temperature was higher during this survey than in January.

The changes in temperatures at which individual bats were refound varied; the smallest variation was +1.1°C and the largest variation was -3.2°C. The variation in temperature compared to the distance from the adit entrance can be seen in Figure 5. It can be seen that the three bats closest to the entrance experienced a similar increase in temperature; these three bats were all in the same adit.

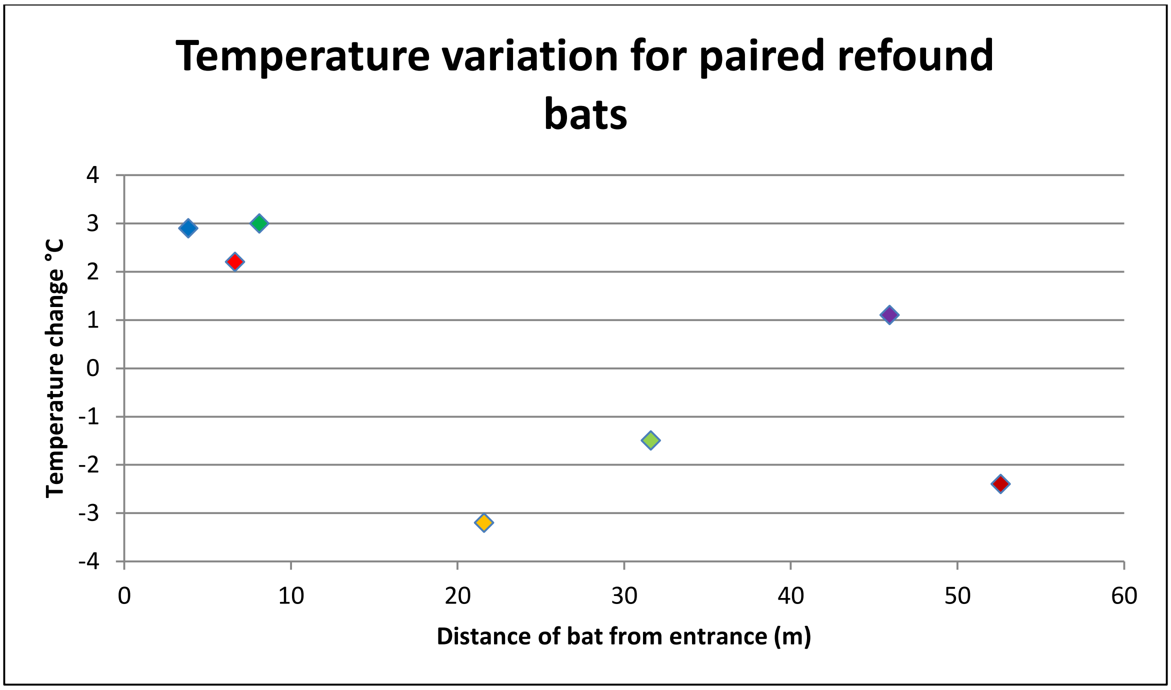

Figure 5 Temperature variation for paired refound bats.

Discussion

Hibernating bats have been found in surveys undertaken in December, January and February. Seven bats have been refound in consecutive surveys.

This data does confirm expected theories; the colder it is outside, the further the cold penetrates into the adit. This has a greater impact closer to the entrance.

This data is best illustrated by the paired bats; these bats have chosen to remain in the same location although the temperature at that point in the adit has changed. Three of the paired bats were first found in December 2014 and refound in January 2015, the average temperature change between these two surveys was -2.4°C. The other four paired bats were first seen in January 2015 and refound in February 2015, in this case the average temperature change was +2.3°C. This fits the expected temperature change over the winter months with January being coldest month.

Interestingly, four bats found in January 2015 were not present in the same locations in February 2015. Is it possible that the temperature change was too great for these animals causing them to rouse and move between survey visits? The overall condition of each bat will also affect whether a bat rouses; an individual may be low on resources and need to forage when conditions are suitable in an effort to survive the winter period.

This data has a very small sample size and none of the results are statistically robust, however this subject is one for further research.

Acknowledgements
Thanks to the willing members of both Northumberland and Cumberland bat groups for your company, laughter and bat finding skills. Thanks also to Stephen Westerberg for the graphs and for staying outside of the adits and trying to supervise us.

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Dietz, C., Kiefer, A. (2016) Bats of Britain and Europe. London.

Hamsterley Forest Bat Boxes.

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Hamsterley Forest is one of the Forestry Commission's public forests, with open access on foot, bicycle and horseback. It is managed to be both productive and useful to the community; being rich in wildlife, both plant and animal. Located in County Durham, the 2000ha is mainly coniferous plantation with some elements of ancient semi-natural woodland, which provides habitat in abundance for bats but limited roosting opportunities.

The changing use of Hamsterley Forest and other factors have led Durham Bat Group (DBG) to rethink the bat boxes within the forest. Our boxes are nailed onto trees at a height of c.3m. In order to check them this has involved the use of ladders and harnesses, a somewhat long and tiresome task and at times positively dangerous.

DBG has over the last couple of years been converting our boxes onto a hanging system whereby the boxes are hung on hooks and moved with a pronged pole, so no more ladders and harnesses. We are also taking the opportunity to re-position the boxes into comparable groups and to move them away from the regularly used public paths (making it safer). Over the coming years we plan to build on the results we have achieved so far.

DBG has had bat boxes in Hamsterley Forest for over 20 years; this study analyses the boxes from 1999 to 2011. One hundred and nineteen bat boxes were erected over five separate series, using 84 oak boxes and 35 concrete boxes. Over time more boxes have been installed and some have been removed or fallen into disrepair giving a total of 238 separate positions for boxes.

Boxes have been checked on an annual basis providing data for 55% of the total number of boxes, 981 of 1770. The number of checks on each bat box range between two and 12 (average 5.2) per box (see Figure 1). Boxes were checked during the summer at a point in time when bats potentially had young with them. In 2012 it was decided to check later in the year to prevent disturbance to females with young. Data from 2012 onwards has been excluded due to the change in timings.

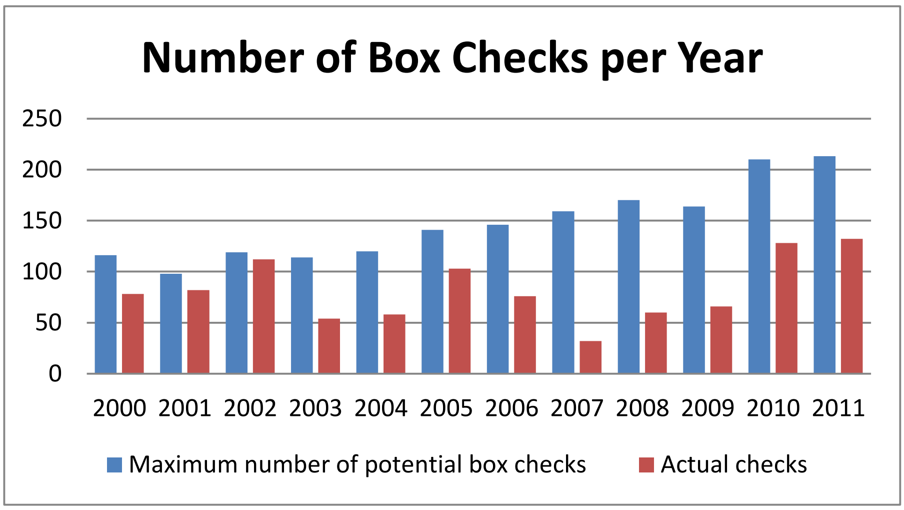


Figure 1 Number of box checks per year.

We have found that our bat boxes are used by bats and birds. Fifty five per cent of the boxes installed have had some activity within them, giving 451 hits on boxes; bird:bat use ratio was 39:6, with boxes having both bat and bird evidence. Bird use was identified by the presence of nests, no actual birds were recorded. Bat use was confirmed by either the presence of bat droppings or the presence of a bat/s. A total of 270 boxes had evidence of bat use, 85 boxes (31%), had bats in residence: 185 boxes (69%), had bat droppings.

