

ISSN 2977-070X

British Islands Bats



Volume One
2020



Welcome to the first edition of British Islands Bats.

We hope this online journal will provide a show case for bat work across the British Islands (England, Scotland, Wales, Northern Ireland, Channel Islands and Isle of Man). It will be an annual publication to record information about bats and bat work across this geographic area, providing a forum for information that might not otherwise be published, from full-length papers to brief notes on items of interest.

British Islands Bats has evolved from two publications no longer in production: Scottish Bats and Northern Bats (the archives of which are available from the [Bat Conservation Trust website](#)). Additionally, there have been multiple requests from the bat community for more information about the variety of projects being undertaken across the British Islands. We heard this call, announcing at the 2019 Bat Workers Forum that we would respond and so British Islands Bats was born!

We would like to take this opportunity to express our thanks to the Bat Conservation Trust (BCT) for agreeing to host the webpage for the journal and promoting it via BCT's Bat Group Bulletin. The publication is independent of BCT, but we certainly appreciate the support. We would also like to thank Morgan Brind for designing the British Islands Bats logo.

In producing the journal we are wholly reliant on contributions from bat groups, other bat workers and students. We have been delighted by the response to our call for submissions for Volume One and have 20 papers in this edition; ranging from descriptive articles about project activities to detailed scientific papers, highlighting the incredible projects being undertaken to understand and conserve our bat populations. The papers on the following pages are organised by the area of the British Islands they relate to in alphabetical order. Your feedback would be welcome as would contributions to future volumes. Our email address is provided below or do use social media #BIBats to let us know what you think.

We hope you enjoy reading British Islands Bats as much as we have enjoyed pulling it together.

Best regards,



Tina Wiffen and Lisa Worledge
British Islands Bats Editorial Team

Email: britishislandsbats@gmail.com

Webpage: <https://www.bats.org.uk/resources/accessing-journal-papers/british-islands-bats>

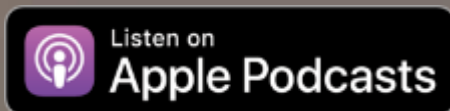
Cover image: Lesser horseshoe bat *Rhinolophus hipposideros* and greater horseshoe bat *R. ferrumequinum* hibernating in a mine in Cornwall (the site is monitored for the National Bat Monitoring Programme). © Anthony Atkinson.



The Podcast from the Bat Conservation Trust

Designed for both Bat Conservation Trust members and the wider bat conservation community, Steve Roe talks to the experts as well as local heroes to bring you the stories from the bat conservation movement.

Click to Listen



Series 1 out now, Series 2 coming later this year



Contents

British Islands Bats, Batting in the Channel – Annika Binet and Liz Walsh (Channel Islands)	<u>6</u>
A large maternity roost of soprano pipistrelles <i>Pipistrellus pygmaeus</i> in Eastern England: monitoring over a twenty-year period by the Bedfordshire Bat Group – Bob Cornes (England – East)	<u>15</u>
Discovering barbastelle maternity colonies in Hertfordshire – Chantal Helm (England – East)	<u>28</u>
A review of the barbastelle <i>Barbastella barbastellus</i> in Norfolk based on the work of the Norfolk Barbastelle Study Group – Jane Harris (England – East)	<u>33</u>
Developing the MOTUS automated radio-tracking system for studying migratory activity of Nathusius' pipistrelle – Jane Harris and Ewan Parsons (England – East)	<u>50</u>
Optimising the Sussex Autobat acoustic lure for catching bats in British woodlands: A preliminary report – David A. Hill and Matt Cook (England – Midlands and South West)	<u>55</u>
Sheffield Habitat Suitability Modelling Project: The City's Use By Feeding Bats – Robert Bell (England – North East)	<u>67</u>
What's sufficient for statics? - How much static detector data is enough? – Greg Slack and Matthew Whittle (England – North East)	<u>84</u>
Bats and Hilbre Island, Wirral, Merseyside – Stan Irwin (England – North West)	<u>97</u>
Parkhurst Forest Selective Harvesting: Measured Impact on Bat Habitat Use – Jon Whitehurst (England – South East)	<u>103</u>
Discovery of a New Barbastelle Colony in the Chiddingfold Forest Complex, Surrey – Ross Baker and Lynn Whitfield (England – South East)	<u>112</u>
Bats at the Beach: Activity levels of <i>Pipistrellus pipistrellus</i> and other British bats above intertidal beaches in Devon, England – Naomi Siân Hawkes-Southern and Paul Lintott (England – South West)	<u>120</u>
Eight years of swarming studies in Purbeck – what does it tell us? – Nick Tomlinson (England – South West)	<u>128</u>
Bat Boxes: Variations on a Theme – Anthony Atkinson (England – South West)	<u>146</u>

When did the Leisler's bat colonise the Isle of Man? – Nick Pinder (Isle of Man)	<u>150</u>
An Acoustic Survey in the Scottish Highlands – Elizabeth Harwood (Scotland)	<u>157</u>
Bats undergraduate research project – Jean Oudney (Scotland)	<u>161</u>
The status of Nathusius' pipistrelle <i>Pipistrellus nathusii</i> in North East Scotland: Breeding or Migratory status? – Katie Barr (Scotland)	<u>174</u>
Glamorgan Bat Group Area Status – Relative Abundance based on local record centre records – Aaron Davies and Matt Mott-Dowling (Wales)	<u>193</u>
Brandt's bat in Bridgend – Jessica Dangerfield, Hal Starkie, Neil Price and Mike Shewring (Wales)	<u>204</u>

Please note: all images within British Islands Bats are the copyright of the authors of the relevant articles, unless otherwise stated, and must not be reproduced without their express permission.

The views expressed by contributors to British Islands Bats are their own and not necessarily those of the editors.

Images within the BatChat Podcast advert are © Steve Roe.

British Islands Bats, Batting in the Channel

Annika Binet and Liz Walsh

ani@jerseybatgirl.co.uk liz.k.walsh@gmail.com

Introduction

Bat work has been carried out in the Channel Islands since the 1980s, initially only bat care was carried out with the odd casual emergence survey and bat walk but all species and location records were made and kept, including the record of a Nathusius' pipistrelle *Pipistrellus nathusii* with a German ring which was found dead at Jersey Zoo. In the early 2000s the first Jersey Bat Survey was carried out by Dr Louise Magris, this was the first formal bat census carried out in the Channel Islands and the first time a species list was officially put together. There were 11 species known to be present in the island at this time, but the status of all those species was not known.

After a hiatus of a few years the Jersey Bat Group reformed in 2006 with the aim of monitoring known bat roosts and raising public awareness of the ecological importance of bats. In 2013 the first Channel Islands Bat Conference was held during which many bat group members got to see bats up close for the first time during a grey long-eared bat *Plecotus austriacus* research trapping session led by Dr Orly Razgour. By 2014, 13 species had been recorded in the island, six of which were believed to be breeding, and 198 roosts identified and the urge to do more than just monitor the same handful of known roosts was strong.

In 2014 a number of projects commenced, including the Jersey Bat Roost Register Project and Woodland Bat Project by the Jersey Bat Group and the Autumn Swarming and Winter Hibernation Project by Annyctalus Ecology, and in 2016 the group joined the ranks of bat groups contributing to the National Nathusius' Pipistrelle Project.

Jersey Bat Roost Register Project

The roost register project was designed to construct a reliable, robust database in which to hold all roost information as well as designing a survey form and protocol to ensure that all future survey data was consistent. This was a collaborative project between the Jersey Bat Group and Government of Jersey Natural Environment Team. It was funded largely through an Ecology Trust Fund grant and put out to tender to local ecologists to carry out the project. Annyctalus Ecology won the tender and started the project in April 2013.

A total of 198 historical records were gathered from a number of sources and merged onto one spreadsheet, on which a process of verification and updating was carried out by contacting roost guardians and arranging updated internal and external inspections and then emergence surveys where possible. Additional roosts were added through contacts with members of the public via Facebook, at public bat walks and through email. In early 2015, at the end of the initial project period, a total of 262 roosts had been identified and input into a custom-built database and over 100 roosts had been surveyed.

Swarming and Hibernation Project

Through the money earned carrying out the Roost Register Project, and a grant from the Ecology Trust Fund, Annyctalus Ecology was able to undertake further training and purchase

a selection of research equipment which, in addition to equipment borrowed from Daniel Whitby, was then used to start the Swarming and Hibernation project in October 2014.

The Channel Islands are very mild in the winter and bat activity is recorded year-round, however the activity levels undergo a significant reduction in the colder months. It was therefore known that the bats must hide out somewhere for this period, but no one knew where. Additionally the possibility of Autumn Swarming taking place in the Channel Islands had been a topic of discussion amongst local specialists for a number of years, but no work had ever been undertaken to try and find out if or where it was happening. The aim of this project was to identify sites which could be used for autumn swarming and winter hibernation and carry out survey and monitoring of these sites to assess scale of use and species present.

There are a diverse and plentiful supply of potential hibernation sites to survey from castles and caves to bunkers and tunnels (Figure 1) from the occupation of Jersey during the 1940s. These winter surveys are time consuming and don't offer a great bat/hour reward, but they are vital to help us understand our local bat populations.



Figure 1: WWII tunnel in Jersey. © Annika Binet.

Through this project we have been able to confirm that greater horseshoe bat *Rhinolophus ferrumequinum* is a resident species through the discovery and monitoring of a roost site, and lesser horseshoe bat *R. hipposideros* was identified to be present in the island!

A key site in the island has been undergoing monitoring using static bat detectors for over two years in order to assess how the species present and frequency of use changes throughout the year. The most exciting discovery so far is the confirmation of second site being regularly used by the greater horseshoe bat.

In addition to carrying out surveys in Jersey the project was also rolled out to Guernsey and Alderney. The Annyctalus Ecology team have visited both islands and carried out surveys themselves, as well as providing training for volunteers based in the islands. Through the work in the other islands small *Myotis* species (whiskered bat *M. mystacinus*, Alcaethoe bat *M. alcathoe* or Brandt's bat *M. brandtii*), and Natterer's bat *M. nattereri* (Figure 2) were confirmed in Alderney, a number of hibernation sites have been identified in Guernsey and greater horseshoe bat has been confirmed to be a resident species in Guernsey with two roost sites identified.



Figure 2: Natterer's bat in a WWII tunnel in Alderney. © Annika Binet.

Jersey Bat Survey Mark 2

JBatS was a project started by Henry Glynn in 2018 as part of his MRes at UCL. The project aimed to develop an island wide bat monitoring scheme using static bat detectors. Using the phase 1 habitat survey of the island it was divided into six primary habitat types: urban, scrub, agriculture, grassland, woodland and water. An initial deployment was carried out at randomly selected sites ensuring equal coverage of all habitat types, 90 sensors/sites were surveyed for three nights. Each site had an AudioMoth bat detector, set to full spectrum constant record for the entire night. Following the trial summer, the JBatS citizen science

pilot survey was rolled out in July 2019 and got a great response from the public with over 30 volunteers attending a training session to participate in the deployment of detectors (Figure 3). Fifty AudioMoth detectors were deployed around the island in a range of habitats to assess the survey's potential as a long-term occupancy monitoring scheme. The scheme has so far successfully demonstrated its ability to deliver trends in local bat occupancy.

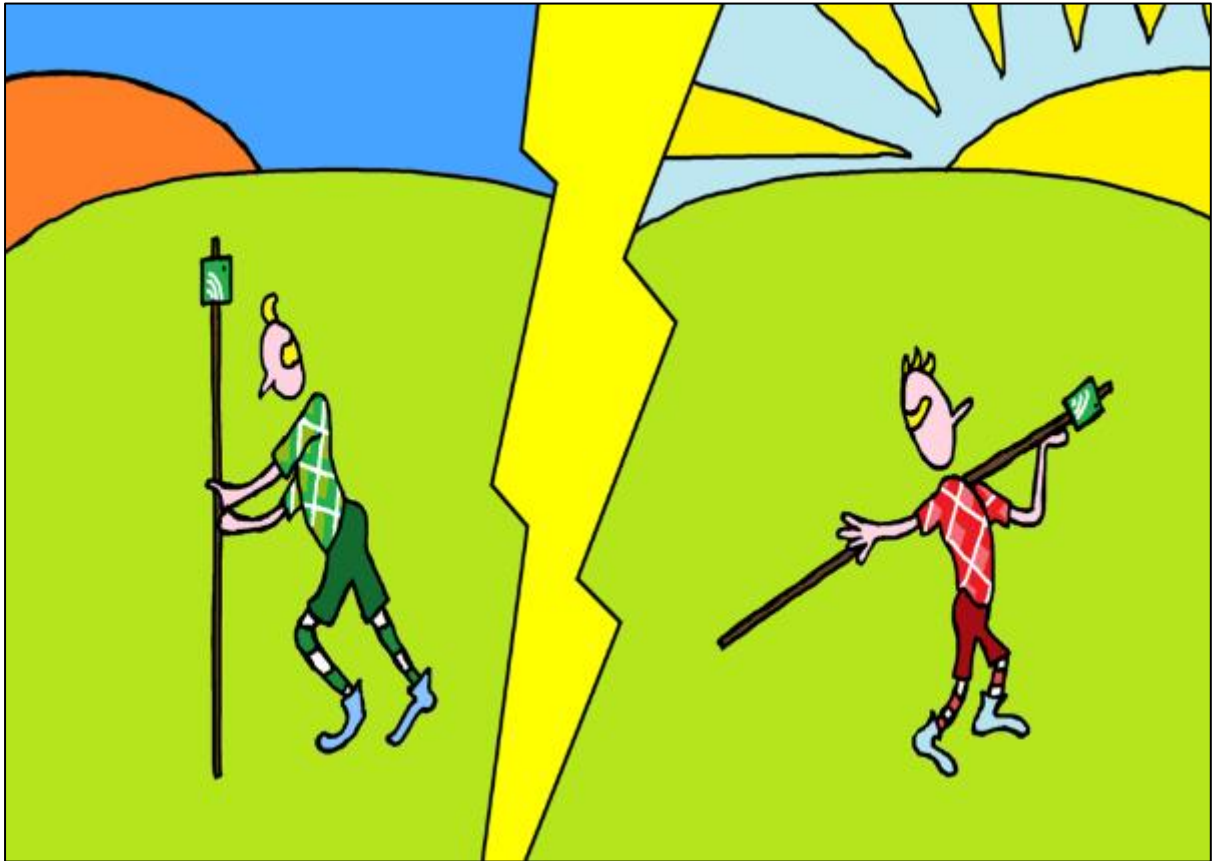


Figure 3: Illustration of AudioMoth detector deployment. © Henry Glynn.

Woodland Bats Project and Bat Box Scheme

The Jersey bat box project is managed by Miranda Collett of the Jersey Bat Group and has been running since 2014. It saw its best year so far for recorded occupations in 2019. The scheme covers nine woodland areas across the island and bats were seen occupying boxes in five of these sites (Figure 4).

Acoustic surveys of the chosen woodlands have also been carried out using static bat detectors and through walked transects.

In 2016 the woodland project was expanded to use advanced survey techniques, including mist netting (Figure 5), harp trapping and ringing; radio tagging and tracking have also been carried out with assistance from BatCRU, who ran their Advanced Bat Survey Techniques course in Jersey in 2016, and from Danielle Linton and Keith Cohen who visited the island in 2017.

During this project two new *Myotis* species were discovered in the island; Alcahoie bat and Daubenton's bat *M. daubentonii*, the first tree roosts in the island were identified and the

breeding status of seven species have been confirmed: common pipistrelle *P. pipistrellus*, Nathusius' pipistrelle, Kuhl's pipistrelle *P. kuhlii*, grey long-eared bat, brown long-eared *P. auritus*, Natterer's bat and Alcatraz bat, as well as increasing the knowledge of species range within the island for rare species such as Geoffroy's bat *M. emarginatus* and serotine *Eptesicus serotinus*.



Figure 4: Brown long-eared bat in a Kent bat box. © Annika Binet.

National Nathusius Pipistrelle Project (NNPP)

Jersey joined the NNPP in the autumn of 2016, but wasn't able to start ringing Nathusius' pipistrelles caught until 2017. By the end of the 2018 season 191 Nathusius' pipistrelles had been caught in the island and 179 of them ringed (Figure 6). A small number of these individuals have been recaptured in the island, but as yet there have been no off-island recoveries.

Channel Islands Bat Conference 2018

In 2018 the third Channel Islands Bat Conference was held in Guernsey. During the conference licenced bat workers from around the UK and Channel Islands undertook the first advanced surveys to be carried out in Guernsey. During these trapping events the breeding status of common pipistrelle, grey long-eared bat and Natterer's bat were all confirmed as well as the confirmation of the presence of Kuhl's pipistrelle (Figure 7) in the island; and as the individuals caught were juveniles the breeding status of this species was also confirmed. One of the Kuhl's pipistrelles was radio tracked and the roost site identified.

A single greater horseshoe bat was caught emerging from the roost during the weekend and the sex and age status were confirmed (adult male) prior to having a ring fitted.



Figure 5: Volunteer Ed Bell extracting a brown long-eared bat from a mist net. © Annika Binet.

Alderney Bat Week

In 2019 the Annyctalus Ecology team headed over to Alderney and with the help of some UK colleagues held the first Alderney Bat Week in collaboration with Alderney Wildlife Trust (AWT). The week was aimed at raising awareness of bats in Alderney, to train local volunteers in survey skills and ecological knowledge and to carry out some research trapping. The highlight of the week was the capture of a brown long-eared bat – a species only recorded once previously in the island in addition to the capture from the roost of the one known Natterer's bat (Figure 8), which was then fitted with a ring to allow for ease of identification during monitoring visits by the AWT staff and volunteers.



Figure 6: Male Nathusius' pipistrelle with ring. © Annika Binet.



Figure 7: Kuhl's pipistrelle caught in Guernsey. © Daniel Hargreaves.



Figure 8: Following processing the Natterer's bat gets a pre-release photo shoot. © Liz Walsh.

In 2019 Jersey lost four key members of the *Annyctalus* Ecology bat research team to other batty adventures in the UK and further afield. The reduced team, with remote assistance from Ani, have been able to maintain a number of activities including assisting with an AudioMoth project (Figure 9) to monitor the migration of *Nathusius' pipistrelle* between the French coastline and the South of England, the Alderney Bat week and continuation of the hibernation surveys in Jersey.

In 2019 the Jersey Bat Group co-hosted a Bats and Buildings course to engage with building professionals, planners and other interested parties as well as hosting the usual public engagement activities such as bat walks, talks and school visits.

Through the increase in research activity over the last few years new bat species have been identified in Jersey, Guernsey and Alderney and the residency and breeding status of some of the known species confirmed, bringing the species lists to 17 in Jersey and seven in both Guernsey and Alderney – there are likely more than this in both of these islands, but only further work will say for sure!



Figure 9: AudioMoth detector on the Jersey coast. © Liz Walsh.

[Return to contents page](#)

A large maternity roost of soprano pipistrelles *Pipistrellus pygmaeus* in Eastern England: monitoring over a twenty-year period by the Bedfordshire Bat Group

Bob Cornes; Bedfordshire Bat Group

rgcornes@gmail.com

Abstract

The Bedfordshire Bat Group has been carrying out bat emergence counts since 1999 at a maternity roost of soprano pipistrelles *Pipistrellus pygmaeus*, which has had a sustained colony size of over 900 adult females since 2011. Fortnightly counts have shown a pattern of fluctuating numbers in each year, typically with peaks in late spring and summer. The pattern of counts in many years gives evidence of roost switching by significant numbers of bats in the perinatal period. During the study period, the bats have increased the number of emergence points they use, and have adjusted to the presence of floodlighting on one side of the building while increasing their numbers over a period of several years.

Introduction

Bedfordshire's largest known bat roost is in a rural area of the county near Biggleswade. It is a maternity roost of soprano pipistrelle. The roost has been monitored by the Bedfordshire Bat Group since the late 1990s on a fortnightly basis from April to the end of September each year. The monitoring has served two purposes: to assess patterns and changes in the use of the roost, and to provide an opportunity for Bat Group members, both newer and more experienced, to observe bat behaviour at a spectacular roosting site. Data from the roost is regularly submitted to the National Bat Monitoring Programme (NBMP).

The roost site

The roost is in the roof of a non-residential building (built circa 1800) in mixed woodland, with a lake about 120m away to the south and the east. Emergence took place from the edges of the roof, initially from the south-eastern corner, with some other positions on the northern and eastern sides discovered later. The lake and woodland have abundant bat activity, with nine species recorded (common pipistrelle *P. pipistrellus*, Nathusius' pipistrelle *P. nathusii*, noctule *Nyctalus noctula*, Leisler's bat *N. leisleri*, serotine *Eptesicus serotinus*, Natterer's bat *Myotis nattereri*, Daubenton's bat *M. daubentonii*, brown long-eared bat *Plecotus auritus* and barbastelle *Barbastella barbastellus*) in addition to soprano pipistrelle. The site is privately owned and, in deference to wishes of the owners, the exact location will not be given here.

Its status as a maternity roost has been confirmed by occasional hand netting of bats as they emerge. All bats caught before June have been adult females. Bats caught after mid-July have been adult females and juveniles (both male and female). During late June and early July, frequent social calls have been heard from bats remaining in the roost after emergence. At this time of year, bats start returning to the roost less than one hour after first emergence.

The roost is relatively free from human disturbance but floodlighting of the southern side of the building begins at sunset. The northern side of the building is not floodlit and, as the side next to the woodland, is well shaded from much of the light.

Methods

Emergence surveys were carried out on a fortnightly basis between 1st April and 30th September. Surveys were numbered according to the fortnight in which they took place. Table 1 gives the date ranges for surveys 1 – 14. The exact dates varied from year to year because surveys were carried out on a fixed night of the week (initially Wednesdays, later changed to Thursdays), and the fortnightly numbering allowed comparisons to be made between comparable surveys in different years. Surveys were a little erratic in the first few years. In particular access restrictions arising from the epidemic of foot and mouth disease in cattle resulted in a complete lack of data for 2001, but from 2005 there were mostly 13 surveys in each year, with 14 in 2010. In June 2017 a survey had to be abandoned as a result of heavy rain. Surveys were continued on some other dates when rain did not stop emergence and allowed counting to continue.

Towards the end of the 2005 season when numbers emerging had been much lower than previously, it was discovered that some bats were emerging from the shaded northern side of the building. In previous years this seemed not to have been the case, but it was not until both sides of the building were regularly watched that it was possible to be certain that all emerging bats were being recorded. From 2006, observers were positioned on both the north and south sides of the building with clear views of the four emergence points (1A and 1B, which were counted together; 2 and 3, which were counted and recorded together in 2006 and separately from 2007). Rarely, occasional bats were seen emerging from other positions – along the eastern edge just north of point 1A and south of point 2, and from the roof apex on the southern side - and were added to the count for the nearest regular emergence point.

Roost counts were carried out following the protocol for the NBMP (Bat Conservation Trust, 2019) with two minor differences: (a) counts began 30 minutes before sunset and, in June and July, 45 minutes before sunset; and (b) the ‘no further activity’ basis for ending the count after the main emergence had taken place was based on a five minute rather than a 10 minute gap after the last emergence. These differences arose because (a) preliminary surveys of the roost had shown that emergence, especially in midsummer, frequently began well before sunset and (b) the protocol for the present study was developed before that for the NBMP. On evenings for which the data were to be submitted to the NBMP, counting continued until 10 minutes after the last emergence. The effect of this on the count was negligible: even when the count was ended on the ‘no further activity’ criterion and additional bats emerged after five minutes, the extra bats never accounted for more than five individuals (generally no more than 1% of the total emergence count).

For the procedure from 2007, developed after the multiple exits were identified, a minimum of three observers with tally counters and bat detectors were positioned with good views of emergence points 1A and 1B (close together on the south-eastern corner of the roof), point 2 (on the north-eastern corner) and point 3 (under the roof apex on the middle of the northern side). A fourth observer coordinated the counting and watched for any bats that emerged from other points. Cloud cover, rain, wind, temperature and relative humidity were recorded at the time of sunset.

Sunset times for calculating emergence data were obtained from the Sunrise Sunset website, specifying the latitude and longitude for the roost. This was done in order to eliminate variations resulting from the use of different sources of sunset data on different dates. Figure 1 shows the layout of the roost and the positions of observers during the counts.

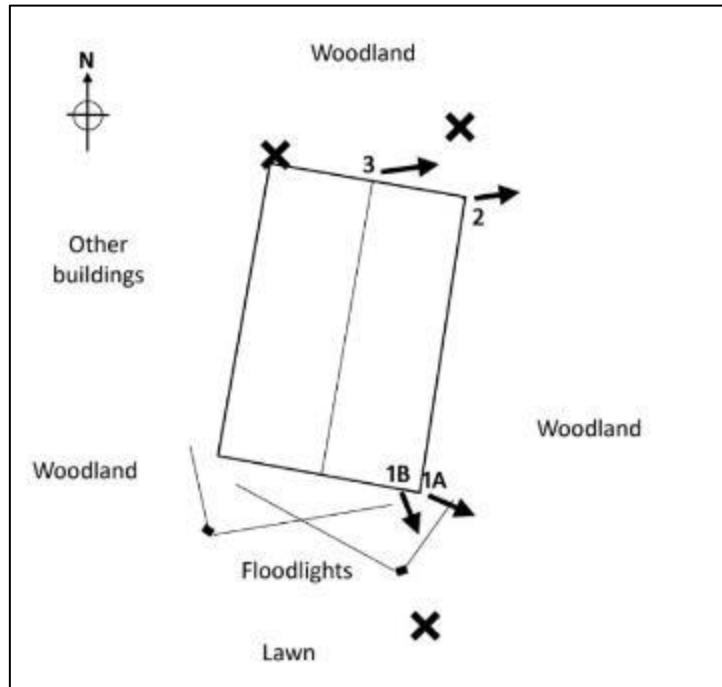


Figure 1: The layout of the roost. Emergence points are shown by numbered black arrows. Positions of observers are shown by black crosses.

Results

Bats were present and emerged from the roost on the great majority of survey evenings. Some early April and late September surveys produced zero counts, but the roost was generally occupied by bats from early April to late September each year. The earliest recorded emergence was on 2nd April (in 2015, with 15 bats emerging). The latest emergence count was on 30th September (in 2010, with 34 bats emerging). All emergence counts are given in Table 1.

Considerable variation in counts is apparent, both within and between years. In most years one or more peaks occur in the counts, but the numbers, dates and relative size of the peaks vary from year to year. The general pattern is shown by Figure 2, which shows the median emergence for each of the fortnights 1-14 as a percentage of the maximum emergence count for the year. There are peaks in fortnights 6 (the first half of June) and 9 (the second half of July) with a slight dip in numbers between the two. Examination of Figure 3 reveals the extent to which this average pattern varies from year to year.

England – East

Table 1: Emergence count results for all surveys. In most years after 2005 there were 13 surveys, but 2010 had 14. A few surveys were cancelled owing to bad weather.

Year	Fortnightly emergence counts – indicates no count in that time period. No systematic counts took place in 2001.														Peak count	Notes Where dates of more than one peak are given, they are listed in order of size (largest first).
	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
	1-7 Apr	8-21 Apr	22 Apr-5 May	6-19 May	20 May-2 Jun	3-16 Jun	17-30 Jun	1-14 Jul	15-28 Jul	29 Jul-11 Aug	12-25 Aug	26 Aug-8 Sep	9-22 Sep	23-30 Sep		
1999	0	-	-	-	555	556	490	667	519	-	285	-	20	0	667	Peaks on 14 Jul and 16 Jun.
2000	0	0	261	632	560	651	659	547	473	266	217	76	0	-	659	Peaks on 28 Jun and 17 May.
2002	-	-	-	330	-	-	-	230	567	322	297	147	-	-	567	Peak on 17 Jul.
2003	-	-	141	309	412	548	493	426	436	398	140	109	34	4	548	Peaks on 4 Jun and 16 Jul.
2004	-	32	78	257	477	341	270	-	266	67	19	15	-	-	477	Peak on 26 May.
2005	-	3	38	257	99	288	211	213	212	104	44	3	0	2	288	Peaks on 8 Jun and 11 May.
2006	-	0	34	81	62	233	98	129	-	243	366	435	83	-	435	Peaks on 30 Aug and 7 Jun. Both sides of building were watched, but not separately recorded.
2007	-	153	184	53	467	453	376	293	513	498	570	3	3	-	570	Peaks on 16 Aug and 24 May. The first year that both sides of building were separately recorded.
2008	-	0	155	104	524	272	434	382	568	372	263	149	118	-	568	Peaks on 24 Jul and 29 May.
2009	17	2	354	492	577	505	540	816	874	87	218	158	83	-	874	Peaks on 23 Jul and 28 May.
2010	0	1	403	172	589	182	729	765	696	1110	868	564	179	34	1110	Peak on 5 Aug. No other clear peak.
2011	-	178	178	998	999	962	943	1250	1532	724	733	462	253	44	1532	Peaks on 21 Jul and 26 May.
2012	-	74	178	632	1140	1162	1197	1157	1178	1340	1102	570	275	111	1340	Peaks on 2 Aug and 21 Jun.
2013	-	0	743	684	483	1099	1169	1130	1087	1066	663	467	246	157	1169	Peaks on 2 Jun and 25 Apr.
2014	328	271	782	1232	1137	1078	999	1241	1004	870	1071	409	151	-	1241	Peaks on 10 Jul, 15 May and 20 Aug.
2015	15	733	162	89	1068	1155	1050	896	1187	1229	768	590	185	-	1229	Peaks on 6 Aug, 11 Jun and 16 Apr.
2016	-	376	0	603	904	873	950	763	785	855	605	301	29	22	950	Peaks on 7 Jul, 25 May and 4 Aug.
2017	-	109	1	428	696	967	-	421	742	1042	617	325	225	39	1042	Peaks on 3 Aug and 8 Jun.
2018	-	0	183	570	939	593	546	340	281	446	452	258	228	37	939	Peaks on 24 May and 16 Aug.
2019	-	53	284	315	527	908	894	608	578	723	740	284	291	26	908	Peaks on 6 Jun and 15 Aug.

England – East

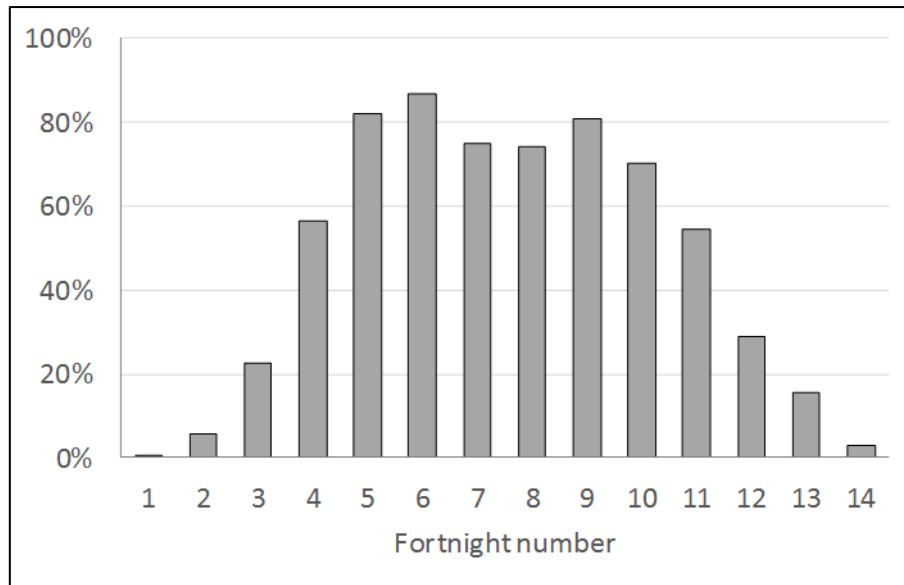


Figure 2: The pattern of emergence counts in each fortnight. Each value is the median of all values for that fortnight of the emergence count as a percentage of the maximum count for the year.

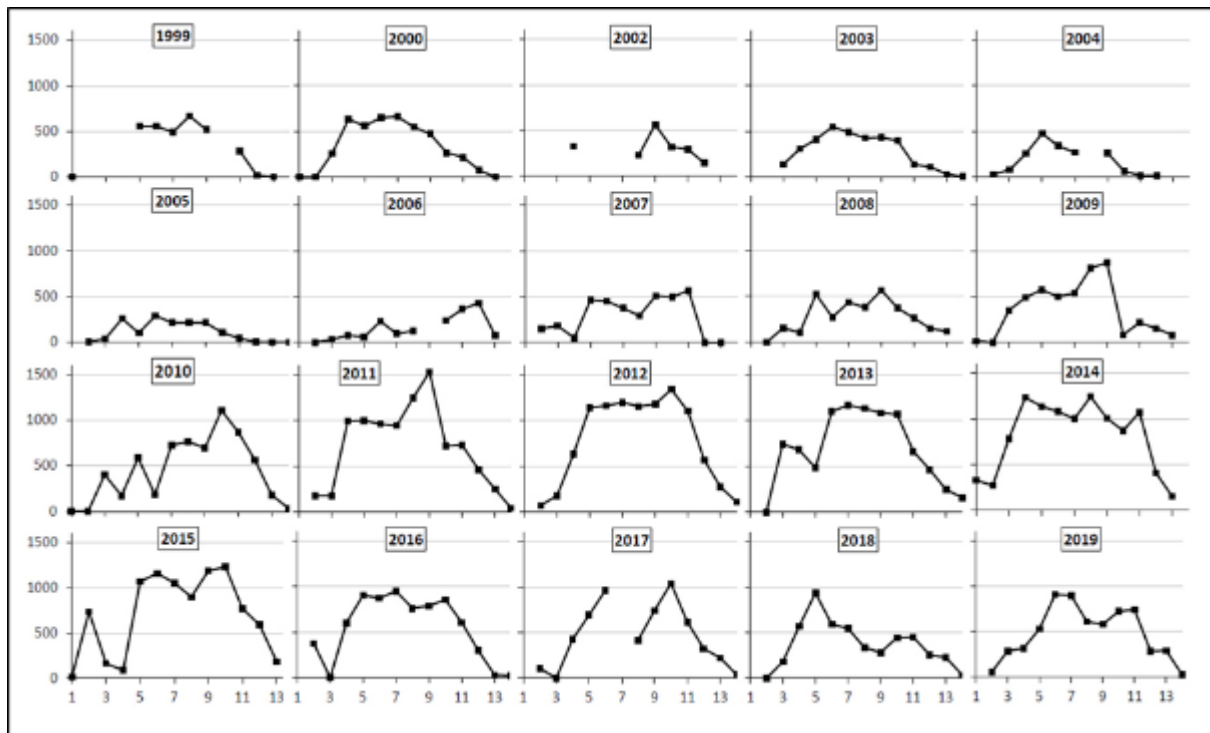


Figure 3: Emergence counts of soprano pipistrelles from the maternity roost from 1999 to 2019. Vertical axes are net number of bats emerging (= total number emerging - number returning during the counting period). Horizontal axes show the fortnight number for counts. There were no counts in 2001.

Of particular interest is the size of the summer peak (after early July) in relation to the late spring peak (before mid-June). The summer peak was larger in every year from 2006 to 2012 and in 2015, 2016 and 2017. The summer peak was smaller than the spring peak in 2000, 2003, 2005, 2013, 2018 and 2019. In 2014, there was an unusual pattern with three peaks

and the summer numbers only very slightly higher than the rather early spring peak. Missing data obscured the pattern in 1999, 2002 and 2004.

The variation in ratio of summer peak to spring peak for each year is shown in Figure 4. Only in 2006, 2009, 2010 and 2011 are the values as high as would be expected on the assumption that most females give birth and remain in the roost with their pups after the perinatal period.

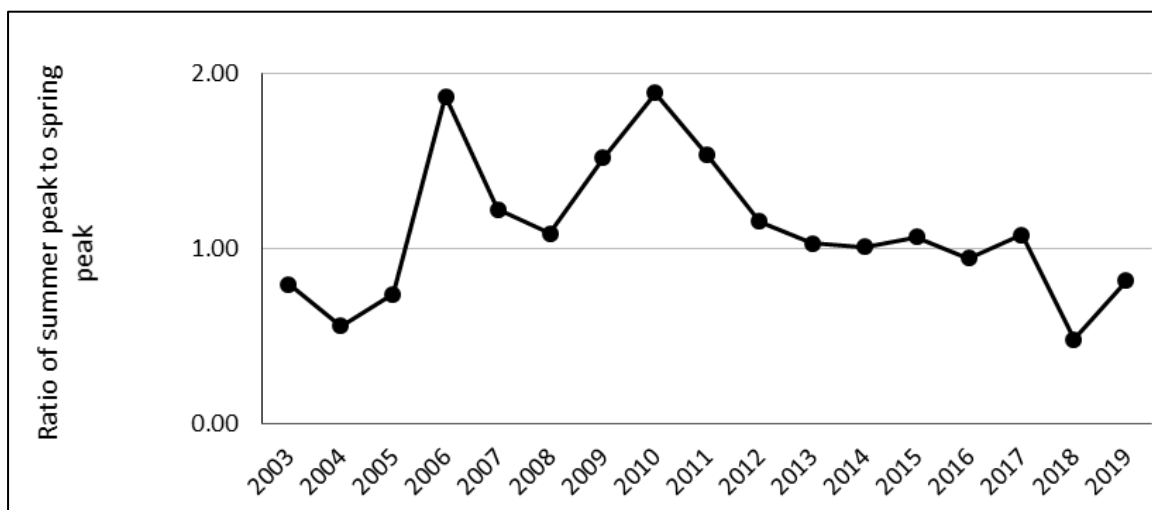


Figure 4. The ratio of summer peak emergence number to spring peak emergence number in each year from 2003. Data from earlier years are omitted because missing surveys made judgement of peak counts unreliable.

The spring and summer peak numbers throughout the 20-year period are summarised in Figure 5. The grey shading shows the numbers indicated by the spring peaks: the females which return to the roost after winter. The colony, or at least the part of it which returns to the roost in spring, seems to have increased in size from 2006 to 2012, followed by a levelling off with a small drop in 2016. The black bars indicate the numbers present in later summer when juveniles would be expected to be flying. Black bars below the level of the grey shading or no more than a little above it suggests that significant number of bats have left the roost in the perinatal period. This is particularly noticeable in 2018. The period during which the spring numbers were building (2006 to 2011) is associated with summer peaks well above the spring peak level. Figure 6 shows the numbers in spring plotted against the numbers in the previous summer.

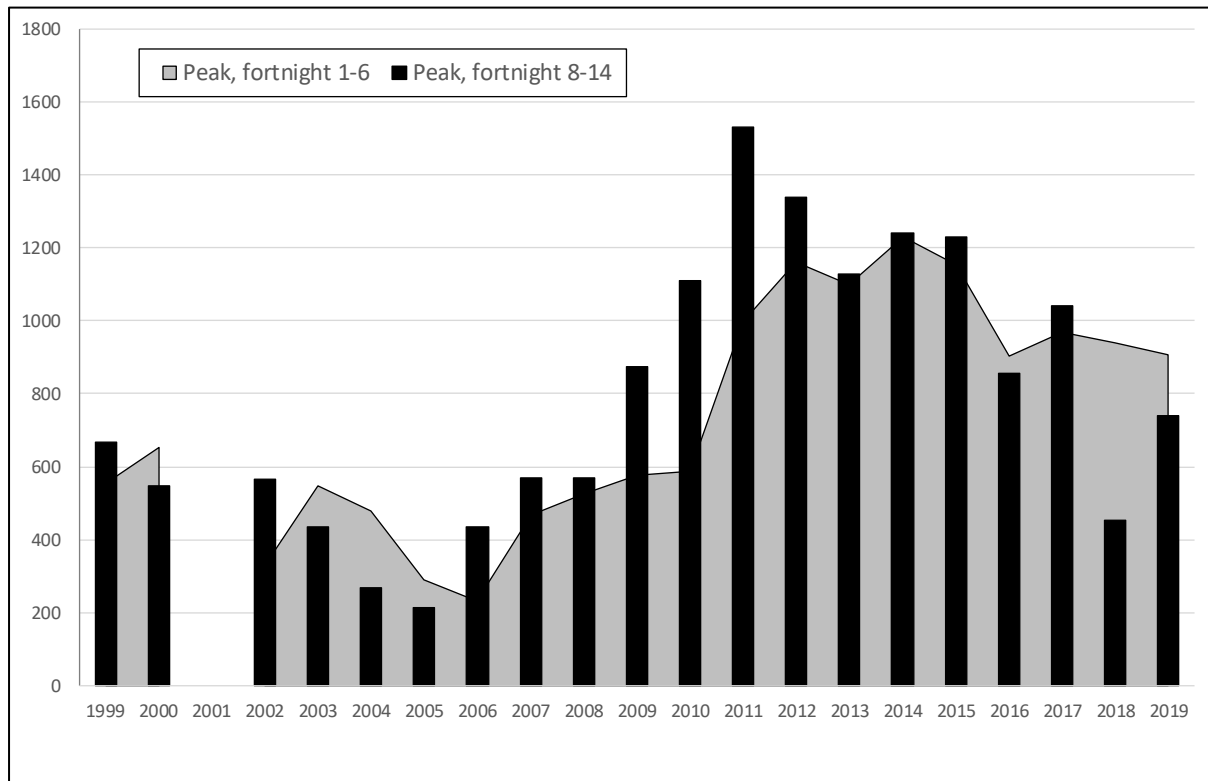


Figure 5: Peak numbers in spring (fortnights 1 to 6) and later summer (fortnights 8 to 14) from the start of the study in 1999. No data were obtained for 2001, as explained above.

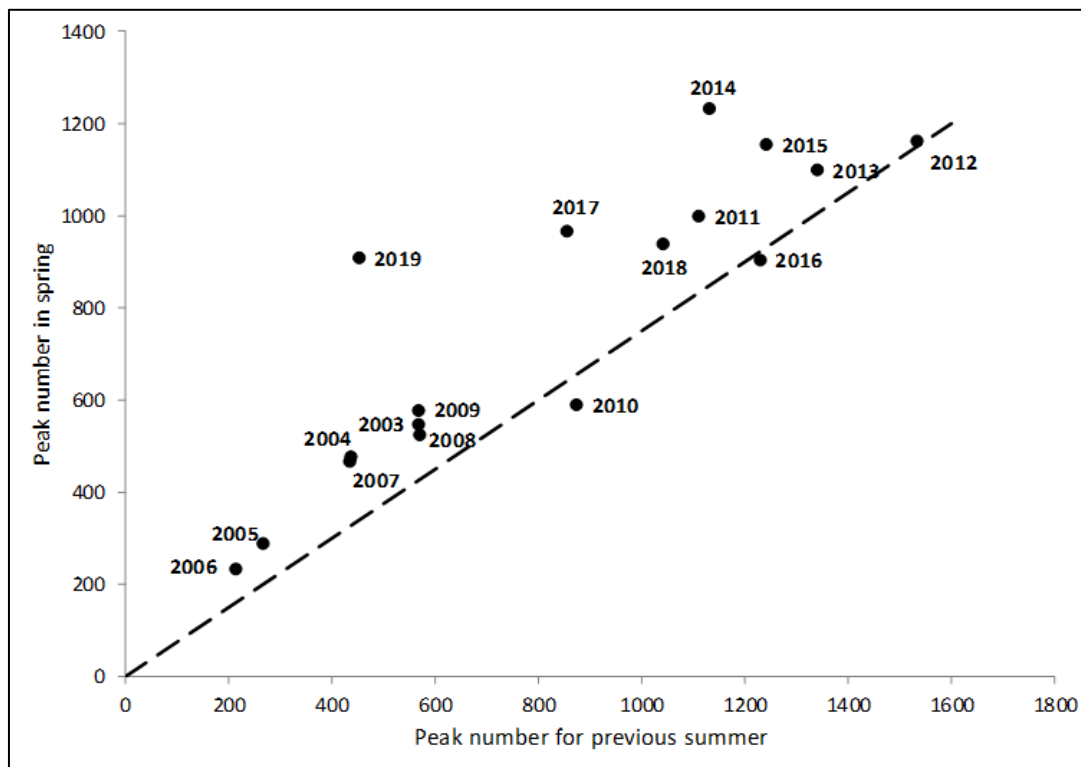


Figure 6: The peak number in spring plotted against the peak number for the previous summer. Points above the dashed line show an increase in numbers, suggesting that bats which were not in the roost the previous summer have returned in spring. The dashed line corresponds to a return of three-quarters of the bats.

Use of multiple emergence points

Prior to 2005, all bat emergences seen were from the south-eastern corner of the building (Figure 1 points 1A and 1B). Emergence counts dropped to the lowest recorded levels in 2005 and it was noticed in August of that year that some bats were emerging from the northern side of the building (Figure 1 point 2). In 2006 both sides of the building were watched and the counts therefore includes bats emerging from both sides. In 2007, the northern side (point 2) and the south-eastern corner (points 1A and 1B) were counted separately. During 2007 a few bats were seen emerging from another point on the northern side of the roof (Figure 1 point 3). These bats were included in the counts for point 2, but from 2008 onwards points 1 (A + B), 2 and 3 were all counted separately. The percentage of emerging bats which use each of the three areas of the roof from 2007 is shown in Figure 7.

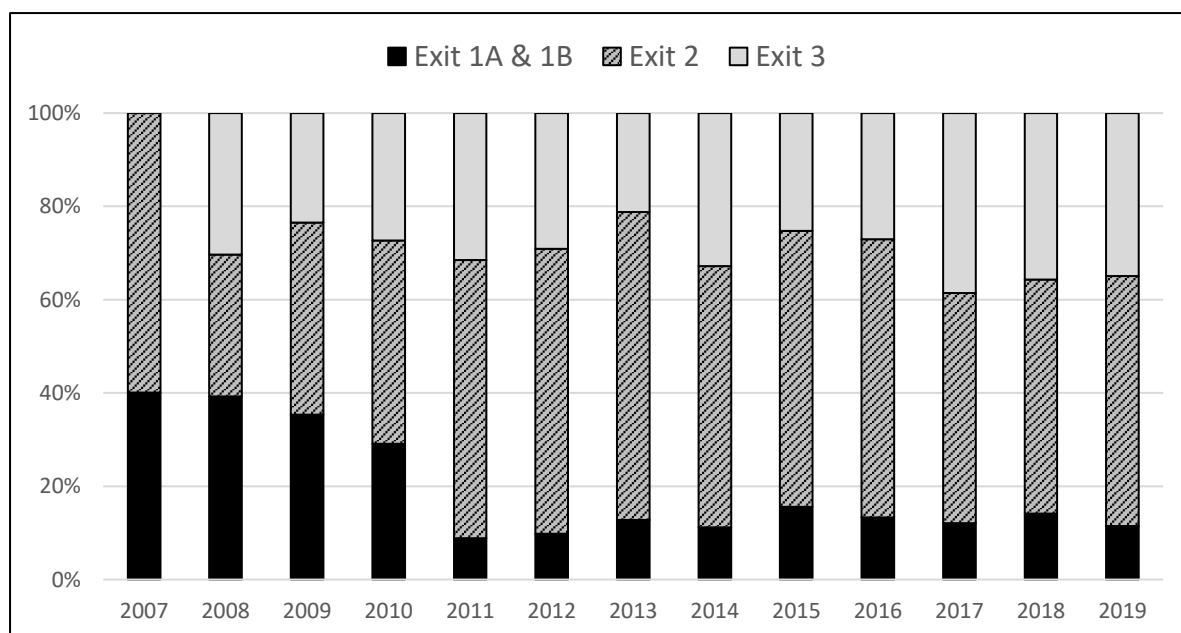


Figure 7: The percentage of bats emerging from the 3 main points from 2007.

While the date at which the bats began to emerge from the northern side of the roof is not certain, it seems clear that the majority of the bats emerged from the south-eastern corner in 2004. In 2007 this had declined to 40%, and from 2011 the percentage was well under 20% in each year.

Timing and duration of emergence

The timing of emergence was consistently recorded in 2000 and from 2003 onwards. The time of first emergence ranged from 44 minutes before sunset (on 26th June 2014) to 24 minutes after sunset (on 27th April 2017), with a median value of 11 minutes before sunset (Figure 8). The time of last emergence ranged from 15 minutes after sunset (on 31st May 2004) to 101 minutes after sunset (on 9th June 2004), with a median value of 49 minutes after sunset. The duration of emergence had a maximum value of 133 minutes (on 9th June 2004) and a median of 62 minutes. Figure 9 shows evidence of a logarithmic relationship between the number of bats emerging and the duration of emergence.

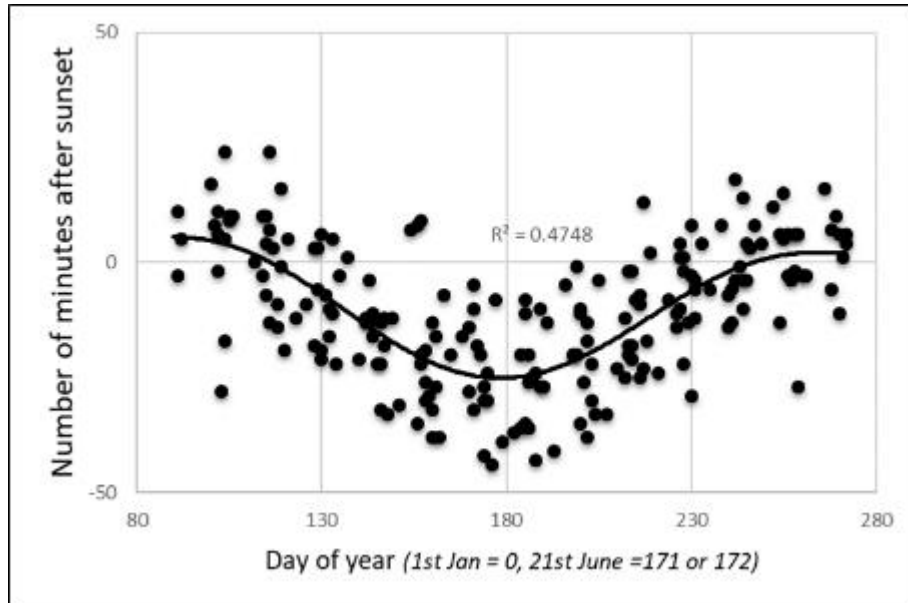


Figure 8: The time of first emergence in relation to sunset plotted against the day of the year for the years 2000 and 2003 to 2019.

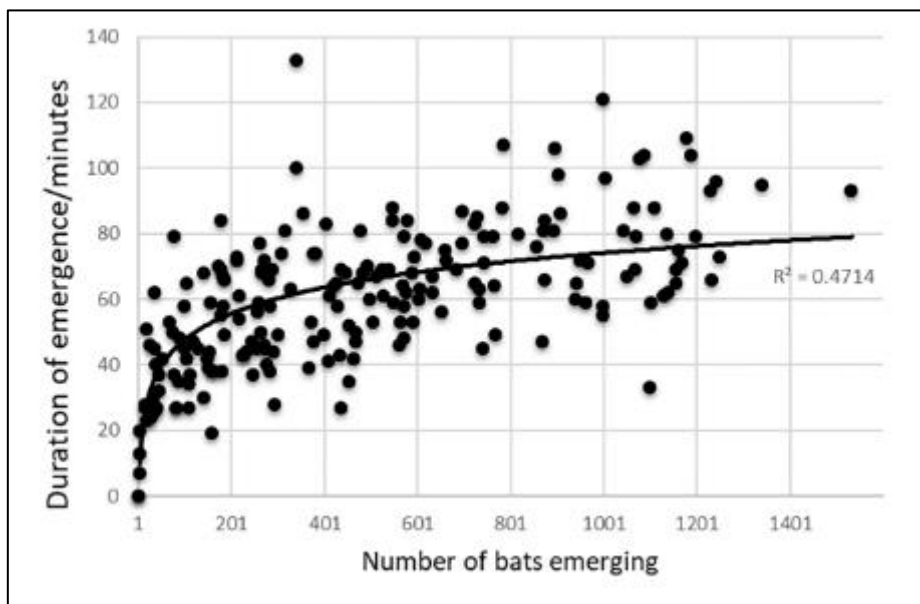


Figure 9: The duration of emergence plotted against the emergence count for the years 2000 and 2003 to 2019.

Discussion

The importance of the roost is evident from the number of bats present. It is by far the largest roost recorded in Bedfordshire and is approaching the size of roosts in Scotland reported by Haddow (1993), Smith (1995) and Tanner (1995). Despite the considerable fluctuations in numbers from year to year, the roost has been used for an extended period in every year of the survey (including 2001, when visits made in the later part of the season after access restrictions had been lifted confirmed that bats were using the roost), and there are anecdotal reports of it being used for many years before that. There is evidence of a great deal of roost switching between the study roost and other roosts used by the colony. Roost switching has frequently been reported in soprano pipistrelles (Bartonička *et al.*,

2008; Stone *et al.*, 2015; Tylden-Pattinson, 2019). The regular dip in numbers emerging in fortnights 7 and 8 (from mid-June to mid-July) could be explained either by bats failing to emerge from the roost until after the surveys were completed, or by bats switching to other roosts in the perinatal period. The median time of completion of the surveys in fortnights 7 and 8 is 45 minutes after sunset, exactly the same as the median for all dates.