A total of seven species of bat have been identified as using the boxes - whiskered/Brandt's' bat *Myotis mystacinus/brandtii*, Natterer's bat *M. nattereri*, noctule *Nyctalus noctula*, common pipistrelle *Pipistrellus pipistrellus*, soprano pipistrelle *P. pygmaeus* and brown long-eared bat *Plecotus auritus* (see Figure 2). The joint occupancy boxes, ie those boxes having two bat species at the same time, contained; whiskered bat/soprano pipistrelle, Natterer's bat/noctule, 2x Natterer's bat/soprano pipistrelle.

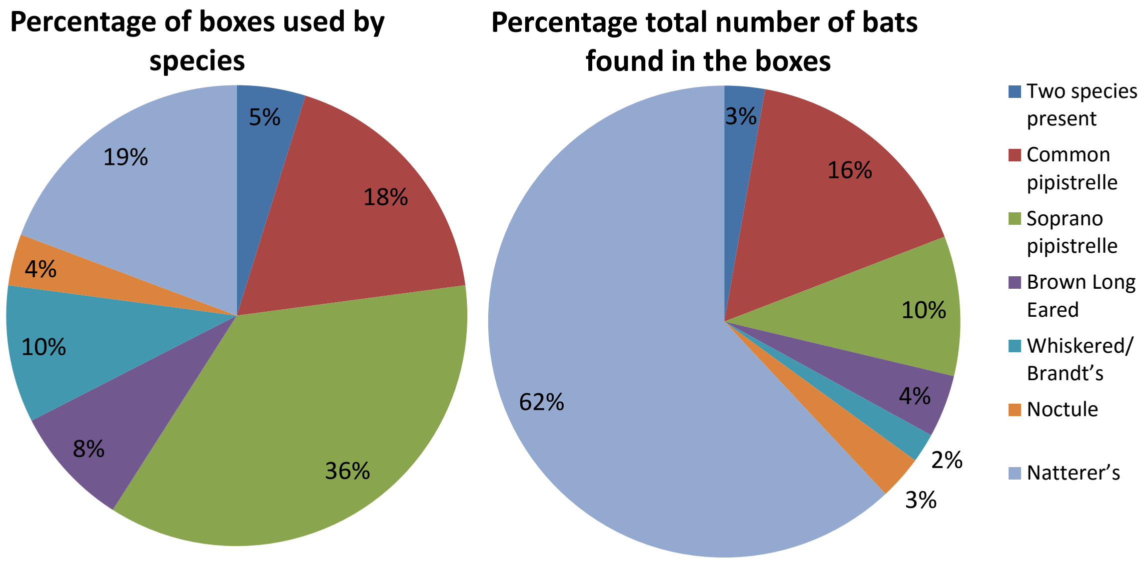


Figure 2 Percentage of boxes used by species, percentage total number of bats found in the boxes.

How many bats found in each box varies from species to species. Individual whiskered/ Brandt's bats and soprano pipistrelle were the mode per box for these species, but 68 Natterer's bat were found in a single box with an average of 15 Natterer's bat per box.

Data recording varies from year to year and between recorders. For example not all bats were sexed. Of the 39 soprano pipistrelle, 20 were sexed as male, the remaining were not sexed. Of the 246 Natterer's bats all but 28 were within maternity roosts, this indicates that different species use bat boxes for different reasons.

Planned future work will look at how the bats use different areas of the forest, to ascertain if there is a variance in bat species using different areas.

Any other suggestions would be happily investigated and we would welcome any additional help.

Gosforth Park Nature Reserve – Bat Box Scheme 2013-2015.

Hazel Makepeace hazelmakepeace@aol.co.uk

Introduction

The Natural History Society of Northumbria has managed Gosforth Park Nature Reserve since 1929. This beautiful 1km x 1km wildlife refuge in the north of Newcastle has a shallow lake, extensive reed bed and mixed woodland.

Studies of different mammals have been undertaken over the years but not much is known about the bats that forage and roost there. In the light of this, 38 bat boxes were installed in 2013, eight boxes in July and then a further 30 at the beginning of September (see Figure 1). The boxes used were 20 Schwegler Woodcrete boxes of three styles (ten 2FDFP, five 2F and five 2FN) and 18 wooden boxes based on the Warwickshire bat box (WBB) (see photograph, from left to right, box style 2FDFP, 2FN and WBB).

The eight boxes that were put up in July were checked in September 2013 and it was with much surprise that a solitary male soprano pipistrelle *Pipistrellus pygmaeus* in breeding condition was found in one of the Woodcrete boxes. The boxes were checked in October 2013 and a further two solitary males were found in separate boxes and in the same box as the one the solitary male was found in during the September check, there was a cluster of soprano pipistrelles, one male with four females.

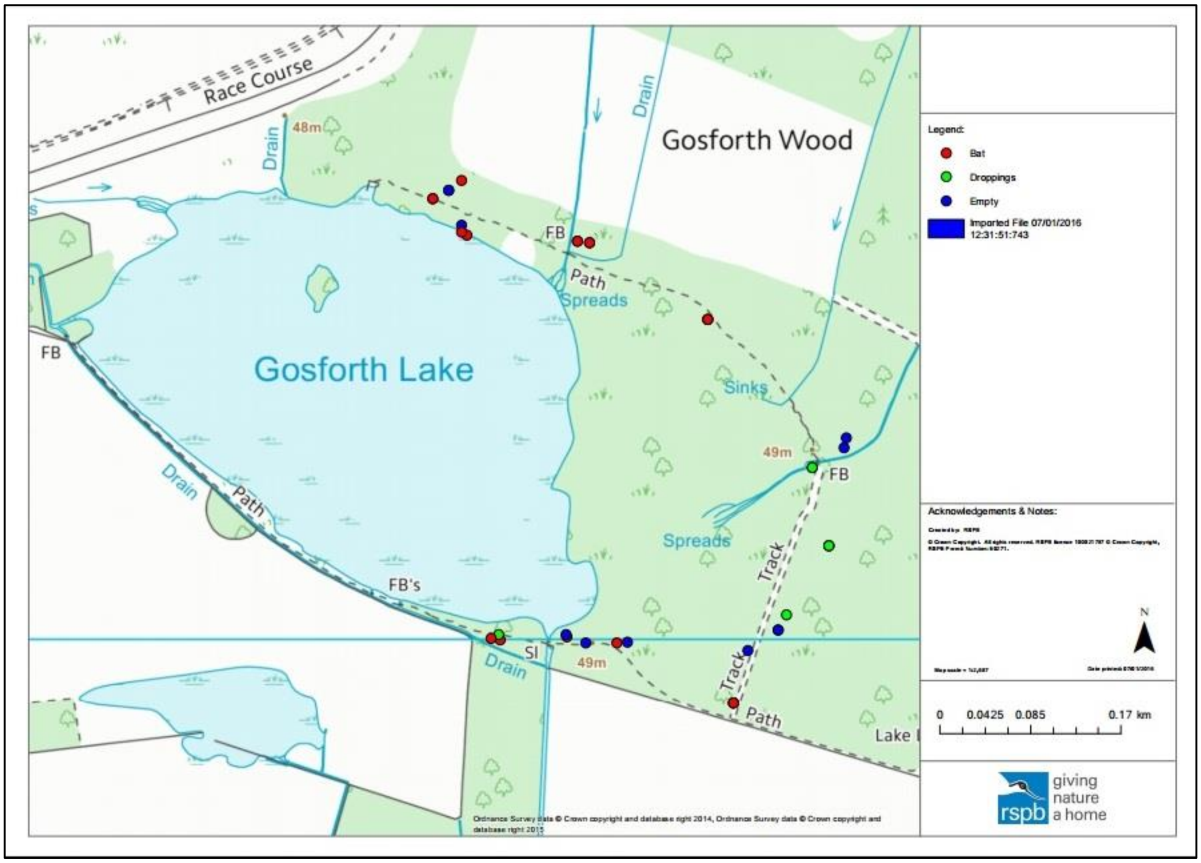


Figure 1 Bat box locations with occupancy.