The timing of roost emergence

The time of first emergence shows a clear seasonal effect (Figure 8), becoming earlier in relation to sunset in midsummer and later again from the end of June. This has been reported elsewhere (e.g. Davidson-Watts and Jones, 2005) and is assumed to be related to the shortness of mid-summer nights. The duration of emergence is related to the number of bats (Figure 9), resulting in long emergence periods when the nights are shortest and when lactation makes early feeding advantageous.

Roost switching

The locations of any satellite roosts used by the colony are unknown and, in the absence of direct evidence of bats moving out of the main roost such as that provided by radio-tracking (e.g. Bartonička *et al.*, 2008; Stone *et al.*, 2015), any evidence of roost switching has to be based on changes in numbers at the main roost. This is problematical because it involves a number of unknown factors – the birth rate, the proportion of non-breeding females in the roost, the mortality rate of infants, the mortality rate of juveniles and adults and whether any adult females emigrate to other colonies. The ratio of the number of bats in the summer peak to the number in the spring peak of the same year (Figure 4) suggests that the majority of the bats stayed in the roost in 2006, 2009, 2010 and 2011. In 2003 to 2005 and 2018 and 2019, it appears that a significant number of bats left the roost before the summer peak. For the remaining years, assessment is more difficult because the proportion of breeding females is unknown, and the number of juveniles flying has to be balanced against the number of adults leaving. During the period 2010 to 2017, when the peak number of bats was close to or more than 1000 (Table 1), the ratio of the summer peak to spring peak declined sharply and then levelled off at value close to 1.0. This could indicate that the roost was at its highest viable capacity, with additional bats being forced to leave to maintain favourable roosting conditions.

Another approach is to examine the peak number of bats present in spring each year compared to the peak number in the previous summer. A theoretical maximum number each spring would be expected to be the number of adults added to the number of female juveniles present in the previous summer. This follows the approach used by Andrews *et al.* (2016) and results in a theoretical maximum of 75% of the peak number from the previous summer returning in the spring. The dashed line in Figure 6 marks this theoretical maximum for the study roost. It is clear that, in every year except for 2010 and 2016, the actual number of returns exceeds the theoretical maximum, which suggests strongly that a significant number of bats had left the roost during the perinatal period in the previous year, but had survived and remained colony members so that they were able to return to the main roost in spring.

The seasons of 2018 and 2019 were unusual. 2018 began with a fairly typical spring peak of 939 bats in late May, but the numbers dropped very sharply in June and July and returned

to less than half of the spring peak in mid-August. During the prolonged period of hot dry weather which extended from mid-June to early August (Bucknall, 2018) it may be that the roost, which is exposed to the sun on its southern side, became too hot for large numbers of bats to remain. Having moved to other roosts, the bats returned in spring 2019 when the peak number (908 in early June) was very similar to that in spring 2018. This is the most dramatic instance of the bats changing roosts during the perinatal period.

The colony size

It seems that the size of the spring peak is the most reliable indication of the number of adult females associated with the roost. The highest spring peak was 1232 (in May 2014), and the number has been between 904 and this value since 2011. Prior to this, the numbers were lower and quite variable, with a low point of 233 in early June 2006. It may be that, after a period of instability in 2002 to 2007, the colony size has risen to a level which is sustainable for the roosting conditions or the foraging habitat nearby.

Possible effect of floodlighting

Since the surveys began, there has been floodlighting in place on the southern side of the roost building (Figure 1), but it was only occasionally switched on until 2005, when the owners fitted time switches so that the southern side of the building was floodlit from sunset until midnight every night. There was no summer peak in numbers emerging in that year, and the numbers fell steadily after the low spring peak. Lighting has been shown to reduce numbers of soprano pipistrelles emerging from roosts (Downs *et al.*, 2003) and to lead to a reduction in mean weight and forearm length in *Myotis* bats (Boldogh *et al.*, 2007). The spring peak in 2006 was the lowest recorded during the study period, but it was also the year in which bats began emerging from the shaded northern side of the building as well as the south-eastern corner. The ratio of summer peak to spring peak had almost its highest level that year (Figure 4), a value reached only once again, in 2010. In the following years, the number using the roost built steadily until it levelled off some seven years later (Figure 5). During this time, the proportion of bats using the emergence point at the south-eastern corner declined in favour of the points on the northern side (Figure 6). There is dense tree cover on the northern and eastern sides of the roost building and tree cover has been shown to reduce the effect of artificial lighting on soprano pipistrelle activity (Straka *et al.*, 2019). It seems that the bats adjusted to the lighting by choosing new emergence points where tree cover provides shade. Whether this was a factor in the numbers building in the following years is impossible to say, but it certainly does not seem to have caused a problem. Also impossible to determine from this study is the reason for the low and variable numbers of bats from 1999 to 2004.

Amateur studies of bats, as carried out by many bat groups, do not necessarily use the sophisticated technology and techniques or the same level of methodological rigour as academic or professional studies but, by continuing over long time-scales, they can contribute to understanding of bat ecology as well as providing excellent opportunities for training of bat group members. Our study of the roost is continuing.

Acknowledgements

The counts were organised and coordinated by members of the Bedfordshire Bat Group: Bob Cornes (1999), Derek and Sarah Niemann (2000-2007) and Irene Sabiniarz (2008 to the

present). Many other Bat Group members have assisted in the counts. The Southill Estate gave permission for the surveys. Thank you to Dr Lia Gilmour for reading a draft of this paper and her helpful comments.

References

Andrews, P.T., Crump, R.G., Harries, D.J. and Andrews, M.M. (2016) Influence of weather on a population of soprano pipistrelle bats in West Wales, UK: a 20-year study estimates population viability. *Endangered Species Research*, 30 pp. 19-28.

Bartonička, T., Bielík, A. and Řehák, Z. (2008) Roost switching and activity patterns in the soprano pipistrelle, *Pipistrellus pygmaeus*, during lactation. *Ann. Zool. Fennici, Helsinki*, 45 pp. 503-512.

Bat Conservation Trust (2019) *National Bat Monitoring Programme Roost Count Instructions*. Bat Conservation Trust/JNCC.

Boldogh, S., Dobrosi, D. and Samu, P. (2007) The effects of illumination of buildings on house-dwelling bats and its conservation consequences. *Acta Chiropterologica*, 9(2) pp. 527-534.

Bucknall, A. (2018) Meteorology 2018. *Bedfordshire Naturalist*, 73 (1) pp. 3-10. Bedfordshire Natural History Society.

Davidson-Watts, I. and Jones, G. (2006) Differences in foraging behaviour between *Pipistrellus pipistrellus* (Schreber, 1774) and *Pipistrellus pygmaeus* (Leach, 1825). *Journal of Zoology (Lond.)*, 268 pp. 55–62.

Downs, N.C., Beaton, V., Guest J., Polanski, J., Robinson, S.L. and Racey, P.A. (2003) The effects of illuminating the roost entrance on the emergence behaviour of *Pipistrellus pygmaeus*. *Biological Conservation*, 111 pp. 247–252.

Haddow, J. (1993) Pipistrelle roosts in Central Region. *Scottish Bats*, 2 pp. 18-23.

Smith, S. (1995) Whittingehame roost – revisited. *Scottish Bats*, 3 pp. 13-15.

Stone, E., Zeale, M.R.K., Newson, S.E., Browne, W.J., Harris, S. and Jones, G. (2015) Managing conflict between bats and humans: the response of soprano pipistrelles (*Pipistrellus pygmaeus*) to exclusion from roost in houses. *PLOS ONE* DOI:10.1371 0131825.

Straka, T.M., Wolf, M., Gras, P., Buchholz, S. and Voigt, C.C. (2019) Tree cover mediates the effect of artificial light on urban bats. *Frontiers in Ecology and Evolution*, 7 Article 91.

Sunset Sunrise Times (2014-2020) *Sunset and Sunrise Times* [Online] www.sunrise-sunset.org [Accessed on multiple dates].

Tanner, I. (1995) The largest pipistrelle roost in Britain. *Scottish Bats*, 3 pp. 10-12.

Tylden-Pattinson, R. (2019) The impact of social networks on the roosting behaviour of soprano pipistrelles *Pipistrellus pygmaeus*. *Northern Bats*, 4 pp. 39-69.

[Return to contents page](#)

Discovering barbastelle maternity colonies in Hertfordshire

Chantal Helm; Herts and Middlesex Bat Group

chantalvhelm@gmail.com

Barbastelle *Barbastella barbastellus* is one of the rarest bat species in the UK and is listed on Annex II of the Habitats Directive. Globally it is classified as Near Threatened, while in Great Britain it is classified as Vulnerable on the IUCN Red List. Their national population was estimated to be approximately 5000 by Harris *et al.* in 1995, but in 2018 a review of the population and conservation status of mammals in the UK (Matthews *et al.*, 2018) was unable to estimate the population size due to insufficient data being available for this species. Few maternity sites have been identified across the UK.

In 2016, the Hertfordshire Barbastelle Project was started. A collaboration between the Herts and Middlesex Bat Group (HMBG) and Herts and Middlesex Wildlife Trust (HMWT), the project aimed to develop an understanding of barbastelle distribution in Hertfordshire and identify maternity roosts for this rare and under recorded species. At the time, only one maternity roost was known (in the Bishop's Stortford area), which had been discovered by HMBG in 2011. This colony was subsequently the subject of much more intensive independent study as a result of the planned development of the A120 Bypass (Davidson-Watts, 2017). A number of other scattered flight records across the county were available in 2016, most being in the east of the county (Figure 1).

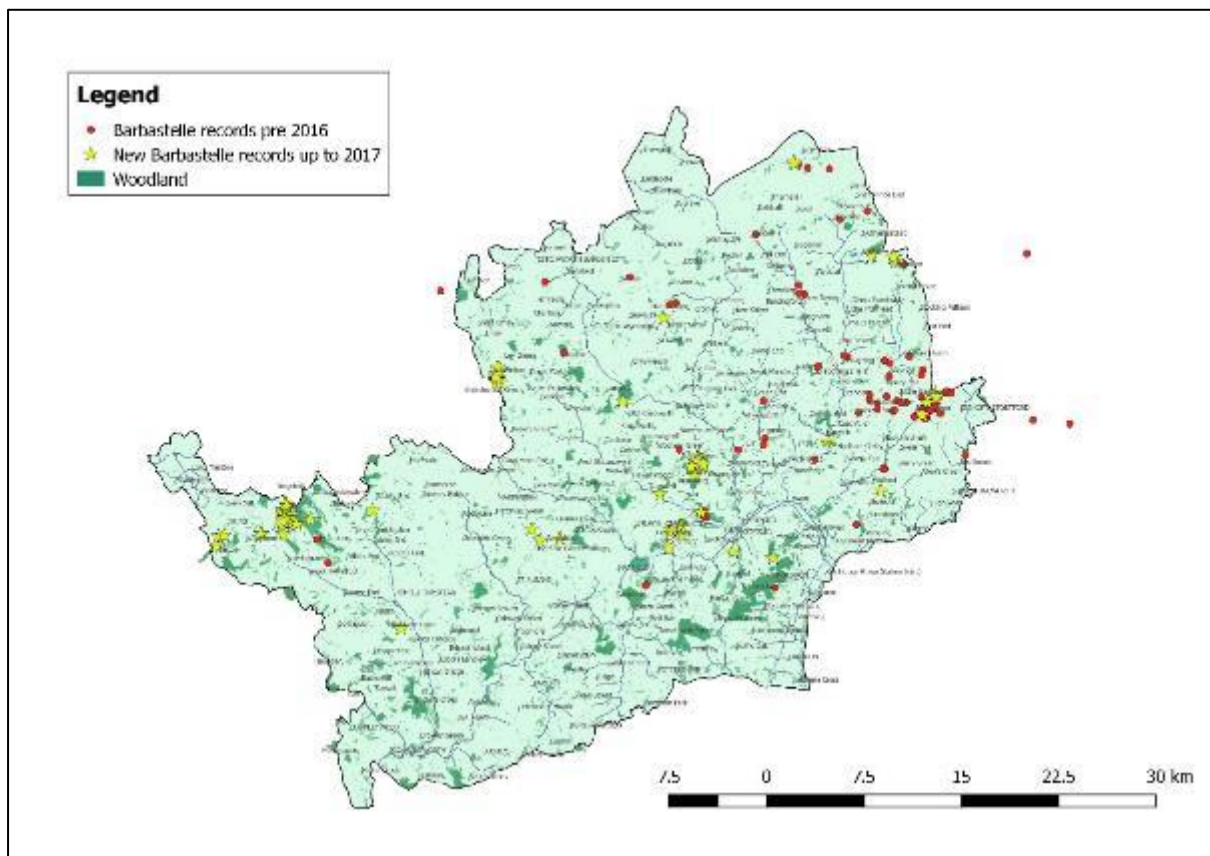


Figure 1: Barbastelle records in Hertfordshire showing all known records up to 2016 and additional records obtained by the end of 2017 once the Hertfordshire Barbastelle Project had started in 2016.

Initial stages of the project involved training interested volunteers and the deployment of full spectrum static detectors (combination of Wildlife Acoustics Song Meter (SM) 4, SM3, and SM2 as available) in woodland across Hertfordshire in order to establish the presence of barbastelle. By the end of 2017, a large number of new barbastelle records had been generated (Figure 1). Most sites only had a few passes recorded around the middle of the night, but those where records indicated barbastelle presence close to sunset were highlighted for further investigation. A trapping survey in 2017 at the Ashridge Estate caught a juvenile female barbastelle on 25th August in a harp trap, strongly indicating the potential presence of a maternity colony. In 2018, a project licence was obtained from Natural England, allowing us to specifically target barbastelle and to ring and radio tag those caught in order to identify roost trees.

In early August 2018, a trapping survey was designed to catch and tag female barbastelle at the Ashridge Estate (SP973120). Due to extensive transect and static detector surveys undertaken in 2017, as well as further static detector surveys undertaken in July 2018, which helped to identify flight lines, trapping locations were carefully chosen to catch the bats as they emerged from their roost sites. Before the nets had been erected fully, seven female barbastelles were caught (four post lactating adults and three juveniles) and the nets were quickly shut down to process the catch. The second known maternity colony of barbastelle bats in Hertfordshire had been found.

Two of the adult female bats were tagged and ringed and subsequently radio tracked over a period of 10 days until both tags had failed. Eight new tree roosts were located and a minimum colony size of 43 bats was recorded by counting bats emerging from roost trees close to sunset. A combination of sweet chestnut *Castanea sativa* and oak trees *Quercus sp.* were used (Figure 2). Only two nights of radio tracking involved following bats across the landscape so limited data on their foraging sites was obtained, but during those two nights most of their time was spent in the woodland making up the Ashridge Estate with two main foraging areas identified. Further details of this survey are being written up separately.



Figure 2: Three of the eight barbastelle roost trees identified at Ashridge Estate in August 2018 through radio tracking two tagged females.

In addition to targeting the Ashridge Estate in 2018, static detectors were placed in further woodland sites across Hertfordshire, and Hitch Wood (TL193 234) was identified as potentially supporting a roosting colony of barbastelle due to a number of recordings made close to sunset. In 2019, Hitch Wood was intensively surveyed through the deployment of static detectors in May and June. Results indicated substantial barbastelle activity throughout the maternity period and a high likelihood of the presence of roost trees in Hitch Wood. In combination with a transect survey in July, the data allowed for the identification of key flight lines and a trapping survey was undertaken on 2nd August 2019.

Due to the open structure of the woodland, placement of nets along rides was not as easy as for the Ashridge survey, however due to the knowledge obtained from the static detectors and transect surveys, nets were placed in suitable locations. A combination of triple high and double high nets and harp traps were placed across flight lines. A total of six barbastelles (four post lactating females and two juvenile males), were caught within 20 minutes of opening the nets (first bat caught 21:15, sunset 20:49) and all the traps were closed down by 21:30. Two of the highest weight female barbastelles caught were radio tagged and ringed on their left forearm (Table 1). The third known maternity colony in Hertfordshire had been found.

Table 1: Barbastelles caught in the nets and harp traps on 2nd August 2019.

No	Sex	Age	Weight (g)	Forearm length (mm)	Radio tag	Ring number
1	F	Adult	9.9	38.1	Yes	J13211
2	F	Adult	9.9	41.1	Yes	J13212
3	F	Adult	8.8	37.5		
4	F	Adult	9.2	39.4		
5	M	Juvenile	8.4	38.8		
6	M	Juvenile	8.5	37.8		

Radio tagged bats were released by 22:30 and tracked as far as possible. Both bats spent some time in the woods but then spread out from the area. Despite significant effort invested in trying to locate the bats once they had left the wood, by driving around the wood in all directions, no further contacts were made by 01:00 when it was decided to break for the night. Radio tracking resumed at 04:00 on 3rd August 2019. Both bats were picked up near the wood almost immediately and spent time flying in the wood until they finally entered their roost tree for the day. J13211 was tracked in the wood and found flying around the roost tree from 05:00 before finally entering the roost at 05:20, just before sunrise which was at 05:25. J13212 was only tracked down after sunset after she had already entered her roost on the southern end of the wood about 750m away.

Over the next several nights, the bats were tracked to their roost trees before sunset, emergence counts were undertaken from the roost trees using infrared video, where available, until either their tags failed or were groomed/dropped off the bat. J13212 only

maintained her tag until 5th August and J13211 maintained her tag until at least 11th August. Although radio tracking was undertaken from 2nd to 8th August, only J13212 was picked up on 4th August at 22:55 at TL213 285 in Great Wymondley and again at 23:16 near Needham House (TL208272). No other contacts were made once the bats had left the wood each night. The bats usually left the wood approximately one hour after emergence, with J13211 leaving much earlier than J13212. Emergence from the roost ranged from 6 to 18min after sunset. Simultaneous emergence counts were made at all known roost trees on 8th August, so as to get a minimum count for the maternity colony. A total of 90 bats were counted out across the three known roost trees. J13211 was very faithful to the same roost tree and up to 34 bats were counted from this same tree over six consecutive nights, only switching roosts when the weather turned windy and rainy. J13212, remained in one roost with a small group of bats (maximum 15) for the first two nights after being tagged, before moving to a larger roost with 51 bats about 500m north west. A total of four roost trees were identified, all were oak trees, ranging in size from over a metre to less than 30cm in diameter (Figure 3).



Figure 3: Three of the four barbastelle roost trees identified at Hitch Wood in August 2019 through radio tracking two tagged females.

In conclusion, the Hertfordshire Barbastelle Project has been very successful in identifying new barbastelle maternity colonies and gaining a better understanding of barbastelle distribution across Hertfordshire. The new collaboration between HMBG and HMWT was key to the success of this project to date. Further sites have been identified as having potential to support maternity colonies and these are being monitored to establish whether trapping surveys should be undertaken in 2020. Given that little understanding of the foraging behaviour of the tagged barbastelle bats was achieved in this project to date, future efforts may focus on improving this understanding. The use of static detectors is proving to be an extremely helpful technique in identifying the potential for maternity activity and for identifying suitable trapping locations, which ensure the target species is caught as soon as possible and with as little by catch as possible. The static detectors are

also recording all other bat species and future projects will be able to use this archived data to improve our understanding of other bat species distributions in Hertfordshire.

Reference list

Davidson-Watts, I. (2017) *Barbastelle Bat Trapping and Radiotracking, A120 bypass, Little Hadham. Report for Arup*. Davidson-Watts Ltd.

Mathews, F., Kubasiewicz, L.M., Gurnell, J., Harrower, C.A., McDonald, R.A. and Shore, R.F. (2018) *A Review of the Population and Conservation Status of British Mammals: Technical Summary. A report by the Mammal Society under contract to Natural England, Natural Resources Wales and Scottish Natural Heritage*. Peterborough: Natural England.

Walsh, A.L., Harris, S., and Hutson, A.M. (1995) Abundance and habitat selection of foraging vespertilionid bats in Britain: a landscape-scale approach. *The Zoological Society of London Proceedings*, 67 pp. 325-344.

[Return to contents page](#)

A review of the barbastelle *Barbastella barbastellus* in Norfolk based on the work of the Norfolk Barbastelle Study Group

Jane Harris; Projects Officer for Norfolk Barbastelle Study Group
janeharris2251@gmail.com

Introduction

More than 20 years since the discovery of a maternity colony of barbastelle *Barbastella barbastellus* at Paston Great Barn Special Area of Conservation (SAC) in north east Norfolk, this nationally rare species is now regarded as something of a Norfolk speciality. Despite being widely cited as a species of riverine woodlands of the south and west of Britain, the barbastelle is also known to be widespread across Norfolk's more predominantly arable landscape. In order to understand more about the species' habitat preferences in Norfolk, the Norfolk Barbastelle Study Group (NBSG) has been studying the autecology of the species and the habitat and landscape features which support barbastelle populations in the county.

The NBSG was formed in 2007 and reported on the first five years of its' work in 2011 (Norfolk Barbastelle Study Group, 2011). At that time, the group had progressed from transect surveys designed to discover new sites for barbastelle to radio-tracking studies to locate maternity roosts and study foraging behaviour. These studies were focussed in the more extensive National Trust woodlands at Sheringham Park, the Felbrigg and Blickling estates and also on the private Ken Hill estate near Snettisham in west Norfolk.

Since 2012, the group has carried out more detailed radio-tracking studies of the Paston Great Barn colony to characterise the pattern of use of the surrounding area. In view of the unusual location of this maternity colony in a building surrounded by arable land, we have investigated the possibility that it is isolated from interactions with other colonies, which might compromise its long-term resilience to environmental and climatic change. These studies confirmed the importance of coastal cliffs as a foraging area for the Paston Great Barn colony. This led to further studies of barbastelle activity in different coastal habitats in north Norfolk which were funded by the Norfolk Coast Partnership.

Radio-tracking has provided information on the spatial distribution of maternity colonies and overlap of home ranges in north Norfolk. Population estimates gained from synchronised emergence counts at individual sites have helped to identify those that are of key importance for barbastelles in Norfolk and which may be worthy of conservation designations at local, national and/or international levels. Repeat counts may also provide a means of long-term monitoring of colonies and a greater understanding of population trends at key sites, as well as feeding into national-scale population assessments. We have also widened our study area to the claylands of south Norfolk and one site in The Broads with a view to comparing a range of landscape types, woodland size, composition and management.

This review pulls together the outcomes of our work which, it is hoped, will give a clearer insight into the autecology of the barbastelle, specifically in the Norfolk landscapes. The group also hopes that this work will help to underpin barbastelle conservation through future agri-environment schemes, informed woodland management practice, site protection and avoidance or mitigation of the impacts of development.

Maternity roosts

To date, the NBSG has located 15 barbastelle maternity colonies by radio-tracking pregnant or post-lactating females, all of which are in woodlands. The presence of maternity roosts is also inferred for a further three sites from trapping of post-lactating females in woodlands containing trees with high roost potential, one of which (Roarr! Dinosaur Adventure and Royal Norwich Golf Club; formerly Weston Park) has since been confirmed by radio-tracking for the Norwich Northern Distributor Road (NDR) pre-construction and post-works monitoring (Packman, 2019). The NBSG supported a University of East Anglia (UEA) Masters project which confirmed the presence of a maternity colony in the British Army's Stanford Training Area, or STANTA as it is known (Mackinnon, 2017). Ecological assessments for planning purposes such as the NDR, have identified a further three maternity colonies. Unusually, the colony at Holkham was discovered by chance when a dawn survey recorded barbastelles swarming at the roost entrance. The locations of all known 24 barbastelle maternity colonies are shown in Figure 1. All are in trees in woodlands with the exception of the Paston Great Barn SAC colony. Maternity colonies occur in the range of Norfolk landscapes, from the more heavily wooded Holt-Cromer ridge to the smaller scattered woodlands of south Norfolk. The absence of colonies in the fens to the west and The Broads to the east is probably a reflection of the lack of studies in those areas, but we expect colonies to be present wherever there are suitable roost woodlands.

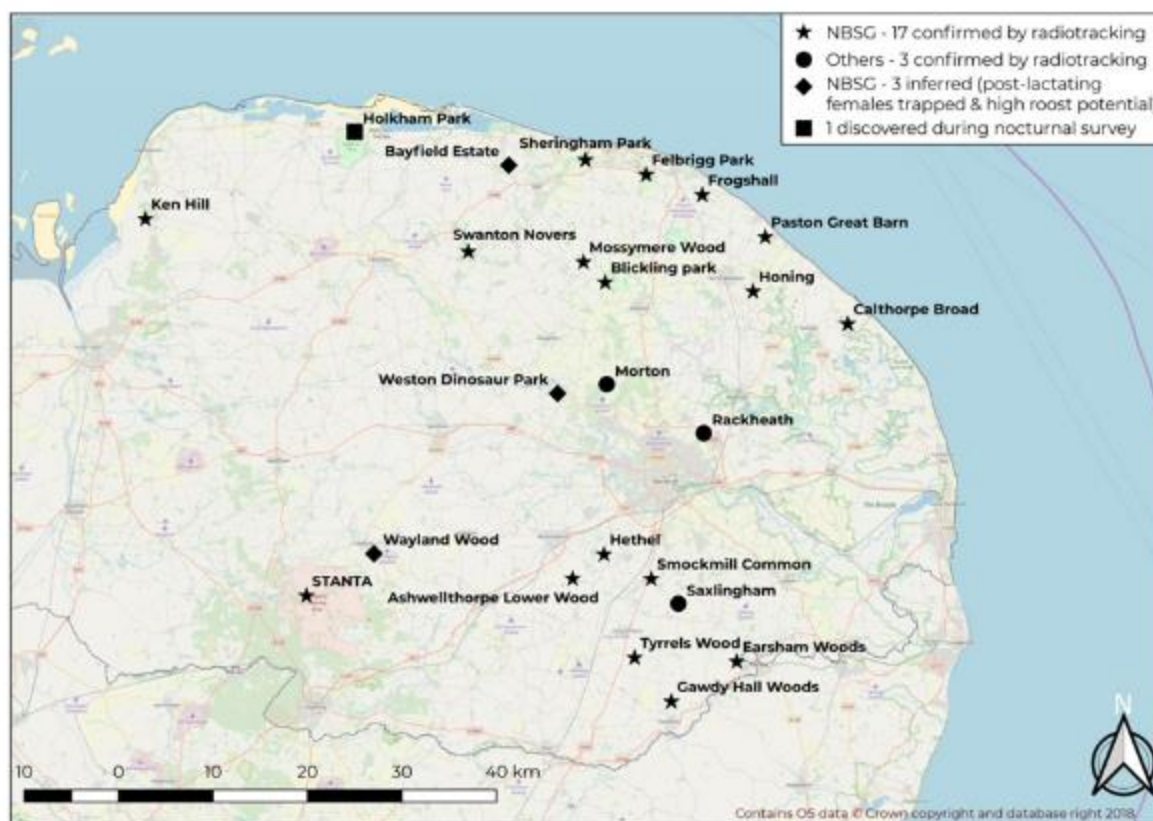


Figure 1: Locations of barbastelle maternity colonies.

Roost woodlands

The size and landscape connectivity of roost woodlands supporting maternity colonies varies greatly. The large estate woodlands of north and west Norfolk (100 - 250ha) are also part of more extensively wooded landscapes, such as the Holt-Cromer Ridge woods,

whereas the small woodlands of south Norfolk (<50ha) are usually more isolated from other woodland blocks. Tree species composition varies both between and within sites.

Pedunculate oak *Quercus robur* and sweet chestnut *Castanea sativa* are the dominant species in north and west Norfolk and north of Norwich, but are frequently mixed with Scot's pine *Pinus sylvestris*, other exotic conifers and beech *Fagus sylvatica*. Ash *Fraxinus excelsior* and hornbeam *Carpinus betulus* are more typical of south Norfolk woodlands, but pedunculate oak is also frequent or occasional. At Calthorpe Broad National Nature Reserve (NNR), an isolated wet woodland site in east Norfolk, oak is interspersed through the alder *Alnus glutinosa*, willow *Salix* species and birch *Betula* species woodland.

Most of the woodlands that support barbastelle maternity colonies are predominantly high canopy with mature trees, and classed as ancient or semi-natural, but may also exhibit a range of age classes through new planting. Blocks of new plantation are often established to fill in gaps between and around older woodland. The understorey usually comprises hazel *Corylus avellana*, holly *Ilex aquifolium*, rhododendron *Rhododendron ferrugineum* and tree saplings, but the level of cover is generally low and some roost woodlands have a sparse understorey.

The majority of roost woodlands identified to date are non-intervention or have minimal management. In contrast, Ashwellthorpe Lower Wood Norfolk Wildlife Trust Reserve/Site of Special Scientific Interest (SSSI), Swanton Novers NNR/SSSI and Wayland Wood SSSI have extensive areas of managed coppice, but at all these sites, areas of non-intervention woodland remain, often around the margins, with blocks of mature high canopy trees. No clear pattern of woodland size, species composition or structure has emerged from the Group's studies, but the consistent feature is the presence of mature trees with loose bark, and especially oak.

Maternity roost trees

Barbastelle maternity colonies show a clear preference for roost sites under loose bark, although splits and fissures may also be used. The data from all the roost woodlands studied by radio-tracking showed that 70-100% of roosts were under loose bark at each site. This roost feature generally falls into two types: bark slabs and bark collars. Bark slabs persist on the trunks of larger trees, usually dead, and are between 2 to 4m above ground level. Bark collars persist on moderately sized aerial boughs of living or dead trees and are at canopy level, often obscured by foliage (Figure 2).

Maternity roosts occur under loose bark on a variety of tree species. Oak is the most frequently used followed by sweet chestnut, indicative of the predominant woodland tree species and consequent roost availability. Roosts in wild cherry *Prunus avium*, Scot's pine, ash, false acacia *Robinia pseudoacacia*, beech, horse chestnut *Aesculus hippocastanum* and under ivy *Hedera helix* on sycamore *Acer pseudoplatanus* have also been recorded, but these were usually post-maternity roosts with small numbers or single females. Roost features in oak and sweet chestnut appear to be favoured during the maternity period, but a wider range of tree species are used post-maternity. Roost feature rather than tree species is the key factor.

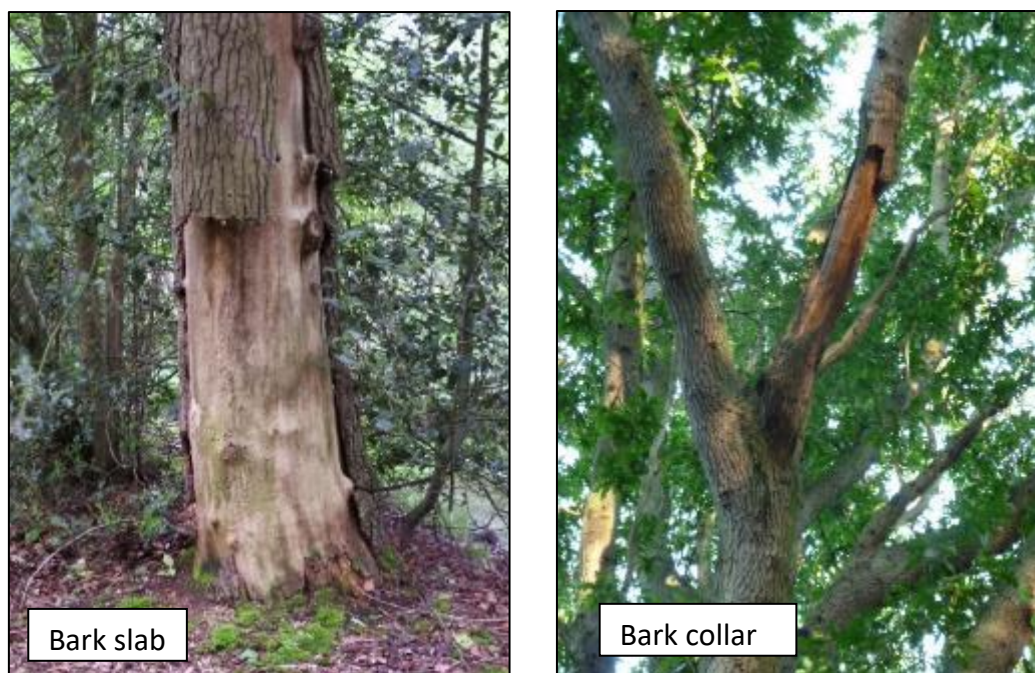


Figure 2: Roost types under loose bark.

Roost trees are usually in an enclosed environment within the woodland and undisturbed, although one in the Felbrigg woods was within 10m of the busy A148. Another exception is a veteran oak tree in pasture approximately 20m from the edge of woodlands at Earsham. Whilst roosts high in the canopy were screened by foliage, lower roosts were often very exposed with no surrounding understorey shrubs. Roost selection may be influenced by temperature, humidity and light penetration and, therefore, by the structure of the woodland.

Roost fragility

Loose bark is a fragile, transient roost feature, lost through natural decay and windblow. Dead or diseased wood may also be deliberately removed as part of woodland management. Monitoring of 11 maternity roosts located at Ken Hill in 2009/11 showed that all ten bark roost features had decayed beyond use within ten years. The only remaining roost was in an intact fissure. Roost loss can be rapid. Four out of nine roost features disintegrated over one winter at Ken Hill and three within two years at Felbrigg Park. Roost potential of the woodland will only be maintained if there is continued availability of suitable roost trees in the long term. This is of concern in woodlands where there are few trees older than 100 years old.

Roost switching

Barbastelle maternity colonies start to form in late May, initially in small groups in different roosts, but then coalesce to form larger groups in late June before the pups are born in early July. No radio-tracking is undertaken during late pregnancy and lactation, so it is not certain if, or how often, the colonies move roosts during this period, but they exhibit roost switching behaviour once the young are volant. The colonies start to fragment in mid to late August and multiple roosts are used. On average, we found that individual females use between two and six different roosts during a tracking period of 7-14 days, a mean of approximately four roosts. The mean number of days in each roost is approximately three,

but this is influenced by weather. Barbastelles may not emerge during periods of adverse weather and remain in the same roost for longer periods.

Tree roosts are located throughout the woodlands, depending on the locations of suitable roost trees. At Ashwellthorpe Lower Wood, the roosts were confined to the south west non-intervention area, the only location with mature oak trees (Figure 3). We have also observed the use of small satellite woodlands for two colonies. The Tyrell's Wood SSSI/County Wildlife Site (CWS) colony used roosts in Bales Plantation (1.2ha) approximately 170m from the main wood (Figure 3). The Hethel colony used Ash Plantation (0.5ha) located 0.9km from the main wood. Roosts in Ken Hill woods were clearly divided into north and south clusters and suggested the presence of sub-groups (Figure 3). Two females radio-tagged in early August in Gawdy Hall Woods remained with separate groups, each comprising 25 females and young, for the tracking period of 12 days, with no sharing of tree roosts. The early studies of barbastelle in Sussex woodlands identified sub-groups (Greenaway, 2008) and it is likely that colony subdivisions occur in large, high quality roost woodlands.

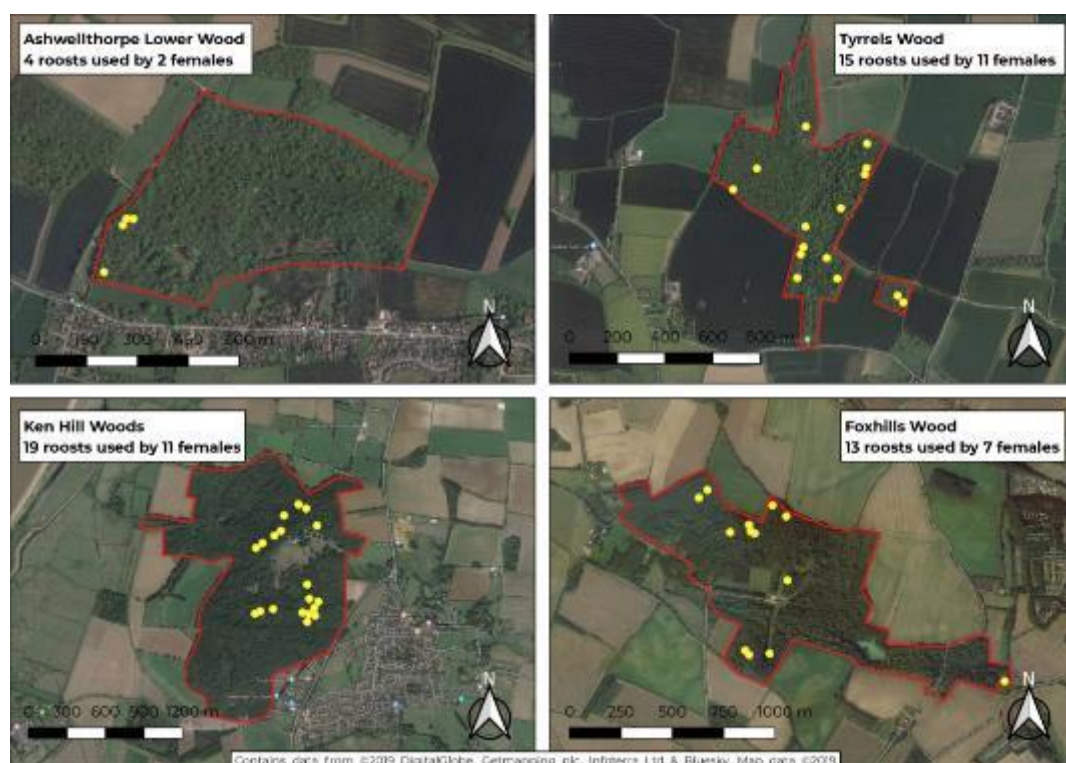


Figure 3: Multiple roosts in maternity colony woodlands.

Roosts in buildings

We are not aware of any maternity colonies in buildings in Norfolk other than at Paston Great Barn, but agricultural buildings are frequently used for roosting by individual barbastelles. Radio-tracking has shown that both females and males occasionally night-roost in undeveloped barns and sheds, usually brick and pantile. We have also recorded females in barns in autumn once the maternity colony has dispersed. Visual inspections for planning applications for barn conversions often record individual barbastelles roosting in barns and sheds at all times of the year.

Roost size

Emergence counts on individual roost trees vary greatly due to splitting and coalescing of the maternity colony in multiple roosts. Pre-parturition emergence counts on individual roost trees range from two to 24 bats, with numbers increasing from mid-May to mid-June as the maternity roosts coalesce. Post-parturition counts for single roost trees have varied from eight to 38 bats, which includes adults and juveniles. Post-parturition counts (with volant young) of 20 to 25 bats are not unusual for a single roost tree, but 38 is the maximum we have recorded to date. Roost size may be influenced by the available space, especially in bark collars on aerial boughs. Space is not limited in the long crevices in the Paston Great Barn timbers and the maximum post-parturition roost size recorded is 55 bats.

Colony size

Maternity colony size is a key parameter for determining the importance of sites in both the county and wider context, as well as for long-term monitoring to assess the impacts of land management changes, conservation actions and other environmental factors, such as climate change. Ideally, the number of adult females in a roost woodland is determined from emergence counts before the young are volant. In practice, this is very difficult to achieve for barbastelles due to their use of multiple roosts and roost switching behaviour, the poor visibility of roosts in the high canopy, the short window between formation of the maternity roost (maximum numbers of adult females) and the young flying and, finally, welfare considerations which preclude trapping and tagging of heavily pregnant and lactating females. In addition, this approach is expensive in time and materials, requiring numerous surveyors and a large number of radio-tagged females to increase the chance of identifying all roosts used by the colony.

To date, we have attempted simultaneous post-parturition emergence counts in Ken Hill Woods on all known roost trees identified by radio-tracking between May and early August in 2011. Surveyors were deployed to watch individual roost trees and this was repeated on two nights in August. Total counts which would include females, juveniles and possibly some males, were 50 and 54 bats. Given the practical difficulties and short window before the maternity colony begins to fragment in mid-August, future work will focus on timing simultaneous emergence counts to coincide with peak numbers of adults and volant young. These counts will also be a measure of annual breeding success.

The highest emergence counts and estimated colony sizes to date have been recorded in woodlands with numerous roost trees, and this may be a key factor influencing colony size. The data so far indicate that woods with few roost trees such as at Ashwellthorpe Lower Wood SSSI and Hethel CWS support smaller colonies (<10 individuals). This has led us to suggest that small colonies may move between woodlands to increase the number of suitable roost trees available to them, particularly in south Norfolk. Future work will try to answer this question.

Foraging behaviour

Radio-tracking of female barbastelles, both pre-parturition and post-parturition, has provided detailed information on nocturnal behaviour and landscape use. After emergence, barbastelles remain within the woodland for up to 45min, following the darker flight paths along internal rides. At Tyrrel's Wood, for instance, they follow the circular tunnel-like paths

in the central area, gradually gravitating towards the south or east boundaries of the wood from which they eventually fly out into open countryside when light levels are low enough. Similar behaviour was observed in other woodlands. However, at Paston Great Barn, where barbastelles fly inside the barn after emergence, it is not unusual to see them emerge before dark and follow flight-lines at great speed towards their foraging areas. In wet and windy weather, barbastelles may continue to fly and forage within the roost woodland, making use of the shelter and available prey.

Similar post-parturition patterns of nocturnal activity were observed in the Paston Great Barn, Old Hills Woods (Honing), Foxhills Woods (Frogshall) and Tyrrel's Wood colonies which have been studied most intensively. After emergence and leaving the roost woodland or Paston Great Barn, barbastelles follow flight-lines to their core foraging areas, feeding continuously for up to three hours. They then return to the roost woodland, or to Paston Great Barn, sometimes becoming stationary for a short period. This may be to visit juveniles reluctant to leave the roost or staying close to it. Females then leave for a second bout of foraging. The same foraging areas may be visited, or only those closest to the roost. Barbastelles were not recorded foraging further away from the roost in the latter part of the night.

Individual females show high fidelity to core foraging areas. Once these have been located by radio-tracking, we have found that behaviour is quite predictable, with females following the same flight-lines, and visiting the same areas night after night, provided weather conditions are favourable. Flight-lines and foraging areas closest to the roost woodland are often shared by several females, but individuals have specific foraging areas further afield. Females from the Foxhills Woods colony (Figure 4) ranged to the north, south and east of the woods. Flight-lines usually followed linear features with vegetation cover such as woodland edge, watercourses, hedgerows and green lanes, but 'female 4' repeatedly crossed open countryside to reach her favoured foraging area on Overstrand cliffs.

Females from the Paston Great Barn colony showed weather-related foraging behaviour. On nights with no wind or light to moderate offshore winds, the coastal cliffs at Mundesley were a favoured location where all six tagged females foraged for prolonged periods. When onshore winds or cold, foggy conditions prevailed at the coast, inland foraging areas were used instead. On some occasions, females flew immediately to the coast after emergence, but returned inland if foraging conditions were poor. Inland core foraging areas were often shared (Figure 5).

High fidelity of individuals to core foraging areas is a means of resource partitioning and is demonstrated by the radio-tracking of 11 females at Tyrrel's Wood (Figure 6). Four females foraged to the east, three to the south and two to the west, crossing the busy A140. Three bats remained within 3km of the wood.



Figure 4: Flight-lines (shown in red) and foraging areas (outlined in yellow) for Foxhills Woods (Frogshall) females.

Habitat preferences and landscape features

One of our targets has been to determine the key habitats in the agricultural landscape that support the foraging requirements of barbastelles. We have radio-tracked females from maternity colonies, and a few males too, and identified the areas in which they spend most time feeding. For colonies within 5km of the coast, coastal cliffs are a major foraging area and the importance of the coast is discussed later on in this review.

All the maternity colonies studied are located in woodlands in predominantly arable landscapes. The roost woodlands are foraging areas in their own right, and especially important in bad weather. Beyond the woodlands, the agricultural landscape is a mosaic of arable, hedges, small woodlands, tree belts, riparian, pasture, country roads, rural villages and farms with gardens and grounds. The foraging areas targeted by barbastelles are typically arable mosaics ranging from 30 to 229ha in area in which the bats move around visiting the habitat features described above. Within these mosaics, linear features (30 to 40ha) are particularly important for foraging, including tall hedgerows, overhung or sunken tracks and country lanes, disused railway embankments and cuttings and woodland edge.

Small tributary watercourses are regularly used. These are usually bordered by pasture on low-lying land but are invariably fringed with tall shrubs and young trees. The Old Hills Woods maternity colony is a typical example. All radio-tracked females foraged along the vegetated section of the North Walsham and Dilham Canal within the home range of the colony, but non-vegetated, open sections were not visited.



Figure 5: Flight-lines (shown in red) and foraging areas (outlined in yellow) for Paston Great Barn females.



Figure 6: Home range and core foraging areas for the Tyrrell's Wood maternity colony.

Pasture and derelict grassland are also targeted, but always in combination with tall boundary hedgerows and hedgerow trees. Tall hedgerows are one of the most important landscape features for barbastelles, and provide foraging opportunities in arable-only areas. Lastly, barbastelles exploit gardens and grounds surrounding rural settlements which typically have an abundance of trees, shrubs and hedgerows, but no street lights. Large country houses with extensive grounds and mature trees are often targeted.

It is clear from our studies that the extent and variety of habitats in the agricultural landscapes of north and south Norfolk contain sufficient insect prey to support barbastelle colonies, although there will be annual variations influenced by weather conditions. To date, we have not fully investigated The Broads landscape to determine if the wet woodlands and wetland habitats provide suitable roosting and foraging potential respectively, although we know that numerous roost trees are generated in the succession to oak woodland at Calthorpe Broad. It would also be of value to determine if the sparsely wooded fens of west Norfolk and the intensively arable areas of east Norfolk support barbastelle colonies.

Home ranges

Home ranges were calculated for the most intensively tracked maternity colonies (Table 1). As expected, colony home range increased with the number of bats tracked, and is likely to be underestimated. The maximum distance travelled from the roost woodland averaged 3.5km with no bats travelling more than 5.5km. This is perhaps surprising for a wide-ranging fast-flying species, but females still in their maternity groups may range less widely than non-breeding females or males.

Table 1: Individual and colony home ranges (minimum and maximum values in parentheses).

Maternity colony	Number of females tracked	Mean individual home range (ha)	Colony home range (ha)	*Mean-maximum foraging radius (km)
Paston Great Barn	7	460 (208 - 755)	1,709	3.5 (2.1 – 4.0)
Old Hills Woods	5	532 (260 – 720)	1,400	3.4 (4.9 – 4.2)
Foxhills Woods	5	427 (353 – 577)	1,253	3.0 (2.2 – 3.8)
Tyrrel's Wood	11	388 (172 – 677)	3,447	3.7 (2.3 – 5.4)

*Maximum foraging radius is measured from roost cluster or centre of roost woodland

Core Sustenance Zones (CSZ) are defined as the area surrounding a communal bat roost within which habitat availability and quality will have a significant influence on the resilience

and conservation status of the colony. CSZ is a valuable tool to assess the potential impacts of development on bats. It is calculated to be 6km for barbastelles (Collins, 2016). The mean-maximum foraging radius from our work is consistently less than this figure. This may be due to the smaller number of barbastelles tracked. However, it does appear that the agricultural Norfolk landscape provides sufficiently productive foraging areas close to roost woodlands which can be intensively exploited by barbastelles, thus avoiding energetically expensive long-distance flights.

Colony interactions

Radio-tracking has revealed territory overlap between adjacent maternity colonies. These are the Paston Great Barn and Old Hills Woods colonies (5.8km apart) and Blickling Park and Mossymere Wood colonies (3km apart). This finding is of particular interest in respect of the Paston Great Barn colony which was considered to be relatively isolated (Figure 7). We have no evidence for movement of females between the Paston Great Barn and Old Hills Woods colonies but the shared use of foraging areas may be indicative of colony interactions.



Figure 7: Overlap of home ranges of Paston Great Barn (outlined in red) and Old Hills Woods (outlined in yellow) maternity colonies.

Importance of the coast

Radio-tracking has established that coastal cliffs are core foraging areas for females from maternity colonies close to the coast. To investigate and compare the importance of different coastal habitats, we deployed static detectors at ten sites along the north Norfolk coast in 2013 (Table 2).

Some detector sites were within foraging range (5km) of known or inferred maternity colonies, or within 5km of woodlands with roost potential, whilst other sites were not. Activity was recorded for one week every month from March to November (Figure 8).

Table 2: Coastal locations of static detectors.

Detector sites (west to east)	Maternity colonies within 5kms	Woods with roost potential within 5km	Minimum distance of colony from coast (km)	Coastal habitat
Inner Trial Bank, The Wash		None		Salt marsh
Snettisham RSPB	Ken Hill	Sandringham Estate Woods	2.0	Open dunes, lagoons
Holme Bird Observatory		Hunstanton Park		Dunes with tall pines
Scolt Head		None		Saltmarsh
East Hills, Wells	Holkham Park		2.0	Dunes with tall pines
Cley	*Bayfield Woods		5.0	Saltmarsh, shingle bank
Cromer	Felbrigg Park		2.3	Coastal cliffs
Mundesley	Paston Great Barn		1.1	Coastal cliffs
Sea Palling	Calthorpe Broad		2.4	Open dunes
Horsey Gap	Calthorpe Broad		2.5	Open dunes

*Inferred maternity colony

High levels of activity were recorded on the cliffs at Mundesley and Cromer where radio-tracking had confirmed that this was a core foraging area for females from the maternity colonies at Paston Great Barn and Felbrigg Hall respectively. Activity increased through the summer, peaking in September. Barbastelles visited East Hills and the Holme Bird Observatory where the dunes are covered in pines and scrub, offering some shelter. Both are within 5km of suitable woodlands and within barbastelle foraging distance. Activity was low behind the shingle bank at Cley, despite being within 5km of the Bayfield Estate woods. Although Sea Palling and Horsey Gap dunes are within foraging distance of the Calthorpe Broad colony, barbastelles were only occasionally recorded there. Radiotracking of the Calthorpe Broad colony showed that females did not target the dunes, but foraged behind them or further inland along woodland edge, hedgerows, lanes and water courses fringed

with shrubs. The lack of activity at Snettisham also suggests that the nearby Ken Hill colony rarely forages along the shingle bank. The single barbastelle call in September on the Inner Trial Bank in the Wash was surprising, and we have conjectured that this might have been a migrant/vagrant from the continent.

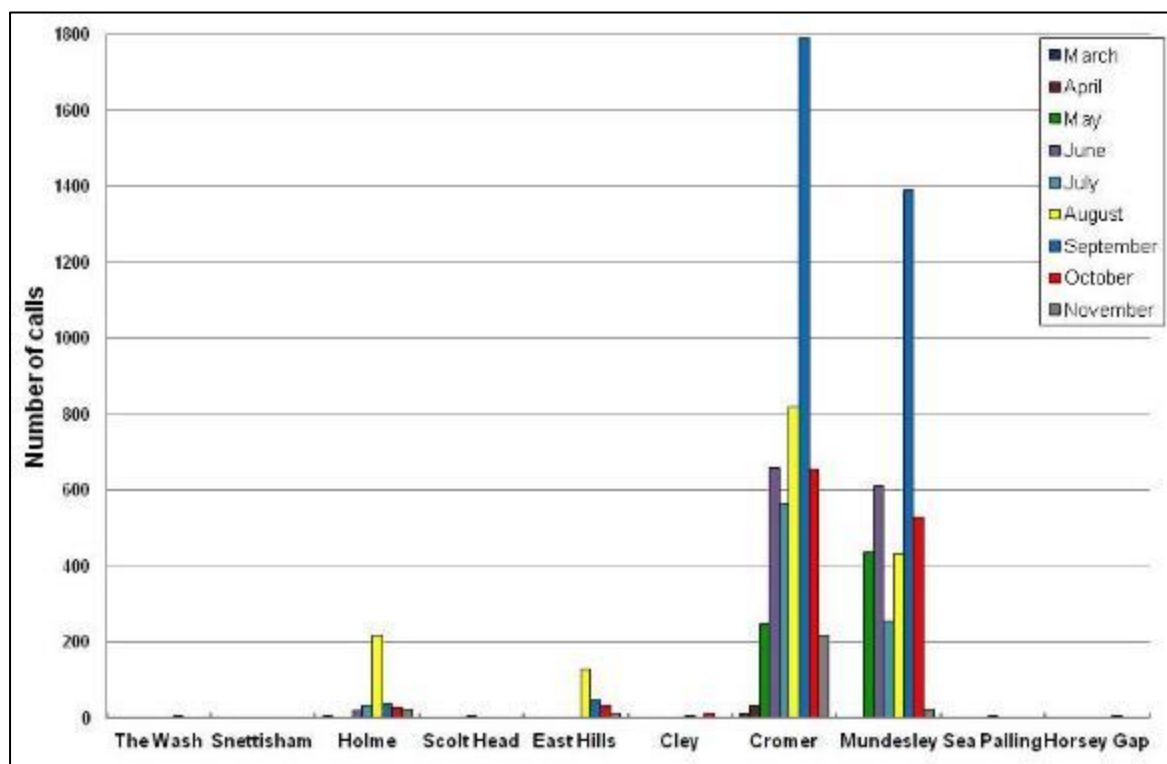


Figure 8: Barbastelle activity at ten coastal locations in 2013.