Results

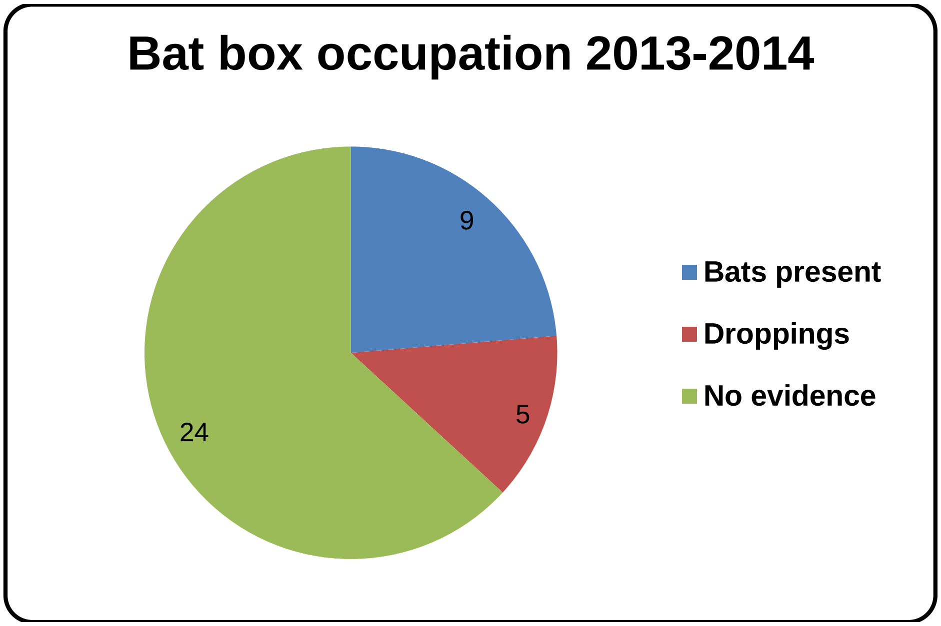
During 2014 the boxes were checked on four occasions, once each in the months of April, August, September and October. The total number of boxes occupied by bats was nine. In addition to these nine, a further five boxes had evidence of occupancy (i.e. droppings in box), bringing the total of boxes used, at the end of the 2014 season, to 14.

Three bat box checks were carried out in 2015, once each in the months of May, August and September (April and October were too cold). There were ten boxes occupied by bats and an additional 13 boxes had droppings in but no bats present. This brings the total number of boxes used during the 2015 season to 23.

The results for all three years together make for more interesting reading and the charts later in this report give a breakdown of occupancy by box type, aspect, tree type, sex and age ratios and the months that a higher number of bats were seen.

The only species to have been found in the boxes is the soprano pipistrelle although not all the droppings collected have been DNA tested.

The total number of boxes occupied by bats is 14 and the number of boxes with droppings but no bat seen is 11 and all but the 2FN woodcrete boxes have been used by bats – the 2FN had droppings in one box, once only. This brings the total of boxes with either bats or droppings found to 25. The total number of bats that we have encountered is 47.



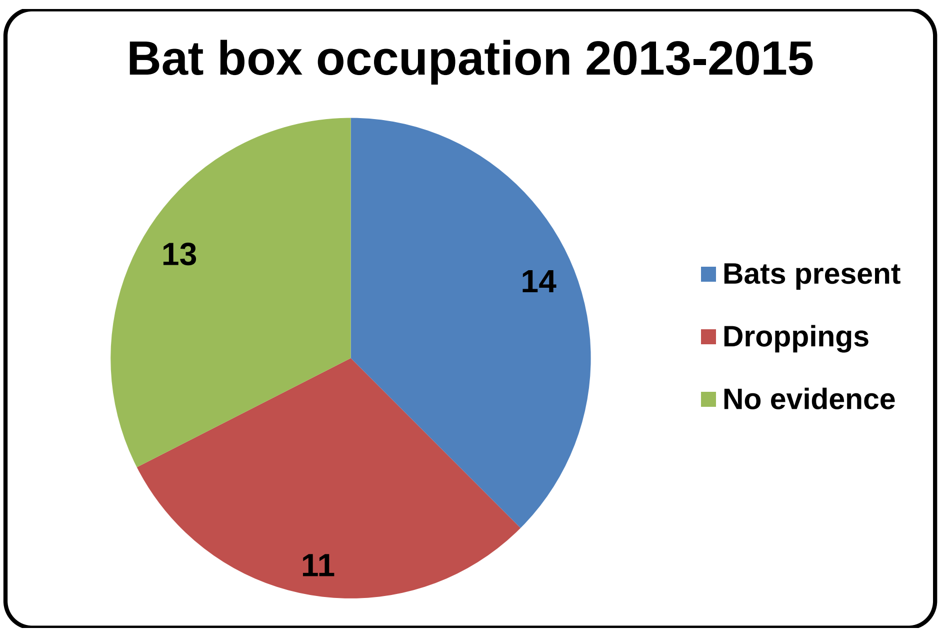


Figure 2 Bat box occupation.

Total bats counted in 2013 = **8 (4 males/4 females)**
Total bats counted in 2014 = **19 (4 males/15 females)**
Total bats counted in 2015 = **20 (11 males/9 females)**

Total bats counted 2013/2014/2015 = 47

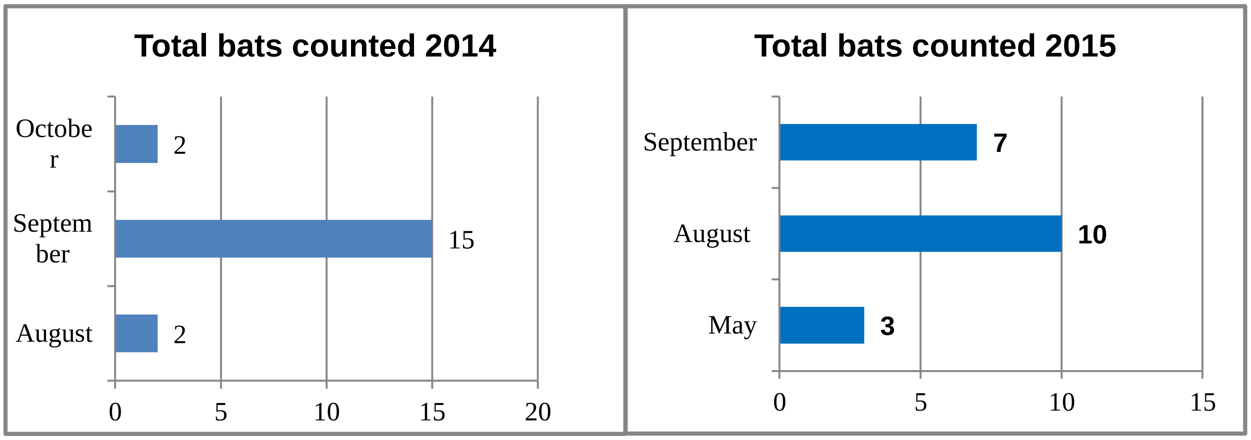


Figure 3 Total bats counted.

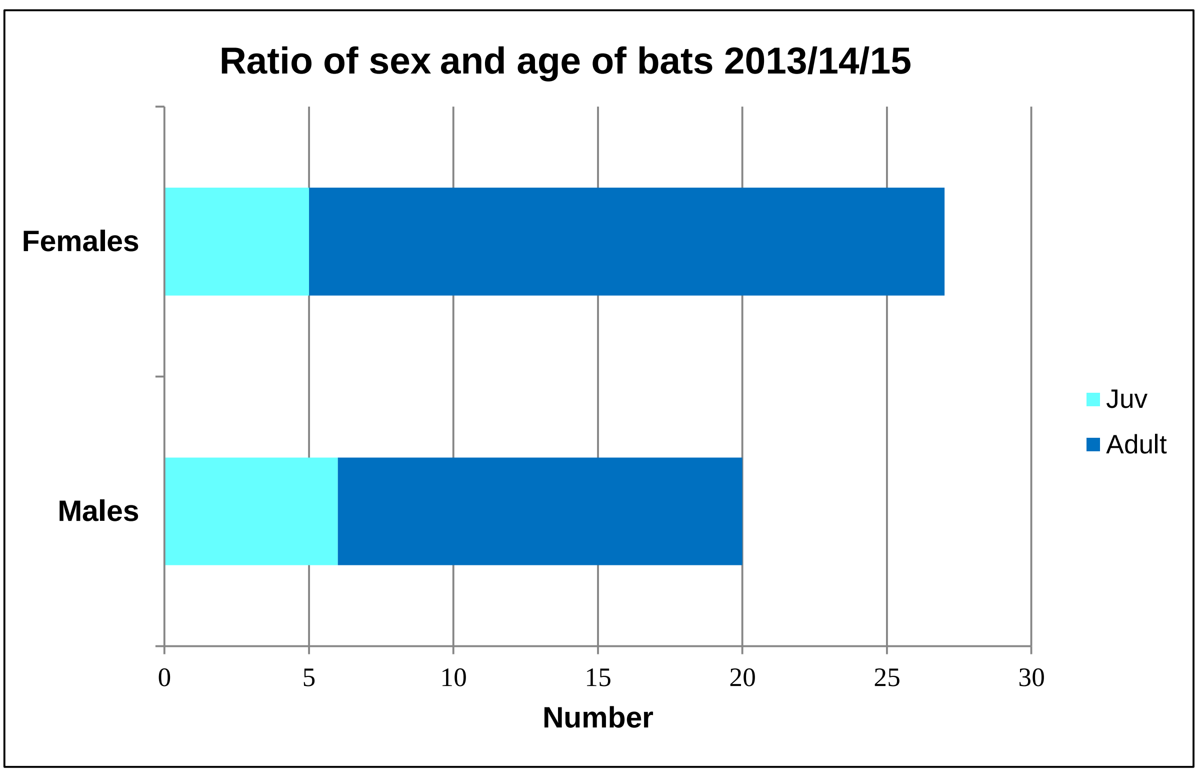


Figure 4 Ratio of sex and age of bats 2013/14/15.

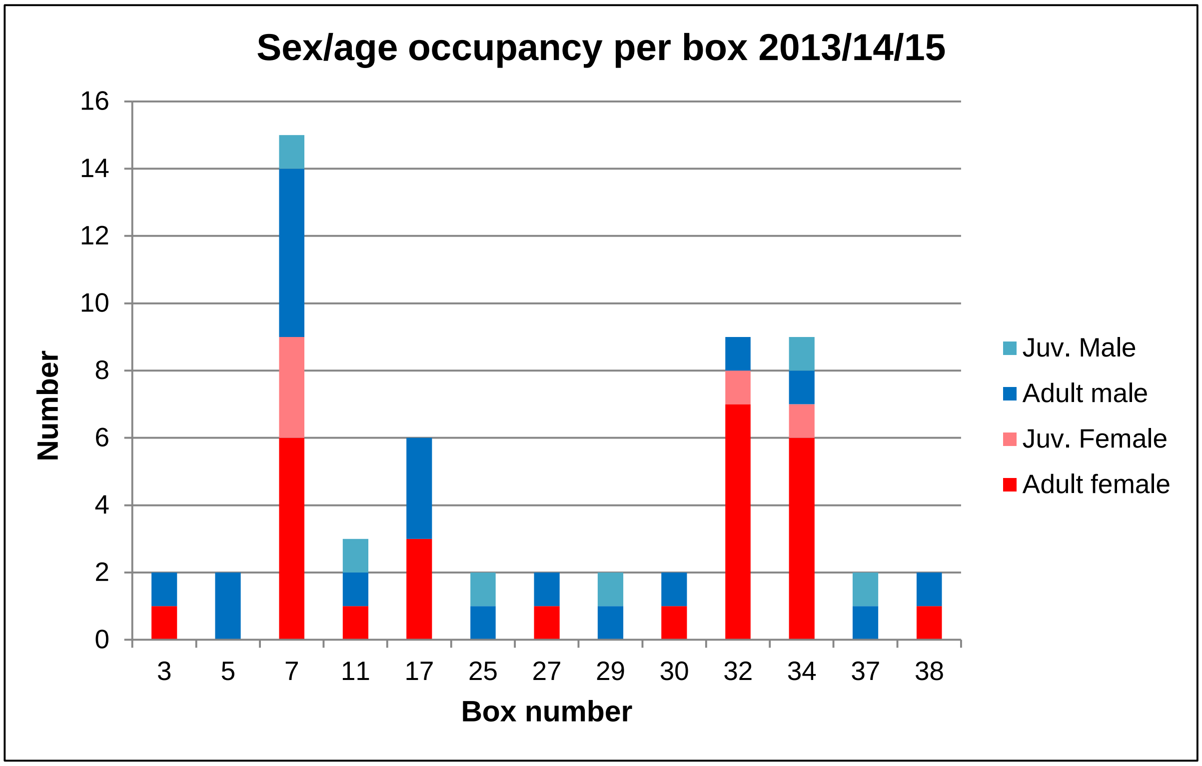


Figure 5 Sex/age occupancy per box 2013/14/15.

Most used box types: Woodcrete 2FDFP and 2F and wooden (WBB)
Least used Woodcrete 2FN

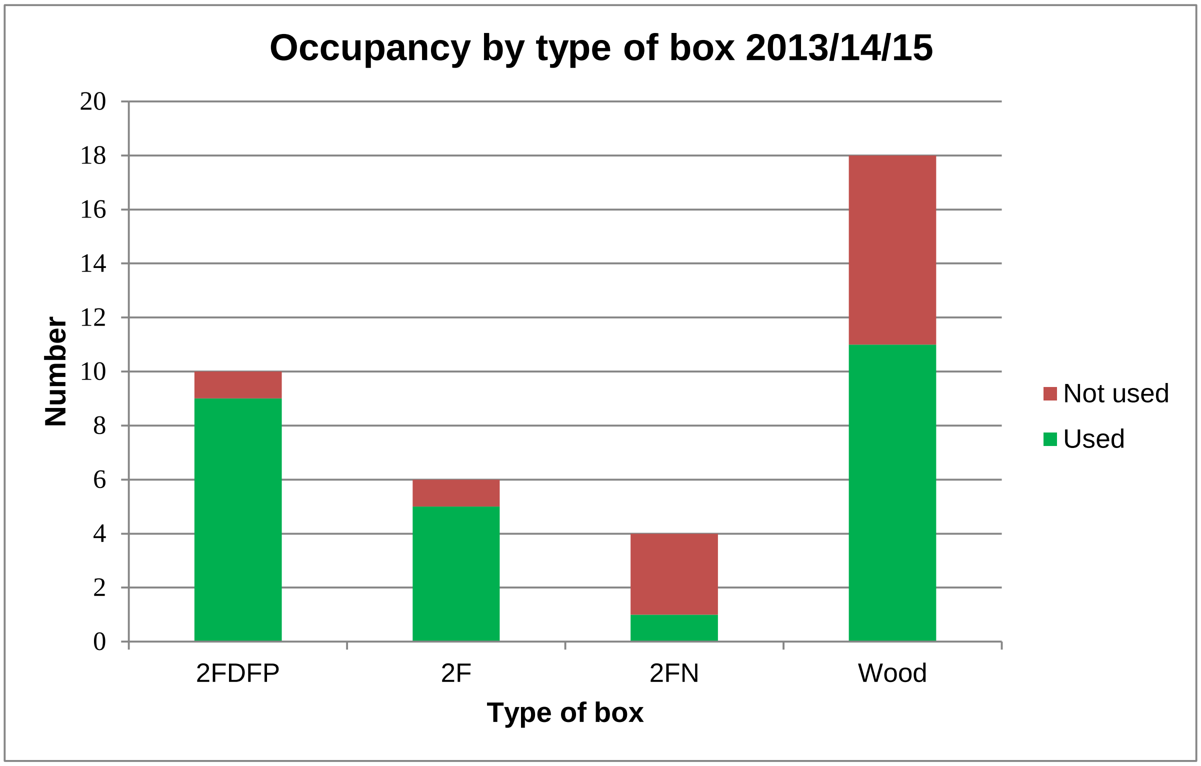


Figure 6 Occupancy by type of box 2013/14/15.