In summary, coastal cliffs are an important resource for maternity colonies within 5km of coastal cliffs at Sheringham Park, Felbrigg Park, Foxhills Woods and Paston Great Barn. This comparison of barbastelle activity at coastal habitats suggests that the major factor is the degree of shelter afforded by cliffs or tall vegetation. Insect abundance is expected to be higher in the lee of the coastal cliffs or tall pines on the dunes compared to open dune and saltmarsh habitats.

Autumn dispersal

We have trapped and radio-tagged a small number of female barbastelles in September and October 2015 to gain information on autumn dispersal. Two females trapped in Foxhills Woods on 30th October continued to roost in trees in the woodland, but switched roosts less often as the weather deteriorated. One female night-roosted in a barn just outside the wood. Two females from the Paston Great Barn colony roosted both in trees and agricultural barns, all within 5km of the maternity colony. On this limited evidence, females do not appear to disperse more than 5km from the maternity roost location and agricultural barns are of importance for roosting outside the maternity period.

Winter foraging and hibernation

Barbastelles are winter-active and are frequently recorded flying in woodlands throughout the winter. NBSG monitors a number of underground hibernation sites, some located in barbastelle maternity roost woodlands, but barbastelles are rarely found. Although there

are historic Norfolk records for ice houses, brick kilns and tunnels, it appears that barbastelles are likely to remain in tree roosts and only move to underground sites in very harsh winters. Numerous records of single barbastelles in agricultural barns during the winter months emphasize the importance of these buildings for winter roosts. Crevices in brickwork, timbers, cladding and roof coverings are the usual locations, but a hibernating barbastelle was found under plastic sheeting in a disused agricultural barn in January 2012 (Figure 6).



Figure 6: Barbastelle hibernating under plastic sheeting. © Jane Harris.

Males

Our work has been focussed on females and maternity colonies which are of high conservation status, but we have also radio-tracked three males. From this limited study, we have found that males roost separately from females, show the same roost switching behaviour and use a wider variety of roosts. These included more unusual tree species (yew *Taxus baccata*) and buildings such as brick and pantile barns and small sheds. One male at each of Foxhills Woods and Old Hills Woods foraged in similar locations to the females and showed fidelity to foraging areas. They did not forage further than 5km from the roost woodland. Males are known to be wide-ranging and responsible for gene flow between colonies, but we have not observed this with the limited numbers tracked to date.

Threats and opportunities

From our current knowledge, we can assess the threats facing barbastelles in Norfolk and where action is needed to avoid or mitigate against potentially damaging land management and development actions. Beyond this, there are opportunities to support existing populations and secure their viability in the long-term. These threats and opportunities are

summarised in Table 3 and we hope they will influence and guide barbastelle conservation strategies in Norfolk.

Table 3: Threats and opportunities for barbastelle conservation in Norfolk.

Management	Threats	Opportunities
Site identification and protection	- Known key sites are not designated - Importance of small woodlands not known or underestimated - No monitoring protocol	- Designate key sites - Survey more woodlands, especially CWS - Develop monitoring protocol
Woodland management	- Roost loss through felling and dead wood removal - Exposure of roost trees - Opening up of dark rides	- Retain dead wood - Retain vegetation structure around roost trees - Retain dark flyways - Leave areas of non-intervention in all woodlands - Encourage natural cycle of growth, damage and decay (non-intervention) - Woodland creation in sparse woodland areas to improve connectivity to the wider landscape - Toolkit for woodland owners¹ - Integrate opportunities into woodland management schemes
Long-term roost availability	- No trees less than 100 years old at some sites - Decline in roost availability within sites	- Encourage planting and regeneration of oak and sweet chestnut - Develop bat boxes to mimic roost features - Use bat boxes where roost availability is limited or declining - Investigate veteranisation of trees to generate roost features
Field boundary management	- Reduction in prey availability through hedgerow loss and intensive management - Loss of sheltered foraging habitat through intensive hedgerow management - Clearance of woody vegetation along watercourses	- Retain and increase mixed native-species hedgerows with nectar-rich trees and shrubs - Plant hedgerow trees - Management prescriptions to encourage untrimmed hedgerows - Maintain a strip of rough grass and woody vegetation along watercourses

¹ A new woodland wildlife toolkit was launched in early 2019.

<https://woodlandwildlifetoolkit.sylva.org.uk/home>

Management	Threats	Opportunities
Landscape-scale management	• Lack of connectivity between habitat features for roosting and foraging • No recognition of habitat use by barbastelle • Small-scale management by individual landowners	• Enhance connectivity between woodlands and woodlands and foraging areas • Agri-environment schemes to identify, retain and create barbastelle habitat features on farm units • Expand to farm clusters to enrich large areas surrounding or adjacent to roost woodlands • Initiatives to halt the decline in insect populations
Coastal development	• Illumination of cliffs • Loss of flight-lines to cliffs	• Reduce existing illumination by low intensity lighting • Hedgerow and tree planting to link to coast
Barn conversions	• Loss of autumn, winter, spring roosts • Loss of night roosts	• Planning conditions to condition installation of barbastelle roosting places in barn conversions within 6km of maternity roost
Infrastructure projects	• Fragmentation of flight-lines to high fidelity foraging areas • Colony fragmentation within roost woodlands • Modification of roost environment, availability and continuity • Disturbance of roosts through public access, new roads	• Risk map for Norfolk barbastelles based on locations of maternity colonies • Planning policy to recognise CSZ • All barbastelle habitat features to be identified and maintained within CSZ • Enhance and create barbastelle habitat features within 6km of maternity roosts

Acknowledgements

NBSG is grateful for funding and support from Natural England, the National Trust, the Norfolk Coast Partnership and Norfolk Biodiversity Information Service at various times over the years. Many Norfolk landowners have assisted with access, and their help and support is gratefully acknowledged. The Group could not have learnt so much about Norfolk barbastelles without the many hours contributed by volunteers. Thanks are also due to Ben Jervis for preparing some of the figures using QGIS.

References

Collins, J. (ed.) (2016) *Bat Surveys for Professional Ecologists: Good Practice Guidelines* (3rd edn.). London: Bat Conservation Trust.

Greenaway, F. (2008) *Barbastelle bats in the Sussex West Weald 1997 – 2009*. Sussex: Sussex Wildlife Trust and West Weald Landscape Project.

Mackinnon, S. (2017) *Multi-scale factors driving habitat selection in a woodland-specialist bat: Barbastella barbastellus. Implications for the conservation of bats in managed forests.* MSc thesis. University of East Anglia: UK.

Norfolk Barbastelle Study Group. (2011) Norfolk Barbastelle Study Group (NBSG) summary 2011. *Norfolk Bird and Mammal Report 2011*, pp. 195-197.

Packman, C.E. (2019) *Norwich Northern Distributor Road post-construction barbastelle bat radio-tracking monitoring report. Year 1: 2018.* Norwich: Wild Wings Ecology unpublished report for Norfolk County Council.

[Return to contents page](#)

Developing the MOTUS automated radio-tracking system for studying migratory activity of *Nathusius' pipistrelle*

Jane Harris and Ewan Parsons; Norwich Bat Group

janeharris2251@gmail.com

Introduction

Recoveries of ringed *Nathusius' pipistrelle* *Pipistrellus nathusii* has confirmed the species' status as a long-distance migrant which crosses the southern North Sea, but has also highlighted the potential risk from the rapidly increasing number of offshore wind farms. Wageningen Marine Research (WMR) in the Netherlands has been studying migratory activity of *Nathusius' pipistrelle* using an acoustic monitoring network on 14 offshore installations with the aim of predicting bat activity in the southern North Sea.

Representative data from one offshore station in 2018 is shown below (Lagerveld *et al.*, 2019). *Nathusius' pipistrelle* was recorded most frequently and the timing of activity indicated that the peak spring and autumn migration periods were April and September respectively. Common pipistrelle *P. pipistrellus* and *Nyctaloids* were also recorded, which shows that there is much to learn about bat migration.

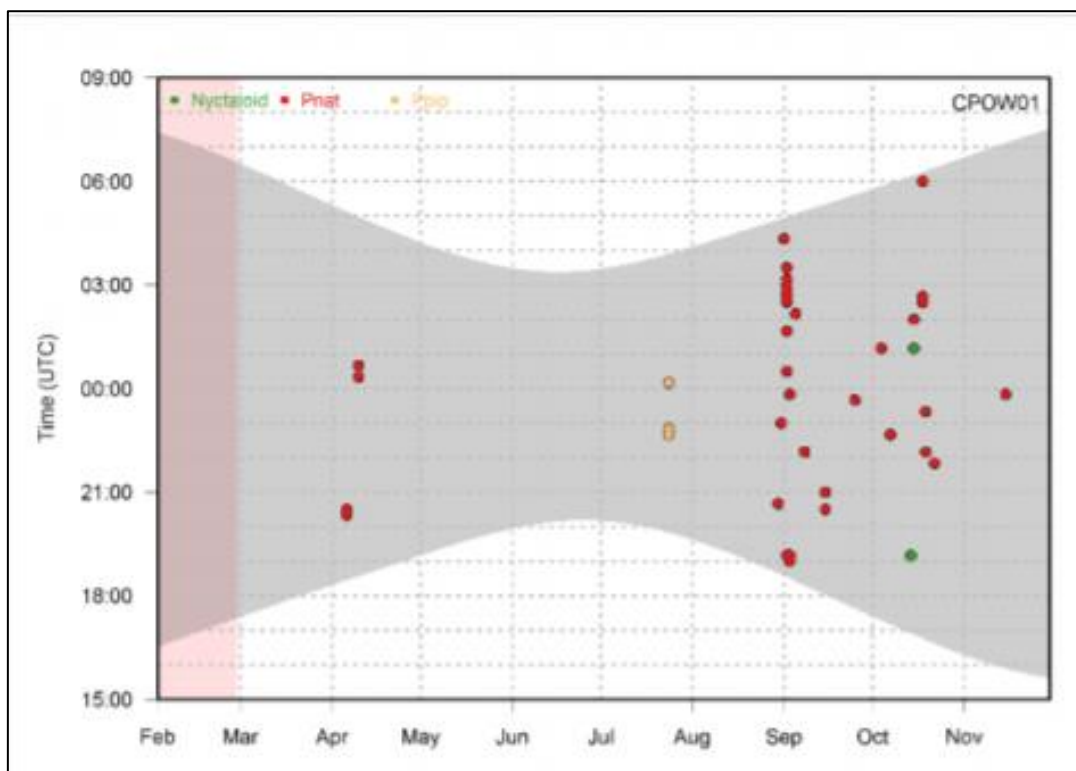


Figure 1: The occurrence of bats in 10-min intervals per night throughout the monitoring season as recorded by the Avisoft detectors at the C-Power offshore station (taken from Lagerveld *et al.*, 2019). The time interval between sunset and sunrise is represented by grey shading. Different species (or species groups) are represented by different colours (Pnat = *Nathusius' pipistrelle*, Ppip = common pipistrelle, Nyctaloid = species group, includes genera *Nyctalus*, *Vespertilio*, *Eptesicus*). The actual monitoring period is indicated by a white background, whereas a pink background indicates no monitoring or recorder switched off.

The MOTUS automated wildlife tracking system

Since 2017, WMR has been studying the autumn migratory behaviour of Nathusius' pipistrelle and other bat species using the MOTUS system. MOTUS is an international network of radio receiving stations, detecting 'coded' radio tags transmitting at 150.1MHz which can be attached to bats, birds and other species. It is managed by Bird Studies Canada, which provides tag decoding, central data storage and access. To date, WMR has installed 42 MOTUS receivers along the Dutch coast, including some on offshore installations, and the network is still expanding.

Lotek NanoTags weighing approximately 0.3g are used for Nathusius' pipistrelle. Each has a unique code incorporated into the transmission which allows individuals to be identified. The lifespan of the radio tags depends on the size (weight) of the battery and the rate at which pulses are transmitted. For Nathusius' pipistrelle, a lifespan of 60 days can be achieved but the limiting factor is the often length of time the tag remains attached. For larger species, especially birds, where 1.5g radio tags can be used, there is potential for multi-year tracking.

A MOTUS receiver station comprises a number of elements: antennae, radio, data hand-off system and power supply. The antennae determine the detection range of the station, potentially up to 6km, so these are mounted as high as possible, ideally on a mast or other tall structure. Usually four antennae will be used, but stations with a single antenna or up to six have been deployed. The radio receiver is the brains of the station. These can be commercial systems from Lotek or Cellular Tracking Technologies, or self-built SensorGnome systems using open source designs and software, and commercially available hardware. The receiver station will consume approximately 10–20W of power so, depending on the location, they can be powered by mains or solar systems.

Detection data needs to be transferred from the receiver station to the MOTUS servers. For remote systems this can require periodic visits to manually download data, whereas systems such as those used by WMR use mobile phone technology to download the data and allow remote log-in to the radio receiver. Currently, the radio tags used in Europe operate on a frequency of 150.1MHz which, in the UK, is reserved for use by radio astronomers. Discussions are underway with the regulator Ofcom to get permission to deploy radio tags operating at this frequency in the UK.

Equipment costs for a receiver station depend on location, the type of installation and method of data transfer, and will range from £2,500 to £4,000. Ongoing operating costs which include annual maintenance, power supply and mobile internet are about £250. The NanoTags are currently approximately £200 per tag.

The UK MOTUS network

In January 2019, WMR approached the Bat Conservation Trust (BCT) with a request to find locations for MOTUS receivers to detect Nathusius' pipistrelles radio-tagged in The Netherlands and migrating across the southern North Sea to the east coast. This would also provide an opportunity to radio tag Nathusius' pipistrelles on the east coast to study the spring migration.

Over the next few months, Norwich Bat Group (NBG) found three suitable locations for receivers in East Anglia (two in Norfolk and one in Suffolk). The receivers must be sited on the coastline on elevated or open land or a tall mast or building, with no surrounding features to obstruct reception. Landowner permissions must be secured. This is not an easy undertaking and required a great deal of map work, site reconnaissance and discussion with landowners and stakeholders. We discovered that planning permission was required for a site in an Area of Outstanding Natural Beauty. WMR funded four receivers and Sander Lagerveld and René Janssen from WMR worked with NBG on the first three installations. Subsequently, with technical expertise from Ewan Parsons, the group now has the capability to install MOTUS receivers (Figure 2).



Figure 2: MOTUS receiver being installed at Caister Lifeboat station (left) and completed installation at Dunwich Coastguard (right).

During this time, the Bird Observatories Council, University of Hull and the British Trust for Ornithology (BTO) started Project Yellow-browed to install receiver stations as part of their long-term bird migration studies. Receiver stations have been installed at four Bird Observatories on the east coast so that the UK MOTUS network now comprises seven receiver stations (Figure 3) with plans for another in Suffolk and more in Kent. BCT, WMR and NBG are represented on the coordinating committee for Project Yellow-browed to ensure that the MOTUS system is being deployed to maximise the benefit for both bats and birds.



Figure 3: Locations of MOTUS receivers on southern North Sea coastlines. From north to south: Spurn Bird Observatory, Caister Lifeboat Station, Lowestoft CEFAS building, National Trust Dunwich Coastguard, Landguard Fort Bird Observatory, Sandwich Bay Bird Observatory, Dungeness Bird Observatory. The inland receiver is a test station built by the RSPB but no data has been received from it.

The autumn migration

WMR plans to radio tag 500 Nathusius' pipistrelles between 2017 and 2020. The bats are captured from bat boxes in coastal woodlands on the Dutch coast between August and mid-October where they roost on their migration journey. The data so far have shown that most tagged bats move north to south down the Dutch coast from which they are expected to depart to cross the southern North Sea (Figure 4).

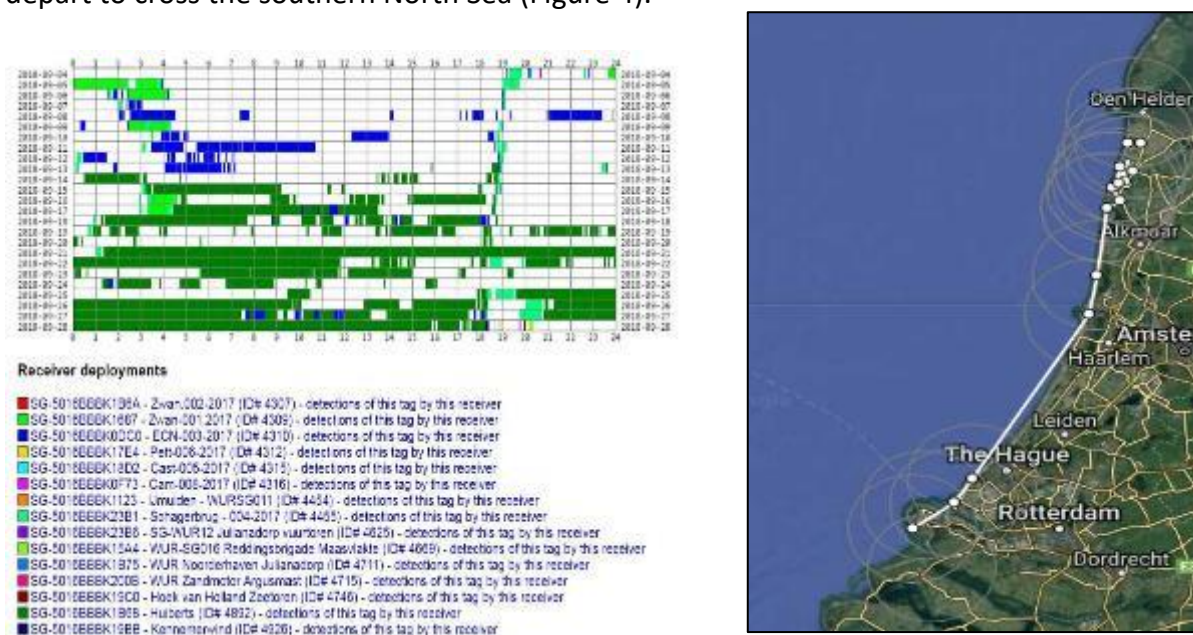


Figure 4: Female Nathusius' pipistrelle tagged September 2018. Taken from www.motus.org. This information is available to project members but not the general public.

The spring migration

As part of this collaborative study, a Natural England Project licence has been obtained to trap and radio tag Nathusius' pipistrelles in coastal woodlands in Suffolk which are potential gathering places prior to the spring migration. NBG will monitor activity with passive detectors from early March and 50 bat boxes, erected in autumn 2019, will be checked for Nathusius' pipistrelles. Trapping, using the National Nathusius' Pipistrelle Project methodology with harp traps and acoustic lures, will also be used. Bats of suitable weight and condition will be radio-tagged and released at the point of capture which is within 2km of the Dunwich MOTUS receiver. Permission for another receiver at Minsmere is also being sought and, if successful, will further increase detections and directional data. It is hoped that radio-tagged spring migrants will be detected by the network of MOTUS receivers in Dutch waters and on the Dutch coast, thus improving our understanding of migratory behaviour throughout the year.

Future plans and intended outcomes

The National Nathusius' Pipistrelle Project, which has been running for six years, has increased our knowledge of the resident and breeding status of this species in the UK, but information on migratory behaviour is still limited. This project is expected to extend into future years, together with expansion of the MOTUS network, and will contribute to a better understanding of the migratory behaviour of Nathusius' pipistrelle and especially the importance of East Anglia. Information on behaviour prior to migration such as locations where Nathusius' pipistrelles gather before departure, movements north and south along the coast and departure points will be used to identify important locations and habitats. This may be extrapolated to other parts of the east coast. The project will also provide more detailed information on the timing and duration of the spring migration from the UK.

BCT has identified the need for bat migration studies to assess impacts of the increasing number of wind farms in the North Sea and is exploring options for this research. This project will feed into these studies as they progress. A knowledge of the migration route and weather conditions when bats migrate will be invaluable in assessing the potential impacts of North Sea wind farms and developing mitigation strategies.

Across Europe, over 24 projects have been registered on the MOTUS system since 2015, with 185 receiver stations deployed and over 2,400 radio tags registered. Thirty-five different species have been tagged, including six species of bats. In the next few years the network will be extended to new countries and will include receivers on offshore wind farms on both sides of the North Sea.

References

MOTUS Wildlife Tracking System [Online] www.motus.org [Accessed multiple times during 2019 and 2020].

Lagerveld, S., van der Wal, J.T., de Vries, P., Verdaat, H., Sonneveld, C., van der Meer, J., Brabant, R. and Noort, B. (2019) *Bats at the southern North Sea in 2017 & 2018*.

Wageningen Marine Research Den Helder [Online]
<https://library.wur.nl/WebQuery/wurpubs/fulltext/496171>

[Return to contents page](#)

**Optimising the Sussex Autobat acoustic lure for catching bats in British woodlands:
A preliminary report**

David A. Hill¹ and Matt Cook; ¹Wildlife Research Center, Kyoto University, Japan
hill.david.2u@kyoto-u.ac.jp

Introduction

The Sussex Autobat acoustic lure was developed in 2001 to improve capture rates for bats in British woodlands, and particularly for the elusive Bechstein's bat *Myotis bechsteinii*. Once the effectiveness of the technique had been demonstrated by field experiment and pilot surveys (Hill and Greenaway, 2005; 2008) it was incorporated into a systematic survey, coordinated and run by the Bat Conservation Trust, which mapped the national distribution of Bechstein's bat in the UK (Miller, 2012; Barlow *et al.*, 2013).

Several subsequent studies have demonstrated the effectiveness of the Sussex Autobat acoustic lure for enhancing capture rates of echolocating bats in the UK (Lintott *et al.*, 2014), mainland Europe and Scandinavia (Goiti *et al.*, 2007; Michaelsen *et al.*, 2011; Napal *et al.*, 2013), Australia (Hill *et al.*, 2014a) and Japan (Hill *et al.*, 2014b). It has also been widely used to capture bats for radio-tagging to study patterns of habitat use and to find roosts for both scientific research (Murphy *et al.*, 2012; Zeale *et al.*, 2012; Fukui *et al.*, 2012; Law *et al.*, 2018) and ecological consultancy (e.g. Davidson-Watts, 2019).

Acoustic lures clearly modify the behaviour of those bats that get caught, but they also have the potential to modify the behaviour of any bat that is able to hear the output. There is therefore a risk that the use of acoustic lures could cause disturbance and have a disruptive effect on bat populations (Hill and Greenaway, 2005; Lintott *et al.*, 2014), especially if used incorrectly. This risk could be minimised by optimising the use of lures to increase their efficiency and so reduce the time required to achieve the research or survey goals.

This paper presents preliminary findings from the first two years of an ongoing project which is examining the influence of various factors on the effectiveness of acoustic lures for capturing UK bat species in woodland habitats. The ultimate goal is to produce a set of guidelines for maximising the usefulness of acoustic lures for research and conservation, while minimising the risk of disturbance.

A great variety of factors have the potential to influence the effectiveness of acoustic lures, including stimulus type, temporal patterning and repetition rate of stimuli, length of intervals of silence and signal strength. It may also be influenced by the equipment used (e.g. type of speaker, mist net or harp trap etc.), the immediate trap environment and speaker location in relation to the trap. In the first two years of the project we have focussed on testing three factors that seem likely to influence the effectiveness of the Sussex Autobat: namely stimulus ('call') type, speaker type and signal strength.

There is some evidence from previous studies that bats are more likely to respond to stimuli modelled on social calls of conspecifics, than to those of other species (Schöner *et al.*, 2010; Murphy, 2012; Gilmour, 2014). Lintott *et al.* (2014) also found that bats at forest sites in Scotland varied in their responsiveness to each of four Autobat stimulus types. By contrast, a study of forest bats in two regions of Japan tested eight different calls, but found no

significant overall effect of stimulus type on capture rate (Fukui *et al.*, 2014). As far as we know, there have been no previous systematic assessments of the performance of different speaker types, or of varying signal strength, on effectiveness of an acoustic lure for bats.

Methods

All trials were run between the beginning of May and end of October in 2018 and 2019 in mature, semi-natural broadleaved woodlands in the Midlands (Nottinghamshire and Lincolnshire) and the South of England (West Sussex, Isle of Wight and Devon). Within each year a different site was used for each trial, but several sites were re-used in the second year. Some large blocks of woodland included more than one site, but in such cases sites were separated from one another by at least 500m.

For each trial two harp traps (double-bank, Faunatech, Australia) were set inside the woodland and each was fitted with a Sussex Autobat acoustic lure. Traps were located away from any obvious flyways, or to one side of them, to minimise incidental captures that were not in response to the lures (Figure 1). As far as possible, the locations of the two traps were matched in terms of their immediate environment (e.g. proximity to a tree, or trees, surrounding vegetation, proximity to water etc.).



Figure 1: Harp trap in situ. © Matt Cook.

The two traps were set in the same woodland block, but were separated by at least 50m (more usually 100m). Each trial began after civil twilight, by which time most bats would have left their roosts to forage or commute to foraging sites. Eight different call stimuli were played in turn. Each call was played for 20 minutes, after which the Autobat was switched off, the trap was checked and any bats were removed and placed in clean cotton holding bags to await processing. The next call was then selected and the Autobat was switched back on. The same procedure was then followed at the second trap.

Call stimuli

The Autobat is an ultrasound synthesiser that produces simulations of bat social calls. All of the Autobat call stimuli have been modelled on recordings of social calls given by bats in flight. Neither distress calls, nor any other calls recorded from bats in the hand, have been used as models for Autobat stimuli.

For each trial the calls were played in a fixed order, but the order started with a different call each night. So, if on one night the order of playing the calls on one trap was A-B-C-D-E-F-G-H, then on the next night it would be B-C-D-E-F-G-H-A, and so on. The starting point for the second trap would be four places ahead in the order. So if the night began with call A played on one trap, then it would begin with call E on the other, and so on. The sequence also included two 20-minute periods of silence: one after the third call of the sequence had been played and another after the sixth call had been played. Thus, the time it took to complete a trial was a minimum of 200 minutes, plus the time required to check traps and extract bats from them.

Speaker type

Two types of speaker were used, both of which incorporated two SensComp 600 series Environmental grade transducers (SensComp Inc., USA). The ultrasonic signal produced by these transducers is very directional (SensComp, 2014). The standard speaker box has two transducers mounted back to back to broadcast the signal in opposite directions. Another speaker type (developed by Frank Greenaway) has the transducers mounted so that they face one another, with a rotating metal vane mounted in between them. Each side of the vane deflects the ultrasound output of one of the transducers. The vane spins rapidly in pulses of less than one second, followed by an interval of 2-3 seconds during which the vane is stationary before the next spin. The vane stops in a random position each time which determines the two directions in which the ultrasound is deflected. Thus the 'spinner' acts as a rotating ultrasound distributor. In both 2018 and 2019 trials the Autobat on one harp trap was fitted with a standard speaker box and the other with a spinner (allocation determined by tossing a coin).

Signal strength

In 2019 we compared the effectiveness of an Autobat playing calls at standard signal strength on one harp trap, with another playing calls with a -6dB reduction in signal strength on the other trap. 'Standard signal strength' refers to the intensity of output of a Mk I Autobat with no auxiliary amplification. The intensity of the output from each of the Autobats we used was tested before trials began and found to be comparable for three test calls. A reduction of -6dB was achieved in the software by attenuating the electrical signal used to generate the output from the transducers for the duration of the call.

Processing bats

All captured bats were identified to species (or probable species for small *Myotis* bats, as explained below), and a record was taken of sex, whether juvenile or adult, reproductive condition, body weight, forearm length and any distinguishing features. The bat was then temporarily marked with chalk pen (so that we could identify any bats that were recaptured on the same night) and released.

DNA analysis has shown that identification of small *Myotis* based on morphological features alone is complicated, and not entirely reliable (Berge, 2007; Lučan *et al.*, 2011; Brown, 2016). Berge (2007) found overlap between male whiskered bats *M. mystacinus* and Brandt's bats *M. brandtii* in all of the morphological measures tested. The Alcathoe bat *M. alcathoe* can usually be distinguished from other small *Myotis* by their smaller forearm and tibia length measurements (Dietz and Kiefer, 2016), but this is also not entirely reliable. Occasionally very small individuals within the range of Alcathoe bat have been identified as whiskered bats by DNA analysis (Lučan *et al.*, 2011; pers. obs.). Consequently, for the analyses all data for these three species were combined as 'small *Myotis*' and are counted as a single species for the purposes of the following summaries.

Results

In 2018 trials were completed on 14 nights in the Midlands and 12 in the South. 142 bats of 11 species were caught while the Autobat was playing and four bats were caught during periods of silence. In 2019 trials were completed on six nights in the Midlands and 12 in the South. 76 bats of ten species were caught while the Autobat was playing, and no bats were caught during periods of silence. As silent periods constituted 20% of total trapping time, overall capture rate with the Autobat for the two years combined was approximately 13.6 times greater than without it. Only one bat was identified as a recapture and the second capture of that bat was omitted from the analyses.

The 218 bats caught to the lures during trials comprised 11 species, with nine species caught in the Midlands, and nine caught in the South. Combining data for both regions, two species accounted for almost 50% of all bats caught. These were the soprano pipistrelle *Pipistrellus pygmaeus*, which dominated the catch in the Midlands and the brown long-eared bat *Plecotus auritus*, which dominated the catch in the South (Figure 2).

Although the three species of small *Myotis* were treated as a single species group in the summaries, at least one of those caught in the Midlands was identified as Brandt's bat based on penis morphology, whereas none of the males caught in the South had this trait. However, some small *Myotis* of both sexes caught in the South were identified as probable Alcathoe bat on the basis of very short forearm and tibia (Dietz and Kiefer, 2016). One of these was at a site where Alcathoe bat has been previously confirmed by DNA analysis (Davidson-Watts, 2015).

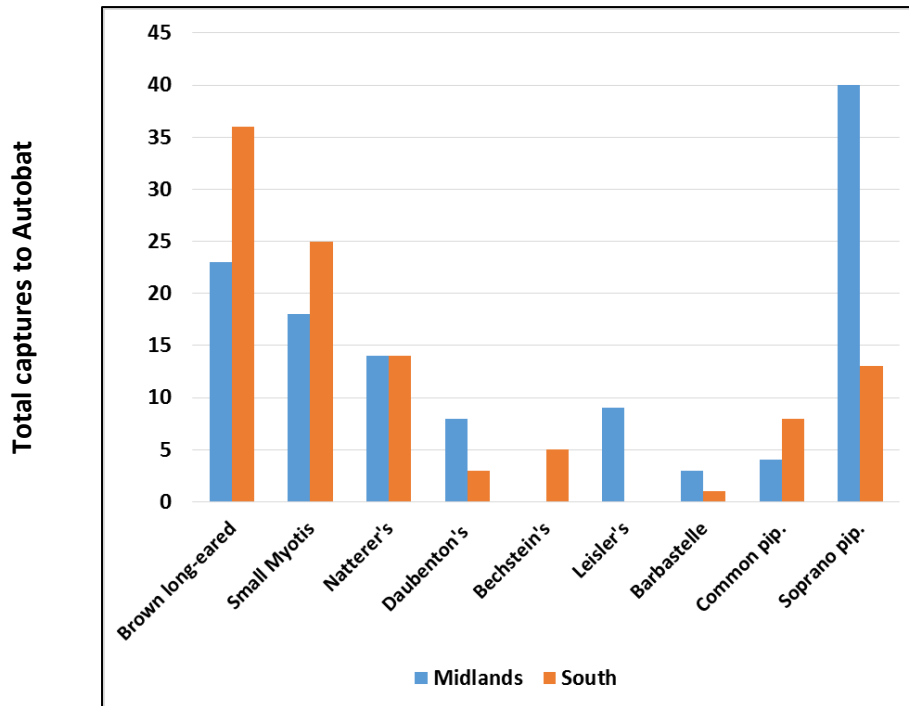


Figure 2: Total captures of each species in each region.

Sex differences in capture rates

For all captures with the Autobat playing, approximately twice as many males were caught as females. A male-biased sex difference was apparent for each species, apart from Daubenton's bat *M. daubentonii*, for which females accounted for 63% of captures (Figure 3). The common pipistrelle *P. pipistrellus* and soprano pipistrelle showed the most extreme sex difference, with males accounting for over 80% of captures for each species.

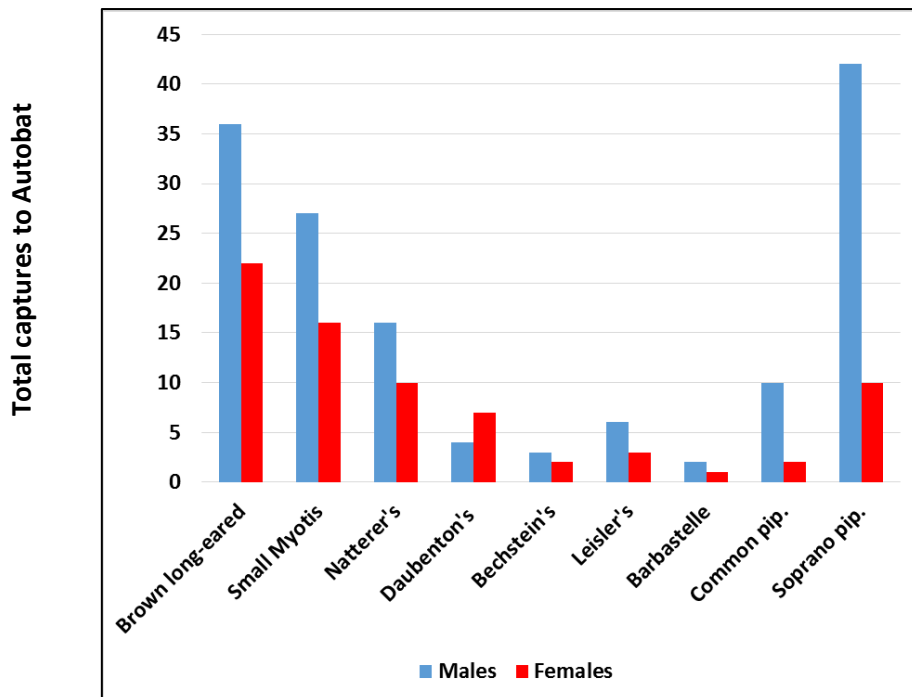


Figure 3: Sex difference in bats captured for each species.

Relative effectiveness of different call types

Eight call types were tested in each trial. Six call types (**Barb**, **Bech2**, **Bech3**, **Bleb**, **Whisk**, **Mmouse**) were used in both 2018 and 2019. After the first year it was clear that two calls, **Leis** and **Nath**, were catching largely soprano pipistrelles and common pipistrelles, so these were replaced in the second year with **Natt** and **Mixpips**. Consequently, each of the latter four call types was tested in only one year. To control for this all capture rates were calculated as bats caught per hour of play.

Three call types, **Bleb** (based on social calls of the Brown long-eared bat), **Leis** (based on social calls of Leisler's bat *Nyctalus leisleri*) and **Mmouse** (a generic *Myotis* call), had markedly higher total capture rates than any of the other seven call types (Figure 4). However, this trend was not consistent across all species. The two *Pipistrellus* species accounted for 71% of bats caught with **Leis** and 51% of those caught with **Mmouse**. Similarly, 75% of bats caught using **Bleb** were brown long-eared bats and 58% of those caught to **Whisk** (based on social calls of the whiskered bat) were small *Myotis*.

The calls that caught the greatest diversity of bats were **Barb**, **Bech3** and **Mmouse**, each of which caught at least seven species. Of the rarer bats captured, each of the four barbastelles *Barbastella barbastellus* was caught to a different call type (Figure 5), as was each of the five Bechstein's bats. Similarly, the nine Leisler's bats were caught to six different call types (Figure 6).

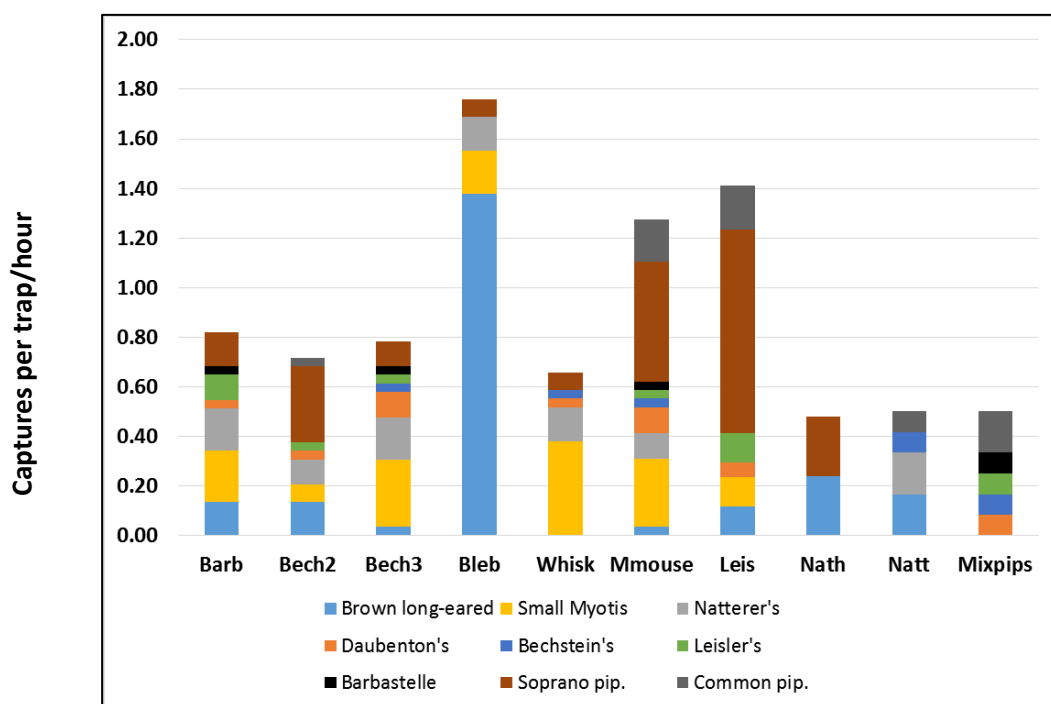


Figure 4: Captures per trap/hour for each call type.



Figure 5: Four barbastelles were caught, each to a different call type. © Matt Cook.



Figure 6: Nine Leisler's bats were caught, responding to six call types. © Matt Cook.

Speaker type

On three trials the spinner failed to work. When data for these trials were omitted 97 bats were caught with the spinner, compared with 99 caught with the fixed speaker. Although this suggests no effect of the speaker type, differences were apparent for some species (Figure 7).

Brown long-eared bats, Natterer's bats and common pipistrelles were all caught more frequently with the fixed speaker than with the spinner. By contrast, small *Myotis* and soprano pipistrelles were caught more frequently with the spinner.

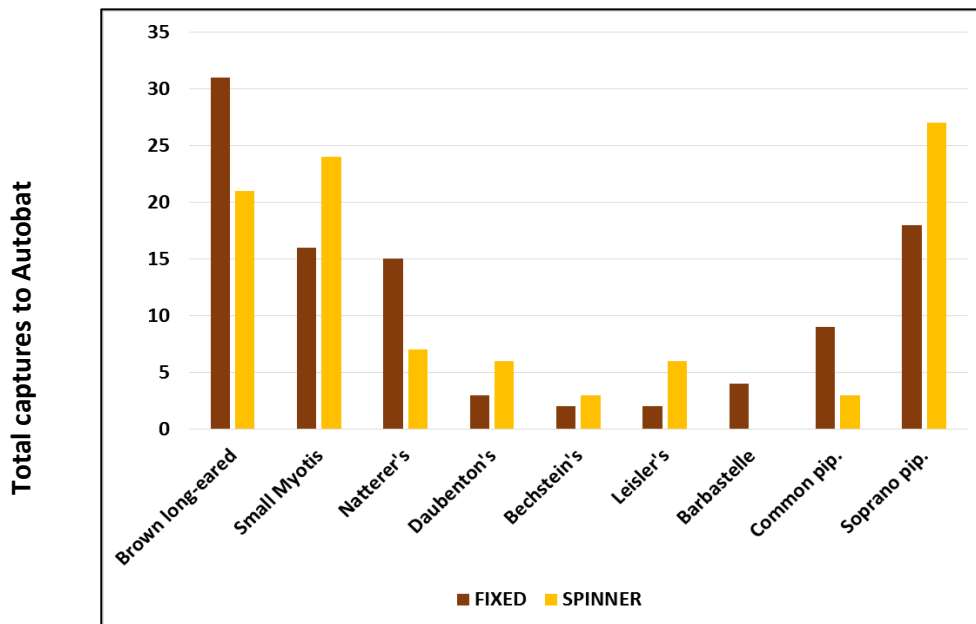


Figure 7: Total captures for each species using each speaker type.

Effect of signal strength

More bats were caught using standard intensity calls than attenuated calls (41 vs 35), but there was no consistent effect of call intensity on capture rates across species (Figure 8). More of both soprano pipistrelles and common pipistrelles were caught using louder calls, whilst more brown long-eared bats were caught using attenuated calls. For other species there was no difference, or the difference was small. The data are too few to draw any detailed conclusions at this stage, but it is clear that the attenuated calls were effective for some species.

Discussion

In 2018 and 2019 we collected data over 44 nights and captured 218 bats using the Sussex Autobat acoustic lure. The findings must still be regarded as preliminary at this stage, however, because of the large number of variables involved and the uneven spread of trials across the season. Nevertheless, the trials were successful in showing that there is potential for improving the effectiveness of the Sussex Autobat for catching bats in woodlands.

Mean capture rate with the Autobat was 13.6 times higher than in the silent periods. This falls within the range of previous studies which have reported increases in capture rates of between 2- and 25-fold (Hill and Greenaway, 2005; Goiti *et al.*, 2007; Lintott, *et al.*, 2014a; Hill *et al.*, 2014a; 2014b). Eleven species were caught using the Autobat, including some rare or relatively uncommon woodland specialist species. Although only five Bechstein's bats were caught, each was at a different site. Similarly, each of the four barbastelles was caught at a different site. The species that was caught most frequently was the brown long-eared bat which, although relatively common and widespread, can be difficult to catch without a lure away from known roost sites.

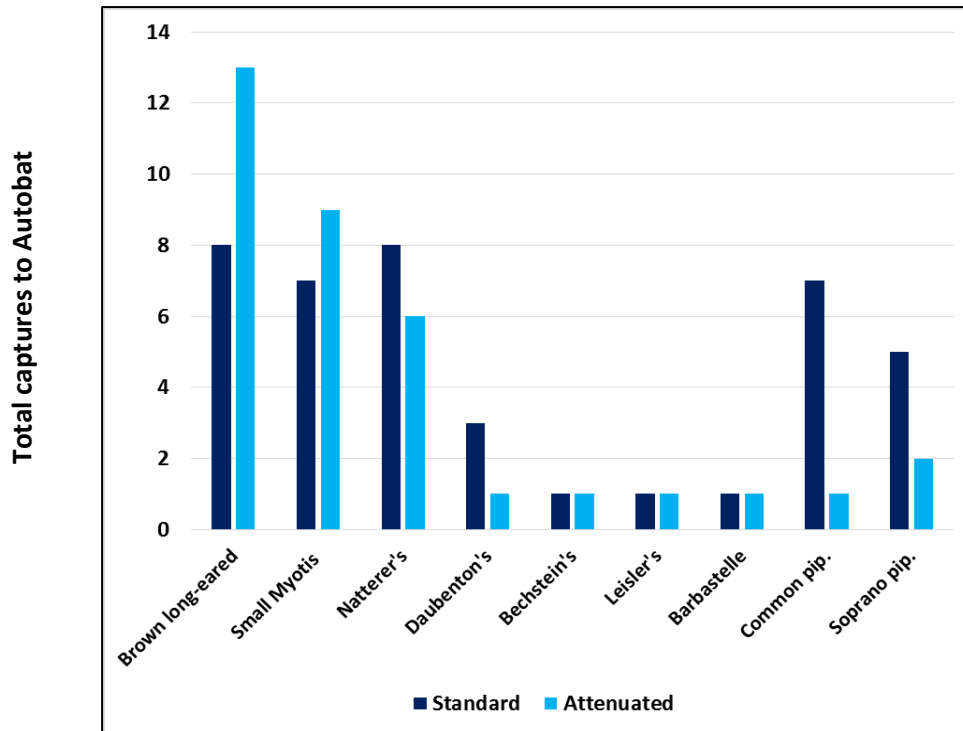


Figure 8: Effect of signal strength on total captures (2019 only).

The main regional difference in captures was the much greater number of soprano pipistrelles caught in the Midlands. This may represent a genuine regional difference in population density of this species in woodlands. Alternatively, as males accounted for over 80% of captures of soprano pipistrelles, it could be due to a regional difference in the responsiveness of males. However, comparison between the regions is complicated by underlying differences in the seasonal distribution of trials. There were no trials in July or August in the South, whereas trials were more evenly spread across the season in the Midlands. Lintott *et al.* (2014) reported a steady increase in the number of male soprano pipistrelles caught with the Autobat from May to September, while numbers of females caught remained fairly constant. As we collect more data over the next few years it should become possible to examine the effects of season and region as part of a multivariate analysis.

There was a male bias in the sex ratio of bats caught for all species apart from Daubenton's bat. The general preponderance of males could have resulted from a difference in the sex ratio of resident bat populations, or from males being more responsive to the lure. The latter seems the more likely explanation, but to test it would require an intensive behavioural study comparing the responses of males and females to the Autobat.

There were clear differences among the calls in terms of the numbers and diversity of bats that were caught. The call with the highest capture rate was **Bleb**, which also had the clearest species-specific response. 60% of the 52 brown long-eared bats were caught using the **Bleb** call. However, the diversity of bats caught with this call was low. The **Leis** call had the second highest capture rate, but more than half of the bats it caught were soprano and common pipistrelles and the diversity of other bats caught was low. Improving capture rates for *Pipistrellus* is not a priority for this project, so the **Leis** call was dropped after the first

year, as was **Nath**, which performed least well for both capture rate and diversity of bats caught.

As small *Myotis* bats were treated as a species group the results for them are not directly comparable with those for individual species. However, it is worth noting that the highest capture rate for small *Myotis* was with the **Whisk** call. They also responded well to other calls, including **Mmouse**, **Bech3** and **Barb**. Similarly, although caught in smaller numbers, barbastelles, Bechstein's bats and Leisler's bats all responded to various different calls.

For the purposes of optimising the Autobat it is clear that brown long-eared bats can be specifically targeted by using the **Bleb** call. Apart from that it is too early to make firm recommendations about which calls to use for what purpose. Results so far suggest that using a variety of calls will be most effective for luring other woodland bat species. As we collect more data we should be able to recommend particular combinations of calls that will maximise chances of catching particular species, or groups of species. We should also be able to assess whether there is any evidence of seasonal or regional variations in the effectiveness of each call.

There appeared to be variation among species in whether they responded more frequently to calls played using the fixed speakers or using the spinner. As we collect more data it will become possible to test statistically whether there are genuine differences between species in the effectiveness of the two speaker types, or if the observed differences were simply stochastic variation.

Data on the effect of signal strength were collected only in the second year, and for most species the numbers of bats caught were too few to show any reliable trends. However, it is clear that the attenuated calls were effective for catching at least some individuals of all species/species groups that were caught using the standard calls. While both species of *Pipistrellus* appeared to be less responsive to attenuated calls, brown long-eared bats showed the opposite trend. More data are required before any firm conclusions can be drawn, but indications are that attenuation of call strength by -6dB does not reduce the effectiveness of the Autobat as a lure for some species and may even increase it.

Acoustic lures have the potential to influence the behaviour of bats in different ways. Our capture data represent only those bats that have been attracted into the traps by the Autobat calls. But there may have been other bats that avoided the calls, or which approached the vicinity of the trap to investigate and then left. Signal strength could influence the effectiveness of a lure in conflicting ways. Sound waves are attenuated as they move through air, so stronger ('louder') signals will carry further than weaker ones and will therefore be heard by more bats and potentially attract them. At the same time, if the signal is too strong it may repel bats rather than attract them. To minimise the risk of disturbance the optimum strength of the signal will be as low as it can be while still functioning as an effective lure. So the fact that attenuated calls still worked is encouraging in terms of potential for future optimisation of the Autobat.

As the project progresses we will continue to run trials from mid-spring until the end of October, but with an emphasis on the mid-summer period, which is currently

underrepresented. In addition to obtaining more data on the effects of call type, speaker type and signal strength, we also plan to test additional factors, such as whether playing the calls in a pre-programmed sequence is more effective than playing each call in turn for 20 minutes and also the effects of lengthening the intervals of silence. We plan to produce the first guidelines for optimised use of the Sussex Autobat for catching bats in British woodlands after a third year of trials. The aim is to make the guidelines available as a developing online resource that can be modified and added to as more data become available.

Acknowledgements

Peter Reed designed and built the Autobats based on an original idea of Frank Greenaway's. Frank also made the original versions of five of the ten Autobat calls that were tested and designed and built the 'spinners'. We are grateful to all landowners for permission to survey in their woods. All trapping was done under a project licence from Natural England (2018-34350-SCI-SCI-1).

References

- Barlow, K., Miller, H., Hill, D., Greenaway, F., Gilmour, L. and Merrett, D. (2013) New frontiers in our understanding of the Bechstein's Bat in the UK. *British Wildlife*, 24(6) pp. 401-407.
- Brown, P.A. (2016) *The Cryptic Group of Small Myotis Bats (M. mystacinus, M. brandtii and M. alcathoe) and Habitat Use by Woodland Bats Species in Britain*. MSc thesis. University of Bristol: UK.
- Davidson-Watts, I. (2015) *Advanced bat surveys of Northup Copse and Dunhurst Copse, Kirdford, West Sussex*. Report prepared for Keep Kirdford and Wisborough Green.
- Davidson-Watts, I. (2019) Conversation with David Hill, 24th February.
- Fukui, D., Hill, D.A. and Matsumura, S. (2012) Maternity roosts and behaviour of the Ussurian tube-nosed bat *Murina ussuriensis*. *Acta Chiropterologica*, 14(1) pp. 93-104.
- Gilmour, L.R.V. (2014) *Modelling, mapping and monitoring bats: Species distribution modelling for Bechstein's bat (Myotis bechsteinii) in Britain and the use of acoustic lure to study bats in woodlands*. MSc thesis. University of Bristol: UK.
- Goiti, U., Aihartza, J., Garin, I. and Salsamendi, E. (2007) Surveying for the rare Bechstein's bat (*Myotis bechsteinii*) in northern Iberian Peninsula by means of an acoustic lure. *Hystrix*, 18(2) pp. 215-223.
- Hill, D.A. and Greenaway, F. (2005) Effectiveness of an acoustic lure for surveying bats in British woodlands. *Mammal Review*, 35(1) pp. 116-122.
- Hill, D.A. and Greenaway, F. (2008) Bats in British woodlands. *British Wildlife*, 19(1) pp. 161-169.

Hill, D.A., Armstrong, K.N. and Barden, P.A. (2014a) Preliminary assessment suggests that acoustic lures can increase capture rates of Australian echolocating bats. *Australian Mammalogy*, 37(1) pp. 104-106. doi 10.1071/AM14019

Hill, D.A., Fukui, D., Agetsuma, N. and Macintosh, A.J.J. (2014b) Influence of trap environment on the effectiveness of an acoustic lure for capturing vespertilionid bats in two temperate forest zones in Japan. *Mammal Study*, 39(4) pp. 229-236.

Law, B., Gonsalves, L., Brassil, T. and Hill, D. (2018) Does thinning homogenous and dense regrowth benefit bats? Radio-tracking, ultrasonic detection and trapping. *Diversity*, 10(2) p. 45. doi.org/10.3390/d10020045

Lintott, P.R., Fuentes-Montemayor, E., Goulson, D. and Park, K.J. (2014) Testing the effectiveness of surveying techniques in determining bat community composition within woodland. *Wildlife Research*, 40(8) pp. 675-684.

Lučan, R.K., Benda, P., Reiter, A. and Zima, J. (2011) Reliability of field determination in three cryptic whiskered bats (*Myotis alcathoe*, *M. mystacinus*, *M. brandtii*) and basic biometric characters: evidence from the Czech Republic. *Vespertilio*, 15 pp. 55–62.

Michaelsen, T.C., Jensen, K.H., and Högstedt, G. (2011) Topography is a limiting distributional factor in the soprano pipistrelle at its latitudinal extreme. *Mammalian Biology-Zeitschrift für Säugetierkunde*, 76(3) pp. 295-301.

Miller, H. (2012) *Bechstein's Bat Survey: Final Report*. London: Bat Conservation Trust.

Murphy, S.E. (2012) *Function of social calls in Brown Long-eared bats Plecotus auritus*. PhD thesis. University of Sussex: UK.

Murphy, S.E., Greenaway, F. and Hill, D.A. (2012) Patterns of habitat use by female brown long-eared bats presage negative impacts of woodland conservation management. *Journal of Zoology*, 288 pp. 177–183.

Napal, M., Garin, I., Goiti, U., Salsamendi, E. and Aihartza, J. (2013) Past deforestation of Mediterranean Europe explains the present distribution of the strict forest dweller *Myotis bechsteinii*. *Forest Ecology and Management*, 293 pp. 161-170.

Schöner, C.R., Schöner, M.G. and Kerth, G. (2010) Similar is not the same: social calls of conspecifics are more effective in attracting wild bats to day roosts than those of other bat species. *Behavioral Ecology and Sociobiology*, 64(12) pp. 2053-2063.