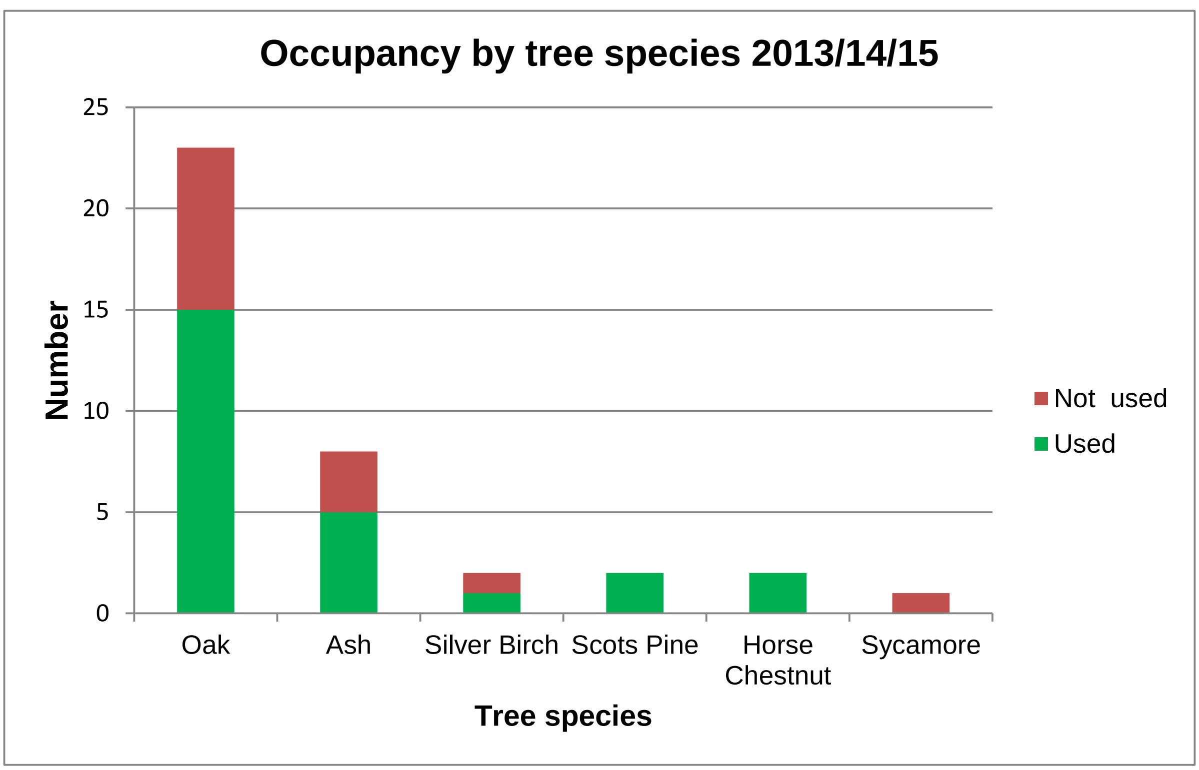


Figure 7 Occupancy by tree species 2103/14/15.

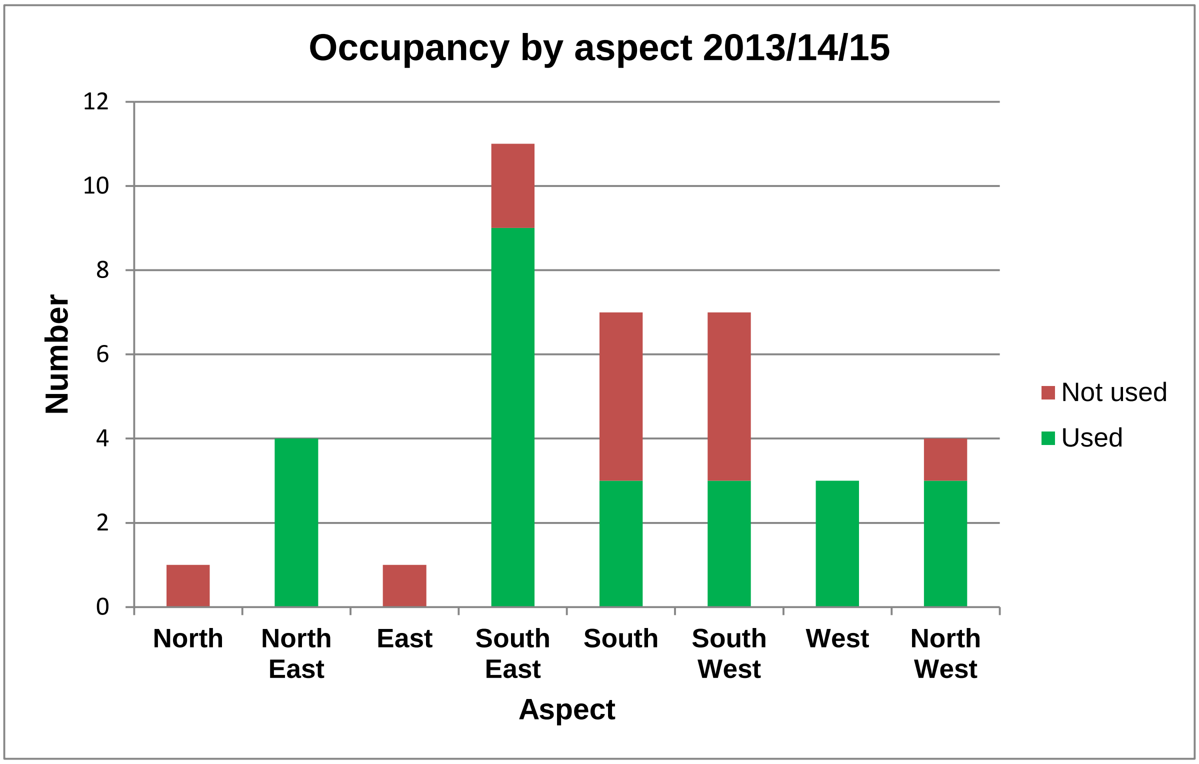


Figure 8 Occupancy by aspect 2013/14/15.

Acknowledgements

Natural History Society of Northumbria (NHSN) and Northumberland Bat Group (NGB).
A special thank you to Geoff Lawrence for making all the wooden boxes.
All NHSN and NBG volunteers.
Paul Drummond (Reserve Warden).

Northumberland Nathusius' Pipistrelle Project 2011–2015.

Hazel Makepeace hazelmakepeace@aol.co.uk

Pre-2011

Very little was known about the distribution of the Nathusius' pipistrelle *Pipistrellus nathusii* nationally. The closest records to Northumberland were grounded bats on North Sea oil rigs and one grounded Nathusius' pipistrelle from Throphill, near Morpeth, on 25/01/2007.

2011

A chance detection of Nathusius' pipistrelle on the River Wansbeck at Ashington in May 2011 and further detections in early June 2011 raised the tantalising possibility that this rare species of bat was resident and breeding in Northumberland. From this the Northumberland Nathusius' Project was formed in late 2011 to continue a community led bat project run by the Bat Conservation Trust (BCT) and Northumberland Bat Group.

Our aim was to encourage members of the public to get involved and to enlist local volunteers to discover where the foraging locations and roost sites of Nathusius' pipistrelle bats were in south east Northumberland. Throughout the bat activity season we organised volunteers to undertake regular bat survey work with the aim of trying to locate Nathusius' pipistrelle roost site(s). The presence of a rare bat species was also an opportunity to promote bats in general with volunteers undertaking public events, talks, leafleting and bat activity surveys.

To achieve this we provided training, support and mentoring to all participants in the project. We provided bat detectors for use by volunteers to enable them to learn how to detect, monitor and identify these rare bats.

At the end of the 2011 we knew that:

- Nathusius' pipistrelle were present in the coastal areas of Northumberland in every month of the year from May to October 2011.
- Social calling was heard and recorded in August and September suggesting that mating activity was at least being attempted (see Figure 1).
- Nathusius' pipistrelle were present in 19 different 1km grid squares (up to 17km apart) within the coastal area of Northumberland during 2011.
- Nathusius' pipistrelle were present at seven different sites up to 13.5km apart at the same time during co-ordinated surveys in September (see Figure 2).

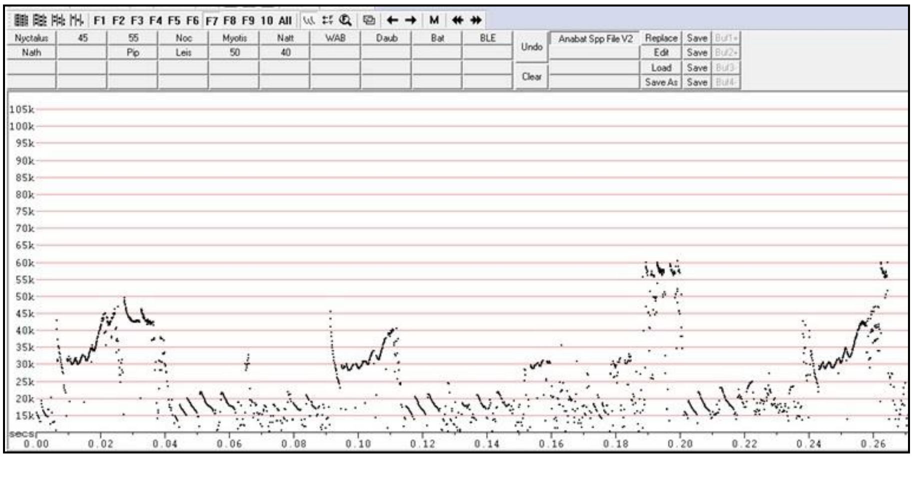


Figure 1 Nathusius' pipistrelle social calling.