SensComp (2014) Series 600 Instrument Grade Ultrasonic Sensor. Datasheet. [Online] <http://www.senscomp.com/pdfs/series-600-instr-grade-ultrasonic-sensor-spec.pdf>

Zeale, M., Davidson-Watts, I. and Jones, G. (2012) Home range use and habitat selection by barbastelle bats (*Barbastella barbastellus*): implications for conservation. *Journal of Mammalogy*, 93(4) pp. 1110–1118.

[Return to contents page](#)

Sheffield Habitat Suitability Modelling Project: The City's Use By Feeding Bats

Robert Bell; South Yorkshire Bat Group

robert.andrew.bell@gmail.com

Summary

The Sheffield Habitat Suitability Modelling project sought to produce maps of foraging habitat for all bat species resident within the Sheffield City Council boundary, using a presence only modelling technique.

A total of 19 transect routes were covered twice, over the summers of either 2014, 2015 and 2019 to collect species presence records. Habitat suitability models were created which utilised environmental information from presence sites to predict the suitability of unsampled locations for each bat species modelled.

It was possible to create habitat suitability models for six species or species groups. Model performance was broadly comparable with previous academic studies. This study shows a negative association between bats and high road densities and highlights the key importance of Sheffield's wooded river valleys to the area's bats, amongst other findings.

The project outputs are now being used to provide habitat creation and management recommendations, guide bat group projects and input into the planning process.

Introduction

The application of Habitat Suitability Modelling to the study of bats

An individual bat can range over several kilometres in a single night (Mackie and Racey, 2007; Davidson-Watts, 2006) and much further across an annual period (Rivers *et al.*, 2006). Bats have complex social structures and colonies can require large home ranges (Collins, 2016). Individual animals, and to a greater extent bat colonies, exploit habitats at a landscape scale when foraging. For this reason, effective bat conservation relies upon a robust understanding of a species' use of habitats across large areas. Bat surveying of individual sites is often labour intensive, and collection of large robust data sets can be costly and difficult (Collins, 2016). Habitat Suitability Modelling (HSM) comprises a method by which data collected from individual sites can be used to predict likelihood of presence in unsampled locations. As a result, HSM can help provide an understanding of habitat connectivity at the landscape scale (Bellamy *et al.*, 2013b), whilst making efficient use of hard-won presence records.

HSM comprises a statistical technique that predicts the distribution of a species from environmental data and occurrence records (Hirzel and Le Lay, 2008; Bellamy *et al.*, 2013). Models are built which describe the relationship between a species and its environment, giving useful insights into habitat preferences and needs. Use of HSM techniques in academic environments has become widespread over the last 15 years (Hirzel and Le Lay, 2008; Bellamy *et al.*, 2013b).

Presence only modelling

Previous studies undertaken on bat populations in northern England have demonstrated that HSM techniques can result in the generation of statistically robust and easily

interpretable bat species distribution and habitat suitability maps, generated from relatively small sets of presence only data (Bellamy *et al.*, 2013b; Brown, 2013; Bellamy *et al.*, 2012). These studies made use of maximum entropy software (MaxEnt) which employs a machine learning process and runs with freeware graphical or command line interfaces (Phillips *et al.*, 2019). The method requires a set of species presence locations and information on environmental variables across the study area presented in 50 x 50m pixels or ‘cells’. The environmental information is overlaid and the cell values for environmental variables within locations where the bat species is present are compared with a randomly selected set of background cells from which the species has not been recorded (pseudoabsences) (Bellamy *et al.*, 2012). An output layer displaying habitat suitability index values for the target species across the study area is generated by the software. Through the application of threshold suitability values, predicted presence-absence maps can be produced.

The accuracy of HSMs is commonly measured using two approaches. The first approach is to examine the area under the Receiver Operating Characteristic curve (Area Under Curve - AUC) value. The AUC value is a non-parametric index that can be produced without first applying an occupancy threshold rule. The AUC value can be understood as the probability that a randomly chosen presence location will be ranked above a randomly chosen background location in the study area in terms of its suitability for the study species. An AUC value of 0.7 shows that 70% of the time a presence location will rank higher than a randomly chosen background location.

The second approach to measuring HSM model accuracy is to apply a threshold habitat suitability index value to generate a predicted presence-absence map. This enables the examination of the omission rate, which comprises the proportion of known presence locations (from a sample that was not used in the model building process) that fall outside the predicted species distribution. A good model will have a low omission rate. Previous studies have shown that models incorporating fewer environmental variables, known as ‘pruned’ models, generally outperform models which include all available variables, when validated using independent testing data (Parolo *et al.*, 2008; Bellamy *et al.*, 2013b). It has been shown these pruned models do not become overfitted to data that was used to build, or ‘train’ the models, to the same extent as models created using all available layers of environmental information.

The Sheffield HSM Project

To date, all bat HSM projects in England appear to have been undertaken in academic environments. Within northern England, bat HSM studies have taken place in the Lake District National Park (Bellamy *et al.*, 2013b), Yorkshire Dales National Park (with testing using data collected from Nidderdale) (Bellamy *et al.*, 2012; Brown, 2013) and the North Yorkshire Moors and Howardian Hills (Bellamy *et al.*, 2013a). These sites all comprise largely upland areas designated either as National Parks or Areas of Outstanding Natural Beauty (AONBs).

Sheffield comprises a major city with a dense urban centre. It was foreseen that undertaking an HSM project in this setting might bring to light different species-habitat associations when compared to other studies undertaken in more rural settings.

It was apparent to South Yorkshire Bat Group (SYBG) that the undertaking of an HSM project would provide useful insights into the usage of our area by foraging bats, with the maps produced likely to be of real practical conservation value. It was anticipated that foraging area maps could provide a useful input into local planning and conservation decisions, whilst informing future SYBG project proposals. Furthermore, we hoped that participation in an HSM project would provide members with new survey and mapping skills that would better equip us to effectively study bats in our region. As an additional benefit, presence records obtained could be input into our existing bat database, which provides a well-used resource that is drawn upon to inform local planning applications.

This document presents an abridged version of the full Sheffield HSM Project report, which will soon be available on the SYBG website (<https://www.sybatgroup.org.uk/>). This document can also be provided upon request from the author (email address as above).

Methodology

Study area

The study area comprises the 36794ha of land falling within the Sheffield City Council boundary. Sheffield is a large city with an estimated population of 582,506 people in mid-2018 (Office for National Statistics, 2019) and a dense urban centre. Sheffield is situated in a natural basin surrounded by seven hills and within the valleys of the rivers Don, Loxley, Porter Brook, Rivelin and Sheaf. The urban settlement is concentrated mainly in the south east part of the study area, particularly alongside the main rivers where the altitude is the lowest. The western part of the study area has the highest altitude (maximum elevation of 550m) and includes extensive moorland (Figure 1).

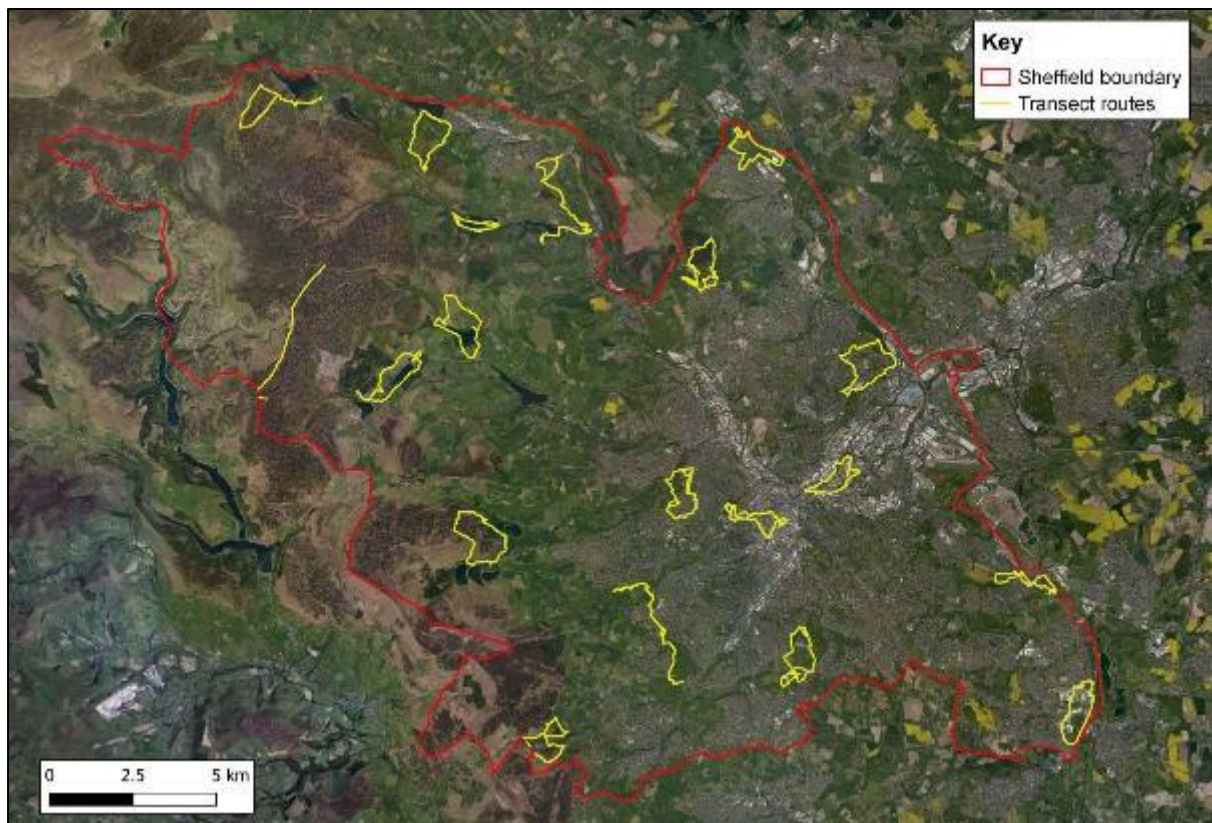


Figure 1: Study area and transect routes.

A total of 36% of Sheffield comprises sites designated for nature conservation, with 25% protected at the European level and roughly one third of the area included in the Peak District National Park (Blackburn, 2018). Sheffield's habitats comprise approximately 25% grassland, 22% upland heathland, wetlands and bogs, 17% buildings or constructed surfaces, 15% woodland and shrub cover, 15% gardens and landscaped areas, 4% cultivated land, and 2% open water (Ersoy, 2017).

Species data

During the summers of 2014, 2015 and 2019 nineteen transect routes were surveyed on two occasions. Eighteen transect routes were walked, with a single water based transect completed. Routes of 3-5.5km commenced 45 mins after sunset and were covered at an even pace for approximately 1.5-2 hours. A Pettersson d500x Mk1 full-spectrum ultrasound recording unit (Pettersson Elektronik, 2019) was used to record bat passes with a Global Positioning System used to log position. Routes completed during 2014 and 2015 (see Figure 1) were chosen from a 5 x 5km grid overlaid on the study area. Routes selected in 2019 were chosen following initial modelling attempts, which had shown that some environmental parameters had been poorly sampled during the 2014/2015 recording period. Transect routes were completed in reverse during survey repeats, with all routes sampled once in May-June and again in July-August during the same sampling year. All surveys were undertaken during suitable weather conditions (Collins, 2016).

All bat echolocation calls recorded were manually examined to check call quality, with low quality calls rejected. Species identifications from recorded echolocation calls were identified with reference to the automated species identification systems Bat Classify (Scott, 2018) and Kaleidoscope Pro (Wildlife Acoustics, 2019). All non *Pipistrellus* sound files were also subject to manual identification according to the method prescribed by Barataud (2015). Results from the three analysis methods were compared and where they disagreed, the majority identification (i.e. two out of the three methods) was typically adopted. This process was undertaken by a single individual (Robert Bell).

Environmental data

The environmental information was produced in ArcGIS (ESRI, 2011) using habitat mapping produced by Dr Ebru Ersoy as part of her PhD thesis (Ersoy, 2017). Dr Ersoy made use of various geographical information sources including Ordnance Survey MasterMap and the Centre for Ecology and Hydrology's Land Cover Map 2007, to produce very fine scale (2m raster) habitat mapping for the study area (Ersoy, 2017).

Environmental variables used during model construction were selected as they comprised final environmental variables retained in one or more of the pruned models created by the Lake District HSM study (Bellamy *et al.*, 2013b). Further information on environmental variables available to this study is detailed in the full project report.

MaxEnt modelling

Species specific HSMs were completed in MaxEnt 3.3.3k (Phillips *et al.*, 2019). These models were created for the bat species: common pipistrelle *Pipistrellus pipistrellus*, soprano pipistrelle *P. pygmaeus*, noctule *Nyctalus noctula*, Leisler's bat *N. leisleri*, Daubenton's bat

Myotis daubentonii, and the species group whiskered/Brandt's bat *M. mystacinus/brandtii*. Although present within the survey area, it was not possible to create HSMs for brown long-eared bat *Plecotus auritus* and Natterer's bat *M. nattereri* due to a lack of presence records. No other bat species have been confirmed from Sheffield, although it is suspected Nathusius's pipistrelle *P. nathusii* may be present at certain times of the year.

Bat species presence data was partitioned into five roughly equal-sized groups (folds), with all data from a single transect route included in the same fold. Data partitioning occurred after species presence points had been reduced, to allow a maximum of one presence point per species per 50 x 50m cell. HSMs were created using cross-validation at all stages of model training. This process uses all of the species data during model training, making better use of small data sets. During the cross-validation process, four of the data groups are used for model training with the fifth used for model testing. A mask was used to force Maxent to calibrate models with data from locations along each transect route or from land included within a 100m buffer.

All environmental variables were included in the initial model for each bat species however the number of layers was reduced down or 'pruned'. No further information on the pruning process is described here, however this is presented in the full project report.

Creation of presence-absence maps and model validation

Two threshold rules were applied to create binary presence-absence maps from the final pruned HSM models for each species. The Minimum Training Presence (MTP) threshold uses the lowest predicted HSI value for a known presence record used in the training process. Consequently, this approach results in a training omission rate of zero. The tenth percentile rule discards the lowest 10% of predicted Habitat Suitability Index (HSI) values at training locations, with the result that 10% of training locations fall outside the predicted presence area (Bellamy *et al.*, 2013b).

The performance of the final HSM for each species or species group was examined by looking at Test AUC and the average omission rate of test presence points, against both the MTP and tenth percentile presence-absence models. A binomial test was then applied using online software (Soper, 2020).

Limitations

Four key limitations to the process used were noted, these are detailed briefly below:

1. Full habitat mapping was not available for the western corner of the study area. This totals less than 1.5% of the full area.
2. For bat HSM projects it is recommended that transects are spaced by more than 3,000m (Bellamy *et al.*, 2013b) to reduce the chance of sampling the same individuals bats on more than one route. Given the relatively small size of the study area used by this project, the separation of transect routes was less than ideal. Nevertheless, separate folds of presence point data were separated by a minimum of 1,000m for all species.
3. It was not possible to create HSMs for brown long-eared bat and Natterer's bat due to a lack of presence records. Both species emerge late and have quite quiet

echolocation calls. Both Natterer's bat and brown long-eared bat are known to make extensive use of woodland (Swift, 1998; Altringham, 2003) during foraging and the lack of models for these species may result in combined species models (both HSI and presence-absence) generated by the Sheffield HSM project undervaluing the importance of woodlands to bats.

4. The HSMs for noctule (15 presence points) and to a lesser extent also Leisler's bat (31 presence points) are likely to be less robust than for the other species or species groups due to the lower number of presence records.

Results

Species data

Bats were recorded from all 19 transect routes and on 37 of 38 individual transect repeats. By far the most frequently recorded species comprised common pipistrelle, followed by whiskered/Brandt's bat, soprano pipistrelle, Daubenton's bat, Leisler's bat, noctule and Natterer's bat (Table 1).

Table 1: Number of records by species, once duplicate presence records per 50 x 50m cell were removed.

Species	Presence points (unique to single 50 x 50m cell)	Transect repeats from which species recorded (%)
Common pipistrelle	848	100
Whiskered/Brandt's bat	81	68
Soprano pipistrelle	57	58
Daubenton's bat	55	53
Leisler's bat	31	32
Noctule	15	42
Natterer's bat	4	3

Model performance

The performance of the final model for each species was calculated using AUC and omission rates (Table 2). The noctule and Daubenton's bat models explained the highest proportion of test sample AUC, with values of 0.82. This shows that in both cases 82% of the time, a presence location within the testing data will rank higher than a randomly chosen background location. The common pipistrelle model performs worst on this measure, with a test AUC value of 0.59. Binomial tests performed on test omission rates, after application of the tenth percentile rule, revealed models for whiskered/Brandt's bat, soprano pipistrelle, Daubenton's bat and noctule performed significantly better than random ($P < 0.001$ for whiskered/Brandt's bat and soprano pipistrelle, $P < 0.01$ for Daubenton's bat and $P < 0.05$ for noctule). Test omission rates for the common pipistrelle and Leisler's bat models were approaching significance but did not exceed the required threshold.

Table 2: Performance of final species models. # average number of test data per fold, ^x range of test AUC scores from replicate runs using different data folds during cross-validation process, * P<0.05, ** P<0.01, ***P<0.001.

Species	Test Data #	Test AUC	Test AUC Range ^x	Percent Suitable Area (MTP)	Percent Suitable Area (10th percentile)	Omission Rate (MTP) (%)	Omission Rate (10th percentile) (%)
Common pipistrelle	169	0.59	0.55-0.62	99.9	82.7	3.4	17.7
Whiskered/Brandt's bat	16	0.717	0.64-0.80	90.4	31.5	0	14.4***
Soprano pipistrelle	11	0.78	0.71-0.92	42.1	12.7	9**	30.6***
Daubenton's bat	5	0.82	0.66-0.90	17.8	4.9	15*	46.8**
Leisler's bat	7	0.75	0.53-0.96	64.9	39.5	22	34.5
Noctule	3	0.82	0.64-0.96	44.7	8.0	12.50	37.5*

Variable composition and contribution

The final model for each species contained either two or three layers of environmental information. All models contained one environmental layer relating to either water or woodland. Of the six models, five contained an environmental layer relating to woodland, four contained an environmental layer relating to water and three contained an environmental layer relating to road cover. A single model also retained the slope layer.

Figures 2-4 show the habitat suitability indices map, presence/absence maps and environmental variable response curves for a subset of bat species modelled. For reasons of space, only a single species from the *Pipistrellus*, *Myotis* and *Nyctalus* genera has been included in this document (further species are included in the full report). The combined HSIs and presence/absence maps for all six modelled species/species groups are presented in Figure 5.

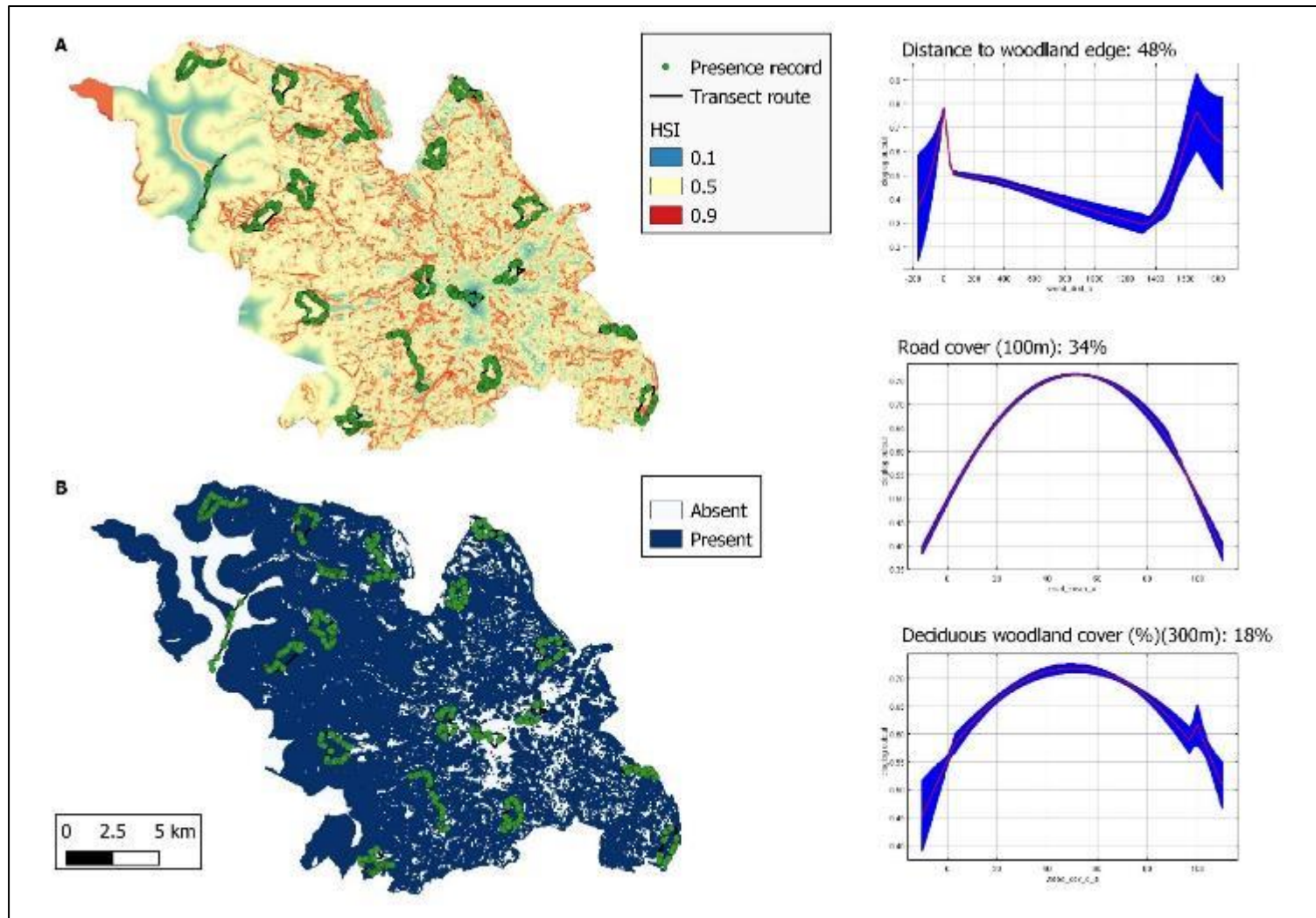


Figure 2: Common pipistrelle model outputs. Continuous habitat suitability indices values are shown in A, with presence/absence (using tenth percentile threshold) in B. The permutation importance of each environmental variable included in the final model is shown alongside the marginal response curve.

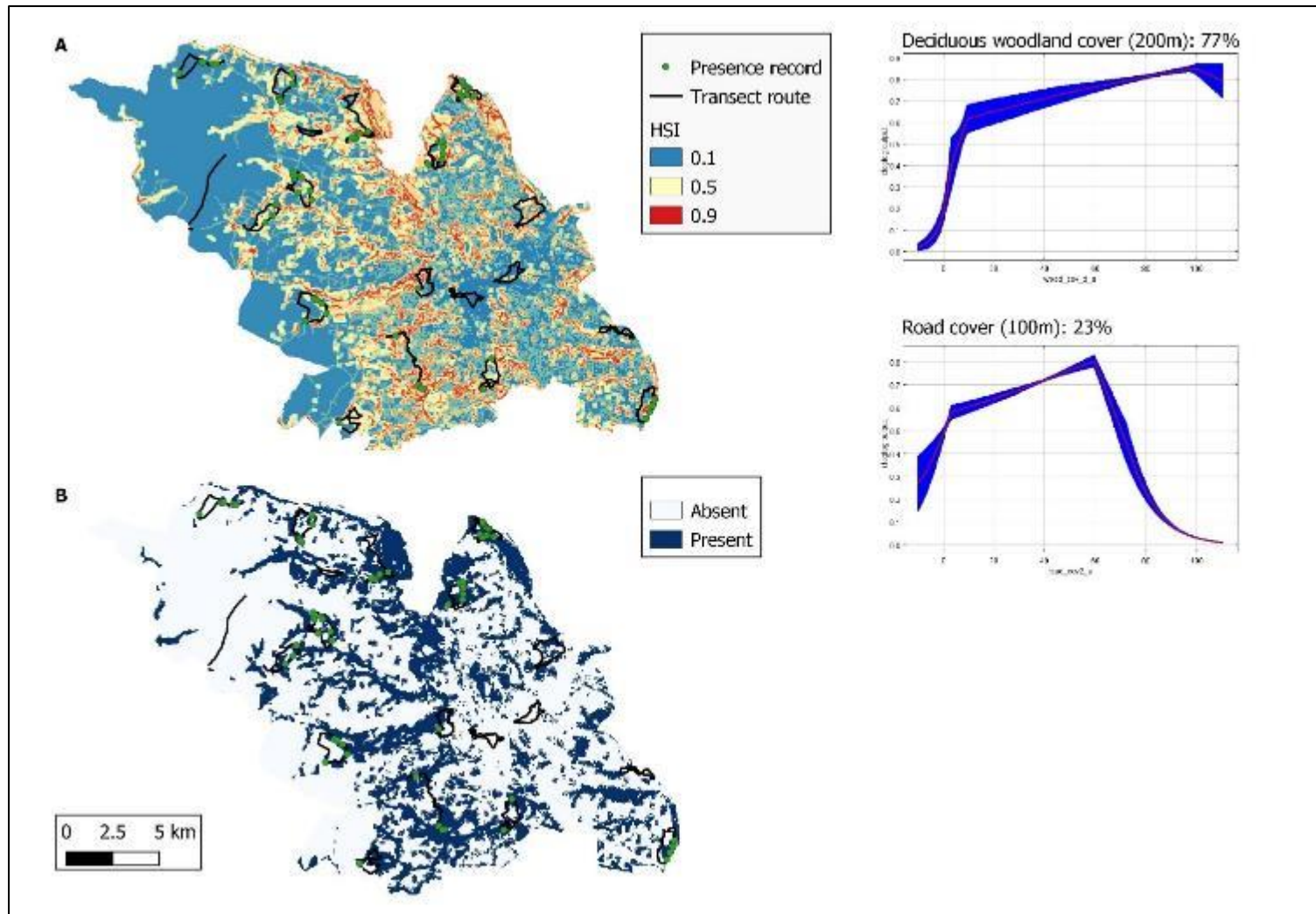


Figure 3: Whiskered/Brandt's bat model outputs. Continuous habitat suitability indices values are shown in A, with presence/absence (using tenth percentile threshold) in B. The permutation importance of each environmental variable included in the final model is shown alongside the marginal response curve.

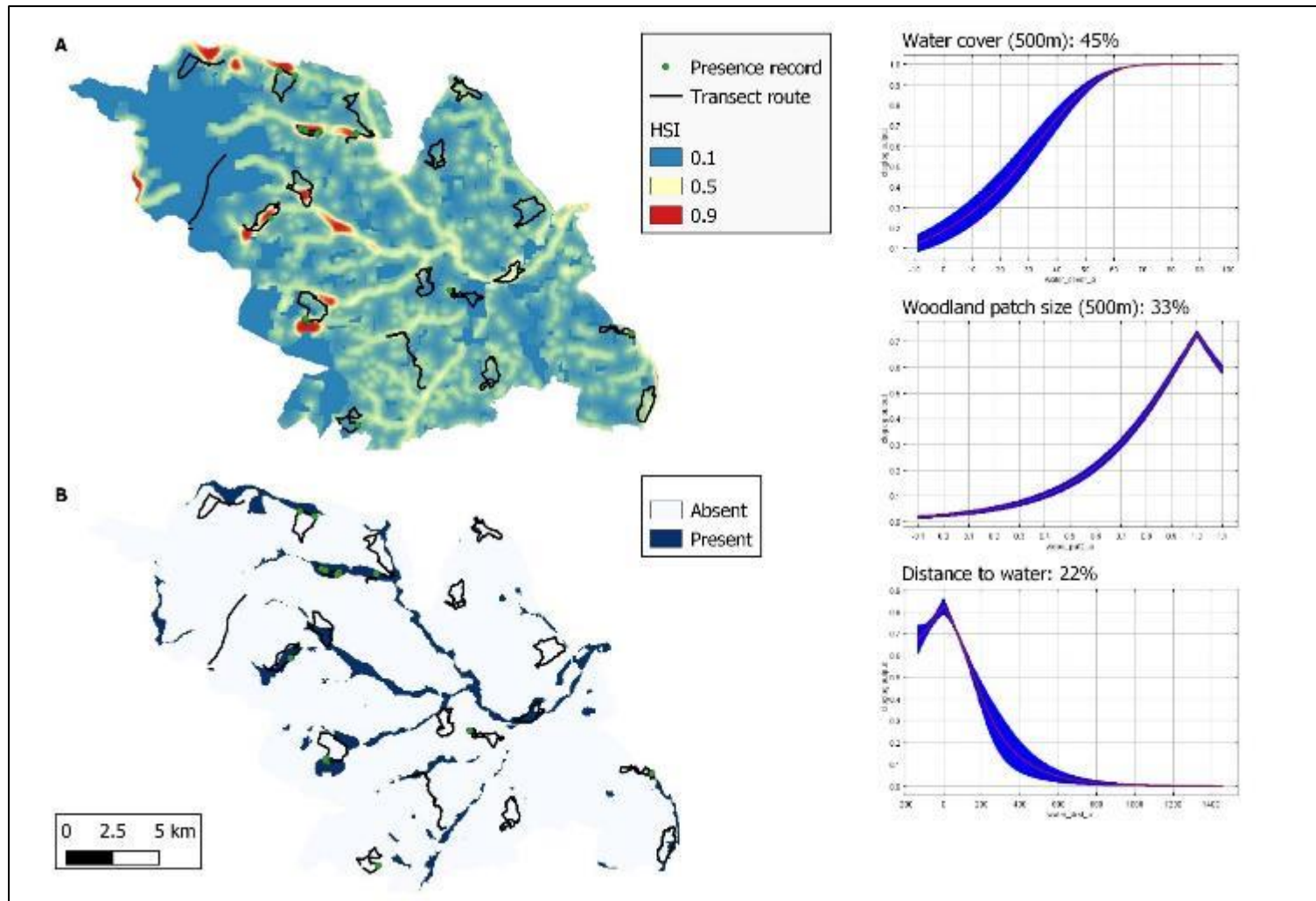


Figure 4: Noctule model outputs. Continuous habitat suitability indices values are shown in A, with presence/absence (using tenth percentile threshold) in B. The permutation importance of each environmental variable included in the final model is shown alongside the marginal response curve.

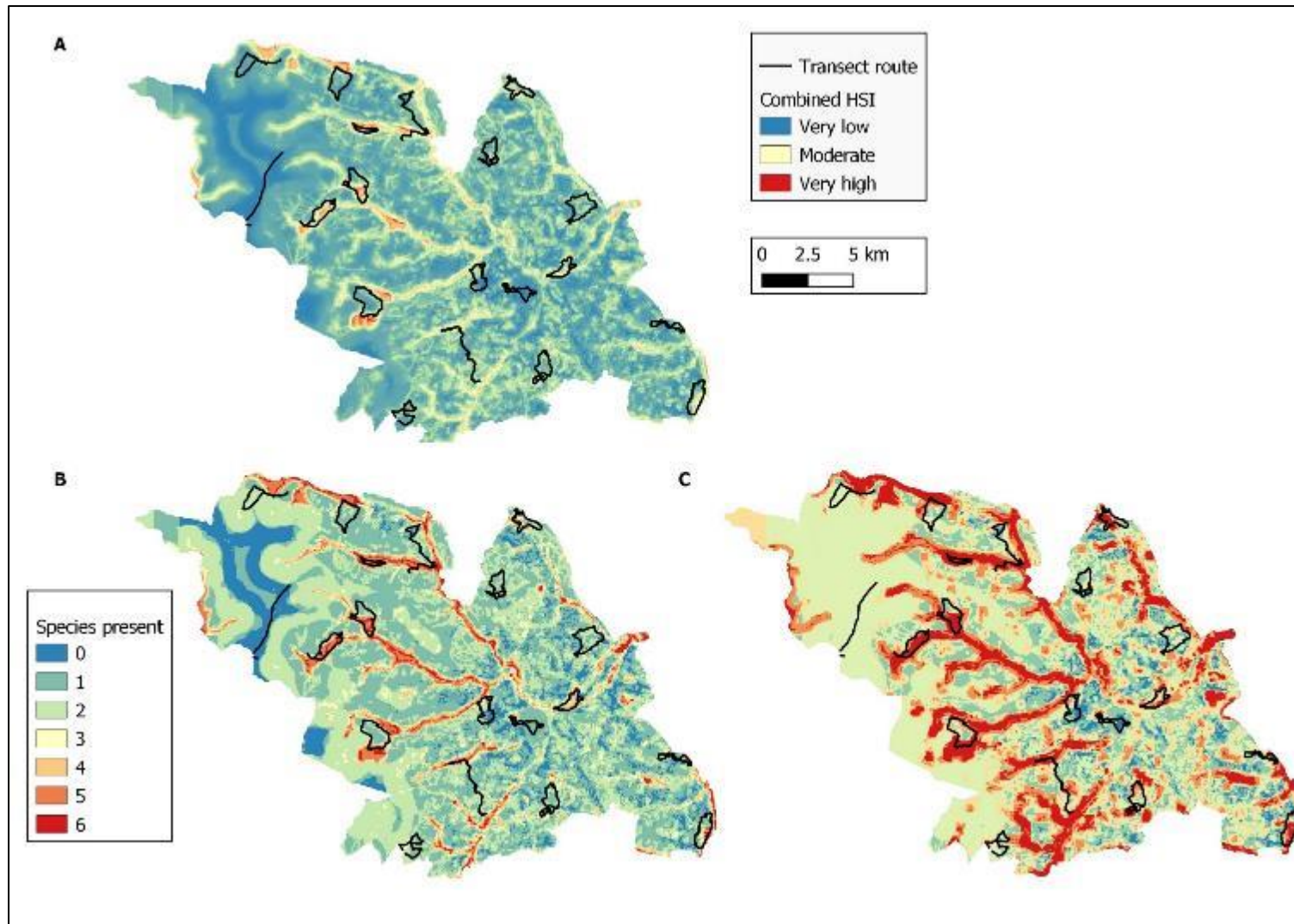


Figure 5: Combined model outputs. Continuous habitat suitability indices values are shown in A, with presence/absence (using tenth percentile threshold) in B and presence/absence (using MTP threshold) in C.

Discussion

Comparisons with other similar studies in northern England

Number of transects and presence records

The number of species presence records used in creation of the Sheffield HSM project's models was generally much lower than used to inform HSM production in the Lake District (Bellamy *et al.*, 2013b), somewhat lower than was used in the North Yorkshire Moors and Howardian Hill study (Bellamy *et al.*, 2013a) but higher than used in the Yorkshire Dales study (Brown, 2013; Bellamy *et al.*, 2012) (Table 3).

Table 3: Number of species records (unique to single cell) used in model training by different HSM studies in Northern England. *assumed all *Nyctalus* call noctule, + *Nyctalus* calls not identified to species.

Study area	Species							
	Common pipistrelle	Soprano pipistrelle	Whiskered/Brandt's bat	Daubenton's bat	Natterer's bat	Noctule	Leisler's bat	Brown long-eared bat
Lake District National Park	769	595	124	91	44	103*		47
North Yorkshire Moors and Howardian Hills	490	82	151	157	47	14+		9
Yorkshire Dales National Park	120	30	55	20	3	14+		0
Sheffield HSM Project	848	57	81	55	4	15	34	0

Model performance

Test AUC values for species models created in Sheffield were broadly comparable with the other three studies. The exception is common pipistrelle, for which the Sheffield model has a relatively poor test AUC value. It is considered the low test AUC value recorded for the common pipistrelle in Sheffield mainly results from a high predicted area of presence for this species, with the overwhelming majority of the study area shown to be suitable for use by common pipistrelle. This is likely to be an accurate finding, with the Sheffield study area less hilly and less remote than the other locations for which HSMs have been built in northern England.

Apparent differences in species abundance and distribution

The ratio of common to soprano pipistrelle in the Sheffield study (15:1) was far higher than for the other three study areas. In comparison, common and soprano pipistrelles were recorded in almost equal proportions in the Lake District (Bellamy *et al.*, 2013b).

When all *Nyctalus* records are combined, this genus was recorded more regularly in Sheffield than in the other three study areas. In common with the Yorkshire Dales National Park study, the number of Natterer's bat records was very low. Brown long-eared bat were recorded in either low numbers or never by most of the studies, with the exception of the Lake District study.

Within the Sheffield study, final models produced for *Pipistrellus* species and Daubenton's bat retained a similar range of environmental layers to models produced for these species in the Lake District and Yorkshire Dales. In contrast, the Sheffield study highlights the importance of water cover to both noctule and Leisler's bat, with water layers not retained in final models for *Nyctalus* bats in these other two locations, although distance from water was retained in the *Nyctalus* model built for the North Yorkshire Moors. The Sheffield study was the first of the four bat HSM studies undertaken in northern England to build a model for Leisler's bat.

Bats and roads

The Sheffield study has demonstrated an association between road cover and the presence of foraging common pipistrelle, soprano pipistrelle and whiskered/Brandt's bat. Previous studies have shown a positive relationship between road cover and common pipistrelle presence, however, the Sheffield study alone shows that whilst suitability of an area for common pipistrelle, soprano pipistrelle and whiskered/Brandt's bat appears to increase with low to moderate road cover, high levels of cover are associated with low suitability. This decline is abrupt in the case of soprano pipistrelle and whiskered/Brandt's bat. This is the first of this group of four HSM studies to show a negative link between high levels of urbanisation and presence of these species. The apparently positive link between low to moderate levels of road cover and suitability of an area may be explained by the presence of woodland edge habitats and hedges next to roads. Such habitats are used as both commuting routes and foraging areas, however this association may also be linked to Sheffield's historic development as a city with very low levels of road coverage mainly associated with the western moorlands, whilst roads align with most, if not all, major river valleys.

Insights into the use of Sheffield by bats

The key role of wooded river valleys

The cumulative species models (Figure 5) shows the key importance of Sheffield's network of rivers, streams, reservoirs and ponds to foraging bats. These areas are of particular value when bordered by woodland or treelines, with woodland apparently the second most important habitat type to foraging bats. The absence of models for Natterer's bat and brown long-eared bat, both often associated with woodland, may serve to downplay the true value of Sheffield's woodlands to bats within the combined species maps. In many parts of Sheffield water and woodland are found together within 'fingers' of woodland which border the rivers Don, Loxley, Porter Brook, Rivelin and Sheaf, together with many smaller streams such as the Ewden Beck, Shire Brook and Blackburn Brook. These wooded river valleys comprise Sheffield's bat hotspots.

Observations on bat species abundance and distributions in Sheffield

Common pipistrelle was by far the most frequently recorded bat species in this study. This species was recorded from all transect routes, ranging from the high moorland (up to 530m) through to several locations within the inner ring road. Within the city centre, common pipistrelle bat were recorded feeding in a range of locations where trees or other semi-natural vegetation was present.

The next most frequently recorded species or species group comprised whiskered/Brandt's bat. This species group was widespread across the study area and heavily associated with the presence of broadleaved woodland, although areas supporting high road densities tended to be avoided.

Soprano pipistrelle comprised the third most frequently recorded species, however the likelihood of presence was strongly linked to the areas with water cover. Near to standing and flowing water, this species is more likely to be encountered close to the woodland edge and away from areas with a high road density. Unlike common pipistrelle this species was not recorded feeding over moorland or within the city centre. Due to its strong association with water, soprano pipistrelle showed a much smaller predicted foraging area than either common pipistrelle or whiskered/Brandt's bat.

Daubenton's bat comprised the fourth most frequently recorded species, found on just over 50% of transect routes. As with soprano pipistrelle, the distribution of foraging Daubenton's bat was very closely aligned to the presence of water, with this species rarely encountered far from the water's edge. The Daubenton's bat model shows flatter areas supporting calmer waters are preferred. Due to its narrow habitat requirements, Daubenton's bat appears to have the most restricted foraging range of any species modelled in this study.

Some level of water cover in the local area was strongly associated with the presence of both noctule and Leisler's bat, with both species more likely to be recorded near the water's edge. Both species models retained a single woodland variable. The positive association between noctule and larger woodland patch size was predictable, however the relationship between Leisler's bat and woodland edge density was more complex, with suitability peaking in areas with a low to moderate woodland edge density. The apparent relationship between Leisler's bat and woodland edge density may be a result of numerous records for this species being collected from both the moorland fringe and within more central parts of the city, both of which display a low to moderate woodland edge density. It is considered unlikely this comprises a causal relationship and it may instead reflect a patchy local distribution or an anomaly that would be smoothed were more survey repeats undertaken. The survey results do however suggest that Leisler's bat may make more extensive use of Sheffield city centre than noctule when foraging. The models also suggest Leisler's bat has a larger foraging range than noctule in the study area.

None of the bat species modelled were wholly restricted to low elevations with all species recorded either at, or above, 350m in elevation.

Opportunities to input into conservation

Informing habitat creation and management

It is intended that the maps produced will highlight opportunities to increase bat habitat connectivity and habitat quality in the study area. Where areas of low habitat suitability connect higher quality areas, these locations could be considered for planting of new broadleaved woodland or tree lines. Similarly, habitats within higher suitability areas could be enhanced through steps such as the replacement of conifer plantation with broadleaf woodland, a measure likely to benefit whiskered/Brandt's bat, the planting of riparian woodlands next to rivers, or the creation of new ponds. The Heritage Lottery Funded Sheffield Lakeland Landscape Partnership project is already making use of this project's maps to inform habitat alteration and management proposals for their project area in northwest Sheffield. SYBG will explore other additional opportunities to engage with landowners and land managers to promote the HSM project's maps as a tool to inform future habitat creation and management. It is the Bat Group's intention to make the HSM maps available as a free resource to any organisation that wishes to use them to the benefit of nature conservation.

Inputting into the planning process

The outputs of the HSM project have already been used to provide and inform Bat Group comments on three residential housing planning applications for sites located adjacent to water courses, where the schemes have potential to impact these key connective habitats. It is hoped that Sheffield City Council will explore the potential for the species' habitat suitability maps to inform local planning policy, perhaps informing new non-statutory site designations, or as a basis for a new bat survey trigger system. With the current requirement to provide ecological net gain within the planning applications often likely to trigger in the need for biodiversity offsetting, it is considered that habitat suitability maps may be used to help identify suitable offsetting locations. Finally, Sheffield City Council may consider habitat suitability maps when planning new large-scale public sector schemes, such as flood management programs, changes to the street lighting regime and tree management proposals.

Bat Group projects

The whiskered/Brandt's bat model has been consulted when identifying new trapping locations for SYBG's small *Myotis* project. The Bat Group also intends to consult the habitat suitability maps when planning future bat box schemes and bat walks.

Acknowledgements

This project could not have been completed without the help and assistance of many people. The members of South Yorkshire Bat Group contributed their time and energy to help complete the 38 transects with initial transect plans drawn up by Mark Parnell. The entirety of the environmental layer preparation process was completed by Andrew Geiger and Paul Liptrot as part of the Heritage Lottery Funded Sheffield State of Nature project, but this would not have been possible had Dr Ebru Ersoy not agreed to share her mapping. Former staff and students from Leeds University have given their time to help explain and assist with the HSM process, including Dr Chloe Bellamy, Dr Anna Berthinussen and Professor John Altringham, with Eloise Brown particularly generous. The project could not

have started without the purchase of a Pettersson d500x which was made far easier as a result of a generous discount agreed by Lars Pettersson. Daniel Whitby also kindly loaned a second Pettersson unit to the project during the first survey season. Final thanks go to Eloise Brown, Greg Slack and Julie Riley for taking the time to review this report and British Island Bats for publishing this article.

References

Altringham, J. (2003) *British Bats*. London: Collins.

Barataud, M. (2015) *Acoustic Ecology of European Bats Species Identification, Study of their Habitats and Foraging Behaviour*. Meze: Biotope.

Bellamy, C., Glover, A., Grubb, E. and Altringham, J. (2013a) *Bat foraging habitat suitability maps for the North York Moors National Park*. Leeds: University of Leeds.

Bellamy, C., Scott, C. and Altringham, J. (2013b) Multiscale, presence-only habitat suitability models: fine-resolution maps for eight bat species. *Journal of Applied Ecology*, 50(4) pp. 892-901.

Bellamy, C., Torsney, A., Brown, E., Glover, A. and Altringham, J. (2012) *Bat foraging habitat suitability maps for the Yorkshire Dales National Park. Habitat Suitability Modelling report, Part II December 2012*. Leeds: University of Leeds.

Blackburn, S. (2018) *Sheffield State of Nature Report*. Sheffield: Sheffield & Rotherham Wildlife Trust.

Brown, E. (2013) *Multiscale habitat suitability models for bat in the Yorkshire Dales. Are site-specific models more accurate than those transferred from other geographic regions?* Leeds: University of Leeds.

Collins, J. (ed.) (2016) *Bat Surveys for Professional Ecologists: Good Practice Guidelines* (3rd edn.). London: Bat Conservation Trust.

Davidson-Watts, I. (2006) Differences in foraging behaviour between *Pipistrellus pipistrellus* (Schreber, 1774) and *Pipistrellus pygmaeus* (Leach, 1825). *Journal of Zoology*, Volume 268 pp. 55-62.

Ersoy, E. (2017) *An Integrated Approach to Enhancing Ecological Connectivity in Urban Areas: a case study of Sheffield, UK*. Sheffield: The University of Sheffield.

ESRI (2011) ArcGIS Desktop: Release 10. Redlands, CA: Environmental Systems Research.

Hirzel, A. and Le Lay, G. (2008) Habitat suitability modelling and niche theory. *Journal of Applied Ecology*, 45 pp. 1372-1381.

Mackie, I. and Racey, P. (2007) Habitat use varies with reproductive state in noctule bats (*Nyctalus noctula*): Implications for conservation. *Biological Conservation*, 140(1-2) pp. 70-77.

Office for National Statistics (2019) *Population Estimates for UK, England and Wales, Scotland and Northern Ireland, Mid-2018*. [Online] Available at: <https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/populationestimatesforukenglandandwalesscotlandandnorthernireland> [Accessed 29th April 2020].

Parolo, G., Rossi, G. and Ferrarini, A. (2008) Toward improved species niche modelling: *Arnica montana* in the Alps as a case study. *Journal of Applied Ecology*, 45 pp. 1410-1418.

Pettersson Elektronik (2019) Pettersson d500x. <https://batsound.com/product/d500x-ultrasound-detector-recorder/>

Phillips, S. J., Dudik, M. and Schapire, R. E. (2019) Maxent software for modelling species niches and distributions (Version 3.4.1).

Rivers, N., Butlin, R. and Altringham, J. (2006) Autumn swarming behaviour of Natterer's bats in the UK: Population size, catchment area and dispersal. *Biological Conservation*, 127 pp. 215-226.

Soper, D. (2020) Binomial Probability Calculator. [Online] Available at: <https://www.danielsoper.com/statcalc/calculator.aspx?id=71>

Swift, S. (1998) *Long-eared bats*. London: Polyser Natural History.

Wildlife Acoustics (2019) Kaleidoscope Pro Analysis Software. <https://www.wildlifeacoustics.com/products/kaleidoscope-pro>.

[Return to contents page](#)

What's sufficient for statics? - How much static detector data is enough?

Greg Slack and Matthew Whittle

Greg.Slack@Jacobs.com; Matthew.Whittle@Jacobs.com

Introduction

The collection of multiple nights of acoustic bat detector data using automated static bat detectors is now standard practice for professional bat surveys used to inform development projects (Collins, 2016).

Generally, the first objective of static a bat detector survey is to identify a list of bat species or guilds¹ using the area. The secondary objectives are usually to attempt to quantify the level of activity at one location, identify seasonal change, and/or determine how this activity level relates to that recorded elsewhere. For many years it has been widely recognised that the level of survey effort should be proportional to the likely impact (Collins, 2016; Hundt, 2012).

The Bat Conservation Trust (BCT) guidelines (Collins, 2016) recommends five consecutive nights of survey² in spring, summer and autumn for sites with habitats considered to be of low suitability for bats, increasing to monthly five-night survey blocks² between April and October for sites with moderate or high suitability. The guidance suggests that these surveys should be completed during nights with appropriate weather conditions. It defines parameters for nights of optimal weather as: sunset temperature of 10°C or above, no rain, or strong wind.

The link between bat activity and environmental parameters is clearly established (Salvarina *et al.*, 2018; Berkova and Zukal, 2010; Dechmann *et al.*, 2017; Geipel *et al.*, 2019). Restricting emergence and re-entry surveys to optimal weather makes sense when attempting to establish the presence, or size of a roost. However, to do so for static bat detector surveys builds in bias by assuming that all compared locations are subject to the same weather conditions.³ It also assumes that bats don't favour certain areas/habitats in suboptimal weather. Habitats which may receive relatively low levels of use in good weather could provide a key foraging resource in less optimal conditions. Studies have shown that the highest levels of common pipistrelle *Pipistrellus pipistrellus* activity can occur in suboptimal conditions (Cooke, 2019; Matthews *et al.*, 2016). In order to truly understand a sites value, a robust baseline must be generated in which the use of a site by bats under 'normal conditions' is identified.

Although the survey guidance (Collins, 2016) is well accepted, there is relatively little research which demonstrates that the recommended level of survey is sufficient to robustly meet the survey objectives. Three pertinent studies that were found are discussed below.

¹ In this context the term guild is used to represent a group of species which may not necessarily comprise a single genus (Denzinger and Schnitzler, 2013).

² In appropriate weather conditions.

³ Although common weather conditions are likely to be recorded across a small site, this may not be the case for larger developments, particularly for linear infrastructure projects.

Hayes (1997) identified that just three nights of data were required to consistently identify⁴ the level of activity to within 50% of the mean. This increased to seven nights of data for an accuracy of within 30% of the mean. Consistently achieving an accuracy within 10% of the mean wasn't possible using the dataset and the maximum number of nights sampled (n=12).

Broders (2003) identified that a minimum of eight to 20 nights were required to consistently identify (probability of 0.9) a level of activity within 50% of the mean for each site, to consistently achieve an accuracy within 30% of the mean required a sample size of at least 20 nights for all locations.

Matthews *et. al.* (2016) showed that between 13 and 16 nights of data were required to consistently identify a peak level of bat activity within 10% of the maximum for all nights.⁵ In that example 138 ground-level locations were monitored for a total of 1,367 detector nights.

Mathews *et. al.* (2016) also tested the level of static detector survey effort required to identify species presence. The study identified that between one and 10 nights of ground level monitoring were required to reliably identify the presence of the range of UK species studied.

The data collected for our study was initially designed to identify the impact of weather on the level of bat activity across a year at one location. The primary study of the data identified that month, year and sunset temperature were the best predictors of common pipistrelle activity over the whole study (Cooke, 2019). Minimum overnight temperature was defined as the most important predictor within any one month (Cooke, 2019).

Here we have attempted to quantify the minimum sample size required to identify the normal level of activity for the site during the monitoring period, rather than for a subset of nights with specific weather conditions. Our study aimed to achieve similar levels of accuracy as those reported in Matthews *et. al.* (2016), Broders (2003) and Hayes (1997).

This study also considered whether the mean or the median was the best statistic to describe the normal level of activity, and whether this was best achieved for all data combined, or on a stratified basis. The peak activity level was discounted as a representative metric as, it was considered likely to represent an outlier within the data, rather than being representative of the level of activity at the location. For studies where low levels of activity could be expected, or where 'worst case' scenarios require consideration, the peak level of activity could be the most appropriate statistic to consider.

Data collection

Data for this study were collected as part of an acoustic monitoring project at one site in South Yorkshire, England (OS grid reference SK254989). The study site was a garden on the northeast

⁴ From here on, unless otherwise stated, a 'consistent result', 'consistently achieving an accuracy', or a result that was 'consistently identified' is taken to mean a result with a probability of 0.8 or greater.

⁵ In appropriate weather conditions.

edge of Stocksbridge, South Yorkshire. Other gardens and a grazed field were separated from the study site by hedgerows and fencing. Small woodland blocks and Underbank reservoir were present within 300m. Monitoring was undertaken from March 2017 until May 2018 inclusive.

The sound files were collected using a Song Meter SM2BAT+. Initially, from March 2017 to November 2017, an SMX-US microphone was used. The microphone was tested every three to four months using the methodology provided by the manufacturer.⁶

During the November test the microphone sensitivity was identified as below the manufacturer's recommended threshold. This required the 140 nights of data collected between 31st July 2017 and 19th December 2017 to be discarded. From December 2017 to May 2018 the microphone was swapped for an SMX-U1 microphone. The SMX-U1 microphone was introduced to the market as an upgrade to the SMX-US model with superior frequency response.⁷ The potential for increased variation in nightly counts as a result of using different microphones is acknowledged. Where applicable this is discussed in the context of the results recorded. Equipment or battery failure also resulted in a total of 34 nights of incomplete recording across 16 separate instances. These nights were also excluded from the analysed dataset. The total number of nights with recordings was 268.

Kaleidoscope Analysis Software (Wildlife Acoustics, 2019) was used to scan raw data files and extract all call sequences of up to 15 seconds, files which contained bat calls (hereon referred to as a 'registration'). The parameters used in Kaleidoscope to extract the files were: signal range 8-120 kHz, pulse length 2-500ms, maximum inter-syllable gap 500ms, minimum number of pulses 2. The registrations were then converted to Zero Crossing Analysis (ZCA) and Waveform Audio File Format (WAV) files so that each file could be viewed, determined, and labelled in Analook. BatSound (Pettersson Elektronik, 2019) was utilised to analyse the full spectrum registration in cases where the files were more difficult to identify.

Registrations were identified to species for common pipistrelle, soprano pipistrelle *P. pygmaeus* and brown long-eared bat *Plecotus auritus* and genus for *Myotis* and *Nyctalus*. The number of registrations of each species group per night was used as the measure of nightly bat activity.

Analysis

R version 3.6.0 (R Core Team, 2019) was used for statistical analysis of data. The Monte Carlo approach described in Broders (2003) was used to determine the minimum number of nights required to accurately characterise the bat activity at the site. The mean number of registrations per night for all data was used as the site level measure of bat activity (defined as the population mean: μ). Data were randomly sampled 1,000 times for between two and 20 nights (at intervals of two). Within each sample, the mean number of calls per night was

⁶ <https://www.wildcare.co.uk/media/wysiwyg/pdfs/Ultrasonic-Calibrator-20150805.pdf>

⁷ Specifically the SMX-U1 was identified as having a flatter frequency response and higher sensitivity at frequencies above 60kHz.

calculated as the sample's measure of bat activity (defined as the sample mean: $\bar{x}$). This resulted in 1,000 estimates of bat activity for each sample size.

The accuracy of the sample mean was calculated as below, expressed in terms of the absolute percentage error of the sample mean.

$$|\%Error| = \left| \left(1 - \frac{\bar{x} + 1}{\mu + 1} \right) \right| \times 100$$

The calculation incorporates a constant of one applied to the sample mean and population mean. This facilitates the comparison of zero means without resulting in indeterminate values.

Broders (2003) define three accuracy thresholds of: $\leq 10\%$, 30% , and 50% error (accuracy criteria). The proportion of each 1,000 sample subset meeting these criteria was calculated to determine the probability of acquiring an accurate sample mean at each sample size. Matthews *et al.* (2016) define a probability of 0.8 (80% of samples) as an acceptable level of confidence in the accuracy of a sample.

For species where an accuracy of $\leq 30\%$ error with a probability of ≥ 0.8 was achieved, no further analysis was completed. For all other guilds the effect of seasonality was investigated with subsequent consideration of the effect of sample size and the use of the median, rather than the mean as the most appropriate metric to compare.

To determine if seasonality had an effect on the level of survey effort required, the above process was completed separately for each season in which data was collected (winter, spring and summer⁸). This resulted in sample sizes of 72 nights in winter, 154 nights in spring and 29 nights in summer. The samples were then compared with the seasonal mean activity level to determine the probability of acquiring an accurate sample mean at each sample size for each season.

The sample size is notably lower for summer ($n=29$) than the other seasons monitored. To account for the differing sample sizes between seasons, the method was repeated by drawing samples from a restricted subset of 29 nights per season.

The effect of sample size on the spring subset of data was then considered. The process was repeated for the 154 spring nights with the exception that data were randomly sampled 1,000 times for between five and 50 nights (at intervals of five).

Due to the natural limit, and prevalence, of zero count data, the distribution of nightly counts had a positive skew. We explored whether the median value, which is resistant to outliers, was a more useful measure than the mean when characterising the general activity level. To

⁸ Winter was taken to be December, January and February; Spring was taken to be March, April and May and Summer was taken to be June and July.

determine whether a lower sampling effort was required to reliably identify the median level of nightly bat activity the above seasonal sampling methodology was also repeated with the median as the measure of bat activity (for all data and the sample subset).

Results

Site Activity

Five guilds were recorded across the 11 months of acoustic monitoring. Common pipistrelle were the most regularly recorded species, followed by *Myotis* with a presence rate⁹ of 0.49 and 0.2 respectively (Table 1).

Table 1: Summary statistics of nightly registrations by guild at the study site in South Yorkshire, England during winter, spring and summer (2017/2018).

Species	Mean	Median	Standard Deviation (SD)	Presence Rate
<i>Myotis sp.</i>	7.4	0	38.1	0.20
<i>Nyctalus sp.</i>	0.3	0	1	0.18
<i>Pipistrellus pipistrellus</i>	24.8	0	57.6	0.49
<i>Pipistrellus pygmaeus</i>	0.3	0	1	0.16
<i>Plecotus auritus</i>	0	0	0.2	0.02

Following the Broders (2003) methodology an estimate with an error rate of $\leq 10\%$ was consistently¹⁰ achieved for brown long-eared bat with a sample size of two. An estimate with an error rate of $\leq 30\%$ was consistently¹⁰ achieved for *Nyctalus* and soprano pipistrelle with a sample size of two. This is likely a function of the low activity of these species in the study area. A sample size of 20 nights was not sufficient to consistently¹⁰ achieve an estimate with an error rate of $\leq 50\%$ for *Myotis* and common pipistrelle (Figure 1).

⁹ The presence rate was identified as the proportion of nights where activity was recorded. A presence rate of one would indicate that activity was recorded on each night monitored. A presence rate of zero would indicate that no activity was recorded.

¹⁰ As identified in the introduction the term consistently is deemed to represent a probability of ≥ 0.8 .

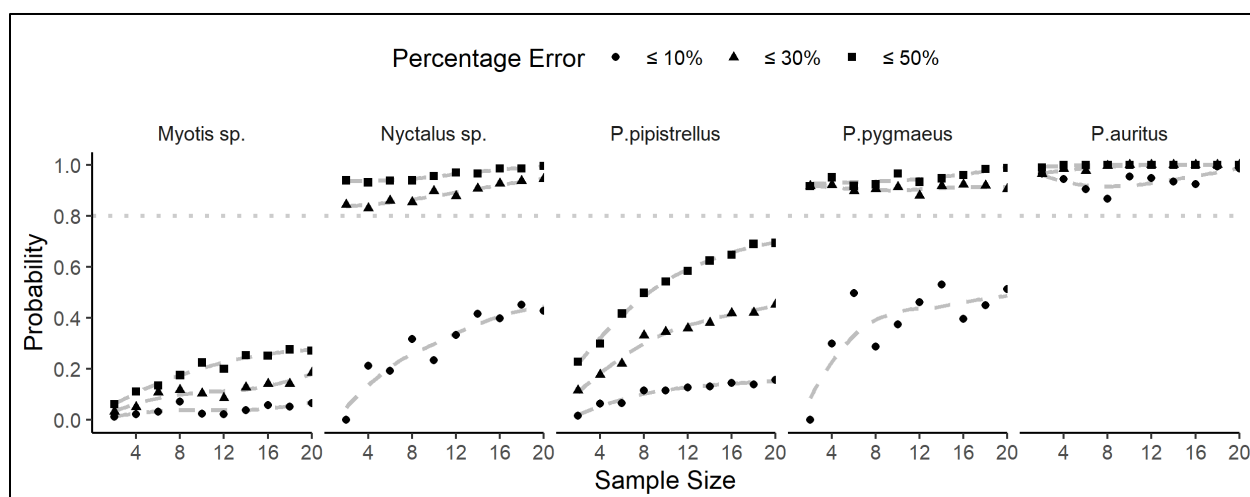


Figure 1: The probability of acquiring a sample mean within 10, 30 or 50 percent of the population mean using samples of between two and 20 nights.

Mean Seasonal Activity

The data was filtered to split out common pipistrelle and *Myotis* data. This was reanalysed to determine if the above result could be improved upon by sampling seasonally.

The distribution of bat activity varied between seasons. Large numbers of zero counts were made in spring and winter for both *Myotis* and common pipistrelle (Figure 2).

Table 2: Summary statistics of *Myotis* and common pipistrelle registrations at the study site in South Yorkshire, England during winter, spring and summer (2017/2018).

Season	Sample Size	Species	Mean	Median	SD	Presence Rate
Winter	72	<i>P. pipistrellus</i>	0.5	0	1.3	0.18
		<i>Myotis</i> sp.	0	0	0	0
Spring	154	<i>P. pipistrellus</i>	34	2	70	0.55
		<i>Myotis</i> sp.	0.5	0	2	0.15
Summer	29	<i>P. pipistrellus</i>	36.7	27	34.8	0.93
		<i>Myotis</i> sp.	62.7	14	97.8	1

Myotis were not recorded on any night in winter but common pipistrelle had a mean (SD) activity of 0.5 (1.3) (Table 2). The highest mean (SD) count for both guilds was recorded in summer (common pipistrelle 36.7 (34.8); *Myotis* 62.7 (97.8)). In spring the recorded level of common pipistrelle activity was higher and more variable than *Myotis* with a mean (SD) nightly count of 34 (70) compared to 0.5 (2) for *Myotis*.

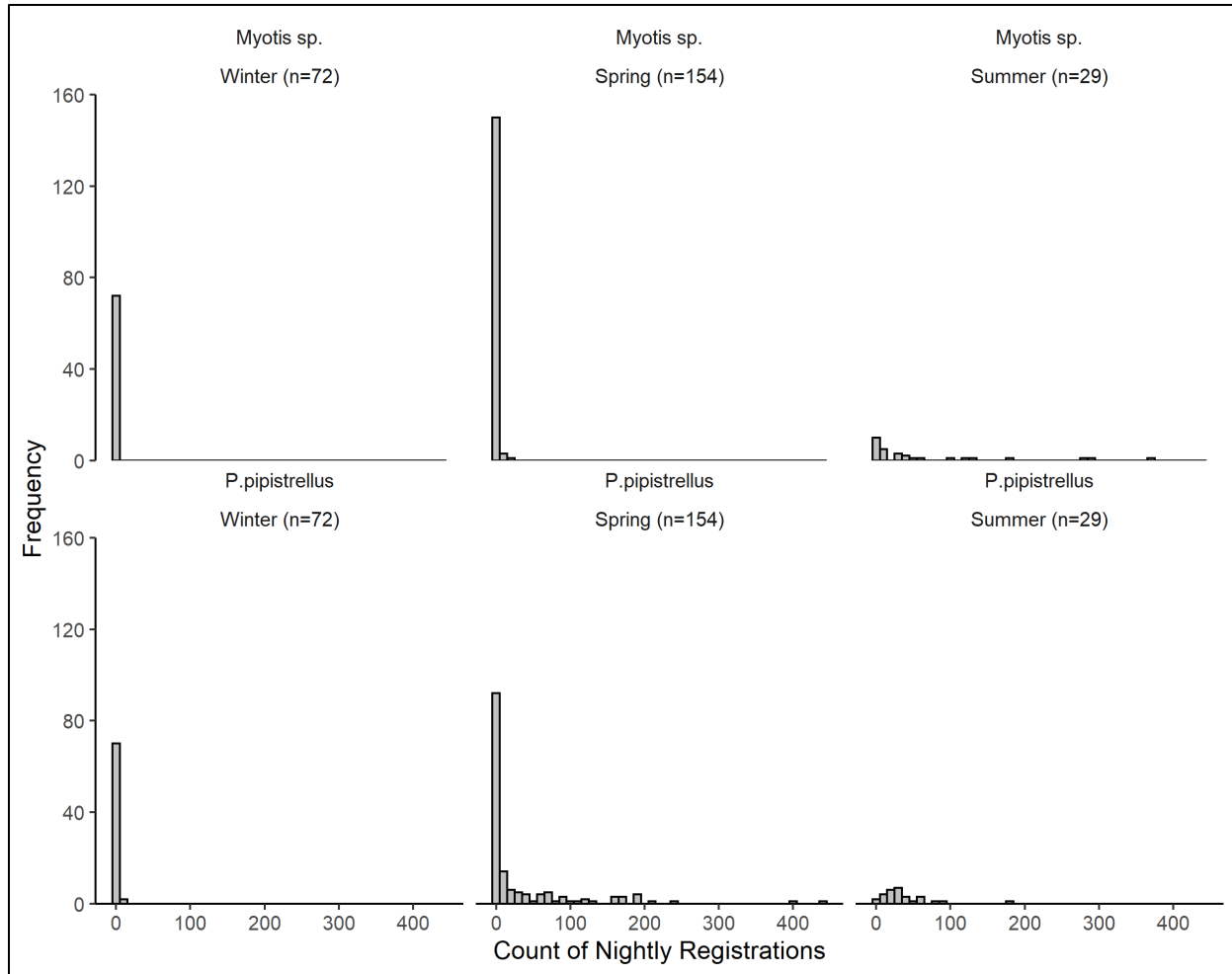


Figure 2: The distribution of nightly common pipistrelle and *Myotis* activity at the study site in South Yorkshire, England during winter, spring and summer (2017/2018).

No *Myotis* activity was recorded in winter, as a result the model achieved a probability of one for all accuracy thresholds. The winter model for common pipistrelle consistently¹⁰ achieved both the 50% and 30% accuracy thresholds after two and 12 samples, respectively (Figure 3).

The model consistently achieved the 50% and 30% accuracy levels for *Myotis* after two and 20 samples for *Myotis* in spring. In this season, *Myotis* activity was generally low and had a low variance. A sample size of 20 nights was not sufficient to consistently meet any of the accuracy thresholds for common pipistrelle.

The maximum sample size was increased to 50 and the sampling interval to five for data collected in spring. After 25 samples the model consistently achieved an accuracy of $\leq 50\%$ for common pipistrelle. The probability of acquiring a common pipistrelle percentage error rate of $\leq 30\%$ was 0.79 with the maximum 50 samples. With an increased sample size the model wasn't able to consistently achieve the 10% accuracy level for either common pipistrelle or *Myotis* for the spring data (Figure 4).

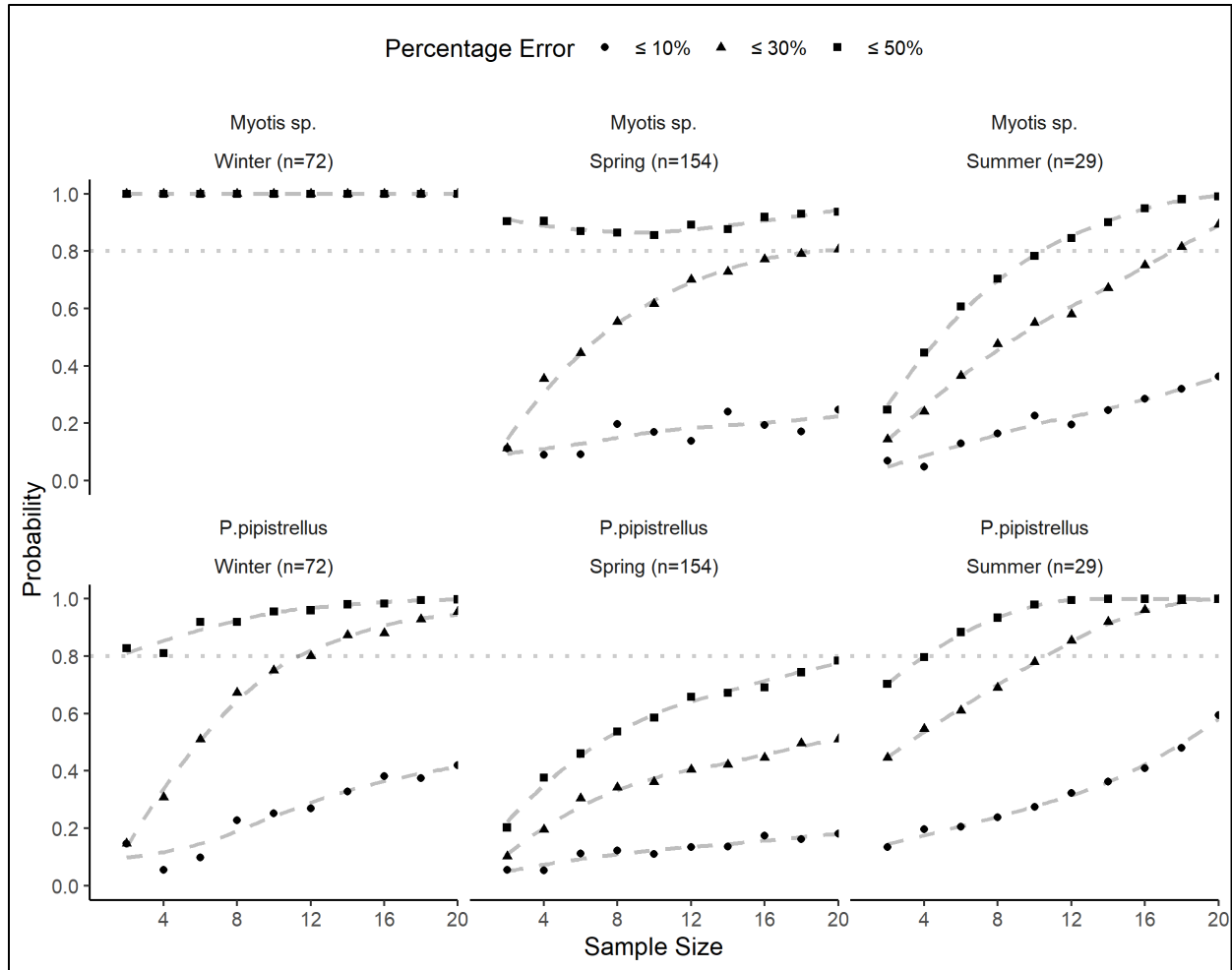


Figure 3: The seasonal probability of acquiring a sample mean within 10, 30 and 50 percent of the population mean using samples of between two and 20 nights.

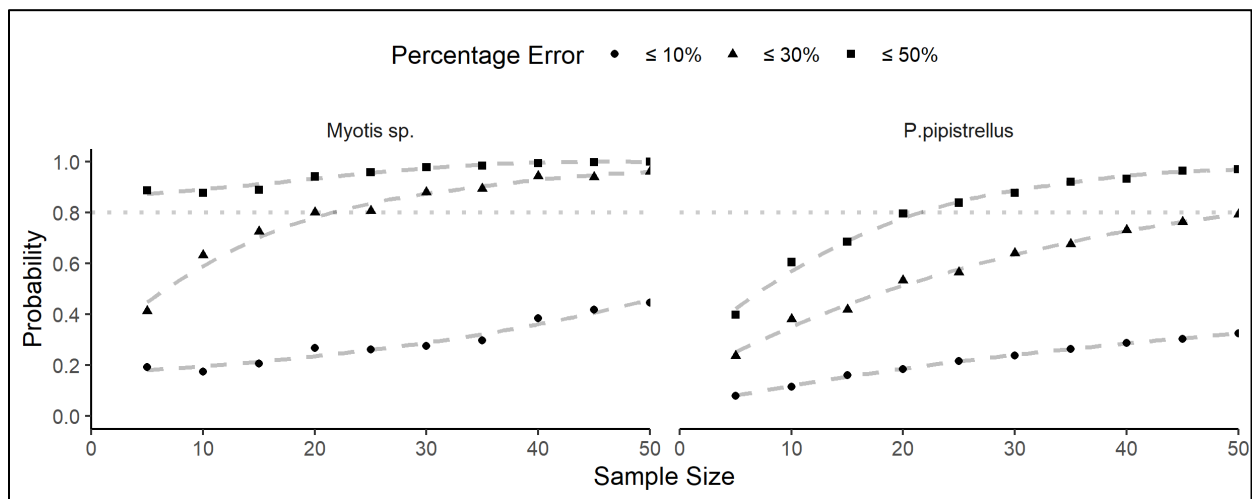


Figure 4: The probability of acquiring a sample mean with a percentage error of within 10%, 30% and 50% of the population mean in spring using samples of between five and 50 nights.

The model consistently achieved the 50% and 30% accuracy levels for *Myotis* after 12 and 18 samples, respectively for the summer data. The model performed better for the common pipistrelle data, consistently achieving the 50% and 30% accuracy levels after six and 12 samples respectively for the same season.

With a standard sample size of 29 nights per season, the same trend was broadly observed. The probability of acquiring an accurate sample of common pipistrelle activity in spring was decreased with none of the accuracy levels achieving a probability of ≥ 0.8 .

Median Seasonal Activity

All nightly counts of *Myotis* passes in winter were zero, as a result the model achieved a probability of one for all accuracy thresholds. The winter model for common pipistrelle consistently achieved a 10% accuracy after four samples (Figure 5).

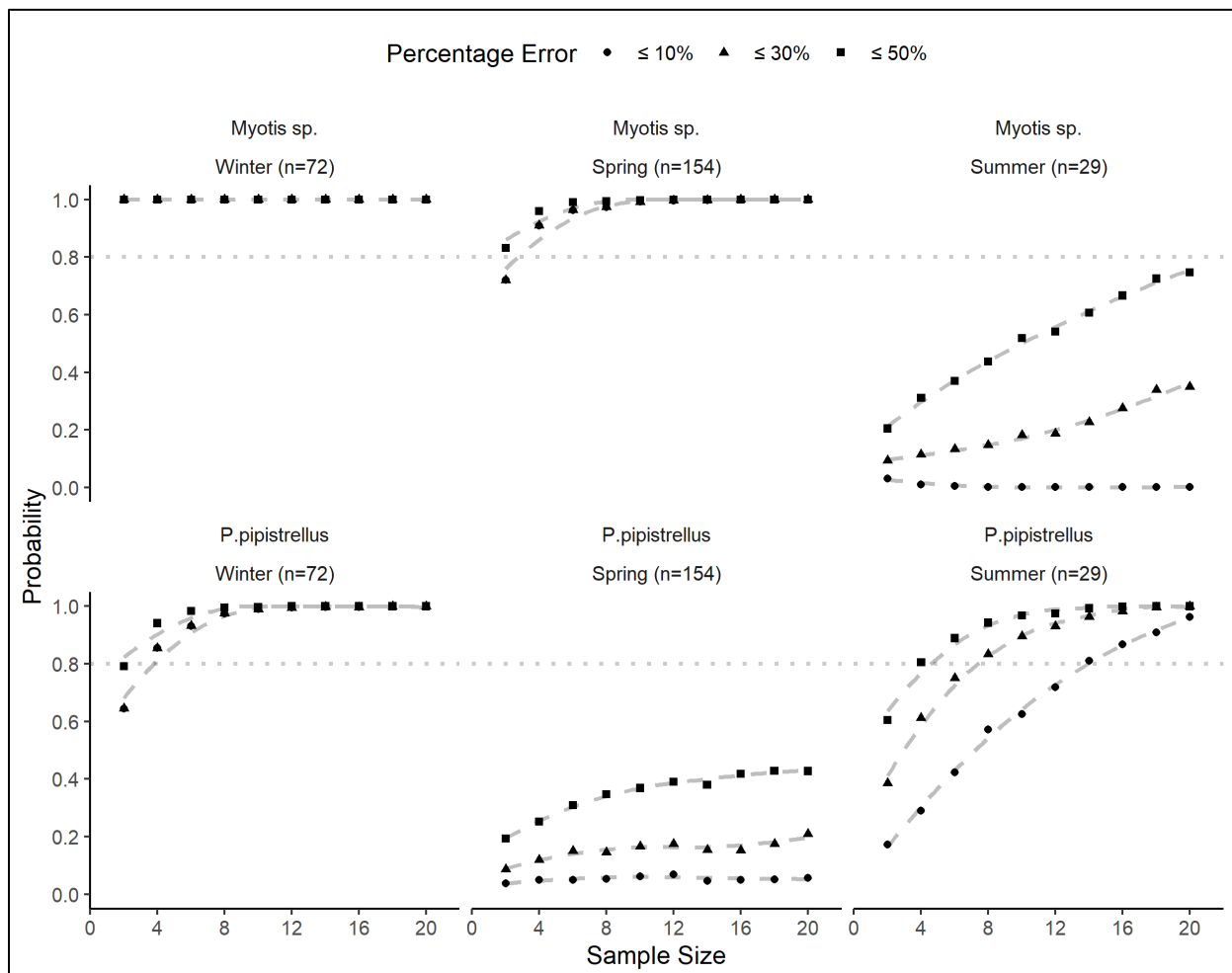


Figure 5: The seasonal probability of acquiring a sample median with a percentage error of within 10%, 30% and 50% of the population median using samples of between two and 20 nights.

For the spring data the model consistently achieved the 50% and 10% accuracy levels for *Myotis* after two and four samples. A sample size of 20 nights was not sufficient to consistently meet any of the accuracy thresholds for common pipistrelle in this season.

A sample size of 20 was not sufficient to consistently achieve an error rate of $\leq 50\%$ for *Myotis* in summer. A notable reduction in performance from using the mean as the measure of activity.

For common pipistrelle data the model consistently achieved the 10% accuracy threshold after 14 samples for the summer data. This accuracy level was not achieved using the mean as the measure of central tendency.

Discussion

The impact of variance and positive skew

The variance and level of positive skew in the distribution of bat activity were important factors in determining the number of samples required to consistently achieve an accurate average. Higher sample sizes were required to accurately characterise a distribution with high variance and a low median or mean. Whilst this is a straightforward statistical deduction, our study demonstrates that the amount of anticipated and recorded variation should be an important, and species specific, consideration in survey planning and interpretation of static detector survey data. The anticipated level of activity and variation should be considered when identifying the suitability of a site for bats (and therefore the amount of monitoring required). The level of variation recorded should be used to verify the initial decision.

The total of 20 nights of monitoring, which was the maximum number sampled, was insufficient to consistently achieve an accurate sample across all seasons monitored for *Myotis* or common pipistrelle at the survey location. For other species a percentage error rate of $\leq 30\%$ was consistently achieved with two samples. The difference in performance appeared to be the result of the differing variance recorded for each guild. *Myotis* and common pipistrelle activity had a considerably larger standard deviation than other species.

Hayes (1997) achieved a percentage error of $\leq 50\%$ with three samples and $\leq 30\%$ with seven samples for *Myotis* species (native to Oregon). Broders (2003) consistently achieved a percentage error of $\leq 30\%$ with 14 samples across two sites but wasn't able to achieve this at a third with a sample size of 20.

Broders (2003) studied three locations, the location with the lowest level of variation required the highest number of sample nights to consistently achieve a percentage error rate of $\leq 30\%$. Notably the mean value for that location was low relative to the standard deviation when compared to the other two locations. Initially this seems to be counter intuitive and does not fit with the general trend observed in our data where samples with low levels of standard deviation tended to require fewer samples.

In our data for all seasons combined, the soprano pipistrelle, *Nyctalus* and brown long-eared bat guilds had considerably lower SD, and accurate estimates of mean nightly activity could be

assigned with fewer nightly samples, than the common pipistrelle or *Myotis* guilds. For the seasonally stratified data, the common pipistrelle figures followed this trend where the highest SD (spring) required the highest level of sampling to develop a consistently accurate estimate.

The summer *Myotis* data recorded the highest SD (97.8) but only required 18 nights of sampling to estimate the mean with an error rate of $\leq 30\%$, fewer than the *Myotis* spring data (or common pipistrelle summer data). It is notable that our summer *Myotis* data had the highest mean of all the data subsets. In the Broders (2003) example, the location with a low level of variation required a high number of sample nights to achieve a low percentage error rate. That location had the lowest mean value of the three sites in the Broders (2003) study. These results imply that a high mean value could reduce the impact of standard deviation on the predictability of the nightly count.

This study identified that the level of temporal variation in nightly bat activity levels was species and seasonally specific. This study identified that, at the site monitored, 18 nights of data were sufficient to reliably estimate a mean level of bat activity with an anticipated error rate of $\leq 30\%$ for most species in winter or summer but that 50 nights of sampling were required in spring.

It is plausible that the indicated large number of sample nights required in spring could be an effect of sampling this season twice with two different microphones, or an effect of the unusually cold and stormy March in 2018.¹¹ It is considered more likely to be the latter, as the average number of nightly common pipistrelle passes recorded in spring 2017 with the SMX-US microphone was higher than that recorded in spring 2018 with the SMX-U1 microphone.

The best statistic to describe nightly data

Careful consideration should be given to the statistics used for the characterisation of a sites bat activity. The probability of acquiring an accurate result was increased in three of five cases by using the median as the measure of the central tendency of the data. This was the case for *Myotis* activity in spring and common pipistrelle activity in winter and summer. The opposite was true of *Myotis* activity in summer and common pipistrelle activity in spring. This appeared to be related to the positive skew of the dataset (measured as the mean divided by the median). The model performed better using the median in seasons with a low positive skew.

Even if an accurate mean or median estimate of the nightly level of activity is determined (for each species and month or season), the single statistic is unlikely to be sufficient to characterise the use of the site without consideration of the regularity, or the sites intensity of use. The standard deviation gives a good indication of the variance in a dataset and is influenced by the presence of outliers. Outliers are not always undesirable in ecology (Benhadi-Marin, 2018) and in the context of bat activity data, they could hold important information about the use of a site by bats. Their influence over this statistic therefore makes it useful for capturing this information.

¹¹ The cold and stormy weather is described in:

https://en.wikipedia.org/wiki/2018_Great_Britain_and_Ireland_cold_wave

If the mean or median value of nightly static detector activity is reported as being representative of a location, the inclusion of the standard deviation figure would appear to be extremely important. Sites with a large standard deviation relative to their mean may require additional sampling to accurately characterise their activity.

Implications

It is important to note that this study has not sampled consecutive nights of data as would usually be done in a professional static monitoring study. Consecutive nights of sampling are likely to yield more consistent nightly counts of bat activity across the sample than the same number of randomly sampled nights because weather conditions are more likely to remain stable over a shorter timescale. However this may mean that consecutive nights are less representative of the 'normal' level of activity across the month, or season they are deemed to exemplify. Further study is required to determine how accurately it is possible to characterise sites with the recommended level of consecutive nights of survey effort.

It is valid to compare the level of activity for any sample size on a night by night basis where locations were sampled at the same time. Where a study aims to identify or compare an average or 'normal' level of bat activity within a month or season our study suggests that sampling effort may need to be increased to 18 or even 50 nights. Where shorter monitoring periods show sites to have anything other than consistently very low levels of activity the implications, in terms of potential error rates, should be considered. This must be factored into any comparisons made and the need for additional survey considered where variation is high and the need for a high level of accuracy is required.

The data presented here may not be applicable to other habitats or areas. As identified in Hayes (1997), in the absence of more extensive sampling and testing, it is prudent to design surveys with the knowledge of the level of survey effort, and error rates identified here in order to tailor the survey to the level of robustness required.

Acknowledgements

We would like to thank Jacobs UK Ltd. for the loan of the static detector monitoring equipment and the contribution of time towards the writing up of these results. Thanks too to Nick Westerman, Robert Bell and Kris Long for their insightful comments which have undoubtedly improved the quality of this work.

References

Benhadi-Marín, J. (2018) A conceptual framework to deal with outliers in ecology. *Biodiversity and Conservation*, 27(12) pp. 3295-3300.

Broders, H.G. (2003) Another quantitative measure of bat species activity and sampling intensity considerations for the design of ultrasonic monitoring studies. *Acta Chiropterologica*, 5 pp. 235-241.

Berkova, H. and Zukal, J. (2010) Cave visitation by temperate zone bats: effects of climatic factors. *Journal of Zoology*. [Online]
<https://zslpublications.onlinelibrary.wiley.com/doi/abs/10.1111/j.1469-7998.2009.00673.x>

Collins, J. (ed.) (2016) *Bat Surveys for Professional Ecologists: Good Practice Guidelines* (3rd edn.). London: Bat Conservation Trust.

Cooke, E. (2019) *Investigating optimum weather predictors of Pipistrellus pipistrellus activity in the Little Don river valley in South Yorkshire*. MSc thesis. Manchester Metropolitan University: UK.

Dechmann, D, K, N., Wikelski, M., Ellis-Soto, D, Safi, K. and O'Mara, M, T. (2017) Determinants of spring migration departure decision in a bat. *Biology Letters*, 13. [Online]
<https://royalsocietypublishing.org/doi/pdf/10.1098/rsbl.2017.0395>

Denzinger A. and Schnitzler H. (2013) Bat guilds, a concept to classify the highly diverse foraging and echolocation behaviours of microchiropteran bats. *Frontiers in physiology*, 4, Article 164.

Geipel, I., Smeekes, M.J., Halfwerk, W. and Page, R.A. (2019) Noise as an informational cue for decision-making: the sound of rain delays bat emergence. *Journal of experimental biology*. [Online] <https://jeb.biologists.org/content/jebio/222/3/jeb192005.full.pdf>

Hayes, J.P. (1997) Temporal variation in activity of bats and the design of echolocation-monitoring studies. *Journal of Mammalogy*, 78(2) pp. 514-524.

Hundt L. (ed.) (2012) *Bat surveys: Good practice guidelines* (2nd edn.). London: Bat Conservation Trust.

Matthews, F., Richardson, S., Lintott, P. and Hoskin, D. (2016) *Understanding the risk to European Protected Species (bats at onshore wind turbine sites to inform risk management*. Report by University of Exeter. Report for RenewableUK. Report for UK Department of Energy and Climate Change (DECC). [Online] <https://tethys.pnnl.gov/publications/understanding-risk-european-protected-species-bats-onshore-wind-turbine-sites-inform>

R Core Team (2019) R: A language and environment for statistical computing. Vienna: R Foundation for Statistical Computing. [Online] <https://www.R-project.org/>

Salvarina, I., Gravier, D. and Rothhaupt, K. (2018) Seasonal bat activity related to insect emergence at three temperate lakes. *Ecology and Evolution*. [Online]
<https://doi.org/10.1002/ece3.3943>

[Return to contents page](#)

Bats and Hilbre Island, Wirral, Merseyside

Stan Irwin; Merseyside and West Lancashire Bat Group

bat.man47@talktalk.net

Introduction and Background

The Merseyside and West Lancashire Bat Group (MWLBG) is pleased to be associated with the Wirral Ranger Service, notably Matt Thomas who is the lead ranger for Hilbre Island and who provided great support, notably negotiating his Landover over some difficult rocky terrain to gain final access to the island and carry equipment.

Wirral is a peninsula that lies between the rivers Mersey and Dee, the northern section is located within Merseyside whilst the remainder is within Cheshire. Of the 17 resident UK bats nine have been recorded in Merseyside.

Hilbre Islands namely; Little Eye, Middle Eye and the main Hilbre Island are an archipelago, sometimes called an island group or island chain; they are located at the mouth of the River Dee estuary Site of Special Scientific Interest/Special Protection Area (SSSI/SPA), Liverpool Bay and are assigned as a Local Nature Reserve under the administration of the Metropolitan Borough of Wirral, Merseyside; although there are buildings on the main island there have been no permanent residents since 2012. Hilbre Island is approximately 1.75km from the nearest mainland point at Hoylake and 7km from the nearest Welsh coast headland at the Point of Ayr (Figure 1). The name is thought to derive from a chapel built on the island and dedicated to St. Hildeburgh.



Figure 1: Location of Hilbre Islands.

The vegetation of the islands consists of open grassland plant communities and scrub that vary in composition according to variations in exposure to the sea, wind, soil characteristics and human interference (Figures 2 and 3). The islands contain one of the most studied populations of invertebrate fauna in the North West of England during which time over 700

species (mainly insects) were catalogued. The distribution of species is related to the vegetation type, tolerance of sea spray and the incidence of occasional inundation by waves.

Some of the species found in the heath and open grassland plant communities are regionally rare but most of those in the paddock and garden areas are locally common. The spider and harvestmen populations are similar to those found on mainland heaths.



Figure 2: Typical grassland habitat.



Figure 3: Scrub area.

To date the only mammals that are known to regularly breed on the islands are field voles. Many other mammals have been observed, having crossed from the mainland, these include rabbits, hedgehogs, foxes, stoats, rats, mice, otters, a grey squirrel and even a fallow deer which was thought to have crossed the River Dee from North Wales.

Long standing bird observation, trapping and ringing has been undertaken on the main Hilbre Island although there has never been any effort to establish if bats are using the island. To address this lack of information the MWLBG were keen to identify what bat species may present on the main Hilbre Island and if present how they are using it.

Whilst we were keen to identify all species the main objective of the exercise was to establish if Nathusius' pipistrelle *Pipistrellus nathusii* is using the island and if so when. Nathusius' pipistrelle is a rare bat in the UK, though records have increased in recent years. It is a migratory species and most bats are encountered in autumn, although some do remain all year and breed in the UK. It is similar in appearance to, but slightly larger than, the much more commonly encountered common pipistrelle *P. pipistrellus* and soprano pipistrelle *P. pygmaeus*. Nathusius' pipistrelle has longer fur on its back, sometimes giving a shaggy appearance.

Previous coastal records of Nathusius' pipistrelle in Merseyside include Ainsdale National Nature Reserve on the Sefton Coast and at Liverpool Seaforth docks (Figure 4) and it is more than possible that they migrate across the Irish Sea to our west coast from Ireland where they are much more common. Hilbre Island is strategically located within the Dee estuary as part of the Irish Sea and as such represents a convenient land fall for any bat species that may migrate from North Wales or from Ireland and the Isle of Man to the UK mainland. As with migrating birds it stands to reason that migrating or vagrant bats will use land falls as a resting place during passage or to fuel up before continuing their onward migration and ultimate destination.

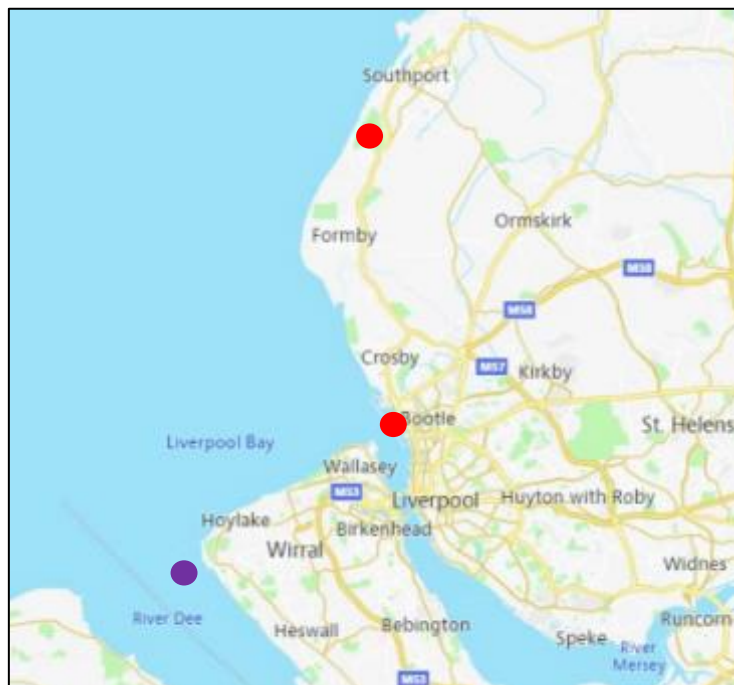


Figure 4: ● Previous coastal records of Nathusius' pipistrelle.
● Hilbre Island record.

Methodology

Two static bat detectors were deployed between June and September 2019 on the main island in separate locations (Figure 5). Detectors included Titley Scientific Anabat SD1 in a window opening of the Old Cottage to the north west of the island (Figure 6) and a Wildlife Acoustics SM4 amid vegetation on the east side of the island. (Figures 7 and 8). The bat detectors automatically recorded bat echolocation calls to set parameters i.e. before dusk and just after sunrise; two visits were made during the deployment time to collect data and avoid excessive files. Calls were then analysed with sound analysis software from which species were, wherever possible, identified.



Figure 5: Location of bat detectors.



Figure 6: Anabat detector powered with 12v battery and solar panel.



Figures 7 and 8: SM4 detector and microphone powered with 12v battery.

Results

The bat detectors recorded five bat species, notably common pipistrelle, soprano pipistrelle, noctule *Nyctalus noctula*, whiskered/Brandt's bat, *Myotis mystacinus/Brandtii* and the target species Nathusius' pipistrelle, which was recorded in July and September. Common pipistrelle was the most frequently recorded species whilst noctule was the second followed by soprano pipistrelle, Nathusius' pipistrelle and whiskered/Brandt's bat. From a total number of 95 deployment nights bats were recorded on 57 nights with no activity recorded

on 38 nights; activity continued during most of the night and into early hours of the morning.

During the two collections of data over 3000 files were recorded from which 2765 were attributed to bats; peak activity was in July/August and reduced slightly in September. From the information gathered so far, i.e. the times that bats were recorded, it appears that they are commuting to the island from dusk onwards and before sunrise they are commuting back to whence they arrived from.

Discussion

Taking into consideration and making an assumption that small bats such as *Pipistrellus* are navigating the approximate 4km round trip from the nearest mainland point across an open, and at times a windy, featureless flat sand landscape, then it has to be productive in context with an available food source and the energy expenditure to reach Hilbre and return.

In terms of comparative foraging habitat on the mainland at Hoylake or nearby West Kirby ample foraging opportunities are available by way of mature residential gardens, golf courses, woodland, an established park and associated lake. It has previously been established that Hilbre has a high number of invertebrates, which is the sole prey item of UK bats, so clearly commuting to the island must be productive.

Future Surveys

Following the success of the acoustic surveys the MWLBG are planning further surveys in the form of deploying static bat detectors over several months and members stationed on the island overnight to undertake visual observations, acoustic recording and possible trapping in order to achieve more information. From the information gained it is anticipated that it will have an input and contribute to any future management plan for the islands.

Surveys will aim to establish:

- from what direction bats arrive at the island
- how long are they staying
- are they roosting on the island either permanently or temporarily
- identify species and numbers where possible
- where are the main foraging areas
- are they foraging on or close to the tide line
- extend surveys to the adjacent smaller islands

Acknowledgements

Matt Thomas (Wirral Ranger Service) for help with equipment and supporting the project. Andrew Dobson (Titley Scientific, UK) for supplying solar panel equipment. Anthony Nickson (Merseyside and West Lancashire Bat Group) for loan of Anabat SD1 bat detector.

References

Wirral Council Parks and Countryside Service Regeneration and Environment Directorate
Hilbre Islands Local Nature Reserve Management Plan 2011-2016.

[Return to contents page](#)

Parkhurst Forest Selective Harvesting: Measured Impact on Bat Habitat Use

Jon Whitehurst; Isle of Wight Bat Group

jon.whitehurst36@gmail.com

Abstract

This paper describes the results of monitoring bat activity within an area of hardwood forest known to have a very high presence of barbastelle *Barbastelle barbastellus* before, during and after selective stem harvesting. Changes in bat habitat use during the different time periods are assessed and discussed. This work was carried out under Forestry Commission England permit 02348/2018.

Habitat Context

The Parkhurst Forest is located on the Isle of Wight and lies approximately halfway between Cowes and Newport (OS grid reference SZ474896). The forest is one of the oldest in the UK (Chatters, 1993) and activities within the forest have been varied, including a royal hunting ground in medieval times, large coppiced areas supporting local laundry and brick making kilns in the 19th century, to the multi-purpose mixed woodland of today. In particular there are large areas of semi-natural ancient woodland (predominately oak) dating back to pre-Napoleonic times. A significant difference between Parkhurst Forest and the other local forests of the same era is the lack of intensive woodland management, which has resulted in a significant number of 'poor quality' trees (dead, bent, leaning, split, etc.) which would have normally been removed (Forestry Commission, 2007). This lack of 'tidying' has provided the ideal background environment for woodland bat species such as barbastelle, which are wholly dependent on tree splits and lifted bark for roosting sites.



Figure 1: Parkhurst Forest landscape context.  Denotes harvested area.

The forest is an unusual mix of both semi-ancient woodland and stands of commercial species such as spruce, larch and pine, and is surrounded on the majority of its perimeter with grazing pasture; see the aerial view of forest landscape context in Figure 1. This unusual composition of tree species, surrounding pasture and the internal networks of road, track, ride and streams has the potential to support a wide range of bat species. The Parkhurst Forest site was first recognised to be of particular importance as bat habitat by Davidson-Watts in 2008 when radio tracking activities resulted in the discovery of the largest known barbastelle maternity roost in the UK (115+ bats) (Davidson-Watts, 2008). The area where the selective harvesting took place is shown in Figure 2, and is known to be one of the most active areas within the forest for a wide range of bat species (Whitehurst, 2016).

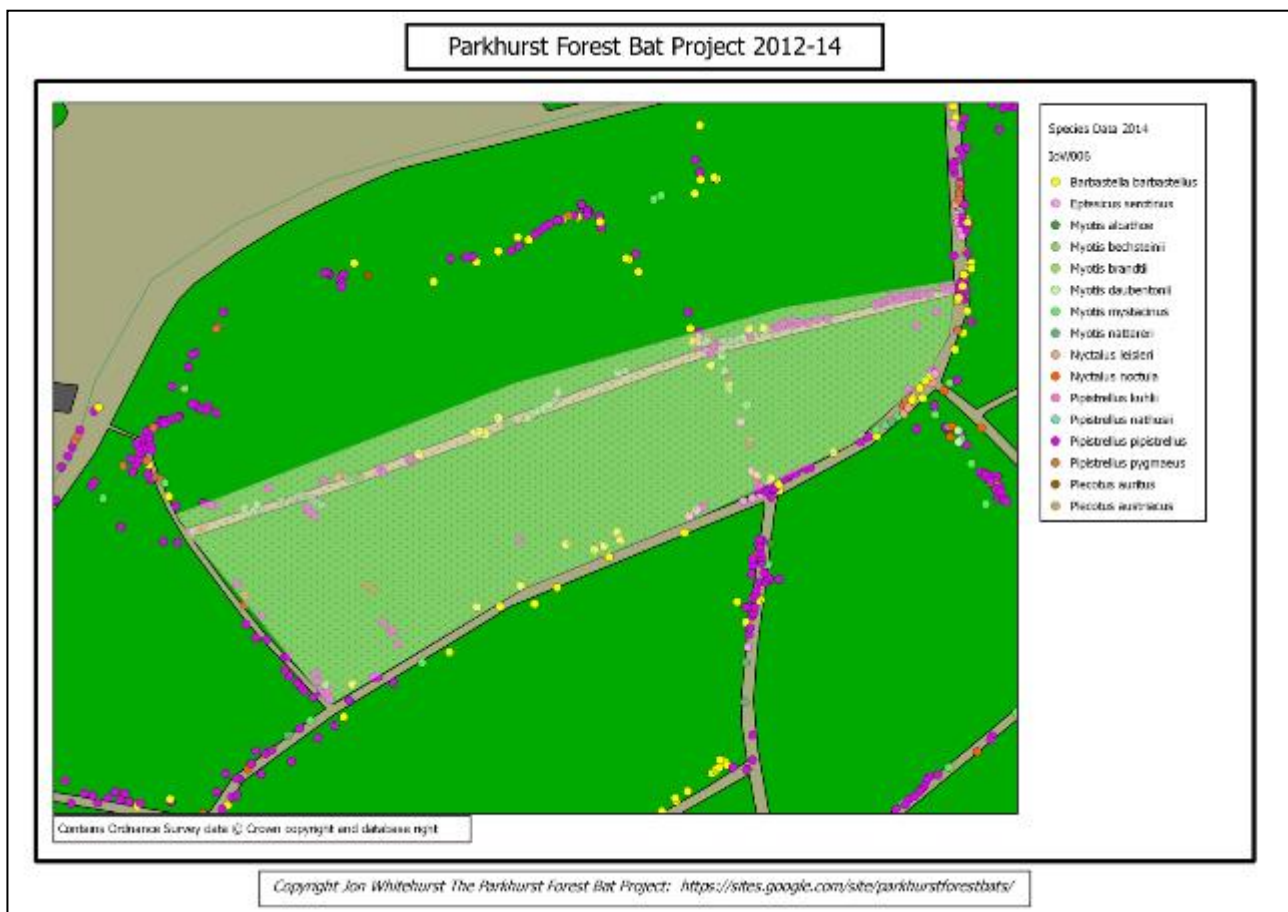


Figure 2: Harvest area and previously recorded bat activity.

The harvested area is classified as native and honorary native broadleaf, and the planting years recorded as 1500-1911, the harvesting has been carried out in line with Forestry Commission England's Isle of Wight Forest Plan objectives (Forestry Commission England, 2017):

- maintain and increase the native composition of ancient seminatural woodland
- initiate restoration of planted ancient woodland sites to native and honorary native woodland
- maintain and enhance the favourable conservation status of nationally important wildlife sites

- maintain and enhance where possible the recreational capacity of the woodland
- maintain and increase the species and age diversity of the woodland
- provide a regular supply of quality timber to support local employment and local timber processing industries

The Parkhurst Forest site and surrounding farmland supports 16 bat species in total. Within the harvested area the main species known to be present are:

- common pipistrelle *Pipistrellus pipistrellus*
- barbastelle *Barbastella barbastellus*
- serotine *Eptesicus serotinus*
- noctule *Nyctalus noctula*
- whiskered bat *Myotis mystacinus*
- Natterer's bat *Myotis nattereri*
- soprano pipistrelle *Pipistrellus pygmaeus*
- brown long-eared bat *Plecotus auritus*

In addition, there is significant acoustic evidence that points to a local colony of Alcaethoe bat *M. alcathoe* in the Marks Corner area. Each species makes use of specific space volumes within the forest consistent with established behaviours. For example, the *Pipistrellus* bats are mostly found foraging in the high canopy gaps and open rides, whereas barbastelles are more usually found foraging in the region above the understory but beneath the canopy. In terms of roost site presence, barbastelle, noctule and *Myotis* bats are exclusively tree roosting species in this area; the other species present are known to use house and outbuilding roosts in significant numbers (however, this does not rule them out from using tree roosts).

Harvesting Approach

The harvesting approach being adopted was one of selective felling, effectively thinning the canopy and in some cases creating new clearings or extending existing clearings. This is considered a sensitive form of woodland harvesting and was adopted in the knowledge of the significant bat presence. Prior to harvest a number of trees were marked to be left, where they presented significant roost site value to barbastelle (principally split and lifted bark). Additional surveys were carried out on those trees to be felled where there may have been roost potential missed by the ground based visual survey.

Survey Protocol

The bat survey protocol adopted for this work was based on a call density principle, i.e. the activity metric is the echolocation calls per unit time measured over a fixed transect carried out in a fixed target time period and walked at constant speed. The fixed transect means that any spatially driven variation is minimized, and the fixed time period ensures that the call density metric is not distorted by very local peaks in activity within the transect.

Echolocation calls were recorded using an Elekon Batlogger and the calls analysed manually using Bat Explorer 2. The transect was planned based on the area of the Forest being harvested and the typical detection range of the Batlogger to ensure that all the harvested area was covered by the survey.

The survey was initiated on the first bat recording or 15 minutes post local sunset time if no bats had emerged by then. For each survey carried out, the number of individual echolocation calls recorded for each species was determined by manual inspection and then the total divided by the actual duration of the survey in minutes to give a call density measure in terms of echolocation calls per survey minute. Whilst this is not an absolute measure of bat activity, it does enable the relative activity across the different surveys carried out to this survey protocol to be directly compared.

Surveys were carried out during the season of harvesting itself, and then in the directly subsequent season over the equivalent time period to assess the post-harvest impact and potentially look for any seasonal shifts in activity without the harvest disturbance.

Results

Results are presented here for two species, common pipistrelle and barbastelle, during the following periods:

- the month before harvest was started
- the month in which harvest took place
- the equivalent time period before harvest in the following season
- the equivalent time period to the harvest period in the following season

A summary of the season 1 results (which was when the harvest took place) is given in Figures 3-5 (below). Paying particular attention to the common pipistrelle results, you can see subjectively in the graphical data that the average and peak activity has actually increased in the harvesting period. However, when reviewing the equivalent data for barbastelle, there is a significant and sudden drop in activity over the same period; indeed there are several surveys where no barbastelles were recorded at all. This is born out in the calculated average activity for each of the species during the different periods:

- pre-harvest: common pipistrelle – 6.2 calls/minute
- harvest: common pipistrelle – 9.0 calls/minute
- pre-harvest: barbastelle – 2.4 calls/minute
- harvest: barbastelle – 0.5 calls/minute

Potential reasons for the differences are covered in the discussion section. The survey results for the equivalent periods in the second season are given in Figures 6-8 (below). In this instance, without the harvesting disturbance, the activity of common pipistrelle remains virtually constant over both time periods. The barbastelle activity shows a slight drop in the average during the equivalent harvest period, but there is no re-occurrence of the sudden drop in activity noted in the previous season when harvesting started. The calculated average activity for season 2 is as follows:

- pre-harvest: common pipistrelle – 14.7 calls/minute
- harvest: common pipistrelle – 13.7 calls/minute
- pre-harvest: barbastelle – 2.3 calls/minute
- harvest: barbastelle – 1.6 calls/minute

England – South East

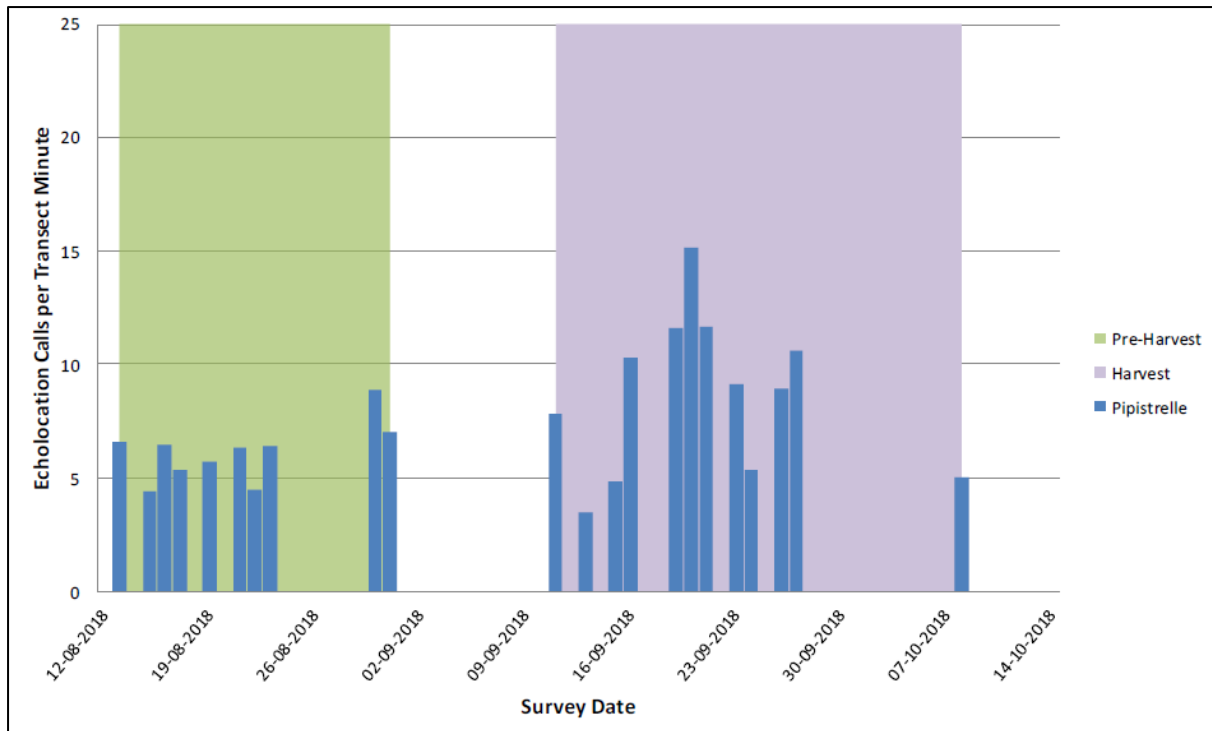


Figure 3: Season 1 common pipistrelle activity.