Figure 2 Locations of Nathusius' pipistrelle recorded during co-ordinated surveys.

On 16/09/2011 a bat was seen flying across the North Sea towards the coast at Newbiggin-by-the-Sea at 8:50am. This bat grounded once it made landfall. The bat was reported via the National Bat Helpline and one of our Nathusius' project volunteers collected the bat, a juvenile male Nathusius' pipistrelle. In Europe Nathusius' pipistrelle are known to be migratory (Kurvits et.al., 2011), moving between summer roosts in the north east to wintering grounds in the south west (see Figure 3).

As this bat was seen to fly in from the sea in prime migration season it strongly suggests that there is a migratory element to the Northumberland population. This bat, found underweight and dehydrated, was successfully rehabilitated and released on the 27th September.

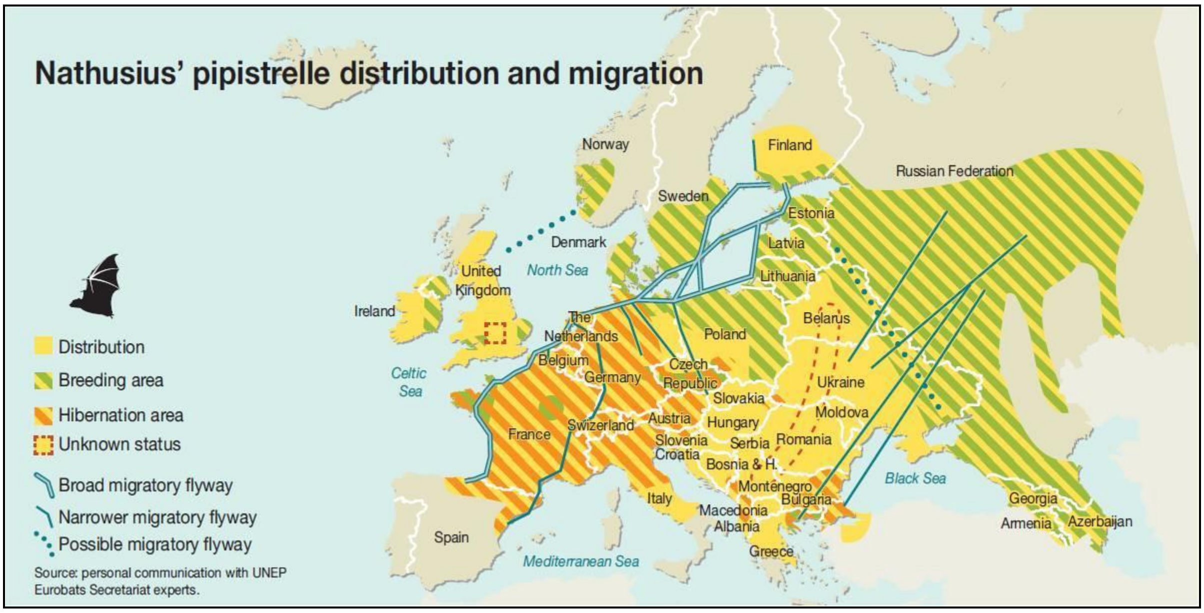


Figure 3 Nathusius' pipistrelle distribution and migration.

- Identify roost sites as well as roost and habitat preferences, by catching and radio tracking individual bats.
- Find out whether both male and female bats are present in Northumberland.
- Investigate possible migration by ringing all Nathusius' pipistrelle bats caught.
- Look for any seasonal variation in activity through volunteer led monitoring at core sites.
- Further test the geographical distribution of the species in Northumberland by car transect surveys and by activity surveys undertaken by volunteers.

By the end of 2012:

- 51 volunteers had been involved with the project, contributing more than 235 survey nights.
- No Nathusius' pipistrelle were caught, however we knew that Nathusius' pipistrelle were present in Northumberland from March to October.
- Nathusius' pipistrelle had been recorded from 22 1km squares with a north-south range of 37km.

2013

In 2013, 31 volunteers took part in a series of co-ordinated surveys throughout the season and, in addition to confirming the ongoing presence of Nathusius' pipistrelle at our core sites, five new sites were identified.

Similar projects in other counties had also been gathering data on the status of the Nathusius' pipistrelle and in August 2013 the first National Nathusius' Bat Conference was held, bringing together all interested parties in the UK. At the end of the conference it was strongly felt that there was a need for a co-ordinated National Nathusius' pipistrelle Project.

2014

A pilot study was established in 2014 funded by the People's Trust for Endangered Species. The survey methodology focused on catching and ringing bats at large water bodies with previous records of Nathusius' pipistrelle. Using a standard methodology and equipment from the BCT's Bechstein's Bat Project, the aim was to catch the species using harp traps and acoustic lures. If Nathusius' pipistrelle were captured, fur samples would be taken and sent for stable isotope analysis at the University of Exeter in an attempt to understand the origin of the individual animals. In addition the bat would be ringed and biometric measurements also taken.

The project's three main aims were:

- To understand the breeding status of resident Nathusius' pipistrelle in the UK.
- To understand the migratory movements of Nathusius' pipistrelle in and out of the UK.
- To provide new increased field skills to bat workers and groups.

The Northumberland Nathusius' Project was one of five groups invited to take part.

Northumberland Nathusius' Project Results

A total of 12 trapping nights were carried out over four sites, 84 bats were caught of which ten were Nathusius' pipistrelle. These were caught at two of our four selected sites.

Of the ten Nathusius' pipistrelle caught three were adult males and seven were juveniles, four males and three females.

Once a bat was caught it was identified and detailed biometrics taken. The species, sex and age of the bat were recorded; additionally forearm length, weight and reproductive status were noted. All Nathusius' pipistrelle were ringed, on the right forearm for males and left forearm for females, with individually numbered rings as supplied by the Bat Conservation Trust. Fur clippings were taken, under licence, from common pipistrelle *P. pipistrellus*, soprano pipistrelle *P. pygmaeus* and Nathusius' pipistrelle to allow for stable isotope analysis to be carried out. Dropping samples from Nathusius' pipistrelle were also taken, if they obliged, to allow DNA analysis for species confirmation.

Northumberland was the only county where juvenile Nathusius' pipistrelle were caught in 2014.

The results of the National Nathusius' Pilot Project are summarised below in Figure 4.