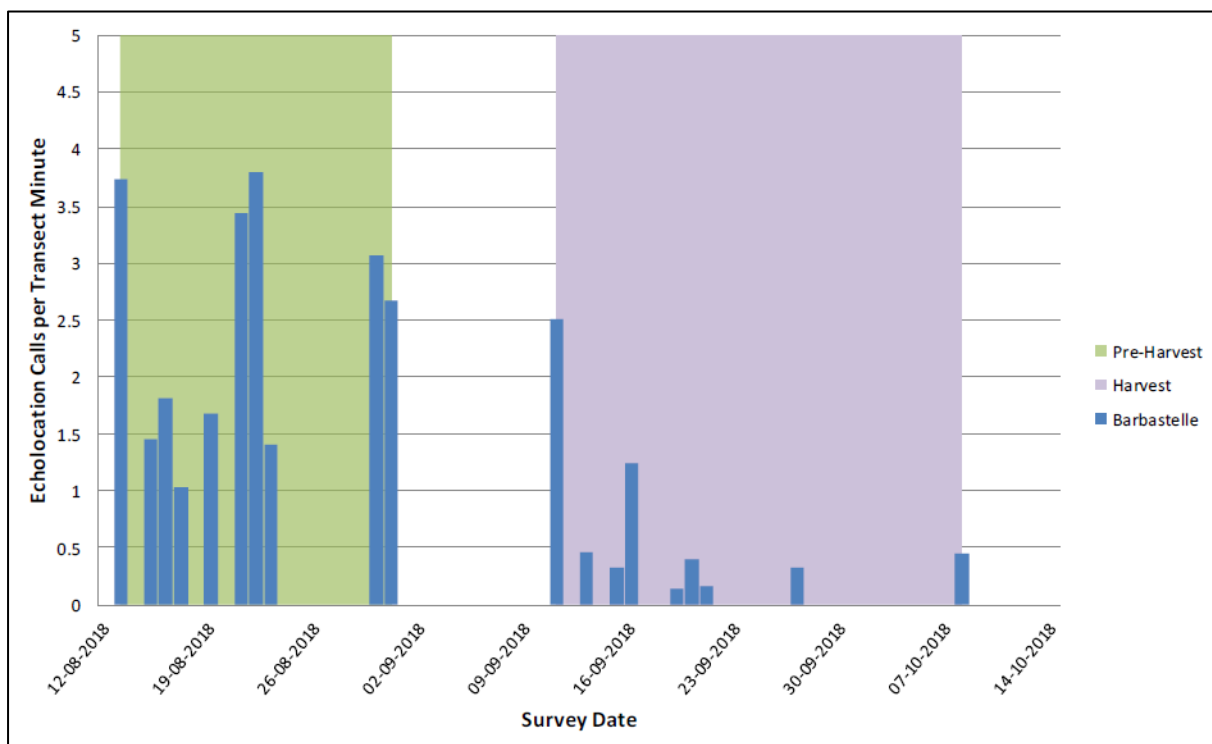


Figure 4: Season 1 barbastelle activity.

England – South East

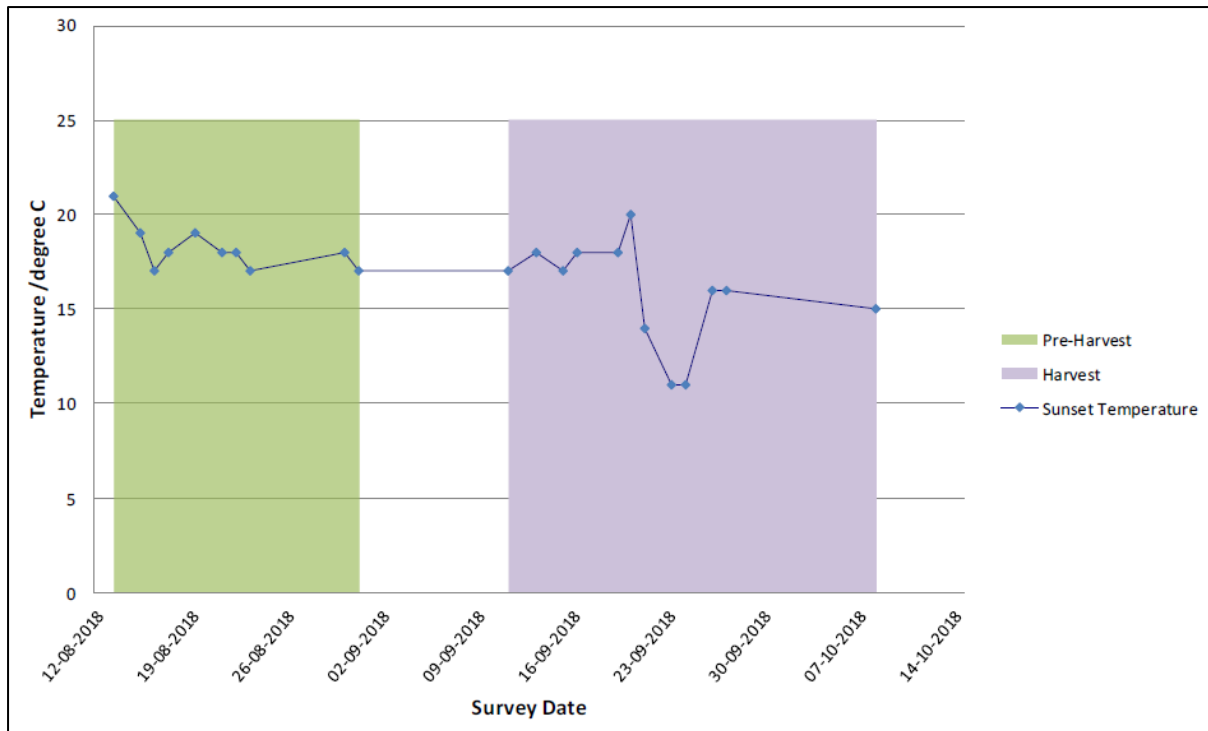


Figure 5: Season 1 survey sunset temperature.

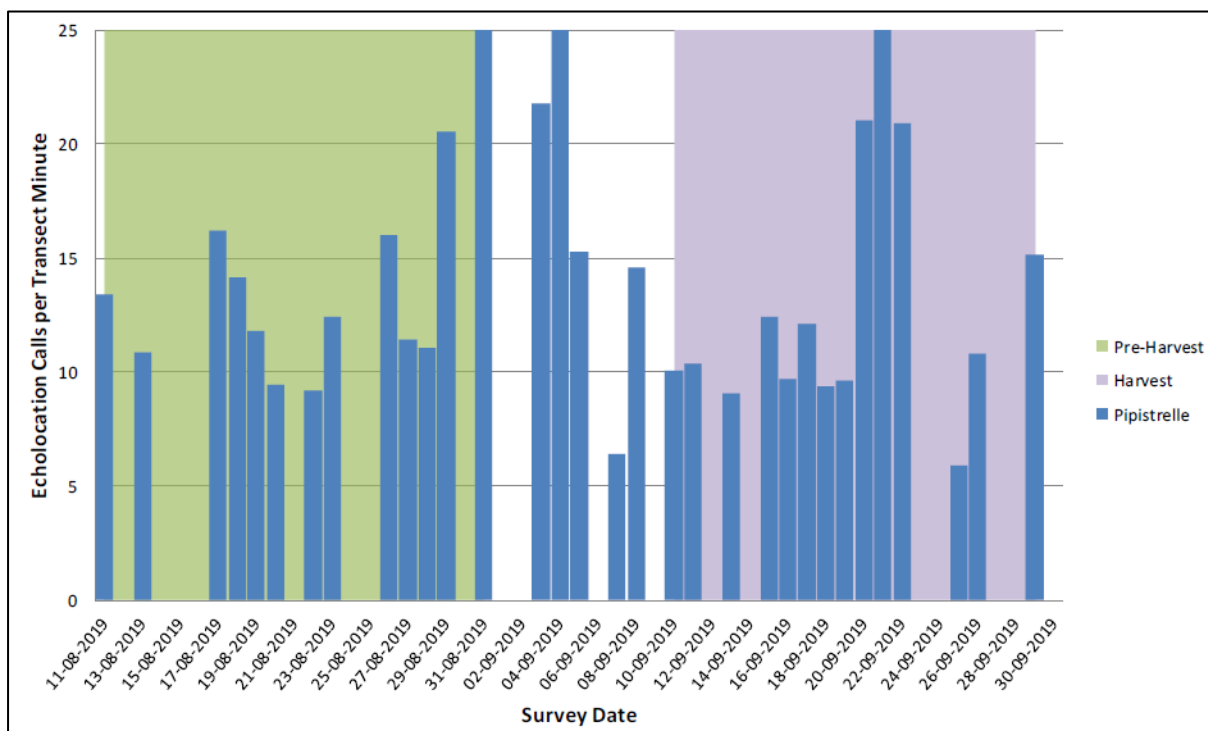


Figure 6: Season 2 common pipistrelle activity.

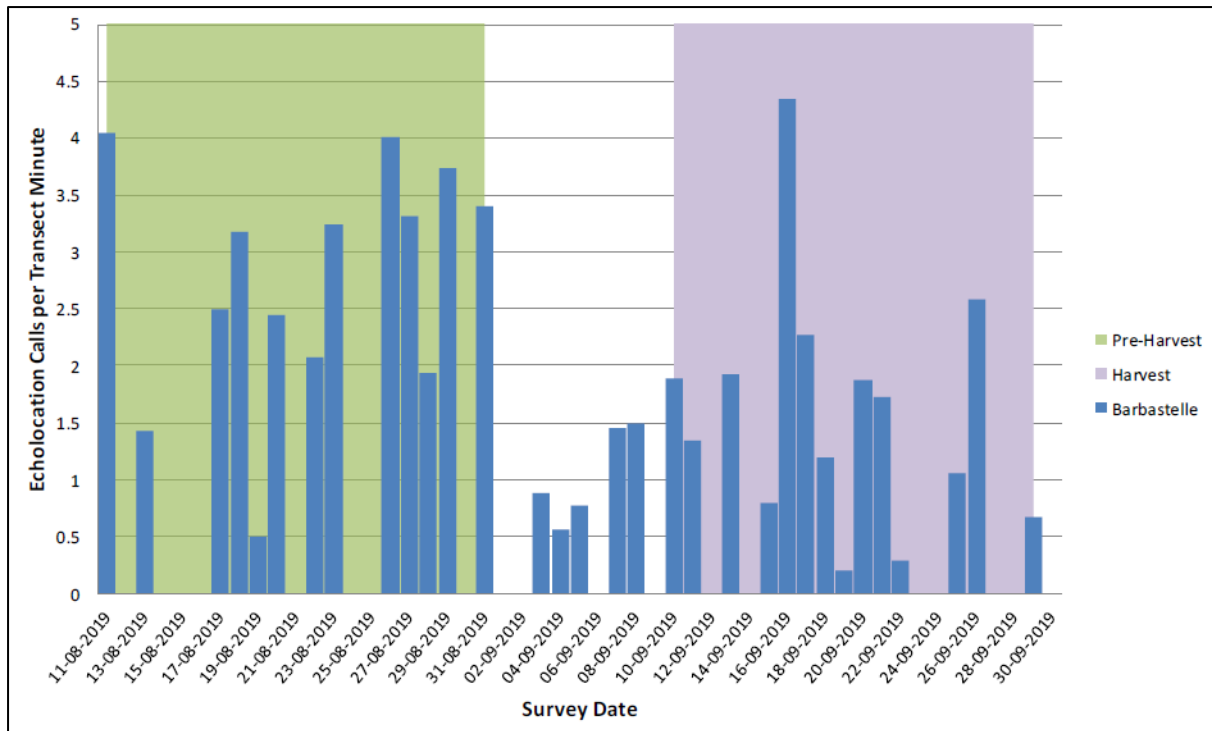


Figure 7: Season 2 barbastelle activity.

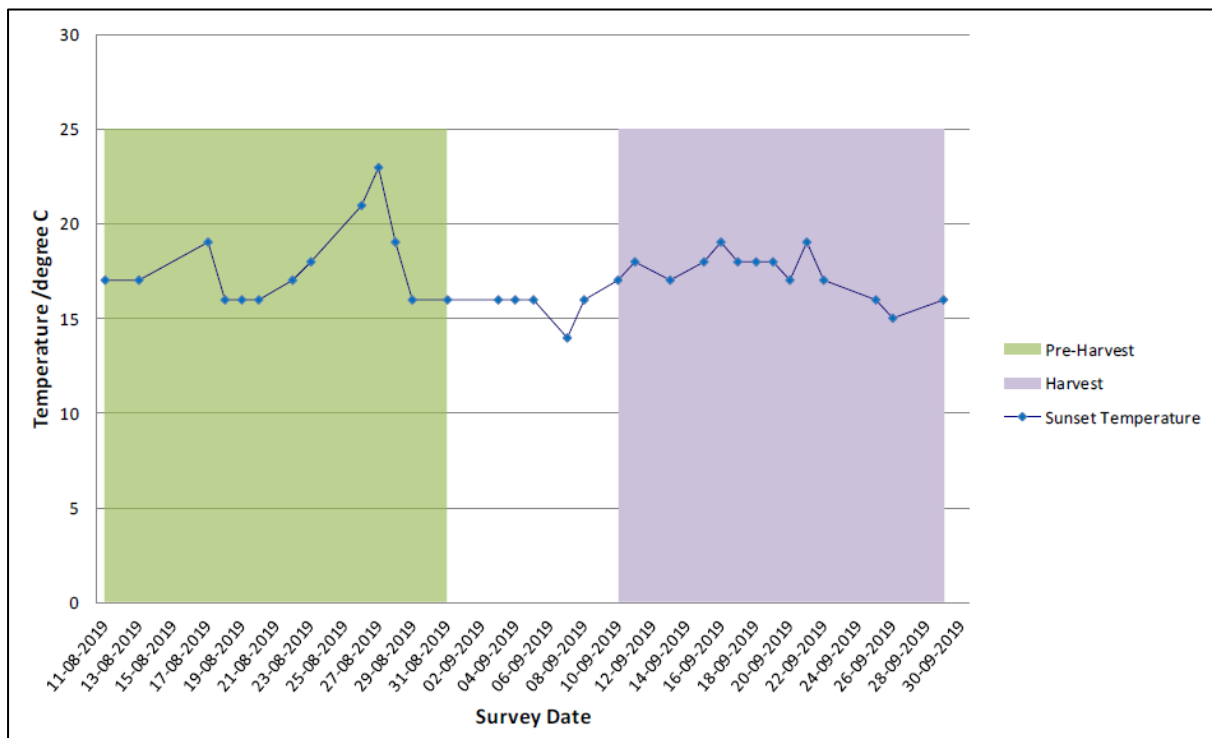


Figure 8: Season 2 survey sunset temperature.

Discussion

The rapid drop in barbastelle activity during season 1 and the start of the harvest period does appear to be linked, indicating a disturbance of the locally roosting barbastelle. The disturbance is unlikely to be roost loss, but possibly the local habitat disruption and displacement of their food source (primarily *Lepidoptera*). At the same time, the opening up

of the canopy has introduced additional foraging opportunity for *Pipistrellus* species, as indicated by the significant increase (45%) in common pipistrelle activity measured during the harvest period.

The repeat of the surveys in season 2 indicated that the common pipistrelle activity was significantly higher (237%) than the previous year. This suggests that increased openness in the canopy has indeed provided a sustainable improvement in the foraging opportunities for this species. This is also borne out by the visual observation and clustering of the bat passes in the clearing and open canopy areas. The initial barbastelle activity was essentially similar to the previous season; a positive sign that the harvesting had not caused a permanent loss of foraging habitat. In addition, the average activity only reduced by 30% over the equivalent period in season 1 where the activity reduced by 80%. Whilst a seasonal shift in the barbastelle activity cannot be excluded, the profound barbastelle activity drop during the season 1 harvest period cannot realistically be excluded as related to the harvesting activity. It is more likely that the regular barbastelle ‘roost hopping’ habit has resulted in the variations seen in season 2.

There were some seasonal differences; season 1 was a wetter period, with a sudden temperature drop during the harvest period. However, this temperature drop did not seem to influence common pipistrelle activity, and it is known from previous work (Whitehurst, 2016) that barbastelle will regularly forage in temperatures as low as 5°C. It is therefore unlikely that this was a key driver in the reduced activity observed for this species in the season 1 harvest period.

Conclusions

The conclusion of this survey work is that the harvesting activity did present a disruption to the local barbastelle population during the period of the harvest. However, this disruption has been temporary and within the limitations of this survey, barbastelle activity has recovered to the recorded pre-harvest levels in the season following the harvest. It is likely in this case that the ‘roost hopping’ strategy for this species, combined with the widespread availability of alternative roosts in the Parkhurst Forest has enabled the barbastelles to overcome the disruption.

The common pipistrelle appears to have benefited greatly from the harvesting activity due to opening up of the canopy, thus providing a significantly improved foraging habitat.

The whiskered bat, Natterer’s bat and serotine present in the area also appeared to have benefited from the more open habitat, but the number of records was too small to present a fully quantitative picture of activity change. An increase in brown long-eared bat activity was also noted, but the records were in areas least impacted by the harvesting activities. It is likely the increase in records was due to the increased sampling effort achieved in season 2, rather than any habitat change.

Overall, the selective felling approach appears to be a good solution to maintaining bat foraging habitat at the same time as effectively harvesting high value hardwood timber. Success of the technique in this case appears to be related to there being alternative roost/foraging locations available within the local landscape context, and the attention to

detail in avoiding the felling of a number of stems with roost potential within the harvesting area.

Acknowledgements

This survey work was carried out with the help of the following Isle of Wight Bat Group Volunteers: Glynn Cooper, Belinda Seebaluck, David Downer and Bernie Hamet.

References

Chatters, C. (1993) A brief Ecological History of Parkhurst Forest Isle of Wight. *Proc. Isle of Wight Nat. Hist. Archaeol. Soc.*, 11 pp. 43-59.

Davidson-Watts, I. (2008) *The Isle of Wight Woodland Bat Survey Final Report*. London: Peoples Trust for Endangered Species.

Forestry Commission (2007) *The Parkhurst Forest Design Plan 2007-2037*.

Forestry Commission England (2017) *Isle of Wight Forest Plan*. FE Plan Reference Number: 304/57,58,59,60.

Whitehurst, J. (2016) The application of acoustic survey and species distribution modelling in estimating bats' use of habitat in detail for small areas. *Proc. Isle of Wight Nat. Hist. Archaeol. Soc.*, 30 pp. 79-87.

[Return to contents page](#)

Discovery of a New Barbastelle Colony in the Chiddingfold Forest Complex, Surrey

Ross Baker and Lynn Whitfield; Surrey Bat Group

ross.lynn@zen.co.uk

Introduction

Until 2019 the Surrey Bat Group database had no records of breeding roosts of barbastelle *Barbastella barbastellus* in the county. For many years the Bat Group has suspected that at least one breeding colony must be present, but work done to date has failed to find any evidence to support this theory.

While working on a small *Myotis* woodland bat project with the Bat Conservation Research Unit, the Bat Group gathered more records for barbastelles in the county, so for the 2019 survey season a licence was obtained from Natural England (number 2019-38922-SCI-SCI) to permit Ross Baker and Lynn Whitfield to fit radio tags to any female or juvenile barbastelles captured. In May 2019 two female barbastelles were caught and radio tracked. The first, from Wanborough Wood near Guildford, was tracked back as far as Witley, but the tag expired before the roost was found. The second was caught at Peartree Hanger in Chiddingfold Forest (OS grid reference SU991336), and was tracked back to a roost in Durfold Wood (OS grid square SU9832). A total of 14 bats were filmed emerging from a feature in a dead oak tree, indicating the presence of a small maternity roost. Full details can be found in the Surrey Bat Group summer newsletter (Whitfield, 2019).

This report presents the results of further radio tracking studies carried out in the Chiddingfold Forest area later the same year.

Methods

The Bat Group returned to Durfold Wood on 7th August 2019 and set up two Austbat harp traps (Faunatech, Australia), one two-bank and one three-bank, each with an AT100 ultrasonic lure (Binary Acoustics, USA), in the woodland understorey, one 9m net (Ecotone, Poland) across one of the main woodland trails and a 3m net across one of the side trails. A 0.29g radio tag (Lotek, UK) was glued between the shoulder blades of bats to be radio tracked using medical grade latex adhesive (Torbot, USA) (Figure 1). The bats were tracked using three-element Yagi antennas and TRX1000 receivers (Wildlife Materials, USA).

When roost sites were located, emergence surveys were carried out from 30 minutes before sunset to at least 15 minutes after the last bat emerged, using Canon XA10 or XA20 video cameras with supplementary infrared lighting to view emergence. Acoustic bat detectors (Elekon Batlogger M or Batbox XD time expansion/frequency division detector connected to a Roland R-05 digital recorder) were set up near the roost trees to record bat calls during the surveys. All bat call sequences recorded were analysed using appropriate software (Elekon BatExplorer/Cool Edit) to check species identification.



Figure 1: Radio tag fitted to barbastelle.

Results

At 23.20 on 7th August a post-lactating female barbastelle weighing 9.5g was caught in the 9m net and 5 minutes later another weighing 10.0g was caught in the same net. Both bats were caught in the north side of the net, implying that they had been heading south. The first bat was fitted with a tag broadcasting at 173.842mHz and the second bat with a tag broadcasting at 173.744mHz. Throughout this report they are referred to as bat 842 and bat 744 respectively. Full details of all roosts identified have been submitted to the Bat Tree Habitat Key database¹ and are summarised in Table 1.

Table 1: Summary of roost tree features.*

<i>Tree ref.</i>	<i>Tree alive/ dead</i>	<i>Tree height (m)</i>	<i>DBH (cm)</i>	<i>Roost aspect</i>	<i>Roost height (m)</i>	<i>DRH (cm)</i>	<i>Distance to edge of wood (m)</i>
TW1	Dead	12	24	Mainly E and SE	Lower 3, upper 4-4.5	24	76
TW2	Alive	12	38	NE	3	28	105
TW3	Dead	12	33	NE	4	22	92
MC1	Dead	16	64	?	?	?	51
MC2	Dead	18	49	?	?	?	39
MC3	Dead	10	39	W and ?	3	39	33
MC4a	Alive	Exact tree uncertain - one of small group close to tree 4b					
MC4b	Dead	14	42	NE	6 (also uncertain area higher up)	42	0

*Heights and diameter at roost height (DRH) estimated by eye from the ground. DBH - diameter at breast height.

¹ <http://battreehabitatkey.co.uk/>

Bat 842

The day after trapping bat 842 could not be found during the day, or at emergence time, nor could it be found during a daytime search on 9th August. However it was picked up foraging around the south of Tugley Wood (to the north of the capture site) in the evening. During a daytime search on 10th August the bat was located to a dead pedunculate oak *Quercus robur* in Tugley Wood West (OS grid square SU9733) (tree ref. TW1: Figure 2). A minimum of 16 bats were filmed emerging from behind lifted bark between 20.58 and 21.17.

The following day bat 842 had moved to a live pedunculate oak in Tugley Wood West, OS grid square SU9734 (tree ref. TW2: Figure 3), where it was found to be roosting in a shearing crack. Accurate filming of the emergence was made difficult by the surrounding vegetation, but a minimum of 19 bats were filmed emerging, the first at 20.49. However, it was still in the same feature within TW2 the next day (12th August) and with the camera in a better position it was possible to get a good view of 21 bats emerging between 20.54 and 21.22.



Figure 2: Tree TW1 (distant and close up) with the two roost features arrowed.



Figure 3: Tree TW2 with roost feature shown in summer (left) and winter.

On 13th August bat 842 was found back in tree TW1, where it remained for a total of five days. On the night of 14th August bad weather prevented filming but attempts were made to film the emergence on all other nights. Filming was difficult as the bats were usually under two separate sections of lifted bark and the maximum that could be filmed emerging on any one night was seven on 15th August.

On 18th August the bat had moved again to a new roost in Tugley Wood West (OS grid square TQ9733) (tree ref. TW3: Figure 4), which was also a dead pedunculate oak in an area where pine clearance appeared to have been recently undertaken. The bats emerged from a feature likely to be a lightning strike enlarged by a woodpecker/grey squirrel, forming a round hole in the bark. During filming on 18th and 19th August the emergence of 22 and 21 bats respectively was recorded.



Figure 4: Tree TW3 with roost exit arrowed.

Bat 744

The day after capture bat 744 was found to be roosting behind a sheet of lifted bark in a dead pedunculate oak (tree ref. MC1: Figure 5) in Manorhill Copse (OS grid square SU9732), to the south-west of Durfold Wood. The roost was not located until late in the day and there was no time to obtain permission to do further work in this privately owned wood.

By the following day, 9th August, bat 744 had moved to a different dead pedunculate oak within the same grid square in Manorhill Copse (tree ref. MC2: Figure 6). It was still there on 10th August but surrounding vegetation made it impossible to identify the roost feature with certainty or to film the emergence clearly. Only six bats could be confirmed emerging between 20.56 and 21.06, but there were certainly more present. A daytime check on 11th August revealed that the bat had moved again to another dead pedunculate oak in Manorhill Copse, but still in SU9732 (tree ref. MC3: Figure 7) where it was found roosting beneath lifted bark. Again there were problems with the camera setup and surrounding holly *Ilex aquifolium*, and only 10 bats could be confirmed emerging. However, there were



Figures 5 and 6: Trees MC1 and MC2: the exact roost locations were not identified.

definitely more bats present. The bat was in the same feature within MC3 the next day and with a better camera setup it was possible to get a good view of 25 bats emerging between 20.42 and 21.25, and a further bat was filmed within the roost but failed to emerge, making a total of 26.



Figure 7: Tree MC3 in summer (left) and in winter. The fallen bark plate that had formed the roost site is circled.

On 13th August the bat could not be located during the day and was not picked up foraging in the area during the evening, and on 14th August bad weather prevented fieldwork both day and night. However, on 15th August bat 744 was found to be back in tree MC3 and the cameras were duly deployed to film emergence, but the bats had moved higher up the tree and the exact emergence point could not be located. The bat was still in the same tree the next day, but bad weather prevented filming that evening.

During a visit to the site on 7th January 2020 it was found that the bark plate that formed the roost filmed on 12th August had fallen off (Figure 7).

The bat disappeared again on 17th August and, despite bringing in another surveyor to cover the countryside to the south, no signal was detected. On 18th August it was back in tree MC3 but a prior commitment meant filming that night was not possible. On 19th August the bat had moved to a new roost somewhere in a cluster of two live and one dead pedunculate oaks on the edge of Manorhill Copse (OS grid square SU9632) (tree group ref. MC4: Figure 8). An attempt was made to film emergence that evening but the results were inconclusive, although the bats appeared to be in one of the live oaks. The last fieldwork took place on 21st August when the bat was still in the same clump, but this time it was clear that the signal was coming from the dead oak and 23 bats were filmed emerging from behind lifted bark. However, long after all the bats seemed to have emerged a signal was still coming from the tree, so it was assumed the tag had been groomed off.



Figure 8: Tree group MC4 with identified roost location arrowed.

Discussion

The radio tracking work on both the Durfold Wood roost in May 2019 and the roosts described above concentrated on finding and describing roosts and filming emergence in order to obtain accurate counts. On one evening in May an attempt was made to follow the bat from the Durfold Wood roost. As on previous evenings, it headed north on leaving the roost, but contact with it was lost to the south of Dunsfold around 21.51. Bat 842 generally seemed to forage in the fields and woodland edges to the immediate west of Tugley Wood following emergence. Some time was spent following it on the 17th August and between 20.40 and 21.25 it was in this area, venturing as far west as the boundary of Chiddingfold Golf Club (OS grid square SU9534), but by 22.26 it was further south, in the vicinity of Little Haymans farm (OS grid square SU9731), and by 22.46 it had worked its way around to the west, broadly along the line of the Sussex border path.

Greenaway (2008) describes how the sub-groups of the colony in Ebernoe, Sussex, would overlap with one another and that bats would move between sub-groups, but that the colonies from Ebernoe and the Mens maintained a strict separation between each other. The fact that both of the bats in the present study were caught in the same mist net within minutes of each other, and that bat 842's foraging range on 17th August included Manorhill Copse, suggests that the two sets of roosts monitored comprised sub-groups of the same colony.

The count on 12th August was significant as a full emergence count was obtained from both groups simultaneously, with 26 bats at Manorhill Copse and 21 at Tugley Wood. These counts would have included newly volant young and so the number of breeding females present is uncertain, but this does provide a minimum count of 47 bats within the two sub-groups at this time.

During the Greenway's 2008 study some of the bats were tracked to Tugley Wood, Peartree Hanger and Manorhill Copse, although the fixes there did not form part of the core foraging area for any of the tracked bats. However, given the unwillingness of bats from different colonies to trespass onto neighbouring territories, questions arise about the relationship of the Chiddingfold bats to Ebernoe. Are these two newly discovered sub-groups part of the Ebernoe colony, has the Ebernoe colony fractured, or is this a new separate colony? At their closest the distance from tree MC3 to Ebernoe is only 4.1km and so some sort of link between the two is quite likely. Bat 744 disappeared entirely for two nights during the tracking period, despite an extensive daytime search of the immediate area.

Management Recommendations

On the whole Manorhill Copse, Tugley Wood and Durfold Wood (the last two managed by the Forestry Commission and the Woodland Trust respectively) appear to be being sympathetically managed for bats. All three sites consequently have a considerable amount of standing dead wood. There are some problems with rhododendron *Rhododendron ponticum* encroachment in Manorhill Copse and there are signs that this has been successfully suppressed in the past, but a further programme of removal and stump treatment would be desirable, particularly in the vicinity of tree MC3. All UK barbastelle research papers (e.g. Greenaway, 2008; Carr, 2018) call for a minimum intervention approach in order to achieve old growth semi-natural broad-leaved woodland, but where conversion from plantation is in progress, as for example in Tugley Wood, greater intervention is likely to be necessary. A large area of Tugley Wood, particularly in the vicinity of tree TW3, appears to have been cleared of pine and left to regenerate, but much of the regenerating vegetation is young pine and this should be removed if possible. Given the ephemeral nature of many of the roosts used by barbastelles it is important that there is a regular succession of oaks, including dying trees. Theoretically new trees will grow through thorny scrub that grows around fallen trees but there is limited evidence of this taking place at the moment and so some additional planting may be required in order to achieve the desired mix along with some deer protection and/or control.

In Sussex wider area enhancements were implemented, for example at Butcherlands fields near Ebernoe where flightlines were improved and arable conversion implemented by Sussex Wildlife Trust. This is thought to have resulted in significant benefits to the Ebernoe

colony and reduced the distance bats were travelling each night in order to reach optimal feeding areas (Greenaway, 2008). The Chiddingfold Forest area forms part of the LW01 Low Weald Biodiversity Opportunity Area identified by the Surrey Nature Partnership (Surrey Nature Partnership, 2015) and so it may be possible to use this as a tool to drive similar beneficial change in the areas surrounding these newly discovered roosts.

However, at present there are a number of potential threats to the habitat surrounding the colony as within the 6km core sustenance zone there is currently an application to drill an exploratory oil well under consideration, Waverley Council has approved a major development of just under 2000 homes, plus associated infrastructure, in a new 'Garden Village' at Dunsfold Aerodrome and the Wey and Arun Canal Trust have ambitious plans to restore a long defunct canal that runs through ancient woodland to the south of the aerodrome.

Acknowledgements

Thanks are due to the many Surrey Bat Group members who assisted with trapping, radio tracking and filming. Also to the Forestry Commission and the Woodland Trust for facilitating access to their sites and to the owners of Manorhill Copse for permission to survey there.

References

Carr, A., Zeale, M.K.R., Weatherall, A., Froidevaux, J.S.P. and Jones, G. (2018) Ground-based and LiDAR-derived measurements reveal scale-dependent selection of roost characteristics by the rare tree-dwelling bat *Barbastella barbastellus*. *Forest Ecology and Management*, 417 pp. 237-246.

Greenaway, F. (2008) *Barbastelle Bats in the Sussex West Weald 1997 – 2008*. Report to the West Wield Landscape Partnership.

Surrey Nature Partnership (2015) *Biodiversity Opportunity Areas: the basis for realising Surrey's ecological framework*.

Whitfield, L. (2019) A tale of two barbastelles. *The Bat Detector*, 93 pp. 3-4.

[Return to contents page](#)

Bats at the Beach: Activity levels of *Pipistrellus pipistrellus* and other British bats above intertidal beaches in Devon, England

Naomi Siân Hawkes-Southern and Paul Lintott; University of the West of England
naomihawkesouthern@gmail.com

Abstract

A clear understanding of how British bat species use different habitats is key to formulating land management strategies that support and strengthen populations. However, knowledge of how bats use different habitats varies widely depending on the habitat in question, with data on coastal habitats particularly lacking. We therefore undertook a preliminary study to investigate the diversity of bat species using coastal habitats, alongside determining the relative importance of beach availability in determining common pipistrelle activity. We recorded a total of 6,867 bat passes of eight species/genera from two beaches in South Devon over a 30 night period. Common pipistrelle *Pipistrellus pipistrellus* were most frequently recorded (89% of total passes), however the presence of a variety of species including lesser horseshoe bats *Rhinolophus hipposideros* and greater horseshoe bats *R. ferrumequinum* indicates that beaches are used regularly by a variety of species. Common pipistrelle activity was strongly influenced by both temperature and beach availability. Common pipistrelle activity increased as the tide went out and more beach habitat became available. Our findings have implications for coastal management strategies, such as beach grooming, given that the exposed intertidal beach appears to be a valuable habitat for a wide range of British bat species, especially common pipistrelles.

Keywords

Acoustic survey, coastal, foreshore, habitat use, tide state, woodland.

Introduction

Accurate data on the relative abundance and frequency of species occurrence is important for calculating species' priority for conservation actions (Rondinini *et al.*, 2006). Should this data be lacking, habitat may be left vulnerable to loss or change (Lintott *et al.*, 2014). Many species of British bat have undergone population declines over the past three decades, due in part to habitat degradation and loss (Mickleburgh *et al.*, 2002). However accurate population estimates cannot be made for a third of British bat species and they are some of the least understood British mammals (Mathews *et al.*, 2018). The lack of robust data on how different bat species utilise the wide variety of habitats in Britain makes them particularly vulnerable to environmental changes. Well-informed land management decisions cannot be made without clear, quantifiable data on how different taxa are associated with different habitats (Guisan and Zimmermann, 2000). Compared to many other British habitats, there is relatively little known about how bats use coastal environments, although sea cliffs (Walsh and Harris, 1996; Ahlén *et al.*, 2009), shingle bars (Spalding, 2015) and beaches (Walsh and Harris, 1996; Russ, 2012; Manx Bat Group, 2019) have been previously found to be important. One key aspect of coastal habitats, which to our knowledge has yet to be studied, is the unique conditions that tides provide in changing the proportion of foraging habitat available across the duration of a night.

As an initial, small-scale exploratory study, this research has two aims: (i) to investigate which of the eighteen species of bat encountered in Britain might be found at a coastal site

in South Devon and (ii) to investigate the relative importance of beach availability in determining bat activity.

Methods

Study area

The study area comprised two beaches: Watcombe Beach (Latitude 50.495864, Longitude -3.515501) and Oddicombe Beach (Latitude 50.482910, Longitude -3.515268) approximately 1.5km apart (Figure 1). These are within the English Riviera Global Geopark in South Devon, England, a bay region comprising 64km² of land and 40km² of sea (Border *et al.*, 2010). All sixteen of the eighteen British bat species present in Devon have ranges that extend across the Geopark (Mathews *et al.*, 2018). Both beaches are located beneath steep coastal cliffs of red breccia and limestone that are covered with broadleaf woodland. Watcombe Beach is a predominantly sandy beach whereas Oddicombe Beach is shingle and sand. Both beaches have been developed for tourism, with concrete hardstandings and cafes separating both beaches from the woodland beyond. However, these manmade areas are not large enough to disrupt connectivity between beach and woodland habitat and are not lit at night. Given that the two beaches are connected by near-continuous woodland running along the coastline, we combined the data from both beaches together within the statistical analysis.

Data collection

Acoustic surveying was conducted for 30 nights from 5th June until 3rd August 2019 using Anabat Express zero-crossing acoustic detectors. A detector was secured on railings at each beach with the microphone pointed towards the beach. Surveying commenced 45 minutes prior to sunset and concluded 45 minutes after sunrise to ensure all commuting and foraging activity was captured. All bat recordings were analysed using Analook Insight (Titley Scientific, version 1.8.6-0-g6439329). Due to the high number of recordings, a bat pass was counted as a sound file which contained identifiable echolocation pulses (following Sowler and Middleton, 2013). Species were identified to species level using Russ (2012) and Middleton *et al.* (2014), however it can often be difficult to distinguish between the echolocation calls of species within the same bat genus due to similarities in call structure. As a consequence, recordings of *Myotis*, *Nyctalus* and *Plecotus* were identified to genus level and were grouped together within genera-wide categories.

Statistical analysis

Statistical analysis was conducted using R version 3.6.1 (R Core Team, 2019a), using MASS (Venables and Ripley, 2002) and foreign (R Core Team, 2019b) packages. Graphics were produced using ggplot2 (Wickham, 2016) and effects (Fox, 2003; Fox and Weisberg, 2019) packages. A generalised linear mixed model (GLMM) with a quasi-Poisson distribution was used with the number of bat passes per 15 minute period in the night as the response variable. Nights with suboptimal weather conditions (following Collins, 2016) were removed from the analysis. Temperature, moonlight illumination, sunlight illumination (categorical variable defined as either between or outside of civil dawn and civil dusk) and absolute tide height (used as a measure of beach habitat availability) were included as explanatory variables. Date was included as a random factor (n=24). Statistical analysis was conducted for common pipistrelles, as this was the only species with sufficient sample size to justify analysis. We present the result of the full model including standardised parameters and confidence intervals for all explanatory variables. Inferences on the effect of each

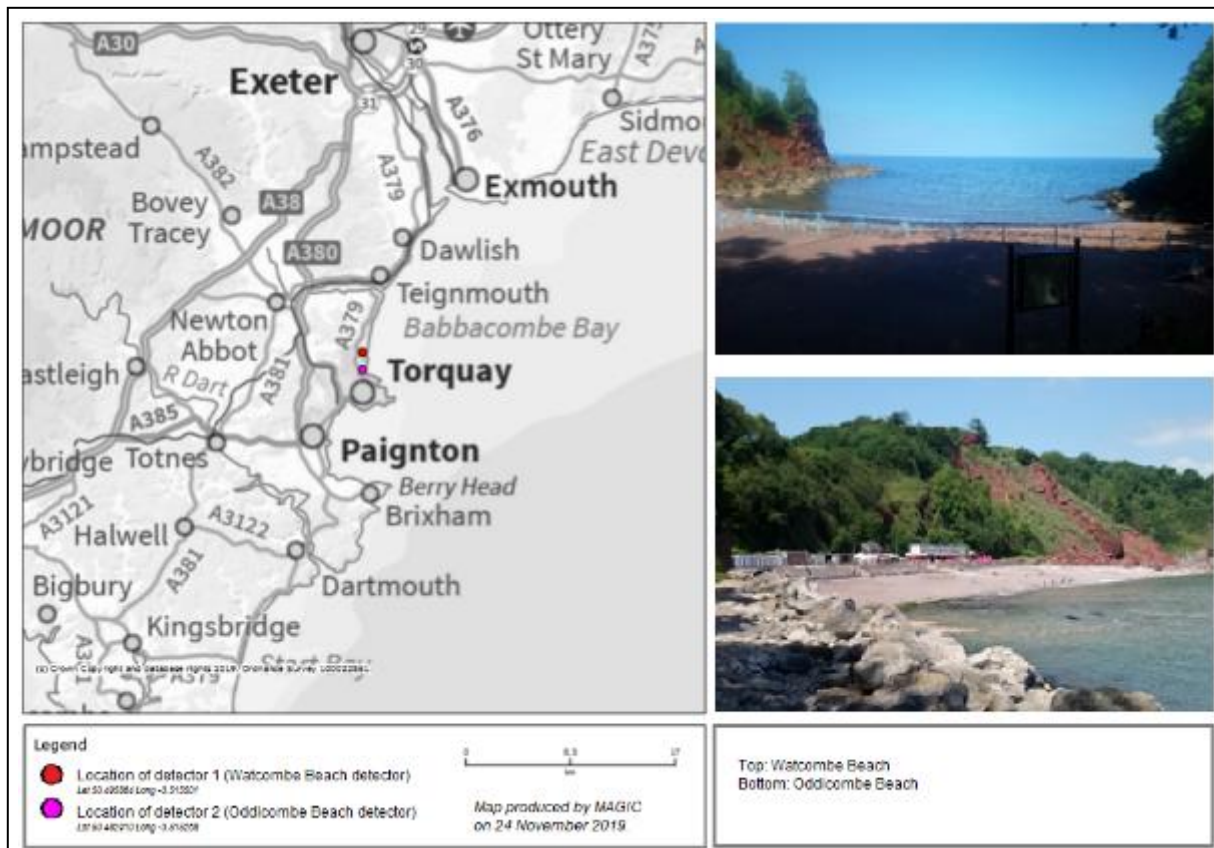


Figure 1: Location of the two beaches studied and their static detectors, with photographs illustrating their common and distinct visual features.

parameter were made by (i) comparing its standardized estimate with other predictor variables to determine relative importance, (ii) the upper and lower 95% quantiles of each parameter distribution obtained from $N=2000$ simulated draws from the estimated distribution and (iii) a comparison of models excluding each parameter in turn using Likelihood Ratio Tests (LRTs). LRTs of main effect parameters also involved in interactions were performed by comparing a model excluding the main effect term to a model including all main effects (but not interactions) only. Prediction plots were constructed by undertaking simulated draws ($n=2000$) from the estimated distribution of one explanatory variable whilst maintaining all other parameters in the model at their median observed values.

Results

Bat activity was recorded every night at both beaches. A total of six genera were represented, representing at least eight different species (Table 1). A total of 6,867 bat passes were recorded during the 30 nights of surveying, the vast majority of which were common pipistrelle bats (88.6%).

Table 1: Total number of bat passes recorded at Watcombe and Oddicombe beach over a 30 night survey period.

Species	Watcombe beach bat passes	Oddicombe beach bat passes	Total passes
Common pipistrelle	3,890	2,193	6,083
Soprano pipistrelle	3	0	3
Serotine	49	63	112
<i>Nyctalus</i> species	217	150	367
<i>Myotis</i> species	25	78	103
<i>Plecotus</i> species	24	33	57
Lesser horseshoe bat	41	4	45
Greater horseshoe bat	32	10	42
Unidentified bat passes	28	27	55
Total bat passes	4,309	2,558	6,867

Ambient temperature was found to have a positive influence and large effect size on the probability of recording common pipistrelle passes (Figure 2A). Based on the estimated coefficients in Table 2, the predicted number of common pipistrelle passes was 1.1 passes per 15 minute interval (95% CI 0.8-1.7) at 12°C, whereas at 16°C this rose to 3.8 (95% CI 3.3-3.4) passes per 15 minute interval. A reduced number of common pipistrelle passes were recorded when the tide was high and beach habitat availability was reduced (Figure 2B). Based on the estimated coefficients in Table 2, common pipistrelle passes reduced from 7.9 passes (95% CI 6.1-10.2) at a tidal height of 0.42m, to 2.7 (2.1-3.6) passes at a higher tidal height of 4.42m. Although significant, moonlight and sunlight illumination had relatively small effect sizes so little biological significance.

Table 2: Parameter estimates and likelihood ratio tests of the GLMM for the probability of recording common pipistrelle at beaches.

Fixed effects	Estimate (SE)	Residual deviance	Deviance	P
Intercept	1.56 (0.06)			
Ambient temperature	0.35 (0.07)	9487.1	372.17	<0.001
Moon illumination	-0.16 (0.05)	9222.1	107.13	0.004
Sunlight illumination	0.14 (0.06)	9182.2	67.28	0.02
Intertidal beach coverage by tide	-0.27 (0.05)	9456.5	341.53	<0.001

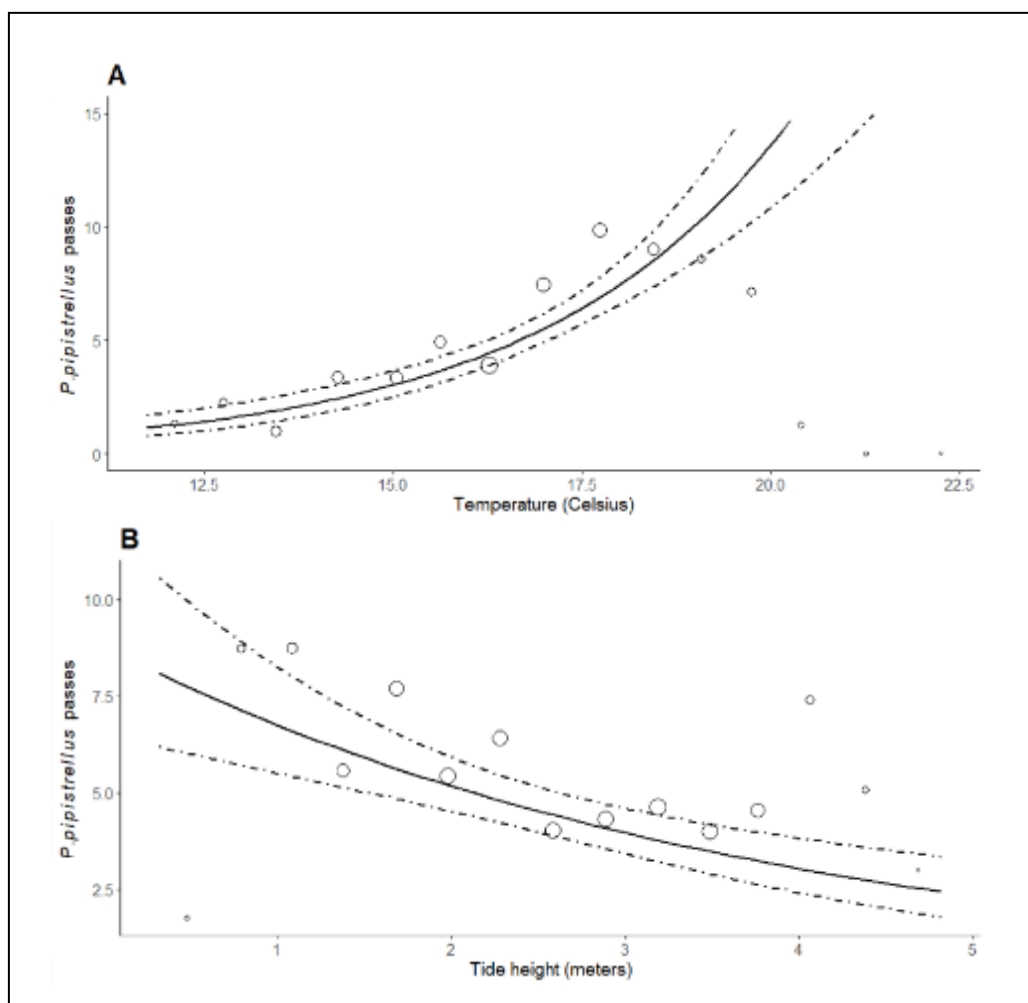


Figure 2: Prediction plots for the responses of common pipistrelles to (A) temperature, and (B) tide height. Original data on the number of common pipistrelle passes recorded are superimposed as grey circles. Diameter of circles proportional to the total number of passes. Dashed lines indicate 95% confidence intervals around the predictions.

Discussion

A wide range of species were detected indicating that coastal habitats are widely used and should be given further attention from a conservation perspective. Although it is relatively unsurprising that *Nyctalus* and serotine bats were recorded given that they are well-adapted to exploit open environments that are characteristic of the foreshore (Norberg and Rayner, 1987), woodland specialists such as *Rhinolophus* species were also recorded. Although we were not able to tell from this study the exact purpose of *Rhinolophus* activity over the beach (i.e. foraging or commuting), our findings highlight the need to investigate how these protected species are using this habitat.

By far the most active species was the common pipistrelle, and from this preliminary study it appears that beaches could be a valuable foraging habitat for this species. The significant relationship between common pipistrelle passes and beach presence (as the tide receded) indicates that this species is exploiting newly available habitat as it becomes available. Common pipistrelles are known to feed on seaweed flies (*Coelop frigida*; Lane, 2012; Meier and Wiegmann, 2002), whilst foraging above seaweed has also been observed (Bat Conservation Trust, 2015; Manx Bat Group, 2019). Analysis of common pipistrelle droppings

will be valuable in determining the relative importance of seaweed flies within their diet, as this may have considerable implications for beach management. Beach grooming to remove seaweed for aesthetic reasons is known to reduce the overall abundance and diversity of strandline-related species (Llewellyn and Shackley, 1996), however its impact on bat populations is unknown.

Very few soprano pipistrelle passes were recorded, which is surprising given the frequency of common pipistrelle passes. Differences in activity levels between common and soprano pipistrelles may be due to habitat partitioning caused by competitive behaviour (Nicholls and Racey, 2006; Rachwald *et al.*, 2016). Alternatively, the opportunities afforded by the site may be different for common and soprano pipistrelles, given that common pipistrelles eat more diverse prey items than soprano pipistrelles (Rachwald *et al.*, 2016), alongside better tolerating deviations from their optimal habitat (Satler *et al.*, 2007). Our findings also support Boshamer and Bekker (2008) and Ahlén *et al.* (2009) who found that greater soprano pipistrelle activity is detected over the open ocean and on offshore installations, whereas common pipistrelle activity was restricted almost entirely to coastlines.

Limitations and further studies

It is worth stressing that this is a preliminary study looking at only two beaches in an area that is known to be particularly abundant in British bat species. However, given the proximity of broadleaved woodland, woodland edges and wildflower meadows it is revealing that we still recorded a high number of bat passes across multiple species using the coastal habitat. A paired study comparing bat activity along beaches to surrounding woodland would give a clearer idea of the relative importance of the coastal ecosystem to bats. Similarly, investigating the impact of anthropogenic activities along the coast (e.g. beach grooming, promenade lighting) is essential to understand if important foraging or commuting habitats are being disturbed or fragmented.

Acknowledgements

We would like to thank Titley Scientific for the loan of two Anabat Express bat detectors; Mark Buck and the Three Degrees West bistro team for assistance at Oddicombe Beach; Chez for assistance at Watcombe Beach; Dr Emma Stone for comments on Naomi's thesis; and Michael Hawkes-Southern for practical support and insight into tides.

References

Ahlén, I., Baagøe, H.J. and Bach, L. (2009) Behavior of Scandinavian bats during migration and foraging at sea. *Journal of Mammalogy*, 90(6) pp. 1318-1323.

Bat Conservation Trust (2015) *Bats in Scotland*. [Online] <https://cdn.bats.org.uk/pdf/Bats-in-Scotland.pdf?mtime=20181101151315> [Accessed 28th November 2019].

Border, M., Proctor, C. and Risdon, J. (2010) *The Official Guide to the English Riviera Global Geopark*. Dorset: Coastal Publishing.

Boshamer, J.P.C. and Bekker, J.P. (2008) Nathusius' pipistrelles (*Pipistrellus nathusii*) and other species of bats on offshore platforms in the Dutch sector of the North Sea. *Lutra*, 51(1) pp. 17-36.

Collins, J. (ed.) (2016) *Bat Surveys for Professional Ecologists: Good Practice Guidelines* (3rd edn.). London: Bat Conservation Trust.

Fox, J. (2003). Effect Displays in R for Generalised Linear Models. *Journal of Statistical Software*, 8(8) pp. 1-27.

Fox, J. and Weisberg, S. (2019) *An R Companion to Applied Regression* (3rd edn.). Thousand Oaks, CA: Sage.

Guisan, A. and Zimmermann, N.E. (2000) Predictive habitat distribution models in ecology. *Ecological Modelling*, 135 pp. 147-186.

Lane, T. (2012) *Do bats like to be beside the seaside? A study of bat feeding behaviour at Selwick's Bay, Flamborough, East Yorkshire*. [Online] <https://eastyorkshirebatgroup.files.wordpress.com/2012/05/bats-beside-the-seaside.pdf> [Accessed 28th November 2019].

Lintott, P.R., Fuentes-Montemayor, E.F., Goulson, D., and Park, K.J. (2014) Testing the effectiveness of surveying techniques in determining bat community composition within woodland. *Wildlife Research*, 40(8) pp. 675-684.

Llewellyn, P.J. and Shackley, S.E. (1996) The effects of mechanical beach-cleaning on invertebrate populations. *British Wildlife*, 7(3) pp. 147-155.

Manx Bat Group (2019) *Manx bats*. [Online] <https://manxbatgroup.org/manx-bats/> [Accessed 28th November 2019].

Mathews, F., Coomber, F., Wright, J. and Kendall, T. (eds) (2018) *Britain's Mammals 2018: The Mammal Society's Guide to their Population and Conservation Status*. London: The Mammal Society.

Meier, R. and Wiegmann, B.M. (2002) A phylogenetic analysis of Coelopidae (*Diptera*) based on morphological and DNA sequence data. *Molecular Phylogenetics and Evolution*, 25 pp. 393-407.

Mickleburgh, S.P., Hutson, A.M. and Racey, P.A. (2002) A review of the global conservation status of bats. *Oryx*, 36 pp. 18-34.

Middleton, N., Froud, A. and French, K. (2014) *Social Calls of the Bats of Britain and Ireland*. Exeter: Pelagic Publishing.

Nicholls, B. and Racey, P.A. (2006) Habitat selection as a mechanism of resource partitioning in two cryptic bat species *Pipistrellus pipistrellus* and *Pipistrellus pygmaeus*. *Ecography*, 29 pp. 697-708.

Norberg, U.M. and Rayner, J.M.V. (1987) Ecological morphology and flight in bats (Mammalia; Chiroptera): Wing adaptations, flight performance, foraging strategy and echolocation. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 316(1179) pp. 335-427.

R Core Team (2019a) R: A language and environment for statistical computing, version 3.6.1. Vienna: R Foundation for Statistical Computing. [Online] <https://www.R-project.org/>

R Core Team (2019b) *foreign: Read Data Stored by 'Minitab', 'S', 'SAS', 'SPSS', 'Stata', 'Systat', 'Weka', 'dBase', ...*, version 0.8-72. Vienna: R Foundation for Statistical Computing. [Online] <https://www.R-project.org/>

Rachwald, A., Bradford, T., Borowski, Z. and Racey, P.A. (2016) Habitat preferences of soprano pipistrelle *Pipistrellus pygmaeus* (Leach, 1825) and common pipistrelle *Pipistrellus pipistrellus* (Schreber, 1774) in two different woodlands in North East Scotland. *Zoological Studies*, 55(22) pp. 1-8.

Rondinini, C., Wilson, K.A., Boitani, L., Grantham, H. and Possingham, H.P. (2006) Tradeoffs of different types of species occurrence data for use in systematic conservation planning. *Ecology Letters*, 9 pp. 1136-1145.

Russ, J. (2012) *British Bat Calls: A Guide to Species Identification*. Exeter: Pelagic Publishing.

Sattler, T., Bontadina, F., Hirzel, A.H. and Arlettaz, R. (2007) Ecological niche modelling of two cryptic bat species calls for a reassessment of their conservation status. *Journal of Applied Ecology*, 44(96) pp. 1188-1199.

Sowler, S. and Middleton, N. (2013) 'Bat passes' – Redundant or still useful? An alternative approach to the analysis and interpretation of large amounts of data. *Bulletin of the Institute of Ecology and Environmental Management*, 79 pp. 16-18.

Spalding, A. (2015) *Loe Bar and the Sandhill Rustic Moth: The Biogeography, Ecology and History of a Coastal Shingle Bar*. [Online] <https://brill.com/view/book/9789004270305/B9789004270305-s006.xml> [Accessed 30th November 2019].

Walsh, A.L. and Harris, S. (1996) Foraging Habitat Preferences of Vespertilionid Bats in Britain. *Journal of Applied Ecology*, 33(3) pp. 508-518.

Wickham, H. (2016) *ggplot2: elegant graphics for data analysis*. New York: Springer.

[Return to contents page](#)

Eight years of swarming studies in Purbeck – what does it tell us?

Nick Tomlinson

nick@elephantsears.org

Introduction

The Dorset Bat Group (DBG) have been undertaking swarming studies in Purbeck for the last eight years. Initially this was undertaken at just one site (Figure 1) but, as the data was gathered, more questions arose, and so more sites were trapped. The group also started ringing selected species, in order to try and help answer some of those questions, but many questions still remain. This article is in two parts:

1. The first part presents the findings of the DBG swarming studies to date. The purpose is not to state definitive facts, but rather to share our findings, suggest possible interpretations, and encourage others to do the same, and to join in the conversation. It is, after all, only by constantly asking questions, and sharing information and ideas that we move forward so, please, feel free to get in touch with your thoughts, ideas and your own interpretation. Tell us we are wrong (or right!), we don't mind, as long as the conversation happens!
2. The second part of the article compares the DBG surveys with the first swarming studies that we are aware of in the Purbeck, undertaken by Jon Flanders as part of his PhD during the middle of the 'noughties' (Flanders, 2008). His work focussed on some of the inland quarries to the west of Langton Matravers (large green oval, Figure 2) and one coastal site at Winspit (smaller green oval, Figure 2). The DBG work has taken place almost exclusively at the sea caves¹ at Winspit (Figure 1), which is around 150m from where Flanders trapped.



Figure 1: Purbeck swarming site.

¹ These sites are actually old quarries but have been referred to elsewhere as 'Sea Caves' so, for consistency that nomenclature is retained here.

As we have gathered more data, and more questions have arisen, we have started to explore some of the other coastal sites (red circles, Figure 2) and re-survey some of the inland sites where Flanders undertook his work, together with a few sites where, as far as we are aware, no bat surveys have been undertaken in the past.² In comparing the results of Flanders' surveys with those undertaken by DBG we consider the differences in survey approach in relation to the differences in findings but the comparison of the two sets of data raises some interesting questions and furthers the conversation about swarming in Dorset.

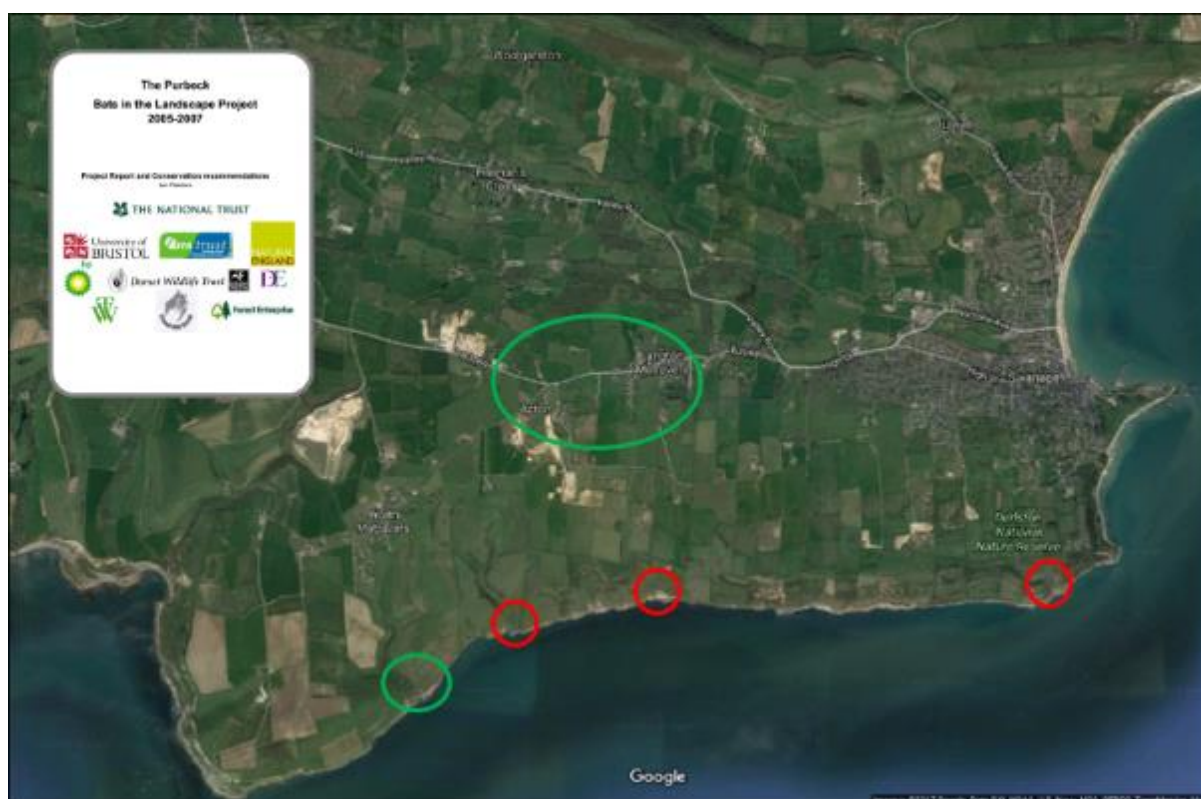


Figure 2: The Purbeck, Bats in the Landscape.

Part 1 – Dorset Bat Group swarming studies in Purbeck

Our site

There are three Sea Caves at Winspit (Figure 3) and we undertake our trapping at two of them, Sea Cave Two and Sea Cave Three. The red shaded boxes show the approximate extent to which the caves extend underground.

Sea Cave Two has two entrances (indicated by red arrows, Figure 3), with a stone pillar down the middle of one of these. Sea Cave Three also has two entrances, one facing into the platform the quarries open onto and one facing directly out to sea.

² Although bat conservation work, including surveying quarries and counting bats, began in the middle of the 19th century it is not always easy, or possible, to relate a particular record to a specific site, either because the name of the site used when the survey was undertaken has now changed, and is untraceable, or there is no OS grid reference or other location mechanism available to identify the site to which the record belongs.



Figure 3: Winspit Sea Caves.

We set up four mist nets on each trapping session. One of these runs across the main entrance of Sea Cave Two (Figure 4), you can just make out the net and one of the poles at the far end of the Figure, but this leaves the second entrance (which is behind the photographer in the picture) free.

The second net runs at right angles to the middle of the first net, but outside the cave, and is designed to cause any bats that fly across the entrance to turn inwards and, hopefully, fly into the main net.



Figure 4: Sea Cave Two.

The third net runs across the inward pointing entrance of Sea Cave Three, blocking it entirely, with the seaward pointing entrance left unblocked (Figure 5). The fourth net is set within Sea Cave Three and is behind photographer in the picture.



Figure 5: Sea Cave Three.

Interestingly, the split of captures between the two caves is almost exactly 50/50. In Sea Cave Two, the main net, across the entrance, accounts for nearly 100% of the captures in that cave, while the split between the two nets in Sea Cave Three is almost 50/50.

Although we have been ringing at Winspit for a few years, it was initially only the rarer species (Bechstein's bat *Myotis bechsteinii*, for instance) that we ringed. We started ringing comprehensively only three years ago and have had a number of re-traps since.

Of those re-traps around 85% have been in the same sea cave in which the bat was originally caught. The data are too few to draw firm conclusions, but it is interesting to ponder whether there is some form of segregation going on between the two caves, or whether it might, perhaps, be 'personal preferences' on the part of individual bats!

Our captures

Over the course of eight years of trapping we have caught 13 of the UK's 18 species, as set out in Table 1, and recorded two other species, Nathusius' pipistrelle *Pipistrellus nathusii* and lesser horseshoe bat *Rhinolophus hipposiderous*, as present on site (through the deployment of static detectors). The only species that we have not, yet, recorded are greater mouse-eared bat *M. myotis*³, Leisler's bat *Nyctalus leisleri* and, knowingly⁴, Alcaethoe bat *M. alcathoe*. Figure 6 shows the proportion of each species that have been caught at the sea caves.

³ Interestingly, although now extinct in Dorset (with the last bat seen in the late 1970s) this species was previously recorded at Winspit (although not in the sea caves) when a small colony existed in the county.

⁴ The group's experience of this species is limited.

Table 1: Species captured during trapping surveys at Winspit Sea Caves, whether they are considered swarming species and key to species references in the figures within this report.

Species	Classic swarming species ⁵	Abbreviation used in Figures
greater horseshoe bat <i>Rhinolophus ferrumequinum</i>	No	Rhy fer
Daubenton's bat <i>Myotis daubentonii</i>	Yes	Myo dau
Brandt's bat <i>Myotis brandti</i>	Yes	Myo bra
whiskered bat <i>Myotis mystacinus</i>	Yes	Myo mys
Natterer's bat <i>Myotis nattereri</i>	Yes	Myo nat
Bechstein's bat <i>Myotis bechsteinii</i>	Yes	Myo bec
noctule <i>Nyctalus noctula</i>	No	Nyc noc
serotine <i>Eptesicus serotinus</i>	No	Ept ser
common pipistrelle <i>Pipistrellus pipistrellus</i>	No	Pip pip
soprano pipistrelle <i>Pipistrellus pygmaeus</i>	No	Pip pyg
brown long-eared bat <i>Plecotus auritus</i>	Yes	Ple aur
grey long-eared bat <i>Plecotus austriacus</i>	No	Ple aus
barbastelle <i>Barbastella barbastellus</i>	Yes	Bar bar

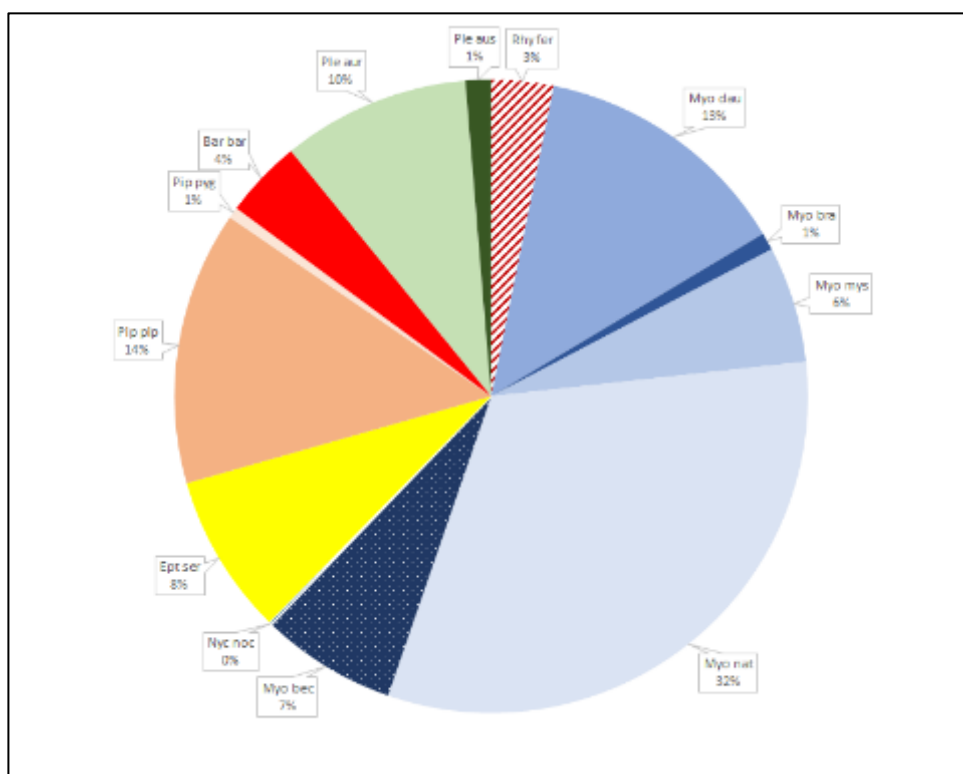


Figure 6: Proportion of each bat species caught in the sea caves.

As might be expected, the 'classic' swarming species (Table 1) represent a significant portion of the captures, although numbers of each vary, with Natterer's bat, Daubenton's bat and brown long-eared bat being the most common. In common with our findings elsewhere in the county, Brandt's bat is a real rarity at Winspit.

⁵ That is members of the *Myotis* genus, barbastelle and brown long-eared bat.

As far as ‘non-swarming species’ (Table 1) are concerned we do catch the occasional noctule and greater horseshoe bat, the latter being present at a nearby roost all year round (in varying numbers). Soprano pipistrelle is another real rarity at Winspit, but common pipistrelle and serotine are caught in reasonable numbers.

Over the last nine years we have caught slightly more common pipistrelle than Daubenton’s bat, and nearly as many serotine as we have brown long-eared bat. Given these similarities, we felt it was worth looking a little deeper at both serotine and common pipistrelle, in comparison to those we consider to be swarming species, to see if there are other similarities.

We looked at capture rates of each species across the year, then across the night and finally, we looked at the sex ratios of the species.

Captures across the season

To look at this in more detail we split the trapping months into two periods, early, when the trapping session would have taken place mid-month, and late, when the trapping session would have taken place toward the end of the month, with the actual dates varying year to year. We then calculated how many of each species (excluding recaptures on the same night) we caught in each of the four periods. Figure 7 shows actual number of animals caught in each period and Figure 8 shows the percentages of the total catch of each species that was caught in each period.

We know from previous studies that some species show a distinct seasonality in their capture. Daubenton’s bats, for instance, are known to peak in August, while Natterer’s bats have their peak in September and our data reflects that expectation very well, with very clear peaks for those two species in those months.

The data for whiskered bat might suggest a peak in August, similar to Daubenton’s bat. The picture with regards Brandt’s bat is far less clear, as we catch far too few for any pattern to be obvious. There may be a slight suggestion of a bias toward September for brown long-eared bats.⁶ The picture for Bechstein’s bat and barbastelle might suggest an even spread across the season.

The pattern for both serotine and common pipistrelle is very interesting. Serotine is clearly an August animal, showing very strong seasonality for that month, stronger than any of the classic swarming species, indeed a serotine at Winspit in September is an uncommon animal.

The picture for common pipistrelle is comparable with whiskered bat, or even Daubenton’s bat, in that there would appear to be evidence of an August peak, but common pipistrelle is found slightly more often in September than the other two species.

⁶ Some studies have suggested this species mates later in the season and even swarms in spring.

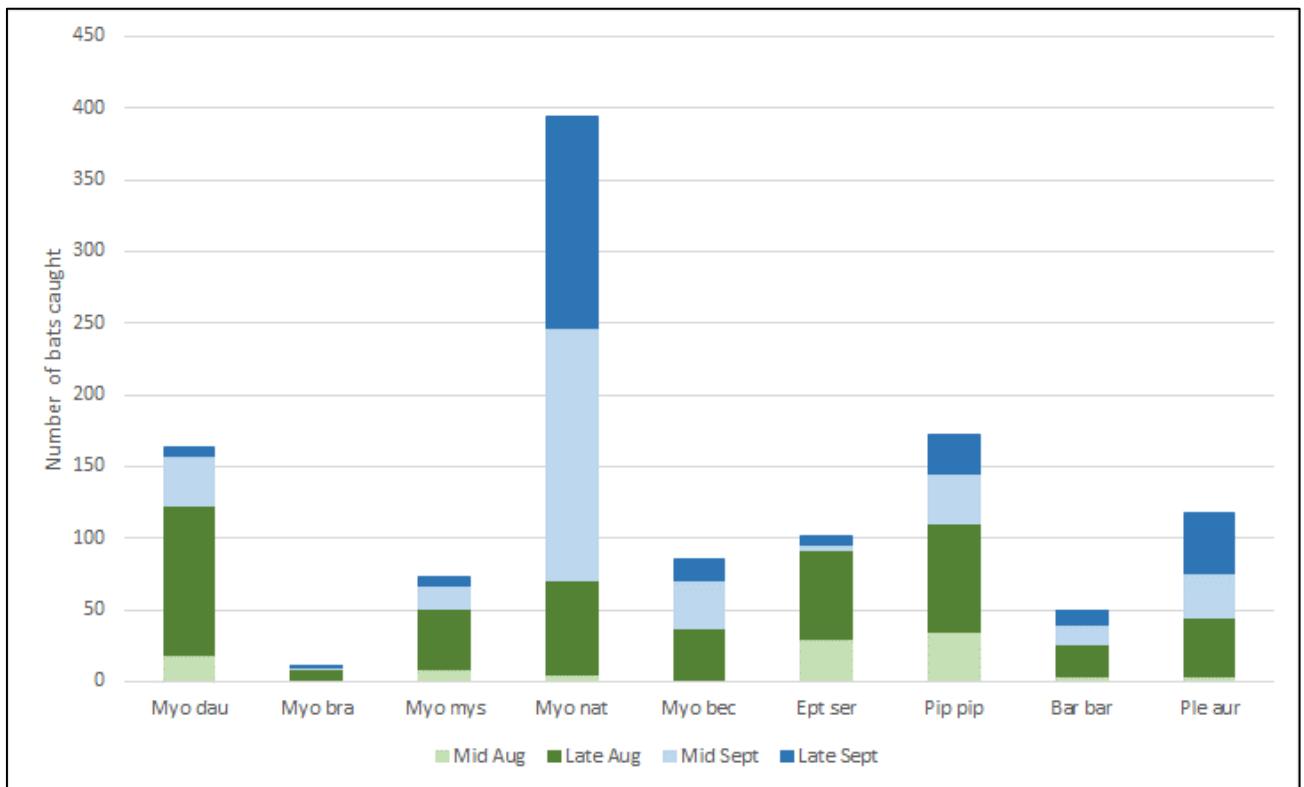


Figure 7: Number of bats caught by species in each of four survey period periods.

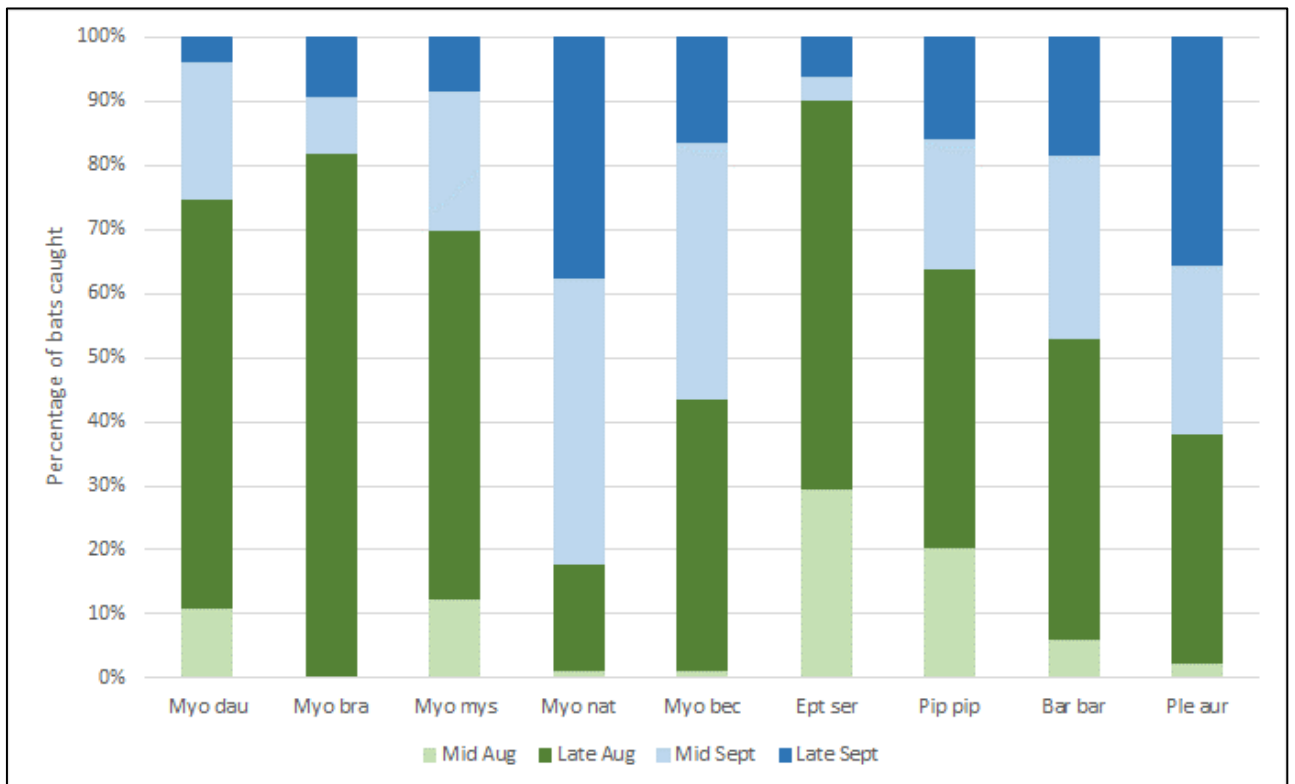


Figure 8: Percentages of the total catch of each species caught in each of four survey periods.

Captures across the night

We then we looked at the time of night we caught each species. To make Figure 9 clearer, the classic swarming species have been combined into one group (orange bars) and serotine and common pipistrelle into a second (blue bars), but the patterns were broadly the same for each individual species. The horizontal axis is time, in hours/minutes, after sunset.

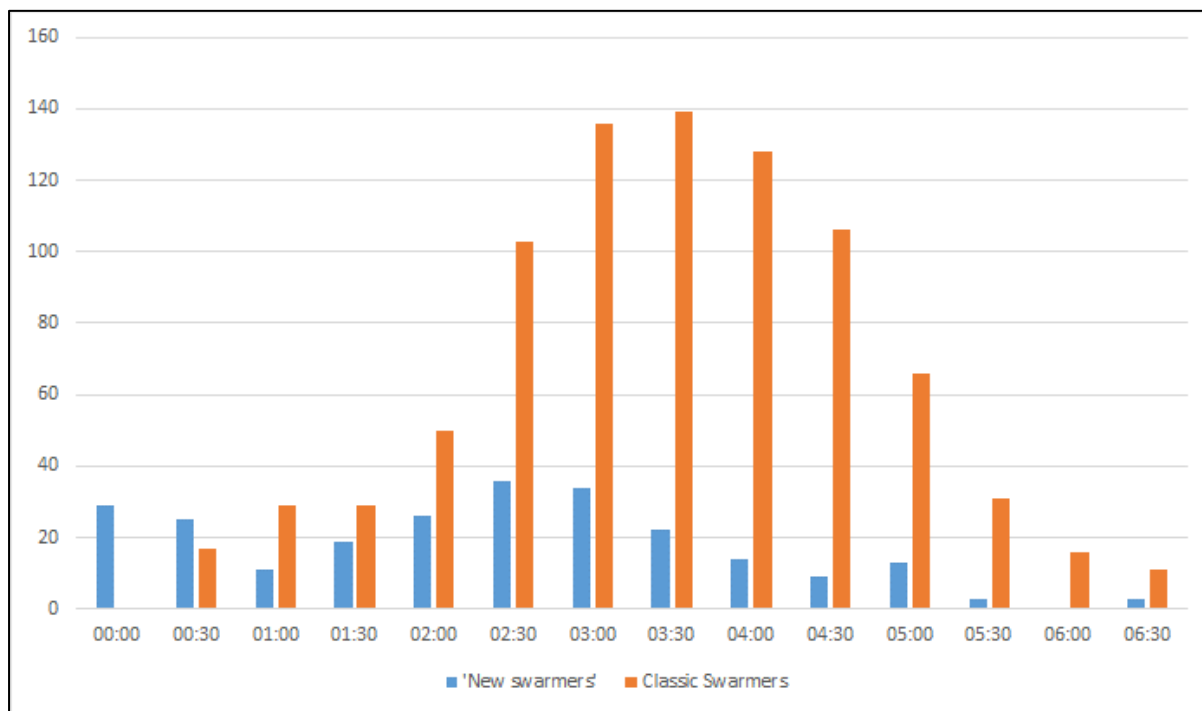


Figure 9: Time of capture, hours after sunset.

Again, from previous studies (Parsons *et al.*, 2003a), we know that the classic swarming species show an increase in activity between two and three hours after sunset. They then occur in good numbers for a further three or more hours, before the activity starts to wane and the animals head back to roosts. Our data for the swarming species reflect this pattern well.

The peak at the start of the blue bars is mainly down to common pipistrelle which roost in the caves getting caught early in the session. Overall, serotine and common pipistrelle appear to show a similar pattern to their activity, albeit with a peak earlier than the swarming species. This perhaps reflects the, on average, earlier emergence of serotine and common pipistrelle when compared to the swarming species who emerge later, on average. There is also a sustained peak of activity, albeit slightly shorter, and a longer tail off over the rest of the night when compared to the classic swarming species.

Taking this together, the pattern of the capture rate for serotine and common pipistrelle, over the course of the night, reflects the pattern shown by swarming species.

Sex Ratios

One of the key functions of swarming is believed to be mating, so not only should we expect to find sexually active males but, because males will accumulate at these sites in order to try

and attract females, we should also expect to find somewhere between three to five males for each female (so between 20% and 30% of the catch should be female) (Parsons *et al.* 2003b; Altringham, 2011).

Figure 10 shows, for most of the swarming species, that our data reflects this pattern well (and are very similar to the ratios Flanders (2008) found in his work). The data for Daubenton's bat is interesting, with fewer females than we might expect, based upon previous studies (Parsons *et al.* 2003b; Altringham, 2011), and Natterer's bat only slightly higher. It is interesting to note that Flanders (2008) also found males comprised 80% of the captures for Daubenton's bat.

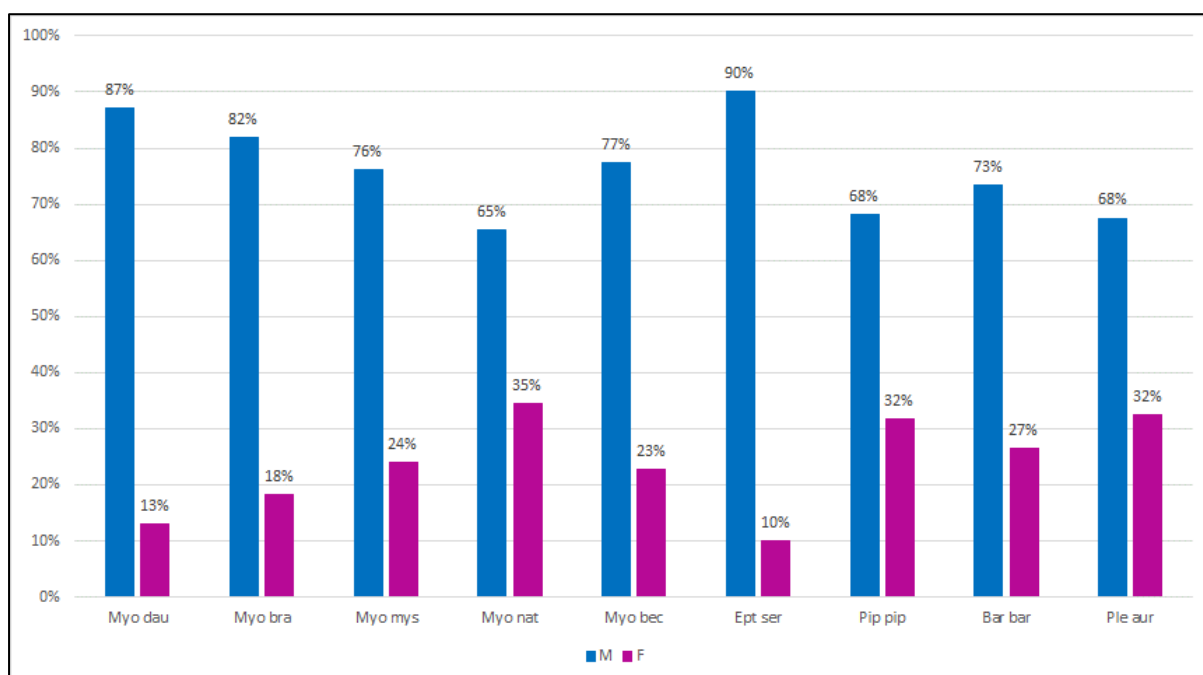


Figure 10: Sex ratio of bats caught by species.

Looking at serotine, the sex ratio is comparable with Daubenton's bat and that for common pipistrelle is comparable with brown long-eared bat and, where we have the data, the proportion of the males of these two species in full breeding condition was the same as for the swarming species.

Conclusions from DBG swarming surveys

Summarising what the data above appears to show:

- we catch similar numbers of serotine and common pipistrelle as we do some of the classic swarming species
- the capture rates for two species considered as non-swarming, serotine and common pipistrelle, over the course of the swarming season (August and September), shows the same kind of seasonality as other species considered to be classic swarming species

- the capture rate over the course of the night for serotine and common pipistrelle shows a very similar pattern to that of swarming species, although there is an earlier peak and a more prolonged tail
- the sex ratios of serotine and common pipistrelle are comparable with some of the classic swarming species, and, where we have the data, the proportion of the males in breeding condition are the same as the swarming species

Taken together the above appears to show that we should consider both serotine and common pipistrelle as a swarming species, or at the very least, as a species that uses swarming as part of its breeding strategy.

Part 2 – Comparing DBG data with previous surveys

It was noted earlier in this report that the first swarming work in the Purbecks was undertaken by Flanders (2008) between 2005 and 2007 and it is interesting to compare the captures from the two projects. Flanders ran 64 trapping sessions, across five sites, over three years. DBG has run 43 trapping sessions at Winspit, over the course of nine years. We do, however, need to be careful in making comparisons, as there are some significant differences between the two projects that we need to bear in mind.

Differences between DBG and Flanders' surveys

The first difference is that Flanders did the bulk of his trapping in September and October, while we have done most of ours in August and September (Figure 11). We have seen above that some species show a distinct seasonality, so we might expect (and indeed the results show) there are differences between some of the capture rates that can be, most likely, explained, mostly, by this seasonal difference.

The second difference is that, with one exception, to which we will return shortly, DBG uses mist nets, while Flanders used harp traps. As a result, our vertical catching surface was greater and, almost by definition, harder for the bats to detect. Also, at most of the sites Flanders trapped the harp trap would not fit 'snugly' across the entrance, allowing bats to fly over, under and/or around the traps.

Comparison of results

Although these differences are significant it is, nevertheless, interesting to compare the data. Figure 12 shows the percentage of the total catch each species makes up, for both projects.

As might be expected, based upon the months in which tapping took place, DBG caught a greater percentage of Daubenton's bat (which have an August peak; Parsons *et al.*, 2002) and a smaller percentage of Natterer's bat (which have a September peak; Parsons *et al.*, 2003b) than Flanders (2008).

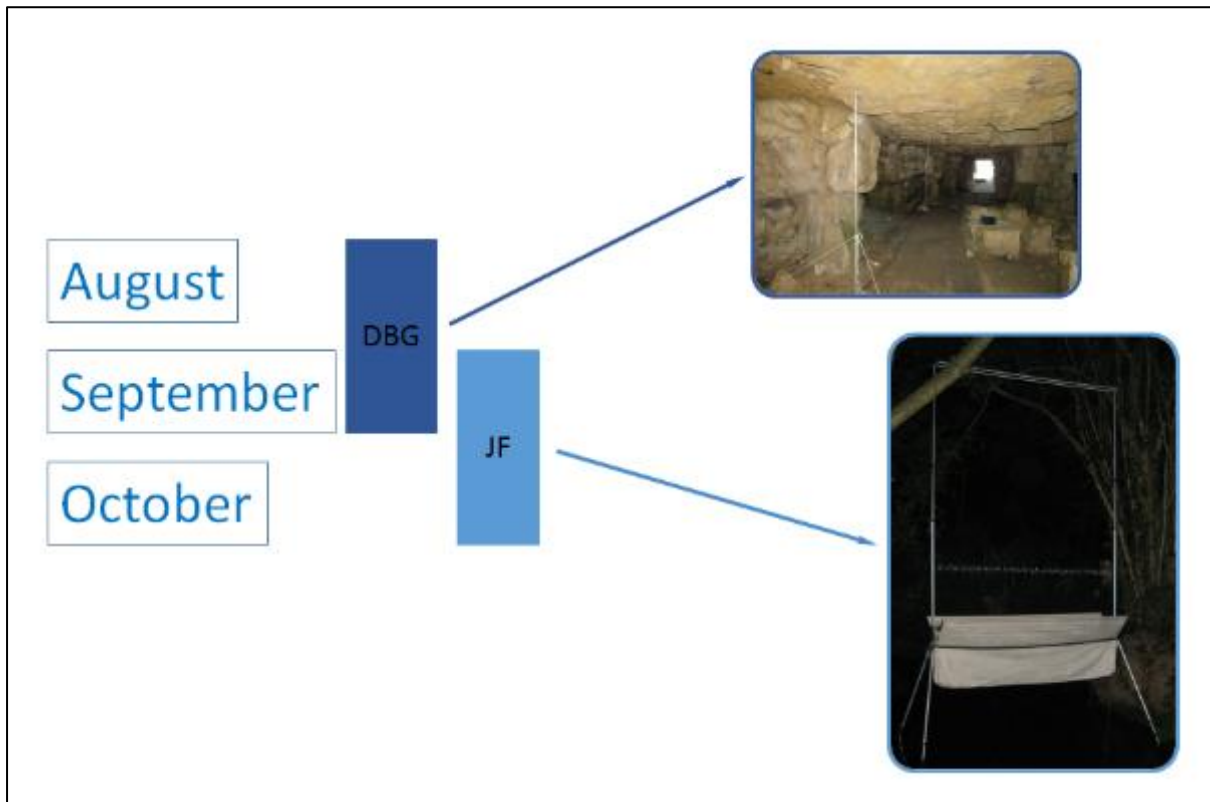


Figure 11: Seasonality and trapping method across the two projects.

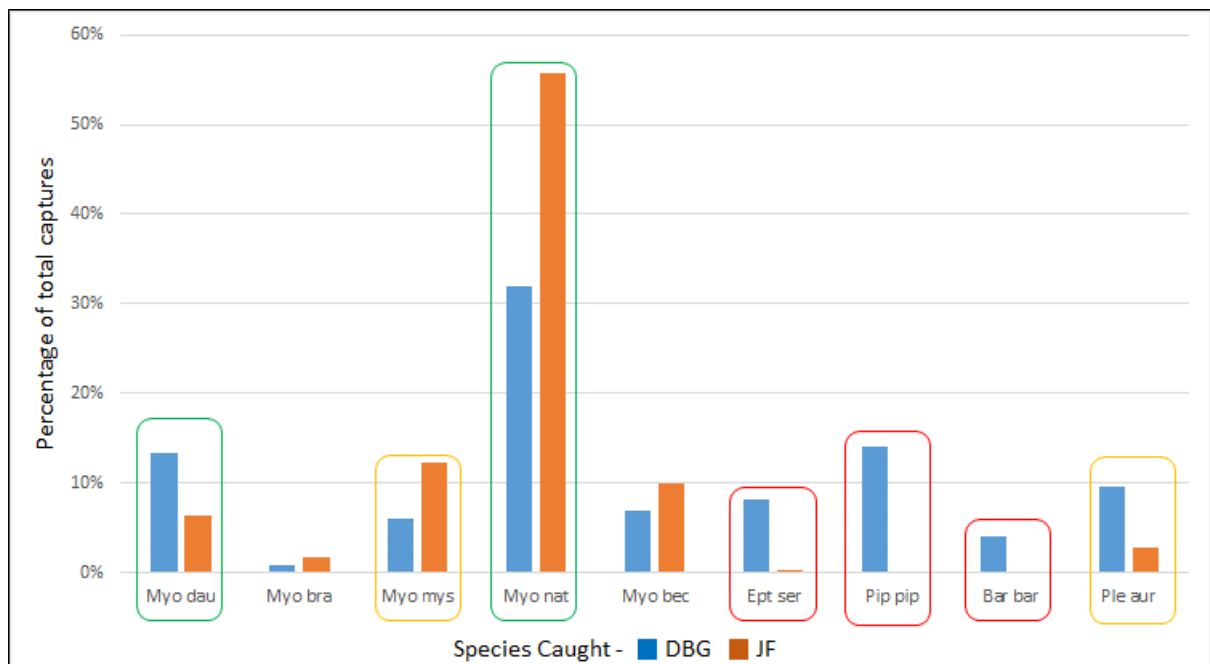


Figure 12: Percentage of the total catch per species for each project.

The differences between the percentage of whiskered bat (which our data suggests may have an August peak) and brown long-eared bat (which our data suggests may have a September peak) are less easy to explain. It is possible that brown long-eared bat may be better able to avoid harp traps, so even if there was a bias in their time of appearance

toward when Flanders was trapping, DBG, using mist nets, might catch more, but even if that were the case, a near four fold difference appears extreme, so there may be something else underlying this difference. Flanders noted a difference for this species in his work, between restored and unrestored quarries, with brown long-eared bat appearing to favour unrestored quarries. It is not clear how/if that apparent bias can be translated to Winspit.

DBG's data shows that serotine displays a very strong seasonality, and is a rare and uncommon animal at Winspit, in September. Given that Flanders did not trap in August it is likely that a large part of the difference in serotine captures between the two projects is attributable to that difference in trapping periods. It is, however, even when the seasonality is taken into account, remarkable how stark that difference is, so there may be more behind this difference than simply the time of year that trapping takes place. It is interesting to note that the two serotine that Flanders did catch were caught at a site around 200m to the east of Winspit and that he caught none at all at the inland sites, across three years of trapping.

An even starker difference between the two projects can be seen for common pipistrelle and barbastelle, of which Flanders caught none at all. Both barbastelle and common pipistrelle are caught across both August and September at Winspit, so the seasonality is unlikely to be the major factor in the difference in capture rates.

It is possible that these two species are just particularly good at avoiding harp traps. That is, however, hard to believe, given Flanders caught good numbers of brown long-eared bat, Bechstein's bat and Natterer's bat, all of which are clutter specialists, and which should be better able to avoid harp traps in a cluttered space than the other two species.

It is probable that the difference in timing of trapping between the two projects is a significant, but perhaps not the only contributing factor to the differences in serotine numbers between the two projects. It is, however, doubtful that timing of trapping, or differences in trapping methodology, are the only, or perhaps even the main, explanation of the differences in barbastelle and common pipistrelle captures. It is, therefore, perhaps worth exploring the nature of the sites at which each of the trapping surveys were undertaken.

Comparison of sites

Winspit is surrounded by wide open spaces, with no clutter at all around the entrance, or on the immediate approach (Figure 13).

Beth's was one of the inland quarries at which Flanders trapped (he placed harp traps at the bottom of the entrance slope) (Figure 14). The wider approach to this site is across open fields, or along hedgerows, but the entrance is very cluttered, with only the small window shown as the free flying access route to the quarry entrances.



Figure 13: Winspit.



Figure 14: Entrance to Beth's quarry.

The only coastal site that Flanders trapped at is around 200m from Winspit⁷ (Figure 15). This site has a lot of clutter on the horizontal approach, which is a narrow (2-4m wide) heavily vegetated gully, however, it has a vertical access route, in front of the grills, that has similar sort of clutter characteristics as the horizontal access at the inland site shown in Figure 14.



Figure 15: Coastal site trapped by Flanders.

It might appear, therefore, that one thing which could be thought of as characterising the sites where Flanders trapped is that the areas immediately around the entrances are heavily cluttered, either horizontally or vertically, whereas the entrances at Winspit are very open and clutter free.

Flanders did trap at one inland site where the two entrances are surrounded by stone walls, but no vegetation, although the two entrances both have bramble encroaching down the entrance slope. He only caught a total of six animals at this site (one Bechstein's bat and five Natterer's bats), over nine trapping sessions, comprising just over 0.5% of his total catch. While it is possible that the bramble and walls combined created the same cluttered approach as seen at his other sites, there may well be some other factor that contributed to the low catch. For instance, the site is reported to flood,⁸ completely, in the winter so, if bats hibernate where they swarm (van Schaik *et al.*, 2015) as has been suggested in other

⁷ This is the site where Flanders caught his two serotine.

⁸ Glover and Altringham (2008) state that swarming activity was negatively correlated with the amount of water carried. While it is not known if this site carried water during the summer, if it did then perhaps that contributed to the lack of captures as well.

research, then the site would be unsuitable for hibernation and therefore, perhaps not used for swarming. Either way, the catch was so poor that it was excluded from the comparison.

If that clutter is a factor, could it be that barbastelle and common pipistrelle require (or prefer) sites that have open entrances, with no clutter. Our trapping at other sites may support that suggestion.

We have trapped at an inland site (Bower's, which is similar to Beth's in the vegetation structure around its entrance) on five occasions, using mist nets, at the top of the slope leading to the entrance⁹ and on the approaches to that point.¹⁰ During that time we have caught 122 animals, of eight species, including four common pipistrelle, but no serotine nor any barbastelle. While it can't be ruled out that the common pipistrelle were there to swarm, the numbers were very low (our average at Winspit is three per session, at Bower's it is 0.8 per session) and they may have been animals foraging along the hedges that surround the site.

We have also trapped at a second coastal site, some 6km along the coast from Winspit (Figures 16 and 17).

There are two parts to this site, which are not physically connected underground, but share a common platform bordering the sea (as is the case at Winspit):

- the Western Entrance (Figure 16) which appears very similar, externally, to Winspit and, in fact, inside is also a cavern of comparable dimensions to Winspit and it has the same degree of openness as Winspit
- the Eastern Entrance, a sloping entrance (Figure 17) comparable with the type of entrance found on the inland sites but, while this has a small degree of clutter in the entrance slope, it is, essentially clear, when compared with, for instance, Beth's or Bower's. At the bottom of a flight of steps, however, that start just inside the gate, it opens out into a large cavern, with a second cavern next to it, and two smaller ones adjacent, all with entrances very similar to the Western Entrance and with a similar platform in front of them

From the coast, therefore, both parts of this site look very similar to Winspit.

We have trapped at the Western Entrance, with mist nets, five times, catching a total of 46 animals of eight species, including common pipistrelle on all five occasions, barbastelle on four of those five and serotine once. The trapping was carried out in September, when we already know serotine to be an uncommon animal at Winspit, but the one in five capture rate for this species, at this site, in September, compares favourably to a one in four capture rate at Winspit for the same time of year.

⁹ Health and safety concerns meant we were not able to set up traps at the bottom of the access slope.

¹⁰ Assuming, of course, that the bats are entering the site through the opening at the top of the slope and not through the clutter surrounding it, which seems a reasonable assumption, given the activity observed at other sites.



Figure 16: Western Entrance of second coastal site.



Figure 17: Eastern Entrance of second coastal site.

We have trapped at the Eastern Entrance three times, using a harp trap at the bottom of the slope, catching a total of 18 animals, including common pipistrelle (once), barbastelle (twice) but no serotine. The data from the Eastern Entrance is a much harder set of data to attempt to interpret but, with barbastelle being caught on 50% of the trapping sessions, it might, perhaps, lend some support the idea that the difference in trapping methodology between the two projects (Flanders and DBG) does not appear to explain, fully, the differences in the capture rates of this species.¹¹

¹¹ Remembering that Flanders caught no barbastelle, at all, across 64 trapping sessions over the course of three years.

Finally, we have trapped, using mist nets, at three other inland sites, all of which share some of the characteristics of Beth's and Bower's, in terms of clutter. Over two trapping sessions at each, taking place in September, we caught a total of 117 bats, of six species, with no common pipistrelle, barbastelle or serotine caught.

Discussion

There are some interesting differences between the results of the two projects, and more work is needed to begin to tease out the reasons for those differences, but we can, perhaps, begin to ponder what they might mean.

Our data does not support the absolute statement that barbastelle, serotine and common pipistrelle need sites that are open and clutter free around the entrance,¹² but they do suggest that such features may be a factor in site selection.

It is also possible that the coastal location may also be important.

Understanding which, if any, of these (or other) factors form part of the site selection process for these three species is important, for two main reasons:

- these coastal sites are rare in Dorset (there are perhaps two or three more that have similarities to Winspit) so, if they are crucial for these species then, given the role of swarming in gene dispersal and the health of the wider populations, ensuring these sites are safeguarded is vital
- many inland sites are as cluttered in the entrances as Beth's and Bower's, some even more so, so, if the lack of clutter is important for these three species, then this should inform long term management practices, not just on those sites that we know of and that are overgrown, but also on the wider quarry resource available to the area's bats¹³

It is also possible that features that echo the structure of Winspit, such as barns and larger agricultural buildings, may play an important role in the breeding strategies of rural populations of these species and loss of these structures may, therefore, have negative impacts on the population as a whole.

Request for more information

We would be very interested to hear of the experience at other swarming sites, whether they support or refute the suggestions above. Please get in touch.

¹² No statement is made about the approach to the entrances, as we do not have any data upon which to base any suggestions, but it is possible that a site with no clutter in the immediate vicinity of the entrance, but to which the approaches are cluttered (so, for instance, a bunker or quarry in a woodland) might be equally suitable, if it is the nature of the site and its entrance that is important, rather than the approach through the wider landscape.

¹³ The degree of clutter does not appear to affect the other swarming species (although there may be factors in the selection of sites by Daubenton's bats and brown long-eared bats that we have yet to understand) but clearing inland sites that are currently cluttered, to promote their use by, for instance, barbastelle, should be undertaken with care to ensure enhancing it for one species does not affect other species adversely.

Acknowledgements

Much of the work undertaken by the Dorset Bat Group in the last decade, and which is discussed in this report, could not have been done without a huge team of volunteers, with nearly 100 individuals being involved, and I owe them all a huge vote of thanks. I would specifically like to thank the following for their continued dedication and support, without which much of the work could not have been done: Pete Banfield, Chris Dieck, Colin Morris, Stuart Smith, Liz and Gaz Watkinson.

References

- Altringham, J.D. (2011) *Bats: From Evolution to Conservation*. Oxford: Oxford University Press.
- Flanders, J.R. (2008) *An integrated approach to bat conservation: applications of ecology, phylogeny and spatial modelling of bats on the Isle of Purbeck, Dorset*. PhD thesis. University of Bristol: UK.
- Glover, A.M. and Altringham, J.D. (2008) Cave selection and use by swarming bat species. *Biological Conservation*, 141(6) pp. 1493-1504.
- Parsons, K., Jones, G. and Greenaway, F. (2003a) Swarming activity of temperate zone microchiropteran bats: Effects of season, time of night and weather conditions. *Journal of Zoology*, 261(3) 257-264. <https://doi.org/10.1017/S0952836903004199>
- Parsons, K., Jones, G., Davidson-Watts, I. and Greenaway, F. (2003b) Swarming of bats at underground sites in Britain—implications for conservation. *Biological Conservation*, 111(1) pp. 63-70. [https://doi.org/10.1016/S0006-3207\(02\)00250-1](https://doi.org/10.1016/S0006-3207(02)00250-1)
- van Schaik, J., Janssen, R., Bosch, T., Haarsma, A.J., Dekker, J.J. and Kranstauber, B. (2015) Bats swarm where they hibernate: compositional similarity between autumn swarming and winter hibernation assemblages at five underground sites. *PLoS One*, 10(7) :e0130850 10.1371/journal.pone.0130850.

[Return to contents page](#)

Bat Boxes: Variations on a Theme

Anthony Atkinson; Cornwall Bat Group
downgatebatman@yahoo.co.uk

I'm a member of the Cornwall Bat Group, and I've been running a boxes scheme in part of a large area of valley-side mixed deciduous woodland on one of the Cornwall Wildlife Trust Reserves in the east of the County. I put them up originally just to see what bats were around, although it is such good old woodland that I did not have great hopes for boxes. But then I realised it was an opportunity to give trainees a chance to handle wild bats.

I've got 15 'conventional' cubic, or wedge-shaped, wooden boxes nailed to trees around the wood, in groups of three. This lot has been going since 1994, with changes as necessary as they rotted out. But since 2007 I've hung up four boxes made of polyurethane insulation panels set like frames in a beehive, encased and lidded with ply. The bottoms are completely open so that one can see up inside them from the ground. They were entirely experimental and rather loosely 'thrown together' from offcuts. So some have lasted better than others and several have had to be replaced. So some of the trees have duplicate boxes on them for short periods while I allow the bats to leave the old box and move into the newer ones. Additionally, since April 2017, I have chain-sawed slots into slabs of 150mm thick insulation boards, and strapped these to trees where they can be inspected from the ground. But notice the fundamental differences between these insulated boxes more recently put up and the conventional wooden boxes. If the box has to be opened to see what is inside, and to handle the bats, a license is required. These insulated boxes can be inspected from the ground (Figure 1), by anyone, but the bats can't be handled, and so a positive identification can't always be made, or even an accurate count taken.