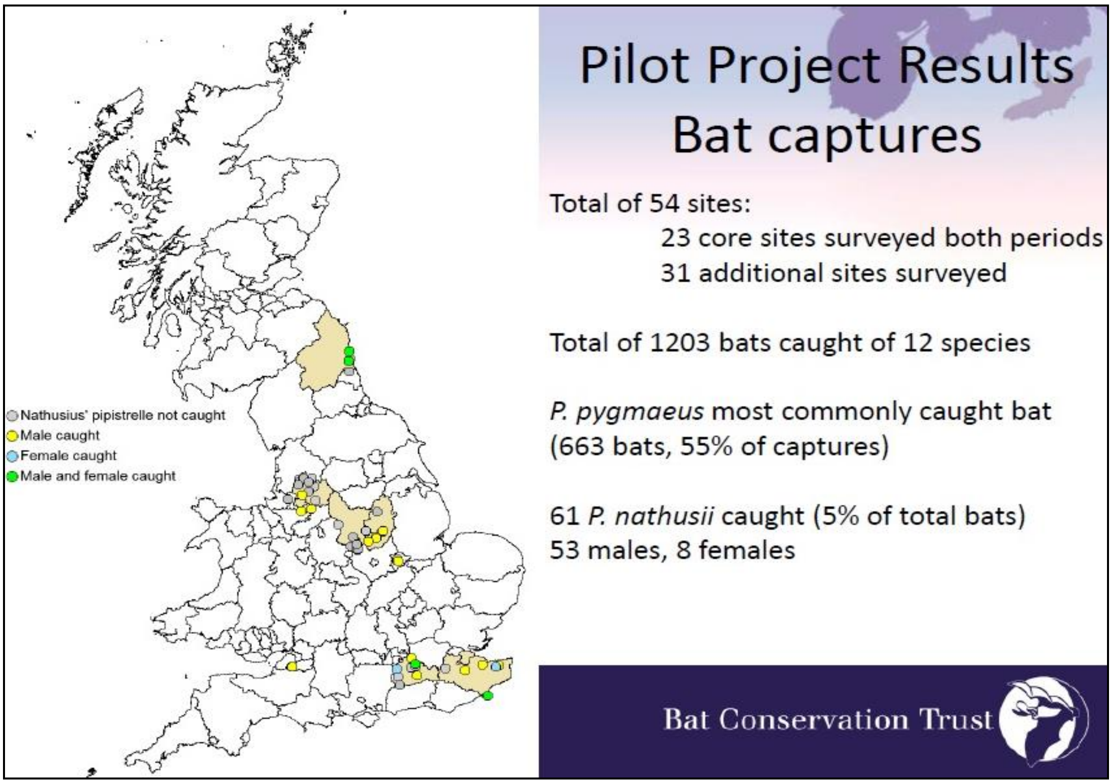


Figure 4 Results of the National Nathusius' Pilot Project.

2015

The National Nathusius' Pilot Project continued in 2015 with a further three groups involved.

In Northumberland, the decision was made to concentrate on the two sites where Nathusius' pipistrelle were caught in 2014. The aim was to catch post-lactating female Nathusius' pipistrelle, fit radio tags and track them to their roost sites.

Site 1 Druridge Bay Country Park (Ladyburn Lake).

Site 2 River Wansbeck Country Park.

Results

May was the first month of the year that we were actually able to get out to the sites because of the incredibly cold conditions in April and we managed to squeeze in two trapping nights. Four Nathusius' pipistrelle were caught on 30/05/2015 at Ladyburn Lake, Druridge Bay Country Park.

These were two males and two pregnant females. One of the females was a whopping 10.5g, she felt and looked heavily pregnant, the other just 7.1g. Unfortunately, we were not set up to track at that point so we could only take biometrics and fur samples and put rings on.

On 07/08/2015 two Nathusius' pipistrelle were caught at the Druridge Bay site, a male and a post lactating female.

I had (rather hurriedly and with the fantastic help of other batty colleagues around the country) got organised for tracking so we fitted a radio tag to the female and a team was allocated to track her, they didn't have to go far as she foraged over Ladyburn Lake for the whole night.

Nathusius' pipistrelle with radio tracking tag fitted

At dawn, we tracked her leaving the lake and picked up her signal about 1.5km south west of the lake. We located the building that she was in, a single storey barn conversion on the edge of Red Row village.

We returned that evening, 08/08/2015, to watch her emerge, rather later than we had expected, at 10.36pm and without echolocating. She was tracked east towards the pools at East Chevington, she was picked up again at Ladyburn Lake where she continued to forage around the lake all night. At dawn she returned to the same roost site in Red Row.

On 09/09/2015 a male advertisement call was heard from the same roosting position as the female. An advertisement call is considered to be an element in mate attraction. Social calls were heard and recorded as well. The tagged bat left the roost at 9.46pm briefly, and then returned to the roost! She finally left the roost at 10.06pm (again no echolocation); no other bats were seen to emerge from the building, although flight calls were recorded. Every night she emerged from the roost at varying times, the earliest was at 9.10pm.

On 12/08/2015 she left and returned three times in quick succession before heading off to Ladyburn Lake to forage. Male advertising calls were recorded on several nights whilst waiting for the tagged female to emerge. This pattern of behaviour continued for 13 nights and she returned to the same roost site except for one dawn where she returned to a different roost site in a stone building approximately 50m distance from the original roost.

The roost owner has been very accommodating and allowed us to inspect the roof void, a dead juvenile *Pipistrellus* species bat was retrieved and is awaiting DNA analysis.

On 08/08/2015 two more Nathusius' pipistrelle were caught at the Druridge Bay site, again a male and a post lactating female.

Another radio tag was fitted to the female and, again, not much tracking was required as she also foraged around the lake all night! At dawn she left and headed north east. Off we went - it took us a while to find her but eventually picked up the signal in a building on the coast in Hauxley Village, a little over 2km from the lake. We went back that evening; at 9.30pm a male Nathusius' pipistrelle was heard advertising for several minutes, then two bats left the roost site, a flat roof on a large dormer window. The tagged female had not left as the tag was still audible, a male was still advertising, the tagged female then left the roost (no echolocation) and was not seen. Additional Nathusius' pipistrelles arrived and flitted around the building and the access point then all left. The tagged bat was picked up briefly foraging over water bodies at Low Hauxley Nature Reserve and then went again to Ladyburn Lake at the Country Park. This bat also returned to the original roost site at dawn.

On 09/08/2015 at 9.32pm two bats were seen emerging from the flat roof, a male advertisement call was heard very loudly. Our tagged female was still in the roost at this point. At 9.36pm the tagged female left and headed south, other Nathusius' pipistrelles arrived and repeatedly flew up to the roost access point. This tagged bat was also tracked to Ladyburn Lake where she foraged on many of the nights between 8th August and 14th August. At 4.41am on 15/08/2015 she left Ladyburn Lake, flying in the direction of her usual roost in Hauxley. Later on that day, the roost site was checked to see if she had returned but no signal was detected. We checked the roost site daily for several more days and also checked her known foraging sites for several nights but with no luck.

It was agreed that it was unlikely that she had left the area as it was quite light on the morning of 15th August when she left Ladyburn Lake so there was insufficient time for her to find an alternative roost further away. It was concluded that the tag had failed after only eight days, which was earlier than expected.

Additional Site

One of our project team, who was involved with a development as part of his work, called me at the end of August to say it was suspected there were Nathusius' pipistrelle roosting in a building that they were surveying. He had been at the trapping nights when we had caught Nathusius' pipistrelle and had handled them so was confident that he had seen Nathusius' pipistrelle on the site. They were then caught to confirm identification, during which droppings were taken for DNA purposes.

One of the bats caught on 25/08/2015 was a female Nathusius' pipistrelle trapped and ringed as a juvenile on 15/08/2014 at the River Wansbeck.

A cluster of bats within the site.

Possible Migration

Nathusius' pipistrelle are known to be migratory within Europe, however there is much less information about Nathusius' pipistrelle moving into or out of the UK. In 2011 a juvenile male Nathusius' pipistrelle was seen to fly in from the sea at 8:50am on 16/09/2011. On 14/09/2015 a parous female Nathusius' pipistrelle came into care from the village of Belford in north

Northumberland. The bat was underweight but otherwise uninjured. She was ringed, tested for flight capability and released a few days later, where she was found. This bat was an adult, it is possible that she had newly arrived in the UK.

Two ringed Nathusius' pipistrelle are known to have moved between the UK and the continent. On 23/12/2013 a ringed Nathusius' pipistrelle was found in Franekeradeel, Holland, this bat had been caught and ringed at Bladgon Lake in Somerset on 14/10/2012.

Reporting of Nathusius' pipistrelle found in Holland, via Facebook.

On 10/10/2015 a ringed Nathusius' pipistrelle was caught in Rye Harbour, East Sussex. This bat had been ringed by a research team in Latvia on 20th August. This bat had travelled at least 1458km in just 50 days, an amazing journey for such a small bat.

Future plans

This is an ongoing project and plans are being put in place for further trapping and tracking during 2016.

Acknowledgements

Northumberland Bat Group, Natural History Society of Northumbria, Bat Conservation Trust, Daniel Hargreaves (National Nathusius' Project lead), Northumberland Bat Group and Northumberland Nathusius' Project Volunteers with special thanks to Tina Wiffen, Graeme Smart, Neil and Mandy Tomas, Nick Morphet, Mark Osborne, Dave Jarema, Steve Westerberg, Joe and Lynda Fean, Sue Keeton, Andrew Mountford, John and Claire Rawcliffe and Tony Purcell (Durham Bat Group), Northumberland County Council, ERIC North East, Newcastle University, Chris Barrington and Nigel Milbourne (YACWAG), Paul Scott (Nathusius' Ireland Group) and a very special thank you to the roost owners.

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The East Cleveland Batscape project.

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The two year project aims to increase appreciation and understanding of the number of different bats in East Cleveland and how they are using the landscape to roost, forage and commute. The wooded nature of East Cleveland and the rural character of the landscape give it the potential to be important for more than eight species of bat including some of the rarer North East bats. The project is working with local communities and volunteers to provide training in field skills and the use of detectors to record bats.

Following two very successful launch events in May 2015, the project has acquired many enthusiastic volunteers within the local community. Thanks to these volunteers, the plan to survey the whole of the East Cleveland area for bats, by kilometre square, is going well with 39 of the 119 of the kilometre squares already surveyed.

Events within the community have varied from walks in the woods with Brownies, to workshops on how to use bio-acoustic software to analyse the data collected by volunteers on surveys. The project has so far focused on the larger towns of East Cleveland, Loftus and Saltburn, but will engage with the more rural areas from now on.

Some data has already been analysed, but the majority will be a job for the winter months. The project is using Anabat Express and SM2 bat detectors. Data from the Anabats is being analysed using Analook, with software to analyse the SM2 data still to be purchased.

So far, a few interesting observations have been made from the data already analysed. Loftus is a particularly good area for bats, with many bats recorded during every survey undertaken in this area. Good numbers of *Myotis* species bats have been detected in the various woods surrounding Loftus. There have so far been very low numbers of soprano pipistrelle *Pipistrellus pygmaeus* detected throughout the whole of East Cleveland.

Several probable Nathusius' pipistrelle *P. nathusii* calls were detected on a heterodyne detector at the cliffs at Saltburn on the 22/09/2015. Unfortunately the Anabat detectors were all out on loan at the time. This area will be surveyed thoroughly towards the end of next season.

Achievements of the project so far:

New website now online: www.clevelandbats.org.uk

45 active volunteers. Volunteers have undertaken surveys, web work, helped with events, bat data analysis, data management, design and photography.

Six workshops held with 63 volunteers trained in surveying and data analysis methods.

26 events held with 603 individuals engaged through those events.

Have BatNav, will travel!

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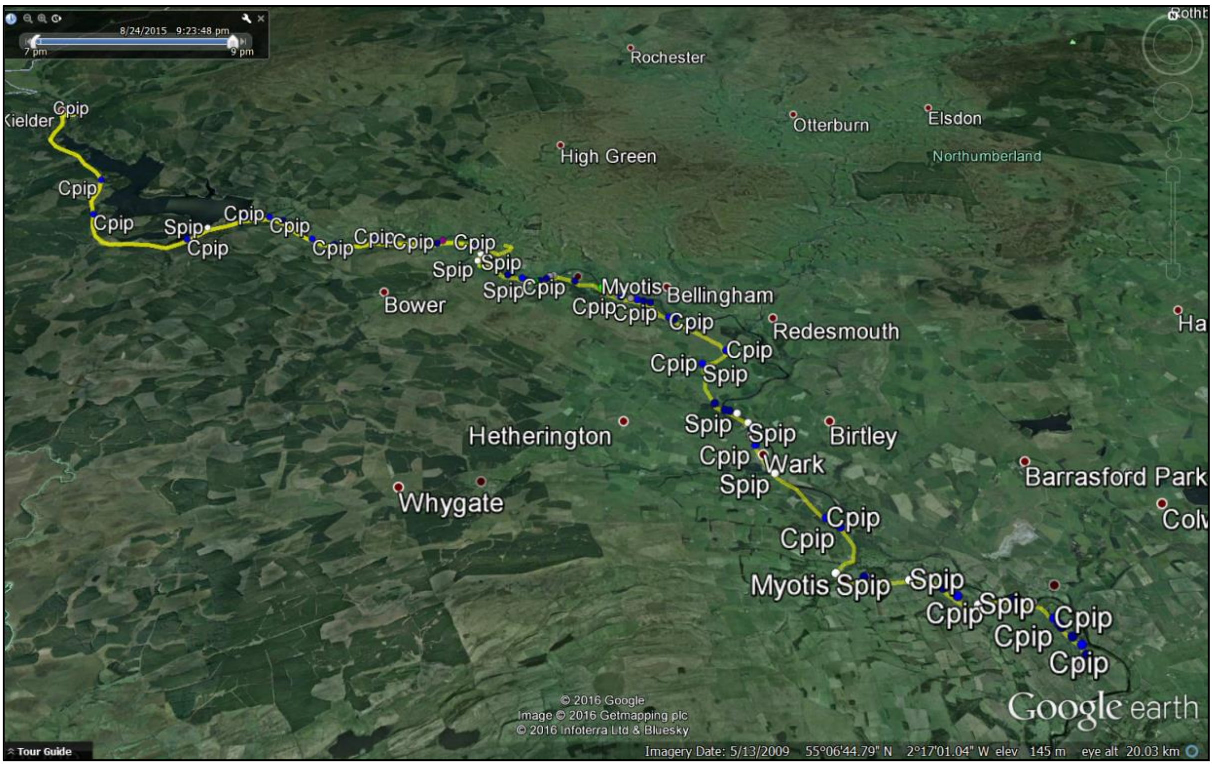
Over the last two summers I have become addicted to driving home at night with the microphone of an Anabat SD2, connected to a BatNav, pointing out of the window. If you drive slowly enough, roughly between 30-40mph, the detector records bat calls as you drive, these can then be mapped.

This short note sets out a method of, and results from, this simple way of collecting up to date bat distribution records at a landscape scale.

The equipment for recording bats has improved so rapidly recently that this technology is now readily available. I use an Anabat SD2 connected to a BatNav GPS system, or alternatively an Anabat Express in transect mode. In either case the microphone needs to be pointing out of the window. The BatNav GPS unit needs to be located on the vehicle roof but the Anabat Express will record location data from the front seat of the car once a GPS fix has been obtained. Other detectors are available, although not all of them allow individual bat calls to be linked to GPS location data. A friend uses a roof mounted microphone, this is probably a better technique as it can record bat calls from both sides of the vehicle and may record more *Nyctalus* species calls as the car roof could act as a sounding board for reflecting calls; as yet we have not compared results to see if there is a difference in the volume or quality of data recorded.

This is an excellent way to collect bat records for areas where there is very little, or even no, data; it is only a brief snap-shot of bat activity but can provide records for many 1km squares in one evening. The only drawback is that I found I was driving home by longer and more convoluted routes, going along roads I had never travelled before, all in the name of finding bats.

The data can be plotted in Google Earth, allowing you to see your route and the location of the bats; this example is the drive home from Kielder to Humshaugh.



The majority of the calls recorded are *Pipistrellus* species calls, as can be seen on the example above. Of the 4608 individual bats files I have recorded only 2.6% are *Nyctalus* species calls and *Myotis* species account for 3.7% of calls. Exceptionally brown long-eared bat *Plecotus auritus* calls have been recorded, although they account for only 0.09% of files, which equates to four calls.

Pipistrellus species bats are known to be widespread and can utilise most habitats but it does seem that this method records a higher number of *Pipistrellus* species bat calls than would be expected. Possible theories for the perceived bias are that although *Nyctalus* species bats have loud calls they are fast moving so the chances of the driven transect intersecting the flight of a big bat is assumed to be low and that *Myotis* species have quiet calls; probably the reason less calls are detected are as the bats would need to be closer to the car than *Pipistrellus*/*Nyctalus* species bats to be picked up. Also habitat would be expected to have a function here; *Pipistrellus* species bats are more likely to feed along roads and under lights than some species and *Myotis* species bats may be more limited by foraging habitat and therefore less encountered along roads.

Even allowing for the fact that the data appears to be biased towards *Pipistrellus* species, the data generated by this method is considerable, especially as the data has been collected opportunistically during the drive home rather than through targeted survey.

The data I have collected in just two summers, when plotted in DMAP (see map below), show how widespread the records are, although a bias can be seen as the records converge on my home in Humshaugh.

This has been a fun project to undertake, requiring little effort but generating many new bat records. There have been unexpected side effects too. Driving at 30mph along the military road in a bright yellow sports car at 12:30 at night did attract the attention of the local constabulary; they used their blue lights to stop me! I explained what I was doing and why and proceeded to educate the officer about bats, he soon decided to let me go on my way.... And then, less than a week later I was stopped again about five miles from the same spot! Once I had complained about being stopped twice in a week, this officer also allowed me go, again having learnt more about bats than he probably wanted to.