Figure 1: Inspecting the boxes with trainees.



Figure 2: Brown long-eared bats *Plecotus auritus* in a conventional wooden box.

So what results. Since 1994 I have inspected the boxes on the second Sunday in May and the second Sunday in October each year, timed to cause as little disturbance to any bats present as possible. I specifically invite trainees to attend to give them handling practice. Occupancy of the wooden boxes has always been low – less than 10%, and perhaps 1-10 bats from the 15 boxes – but with a range of species represented, including common *Pipistrellus pipistrellus* and soprano pipistrelle *P. pygmaeus*, brown long-eared bat (Figure 2), noctule *Nyctalus noctula*, Natterer's bat *Myotis nattereri* and Daubenton's bat *M. daubentonii* (and dormouse). But even these low numbers have decreased in recent years, and not entirely as a result of the success of the insulated boxes. So at the May visit this year only one box had a lone soprano pipistrelle in it.

The hanging insulated boxes are a different story. Take up was immediate, and the occupancy is running at about 75% (from four boxes – a bit difficult to say accurately, when one box is put up beside another to affect a change-over due to wear and tear, but the bats won't leave their old slum!). We have had mostly soprano pipistrelles, but also, we think, common pipistrelles too. And fairly regularly noctules and on one occasion Natterer's bat. In one we've had a breeding colony of over 100 soprano pipistrelles for several years running (Figure 3). Because these boxes can be surveyed from the ground without disturbing the bats, I make several other occasional visits during the year to see how they are doing. In January one box was shared by a couple of noctules and one soprano pipistrelle and two others had a single and a couple of soprano pipistrelles. But in August the box with the two noctules had increased to about 100 soprano pipistrelles and still the two noctules!



Figure 3: Count that lot!

The chain-saw slots (Figure 4) are less successful. Of the five, only one has been regularly used by a lone soprano pipistrelle, until August 2019 when I had counts of one, two and five soprano pipistrelles. I have had one brown long-eared bat in one of these, but this species obviously prefers the cubic wooden boxes. (The more regularly used of these ‘chain-saw’ boxes is the longer one, of about 40cm total depth.)

The ‘insulated’ boxes (Figure 5), being experimental and using off-cuts, have varied in shape and size, but it would appear that the deeper (more than 40cm) boxes are preferred over shallower boxes, but the other dimensions don’t seem to matter much. Slot dimensions are rather arbitrary; the foam tends to warp, and if the gap is too small it tends to get filled with debris from the foam which blocks the visibility, rather defeating the object of the scheme. So I’ve tended now to keep the gaps at about 25mm. Made using wooden or foam spacers, PVC adhesive and only the outer carcass (to protect the foam) is nailed. They are hung at any convenient height over a convenient place to stand, though they may need hanging higher if there is a chance of interference. I use the denser foams; the soft stuff often used for ceiling tiles and packaging, like rice biscuits, is too soft and powders away badly.

So to summarise, it is obvious the common and soprano pipistrelles aren’t so fond of the wooden ‘cavity’ boxes, but they do like a bit of comfort from the insulated boxes. Whereas the brown long-eared bats aren’t so fond of the ‘crevice’ insulated boxes. So it is obvious that to maximize the species on a site, a mix of crevice and cavity type boxes is required. You will also have to decide whether you want to handle the bats, with all the hassle of carrying a ladder round, being licensed, and restricted as to the time of the year, or whether you want the freedom to look at any time, without a licence. The open bottomed, insulated

boxes are likely to be more vulnerable to vandalism, but neither type is entirely without that risk. So perhaps, like me, you will go for a mixture.



Figure 4: Chain-saw box.



Figure 5: Insulated box.

[Return to contents page](#)

When did the Leisler's bat colonise the Isle of Man?

Nick Pinder; Manx Bat Group

nickpinder@manx.net

Abstract

Records of Leisler's bat *Nyctalus leisleri* have increased in number and frequency since the species was first recorded for the Isle of Man in 1990. The apparent absence of this species until relatively recently, despite searches in the last century, suggests that it might have only recently colonised the Isle of Man.

Introduction

All mammal species resident in the Isle of Man have colonised the island since the end of the ice ages and most are thought to have done so before the flooding of the land bridge connection to England by the subsequent meltwaters. Bats however are not dependent on dry land for dispersal and all the Manx species are perfectly capable of flying the few tens of miles to adjacent lands so it is generally assumed that they have always been present, i.e. since climatic conditions and vegetation returned to historic norms. Analysis of the records of occurrence of Leisler's bat indicates that this assumption might not be warranted.

An early call for sightings

First recorded in 1990 (Bolton and Pinder), Leisler's bat is now regarded as widespread in the Isle of Man, as it is in Ireland, said to be its European stronghold. Yet, just over a hundred years ago P.M.C. Kermode, the first secretary of the Isle of Man Natural History and Antiquarians Society, asked members to look out for Leisler's bat (as well as the whiskered bat *Myotis mystacinus*): "The following species should be looked for, and I should be very glad to receive specimens for our Museum or to hear of any if noticed in our district :- *Nyctalus leisleri*, hairy-armed bat. This little creature is found round the East and North of Ireland and in many parts of England, It is about the size of the common bat, but may be distinguished by the greater length of the fore-arm, which is clothed with fur or soft hair on the inner side. It is to be seen morning and evening from about the middle of April till towards the end of November" (Kermode, 1916).

P.M.C. Kermode was the first Director of the Manx Museum and in addition to his antiquarian activities he was also an accomplished naturalist, publishing many observations on the birds and mammals of the Isle of Man including early records of one or two species of bat. He published the first record of brown long-eared bat *Plecotus auritus* for the Island, having been sent a corpse by one of his correspondents, and he evidently even kept bats as pets, describing them as easy to tame, feeding one of them by holding it up to the window to take flies (Kermode, 1889).

Leisler's bats are the first bats to emerge in the evening, often flying before swallows and swifts have retired. In addition to being visible almost in broad daylight, Leisler's bats also roost in houses and have a habit of introducing themselves into human habitation spaces. Ten per cent of the Manx records of Leisler's bats, to 2015, have been of animals found in houses (and some other buildings) and it can be assumed that they would have entered human habitations in Kermode's time also and thus been brought to his attention.

In 1945, the then Keeper of Natural History at Liverpool Museum, Mr R. Wagstaffe, published a note on a new Manx mammal record for the Isle of Man, the Natterer's bat *M. nattereri*, which he had found on an excursion to Ballaugh with a friend (Wagstaffe, 1945). In that article he, too, called for naturalists to look out for Leisler's bats, as well as whiskered bats, on the grounds that they were found nearby in neighbouring countries. It seems that Wagstaffe himself found the first whiskered bat in the island but neither he nor his friends, including a prominent local naturalist, W.S. Cowin, came across a Leisler's bat. An editorial in the same issue of *Peregrine* referred to Wagstaffe's article and stated that subsequent researches had failed as yet to add the further species to the Manx list, although it is not known exactly what research effort was undertaken.

The earliest records

All Manx bat records to 2015 have now been reviewed (Pinder, 2018) making it possible to speculate on the accumulation of records of Leisler's bats and the absence of records prior to 1990.

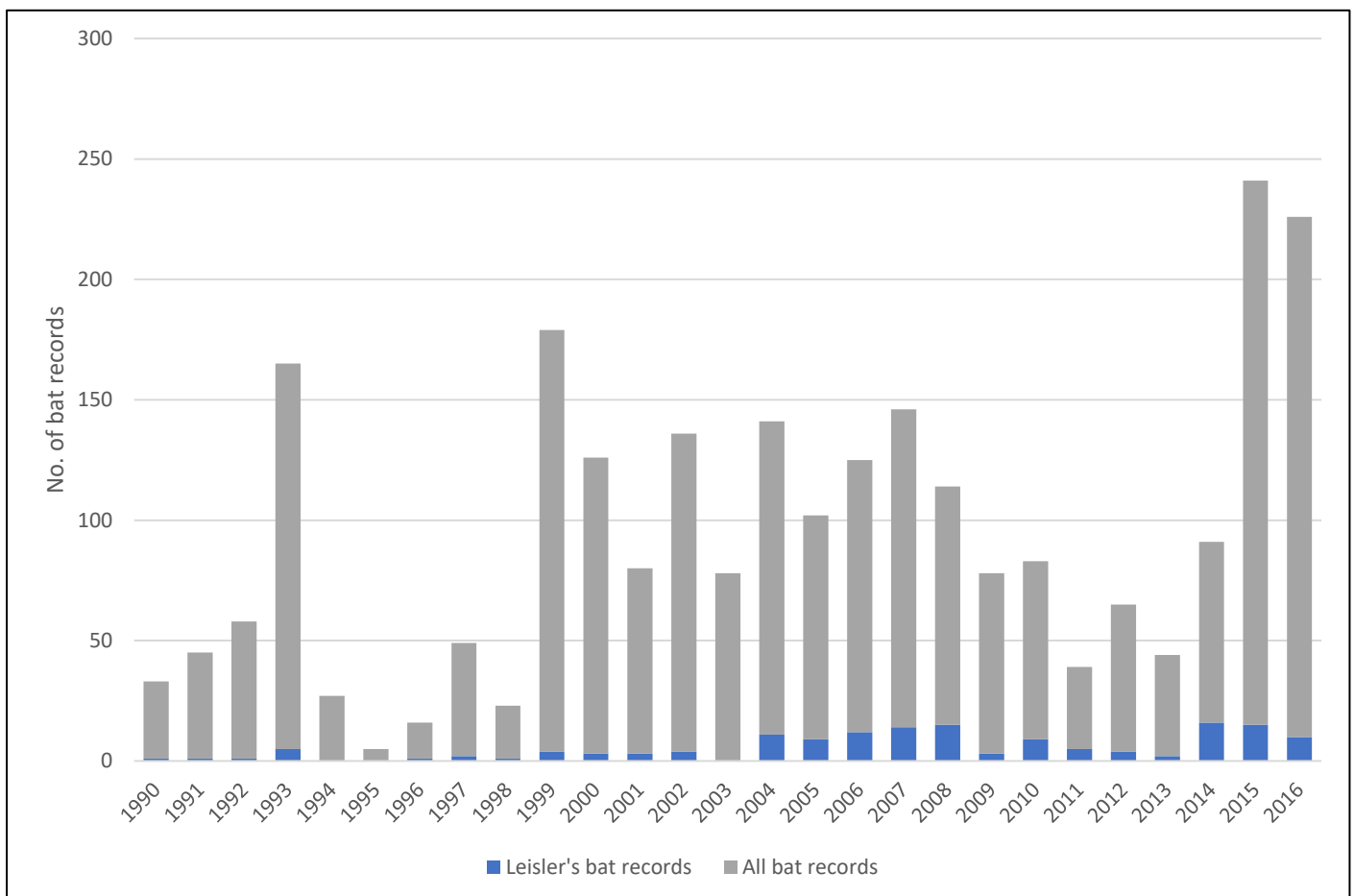


Figure 1: Records of Leisler's bats 1990-2016 compared to all bat records.

The first Leisler's bat recorded on the Isle of Man was found grounded in a chapel in the north of the island in 1990 and one was seen flying over a country house estate in the far south the following year. One was found in a house in 1992 and again in 1993, along with four observations of them hawking at (now) favoured locations in the north, south and centre of the island. There was a gap in the records for two years but from 1996 to 2008

there was a steady increase in the number of observations each year. Then followed five leaner years but in 2014 the number of records of Leisler's bats again returned to double figures (Figure 1).

In addition, the records of Leisler's bats as a percentage of all records have also increased over time, with 5 year averages increasing from 2% for 1990-94 to 11% for 2011-15 (Figure 2). No other species shows this trend partly, perhaps, because of difficulties in identification while Leisler's bat can be distinctive enough to identify with some confidence (although it may be confused with noctule *N. noctula*). This increase might also perhaps be attributed to the increasingly widespread introduction of bat detectors but the Isle of Man was the venue for an intensive survey of its bat fauna in 1997, before the introduction of modern sophisticated detector/recorders.

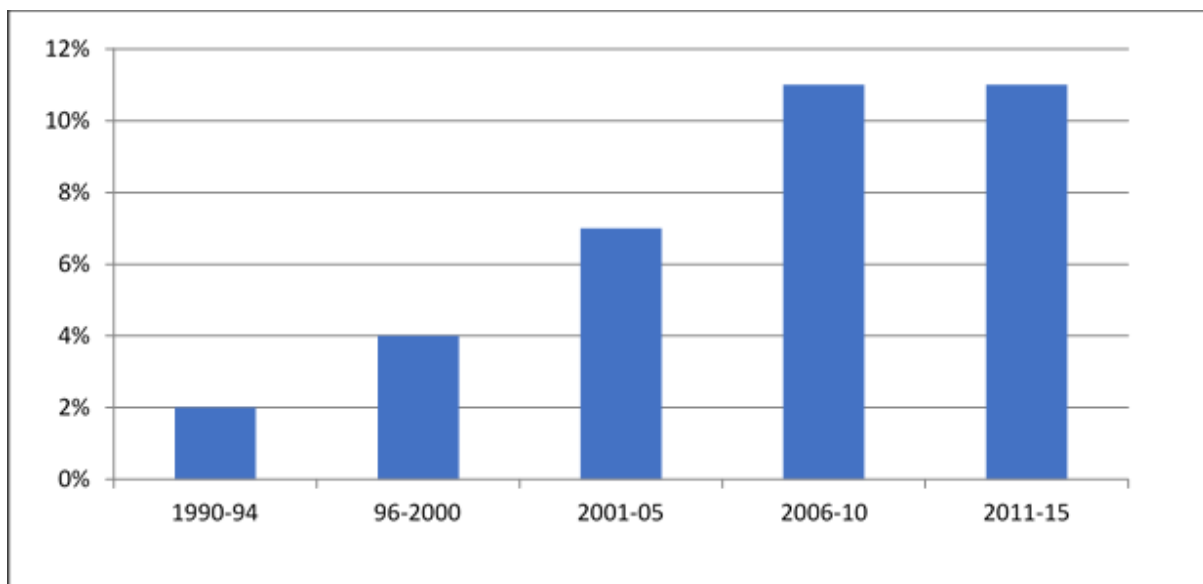


Figure 2: Five year averages of Leisler's bat records as a percentage of all bat records.

A nightly occurrence

The Manx Bat Group held a detector workshop over one week in June 1997. This was led by Herman Limpens from the Netherlands and tutors included Brian Briggs, Geoff Billington, Steve Bradley, Tom McOwat and Clem Fisher, all experienced bat workers from the UK (Manx Bat Group, 2000). The aim of the workshop was to train Bat Group members in the use of heterodyne bat detectors for biological recording purposes and the area studied was the Peel embayment, an area of lowland farmland encircling the harbour town of Peel in the west of the island.

The workshop found Leisler's bats on every night but always in the same locality, or flying away from or toward it, leading participants to suspect the presence of a roost which was, however, never located. There had been one record of Leisler's bat in this part of the island prior to the workshop but over the years since then they have been recorded in nine different localities in this area.

A case of mistaken identity

Later, in 2003, a student visited to study bats in the Isle of Man for her university project, concerning the effect of altitude on the foraging habitats of two pipistrelle species (Dunn, 2003). In order to do that, Dunn conducted 42 transects with a Tranquillity detector all over the island but only made three recordings of Leisler's bats (to judge by her map, two in the Central Valley and one in Sulby Glen). Dunn also had four recordings of what she felt, but couldn't prove, were noctule bats. Since, as already mentioned, noctule calls can be difficult to separate from those of Leisler's bats, and noctules are not otherwise recorded from the Isle of Man, it might be that Dunn actually recorded Leisler's bats on seven occasions in four widely separated locations leading her to describe Leisler's bat as "relatively rare but appears to be widespread".



Figure 3: Records of Leisler's bat collected during Bats and Roadside Mammals surveys, 2006-2008.

Bats and roads

A Tranquillity detector was also used for the Bats and Roadside Mammals surveys undertaken by the Manx Bat Group, in 2006, 2007 and 2008. The car surveys involved 10, 4 and 4 car-based transects in each year respectively, resulting in 27, 18 and 10 recordings of

Leisler's bat. Even adjusting for the greater distance covered by the cars, Leisler's bats were encountered at least twice as frequently as they were by Dunn and in all quarters of the island (Figure 3).

An island-wide species

Leisler's bats have now been recorded from virtually all parts of the island and one or two Leisler's bat recordings are made almost whenever and wherever a bat survey takes place. There were three Leisler's bats in view at once at a survey of a meadow nature reserve in 2017, whilst the introduction of Anabat Express detectors has increased the proportion of records in 2018 closer to 20%. In contrast to the earlier description it would now appear that the Leisler's bat is definitely widespread and probably not that rare.

The books say that the Leisler's bat is a typical woodland bat, "found in particular in hardwood forests and more rarely in traditional orchards and parks" according to Dietz and Kiefer in their field guide 'Bats of Britain and Europe' (Dietz and Kiefer, 2016). However, the Isle of Man can hardly be described as a country of hardwood forests and, indeed, it is often said that in the first half of the eighteenth century the island was treeless. However, Andree Dubbeldam of the Manx Wildflower Project disputes that and says that "estate maps of the time show some tree cover so a treeless island was an exaggeration... most likely that most woodland was in ravines so possibly did not contribute to the visible landscape of the Island. By the mid-1800s woodland cover was creeping above 1% as a rough estimate, and from there a steady increase to a current 7.5%ish" (Dubbeldam, 2018).

If the wooded area increased at a steady rate, as Dubbeldam suggests, then at the time Kermode was suggesting naturalists look for Leisler's bats 100 years ago there would have been about 3.5% woodland cover. It is not too fanciful to suggest that that figure might be too small for a woodland bat to colonise. Leisler's bat might have had to wait until the cover had risen further, aided by the planting of the national glens and perhaps even the forest estate, since the species seems to do well in coniferous forests. Most records for the UK, up to 1991, were from bat boxes in conifer forests (Whitely and Clarkson, 1985); while a recent study has shown that in Norfolk the stronghold for Leisler's bat is Thetford Forest, comprising mainly of post-war planted coniferous plantation (Newson and Parry, 2018).

Coniferous plantations in south-west Scotland provided the first known roosting sites for Leisler's bats in that country. Until 2010 Glen Trool and the Cree Valley was the only part of Scotland with a known population. In 2011 the first breeding roost in Scotland was found in trees in South Ayrshire, and the second in Galloway forest, east of the Cree Valley, in 2017. Further records show a concentration of the species in the south-west, including the Isle of Arran, with the species replaced by the closely related, but larger, noctule east of the M74, and also around Dumfries (Haddow, 2020). It is therefore tempting to speculate that the Scottish bats are derived from a recent eastward expansion out of Ireland in which case Ireland might also be suspected as the source of the original colonists to the Isle of Man.

There have been DNA studies carried out on Leisler's bats and some specimens from the Isle of Man were included in one study (Boston *et al.*, 2015). For the purposes of the origin of these bats, the results were far from clear cut, however, and bats with Manx genes were found in Ireland, the United Kingdom, continental Europe and even the Azores Islands. It is

not possible to use the DNA results to infer from which direction the first Leisler's bats arrived in the Isle of Man and current data are insufficient to discriminate between competing hypotheses explaining the demographic history of the species in Europe (Boston *et al.*, 2015). However, palaeo-climatic modelling clearly shows potential habitat south and west of Ireland during the late glacial maximum extent of the ice-sheet providing refugia from which Ireland, and eventually western Scotland and the Isle of Man could be re-colonised after the ice retreated.

The above evidence points to a middle to late 20th century date for this colonisation of the Isle of Man.

Acknowledgements

This article first appeared as a paper in Isle of Man Studies DOI:

<https://doi.org/10.5284/1050092>, and is reproduced here by permission of the publishers, the Isle of Man Natural History and Antiquarian Society www.manxantiquarians.com (with minor updates by the author and edits at the request of the British Islands Bats editors).

With thanks to Richard Selman for his encouragement and the many members of the Manx Bat Group for submitting the records which formed the basis of this article, and especially Sandra Bolton as the first records officer for the MBG and for her work transcribing many of the early records.

References

Boston, E.S.M., Montgomery W.I., Hynes R. and Prodöhl, P.A. (2015) New insights on postglacial colonization in western Europe: the phylogeography of the Leisler's bat (*Nyctalus leisleri*). *Proceedings of the Royal Society, B*, 282 pp. 2014-2605.

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

Dubbeldam, A. (2018) Email to Nick Pinder, 13th June.

Dunn, J. (2003) The comparative distribution of the foraging habitats of the common and soprano pipistrelle bats (*Pipistrellus pipistrellus* and *P. pygmaeus*) with relation to altitude on the Isle of Man. MSc thesis. Leeds University: UK.

Haddow, J. (2020) Email to Nick Pinder, 20th January.

Kermode, P.M.C. (1889) Notes on Manks mammals (read 19th May 1885). *Yn Lioar Manninagh*, 1(1) p. i44.

Kermode, P.M.C. (1923) Notes on Manx mammals (read 7th December 1916). *Proceedings of the Isle of Man Natural History and Antiquarian Society*, 2(3) pp. 243-248.

Manx Bat Group. (2000) *Report of Bat Detector Workshop, 12th-15th June, 1997*.

Newson, S.E. and Parry, J.V. (2018) Using large-scale citizen science to examine the importance of the Brecks for bats. *Journal of Breckland Studies*, 1 pp. 61-78.

Pinder, N.J. (2018) Manx bat records to 2015. *Peregrine*, 10(6) pp. 714-720.

Pinder, N.J. and Bolton, S.M. (1990) Some recent Manx bat records. *Peregrine*, 6(4) pp. 66-68.

Wagstaffe, R.G.(1945) A new Manx mammal. *Peregrine*, 1(3) p. 1.

[Return to contents page](#)

An Acoustic Survey in the Scottish Highlands

Elizabeth Harwood

bethharwood.eh@gmail.com

Context and Methods

Little is known about bats and their distribution in the Scottish Highlands, which represent a vastly under-surveyed area. It was therefore deemed interesting to conduct an acoustic survey of bats on two Scottish Wildlife Trust wildlife reserves in this area of Scotland with the aim of determining which species of bats are present.

The methodology used for this study followed the methods established by the British Trust for Ornithology for the Southern Scotland Bat Survey (Newson *et al.*, 2017). This consisted of deploying six Wildlife Acoustics SM2+ broadband bat detectors on two Scottish Wildlife Trust Reserves situated in the north of Scotland: Talich Wildlife Reserve (OS grid reference NH8529678735) near Tain and Spey Bay Wildlife Reserve (OS grid reference NJ3490864514) near Elgin (Figure 1). These were set to record continuously from 30 minutes before sunrise to 30 minutes after sunset.

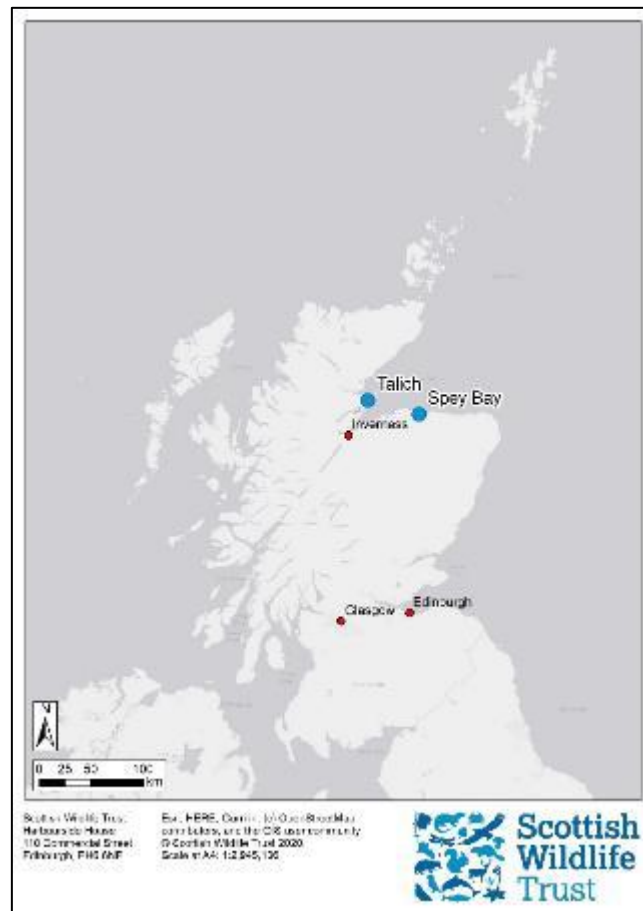


Figure 1: Location of study areas.

The data collected was analysed using Wildlife Acoustics Kaleidoscope Viewer software. Sonogram analysis was carried out to identify species using the call parameters described in *British Bat Calls: A Guide to Species Identification* by Russ (2012) and in *Social calls of the Bats of Britain and Ireland* by Middleton *et al.* (2014).

Talich Wildlife Reserve

Six detectors were deployed for seven consecutive nights from 1st July 2019 to 8th July 2019 at Talich Wildlife Reserve, a small site of Special Scientific Interest (SSSI) of wet alder woodland, set in an intensely managed agricultural landscape (Figure 2). The results revealed the presence of four species of bat on this reserve: common pipistrelle *Pipistrellus pipistrellus*, soprano pipistrelle *P. pygmaeus*, Daubenton's bat *Myotis daubentonii* and Natterer's bat *M. nattereri*. A total of 11,852 bat calls were recorded over the surveying period. Most of this activity was *Pipistrellus* bats, representing over 99% of all data recorded, with only 31 Daubenton's bat passes and 18 Natterer's bat passes.

Whilst the aim of this study was a presence survey the information gathered was analysed to look for patterns which could be indicative of roosting and/or foraging behaviour. At Talich, two SM2+ detectors recorded significantly more bat passes than the other detectors. Both of these detector locations were along treelines; one where the woodland opens up into a glade and one where the woodland opens up into a meadow. This is typical behaviour of common and soprano pipistrelles who use linear features for both commuting and foraging (Boughey *et al.*, 2011; Downs and Racey, 2006).



Figure 2: Deploying a bat detector. © Michelle Henley.

During the survey a nightly pattern was observed in *Pipistrellus* activity. There was consistently a peak in activity 45 to 90 minutes after sunset and a second peak 60 to 160 minutes before sunrise. This may indicate that common and soprano pipistrelle do not roost on the reserve but roost somewhere nearby and visit the reserve to feed and commute to another feeding site at the beginning of the night and on their return before dawn.

Spey Bay Wildlife Reserve

The second survey took place at Spey Bay Wildlife Reserve during the first week of August. Six SM2+ bat detectors were deployed for five consecutive nights from 2nd August 2019 to 7th August 2019. Spey Bay is a SSSI which supports a variety of different habitats: woodland, scrub, grassland, heath, swamp and tall herb. Due to the large size of the reserve and open nature of some habitats, the survey focused on the woodland to reduce disturbance to other wildlife and minimise the risk of the equipment being stolen. This small wet alder woodland lies between the river Spey on the west side and agricultural land to the east. Sycamore trees are the dominant tree in the northern part of the wood, whilst alder dominates the south, and beech, birch and willow grow throughout the woodland.

The results revealed the presence of the same four species as found at Talich: common pipistrelle, soprano pipistrelle, Daubenton's bat and Natterer's bat (Figure 3). A few problems were encountered during this survey which may have affected the results. One of the microphones malfunctioned during the first three nights meaning that the data collected could not be analysed because the sonograms were of poor quality. During the fifth night of the survey heavy rains caused the woodland to flood, meaning further data was lost for the fourth and fifth nights for one SM2+ bat detector, at which point the equipment was removed meaning only five nights of data was collected. A total of 3,877 bat calls were recorded during this second survey. Once again most of the data was due to *Pipistrellus* (95%) with the remaining 5% Daubenton's bats, and a further six Natterer's bat passes also recorded.

There is insufficient data to determine any patterns of behaviour, however, three locations had significantly more *Pipistrellus* activity than the others. These locations were along a treeline between the woodland and a glade, which studies have shown is an important foraging and commuting habitat for common and soprano pipistrelles (Boughey *et al.*, 2011; Downs and Racey, 2006).



Figure 3: Natterer's bat. © Daniel Hargreaves/Bat Conservation Trust.

Conclusion

Talich and Spey Bay Wildlife Reserves are important foraging areas for four bat species: common pipistrelle, soprano pipistrelle, Daubenton's bat and Natterer's bat, which are new records for the reserves. This survey has also confirmed the presence of Natterer's bat in a 10km grid square surrounding Talich Wildlife Reserve which had no previous records for Natterer's (JNCC, 2019; NBN Atlas, undated). Similarly, this survey has confirmed the presence of Natterer's bat and soprano pipistrelle in a 10km grid square around Spey Bay Wildlife Reserve which did not have any previous records of these species (JNCC, 2019; NBN Atlas, undated).

The information gathered at Talich Wildlife Reserve suggests that this reserve is used by common and soprano pipistrelles, Daubenton's bats and Natterer's bats for foraging. The survey method did not enable roost sites to be identified, and this would be an interesting subject for further study.

References

- Boughey, K., Lake, I., Haysom, K. and Dolman, P. (2011) Improving the biodiversity benefits of hedgerows: how physical characteristics and the proximity of foraging habitat affect the use of linear features by bats. *Biological Conservation*, 144(6) pp. 1790-1798.
- Downs, N. and Racey, P. (2006) The use by bats of habitat features in mixed farmland in Scotland. *Acta Chiropterologica*, 8(1) pp. 169-185.
- Joint Nature Conservation Committee. (2019) *Article 17 Habitats Directive Report 2019: Species Conservation Status Assessments 2019* [Online] <https://jncc.gov.uk/our-work/article-17-habitats-directive-report-2019-species/> [Accessed 28th October 2019].
- Middleton, N., Froud, A. and French, K. (2014) *Social calls of the bats of Britain and Ireland*. Exeter: Pelagic Publishing.
- National Biodiversity Network Atlas (undated) *Myotis daubentonii distribution map*. [Online] <https://species.nbnatlas.org/species/NHMSYS0000376160> [Accessed 7th January 2020].
- Newson, S. E., Evans, H. E., Gillings, S., Jarrett, D. and Wilson, M.W. (2017) A survey of high risk bat species across southern Scotland. *Scottish Natural Heritage Report No. 1008*.
- Russ, J. (2012) *British bat calls: guide to species identification*. Exeter: Pelagic Publishing.

[Return to contents page](#)

Bats undergraduate research project

Jean Oudney

jeanoudney@gmail.com

I graduated as a mature student from Edinburgh Napier University in the summer of 2019 with an honours degree in Animal Biology. Being a bat enthusiast and present chair of Tayside Bat Group, I had looked for something batty to do for my honours project! This is the story of that research, and how it didn't finish with the research.

With a batty project in mind I eventually decided my honours research project would be to investigate the local graveyards and cemeteries to find out what bats were using them and what they are doing: were they merely commuting through or were the graveyards providing foraging habitat for the bats? I also wanted the project to be of practical conservation use so this information would provide some baseline data for our local records and could be rolled out to more graveyards across Tayside in the future.

In addition to this, the project had a second part to it (which was not an official part of my university research project) and this was to provide recommendations to organisations and graveyard owners on how to protect and improve the graveyards for their bat populations; many organisations have biodiversity objectives to work towards and this could form part of some of them along with helping our local bats.

Why graveyards? Well I had organised a bat walk in Perth the previous summer and had picked a park along the River Tay that had a) parking and b) habitat for both *Pipistrellus* species at dusk and Daubenton's bat *Myotis daubentonii* later on in the evening. It happened that the park has an old graveyard in it and I thought how cool it would be to watch the bats from the graveyard. The bat walk ended up being very popular and many parents brought their young children, one of whom kept repeating confidently that "But there are no zombies" every time I spoke to him which was quite hilarious. I think he was slightly freaked out about being in a graveyard, but it turns out this was the fault of a cartoon he watched, he was fine with the bats.

Bat activity has been studied on organic farms which are largely free of agrochemicals and they have shown a significant difference in bat foraging activity compared to conventional farms (Wickramasinghe *et al.*, 2003). Insect abundance is also significantly higher in pastoral and water habitats on organic farms (Wickramasinghe *et al.*, 2004) and many of the characteristics of organic farms (such as the lack of pesticides, herbicides and fertilisers, vertical vegetation and understory vegetation) are also elements found in graveyards, particularly those in place for hundreds of years (Kowarik *et al.*, 2016). They are often the only pieces of land to have escaped development or the widespread spraying of fertilisers and herbicides (Barrett and Barrett, 2001) and are sometimes remnants of ancient grassland (English Heritage, 2007), making them an important part of green corridors linking parks, gardens and other larger patches of urban habitat (English Heritage, 2007).

Graveyards and cemeteries have large old trees, protected by religion and reverence and have rare natural roost holes that bats and other animals use. They are also unlikely to be developed for housing and are often quiet and dark areas, escaping light pollution. All of which is, of course, excellent for bats! In rural areas surrounded by intensive arable farmland (of which we have a lot of in Tayside) they can also provide a refuge in areas of poor habitat.

Table 1: The graveyards selected in this study and the features of each graveyard, the surrounding landscape and any roosting opportunities available.

Name of site	Graveyard features	Roosting opportunities	Landscape features
Clunie Kirk and graveyard	19th century church built on 12th century site, still in use. No vegetation or trees within the graveyard and the grass is cut regularly throughout the year. No light pollution.	Available in both the church and the small mausoleum which have slate roofs. The occupied former manse next door could provide enough warmth for a pipistrelle maternity roost.	Next to semi-natural woodland and loch, adjoining farmland has patches of woodland with tree and hedge lines which has retained some connectivity of habitat.
Kirkton of Lethendy	Ruined 16th century church with unmaintained adjoining graveyard which has long grass but little understorey and a small number of trees in the NE corner. No light pollution.	Cracks in the stonework of the ruined church and nearby slate roofed houses could provide roosting opportunities.	Bordered by intensive arable farmland on three sides and a large area of woodland to the north. Nearest water source is a small burn approx 90 metres to the south.
Hill Kirk and graveyard, Blairgowrie	19th century church built on an early medieval site positioned above the town, in use by the local drama group. Separated into an upper section with mature trees and dense graves, and a lower unmaintained section with long grass and trees and understorey. Some light pollution in upper graveyard but none in lower graveyard due to dense vegetation and slope of the ground.	Available in the church which has a slate roof and nearby slate roofed house, some of which could be suitable as maternity roosts. Neaby woodland has many mature trees which could also provide roosts	Situated beside extensive mature semi-natural woodland with a burn running past the church to the river below.
Blairgowrie Cemetery	19th century cemetery with many mature trees surrounding and inside the graveyard. Cemetery is still in use and is maintained regularly.	Roosting opportunities available in mature trees and a small number of slate roofed properties locally	Situated next to A93, surrounded by residential houses and new primary school and fields earmarked for development in the near future, with mature birch woodland beyond. Nearest water is almost overgrown curling pond approximately 180m to the NW
Dundee Howff cemetery	Medieval cemetery in the city centre which, although no longer in use, is still maintained regularly but with many mature trees in the central and southern area of the cemetery.	Roosting opportunities available in the mature trees and in the surrounding slate roofed properties.	No connectivity to any habitat and no residential gardens in the immediate area. Light pollution enters the cemetery from most directions from streetlights and windows, particularly the building of DC Thomson which has eight stories of unshaded windows shining light into the cemetery during the night. Nearest water is the River Tay, approximately 0.5 km to the SE.
Carmyllie Kirk and graveyard	17th century church and graveyard which is in current use with many mature deciduous trees. Graveyard is maintained.	Roosting opportunities available in the mature trees and the slate roofed church and nearby former manse, which may be warm enough for a maternity roost.	Situated in an area of intensive arable farmland with no connectivity to other areas of habitat or water bodies. Former manse next door has a large mature garden. Nearest water is a small burn 0.2 km to the south.

The six graveyards were chosen for a variety of different features: rural/urban, good and bad surrounding habitat, maintained (i.e. grass cutting regime), roost potential and light pollution, Table 1 shows the features of each graveyard and Table 2 shows the scoring that was used.

Each graveyard was surveyed five times from May to September 2018 with four dusk surveys and one dawn survey carried out on each site.

The survey method was to count bat passes to identify the activity level and feeding buzzes (indicating feeding attempts) and then both the ratio of passes to feeding buzzes was used to calculate foraging efficiency. These were then measured against the different graveyard factors I identified in the graveyards and abiotic factors (such as temperature).

Table 2: The graveyard features and their scoring, which was between 1 (poor) and 4 (excellent). The maintenance scoring was a simple yes or no, graveyards strimmed once a year were considered unmaintained because the grass grew back quickly. Lighting was scored between 1 (extensive light pollution) and 4 (no light pollution).

	Maintained (1 = yes, 2 = no)	Understorey density	Tree density	Lighting (in or nearby affecting graveyard)	General landscape scale	Graveyard scale
Clunie Kirk	1	1	1	4	4	1
Kirkton of Lethendy	2	2	2	4	3	3
Hill Kirk, Blairgowrie	2	4	4	3	4	4
Blairgowrie Cemetery	1	2	3	2	2	2
Howff Cemetery, Dundee	1	3	3	1	1	2
Carmylie Kirk	1	1	2	4	1	2

Initially, I had intended to count on both my hand held Pettersson time expansion bat detector and my Anabat swift passive full spectrum detector, but I quickly found in levels of high activity it was impossible to count passes and buzzes efficiently on my hand held detector. I also couldn't record them all for later analysis because of the detector's method of replaying the call for downloading, while it is replaying the call it is not recording the next load of calls. So, I changed strategy and relied solely on my passive detector for recording all the passes and buzzes, while I moved around the graveyard watching the bat behaviour and doing a partial emergence survey of the buildings.

Results

Tayside has only five species of bats recorded (officially) in the area: common pipistrelle *Pipistrellus pipistrellus*, soprano pipistrelle *P. pygmaeus*, brown long-eared bat *Plecotus auritus*, Daubenton's bat and Natterer's bat *M. nattereri*. All are fairly widespread with the exception of Natterer's bat, which are at the northern limit of their range and consequently are found but are not as numerous as the other species.

In Clunie Church (Figure 1) I was excited to discover one of the biggest maternity colonies of brown long-eared bats we have recorded in Tayside and one that was completely unknown (by the Bat Group and the local ecologists anyway). There were also *Pipistrellus* species

roosting elsewhere in the church and in the wee mausoleum on site. The bats were mostly commuting across the graveyard or emerging from roosts, but there was some foraging activity despite the lack of trees and vegetation within the graveyard. I suspect this is because of the excellent surrounding habitat and mature garden in the next door manse and its insect population spilling over into the graveyard, rather than because there was much in the way of insect habitat within the graveyard itself.

The brown long-eared bats emerge from the church tower and fly over the car park into the trees. It was such a good site for seeing the bats flying close overhead that I organised a Bat Group outing later in the summer and we counted 33 bats emerging from the church tower. We visited again in 2019 and counted 37 brown long-eared bats. Although there were only two species of *Pipistrellus* and brown long-eared bat found in the graveyard, the nearby Clunie Loch is about 20m away and has Daubenton's bats, so afterwards I took the Bat Group down among the midges to watch the Daubenton's bats flying past over the loch.



Figure 1: Clunie Kirk and the wee mausoleum, which is partly constructed of stone from the previous medieval church on this site. Clunie Loch is beyond the trees in the background. © Jean Oudney.

Kirkton of Lethendy (Figure 2) was relatively unexciting in terms of bat activity because the activity was almost entirely outside the graveyard, despite this being a graveyard that is entirely unmaintained with long grass (although with a few trees and bushes). Most of the activity across the graveyard was bats commuting towards a small burn about 20m away

and back again to the woodland. However, I did find what I think might be a breeding roost in a crack above a doorway in the ruined church in the final survey in September.



Figure 2: Kirkton of Lethendy Kirk and graveyard. © Jean Oudney.

The early medieval Hill Kirk in Blairgowrie proved to be as exciting as I hoped and I managed to record all five species of bat found in Tayside at the bottom of the lower graveyard. The lower graveyard was very busy on the dusk surveys and it was like bat city, so many calls and feeding buzzes it took a very long time to count all the calls during the analysis!

The Natterer's bat calls were recorded throughout the night and after consultation with my friend and mentor to double check my call analysis, I concluded that this graveyard is an important foraging area for this species making it a very special place indeed. I was almost certain that I had recorded a Natterer's bat entering the church at dawn but frustratingly I had pulled the lead out of my recorder on the first occasion and the call wasn't recorded. On the second occasion I watched it flying along the building, right over my head around the corner where I was standing – not echolocating at all! However, a survey in the church a few months ago only found signs of a single brown long-eared bat roost, so the jury is still out on whether it is also a Natterer's bat roost.

Blairgowrie's 19th century cemetery had a very low numbers of *Pipistrellus* at dusk and nothing at all at dawn but surprised me with a random recording of two Natterer's bat calls on an August dusk survey, which was very unexpected because of the surrounding houses,

light pollution and road that separates it from the woodland 100m away. The light pollution was not as bad here as expected because of the large deciduous trees lining the outside of the graveyard that shaded the inside from the worst of the pollution. This observation was welcomed by the lady that runs the local biodiversity partnership, who was pleased to find another reason to protect the mature trees in the graveyard.

The medieval cemetery in the middle of the city of Dundee called The Howff (Figure 3) has no connected habitat at all and surprisingly had one single common pipistrelle that evidently lives its whole summer there because it was present on every survey I did. There are quite a lot of trees in one area of the cemetery (which is locked at night) and lots of mature bushes throughout the cemetery and the bat mainly foraged around the trees with the occasional foray into the other areas. There were a lot of gulls present through the survey and it kept close to the trees when they were around, diving under cover when they came too close.

The light pollution from the nearby DC Thomson (newspaper printers) was very bad and they have a tall building with bright light shining from almost every floor without shades. I wasn't able to establish where the bat was roosting as there were slate roofed tenements on two sides of the cemetery and it was too much for one person to watch. This result does show that even the most unlikely of places can have sufficient resources to support at least one bat.



Figure 3: The Dundee Howff medieval cemetery and some of the tenements that border two sides. © Jean Oudney.

I did have an interesting experience one evening in the Howff with a young laddie and his girlfriend who had apparently scaled the wall into the cemetery and wandered up to chat in the dark. They didn't seem to be too surprised to find me standing there, even asking if I was looking for ghosts but simply nodded knowingly when I said no, I was studying the bats. The laddie (who looked the worse for wear) asked me if I could recommend somewhere that he and his 'burd' could 'get cosy', but when I said "No, sorry" (wondering if there is anything else I could or should say in the circumstances that wouldn't incite some sort of violence...) they wandered off to a corner when I saw him gallantly taking off his hoodie and laying it down for her on a grave. As you can imagine I kept away from that section for the rest of the evening!

The graveyard at Carmyllie in deepest arable Angus (Figure 4) was also surprising as it had a lot of activity, again through most of the night. I suspect there is a small common pipistrelle maternity roost nearby that forages solely in a nearby garden and in the graveyard. There were also two soprano pipistrelles roosting in the church itself. The graveyard has a beautiful selection of mature deciduous trees lining all sides and down the middle of the graveyard, and the *Pipistrellus* concentrated all their foraging around the trees, as did the *Pipistrellus* on the other sites. It was clear that this graveyard is a vital foraging area for the local populations of bats and shows the importance of isolated rural cemeteries to the wildlife that has managed to cling on as intensive farming has taken over.



Figure 4: The graveyard in Carmyllie, Angus when the haar from the distant sea crept over the graveyard and I tried to take some atmospheric photos. © Jean Oudney.

Although attempts were made to identify all bat species present, the data I used in my research was solely from the two species of *Pipistrellus* because there were not enough calls recorded from the other species. This was not unexpected, given the method of hunting and the low call intensity of brown long-eared bat and Natterer's bat. However, I did include the small numbers of brown long-eared bats, Natterer's bats and Daubenton's bats that I recorded elsewhere in my observations and recommendations.

I won't go through all the results, but I will mention a couple that I thought were interesting:

Graveyard and Landscape quality

The common pipistrelle showed a preference for higher quality graveyards, whereas the soprano pipistrelle showed very different results, with their activity and feeding attempts showing a preference for the lower quality and higher quality graveyards, but not the intermediate scaled graveyards (Figure 5). This indicates an involvement with another factor not measured in this scale.

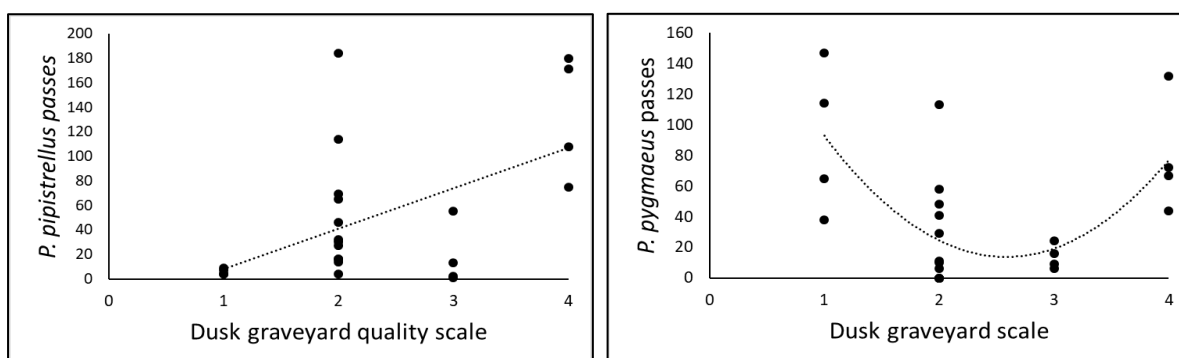


Figure 5: Dusk activity levels of common and soprano pipistrelle compared to the graveyard quality scale.

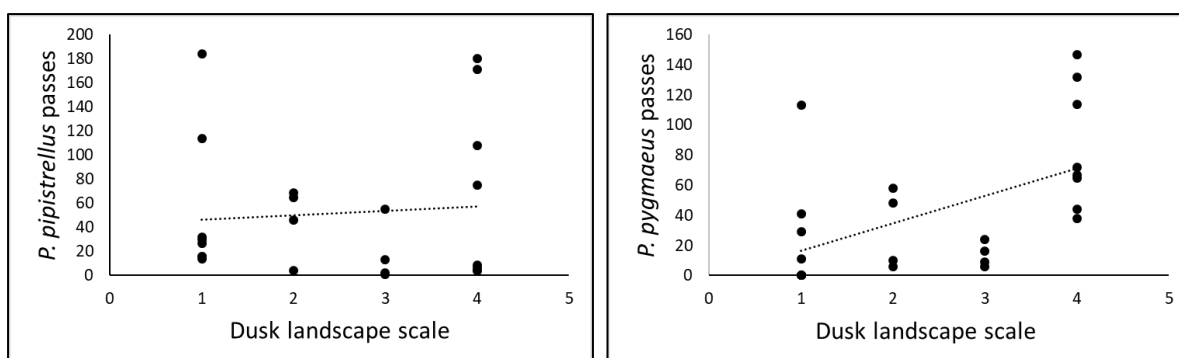


Figure 6: Dusk activity levels of common and soprano pipistrelle compared to the landscape quality scale.

Common pipistrelles are known to be generalist foragers (Barlow, 1997; Davidson-Watts *et al.*, 2006; Lintott *et al.*, 2015) and their foraging success may be similar in poor and good quality habitats because they are generalist foragers able to adapt to many different

situations. Soprano pipistrelles are known to have a strong relationship with riparian and water habitats (Barlow, 1997; Davidson-Watts and Jones, 2005; Nicholls and Racey, 2006). Water was not a feature that I measured in the quality of the graveyards, as none of them had water features within their boundaries, however I did include this in the landscape quality scale (Figure 6).

Common pipistrelles have significantly smaller colony sizes than soprano pipistrelles and are known to move roosts frequently (Davidson-Watts and Jones, 2005) which maybe a reflection on the foraging capability of the local areas and a restriction on colony sizes, with the result that common pipistrelles are forced to move roosts frequently.

In contrast, soprano pipistrelles often have roosts that number hundreds and even thousands, especially in Scotland (Swift, 2016) and their preference for foraging areas with high density swarms of *Chironomidae* (Barlow, 1997) may reflect their need for a good quality habitat to support their roost numbers. Roosting areas large and warm enough to support a large numbers of bats may be relatively rare, but the benefits of large numbers of bats roosting together and lowering their thermoregulatory costs may allow soprano pipistrelles to roost further away and travel to one particular habitat that provides a high quality foraging area (Davidson-Watts and Jones, 2005).

These results show that most of the differences in graveyard selection by the two *Pipistrellus* species can be explained by different resource and habitat preferences.

Graveyard maintenance

Again, differences between the two species of *Pipistrellus* are shown, with the common pipistrelles showing a preference for unmaintained graveyards but the soprano pipistrelles relatively unaffected by the maintenance of the graveyard, which was measured chiefly on the grass-cutting regime. This is likely to be because of resource partitioning between the two species, with soprano pipistrelles foraging mainly on aquatic *Chironomidae* (Barlow, 1997) and common pipistrelles foraging on a wide range of insects found in long grass, understorey and trees, indicating that unmaintained graveyards are more important to common pipistrelles than soprano pipistrelles.

However, the maintenance of the graveyards is likely to be essential to the closed-clutter specialists that glean their prey by means of passive listening and specially adapted echolocation, brown long-eared bats, Natterer's bats and Daubenton's bats, which are present in some of the graveyards in this study. Moths are the preferred food of brown long-eared bats (Swift, 1998) and a well-developed understorey is essential foraging areas for both brown long-eared bats (Law *et al.*, 2015) and Natterer's bats (Swift, 2009), which eat few moths but do feed to a large extent on insects caught very close to ground vegetation.

The Hill Kirk graveyard and its immediate surroundings contain many mature trees and a complex understorey which is known to support a wide variety of biodiversity (Law *et al.*,

2015) and this habitat is probably essential for the survival of the clutter adapted bats found in this graveyard. The lower section contains undisturbed long grassland which is likely to be an essential foraging area for Natterer's bats that forage over long grass and are known to feed extensively on small nocturnal *Scarabidae* (UK Beetle Recording, 2019) ground beetles or chafers *Serica brunneae* that live in undisturbed grass roots and climb to the top of the grass at certain times of the year.

Recommendations

This small research project shows that even the most unlikely graveyards have potential to support bat populations. Simple measures can be taken by graveyard managers protect the mature trees and understorey as much as possible to preserve the foraging areas of their bat populations and avoiding insecticide use. Unmaintained wild areas could be left in areas with no graves to provide long undisturbed grass and native flowers for insects that require this habitat (Figure 7). Light pollution can be prevented from entering the graveyards by ensuring the mature tree canopy is protected, which stops light from shining during the important summer season when female bats are raising their pups. Installing directional lights that shine only on the paths and roads needed by humans can help to preserve the dark areas used by wildlife and red light can be a useful substitution when light is necessary. Roosting areas can be provided by installing bat boxes in the graveyards and cemeteries and greater value should be placed on landscape features such as hedgerows and tree lines that connect smaller areas of habitat and are vital to the movement of bats and other wildlife.



Figure 7: The lower graveyard of the Hill Kirk. © Jean Oudney.

After the project

During 2019 I wrote a summary report of the project for the graveyard managers, outlining the reasons why it was done and the general results of the project. Then I wrote a section specific to each graveyard and put in recommendations on how to protect and improve their graveyards for the local bat populations. I have sent this to the local managers and to Tayside Biodiversity Partnership, who were very interested in the project and hope to incorporate it in future projects. I hope to organise some bat box installations with the Bat Group this year, and even survey some more graveyards.

In the winter of 2019 through the local Facebook page I came across a plan for locals getting together to clean up the Hill Kirk. Some locals were offended by the wild look of the graveyard and the local genealogy group were unable to send visitors to the graveyard to look at graves of their ancestors because it was so overgrown. Fearing well-meaning people would come along and strim to death the precious lower graveyard (Figure 7), where all five species of bats found in Tayside are found, I immediately leapt into action and started to lecture them all about its importance for the bats, in particular the Natterer's bat, which is as you know is an internationally rare species.



Figure 8: British Lichen Society members surveying one of the gravestones in the upper graveyard.

I worked out a deal with the different groups where I would clean and map the gravestones and they would agree to leave the majority of the ground in the lower graveyard untouched. I cleared the gravestones as promised over the past year and even found some lost internment records, which made the genealogy people very happy. I also invited the very knowledgeable members of the British Lichen Society to visit and survey the lichens (Figure 8) and I was very excited to find out they recorded over 80 different species,

unfortunately in terms of lichen surveys it is not that unusual but it was a very interesting few hours following them around.

As it turned out the graves are all located around the outside, so I was able to design a path that visits all the graves while leaving the long grass in the centre of the graveyard and the happy strimmers will be restricted to this path only. Tayside Bat Group is funding a sign to explain to visitors the value of this wild area and how it supports the bat population and we now have many other local groups involved, including high school pupils working towards their John Muir Award. It is a great example of how local interest groups can all work together and create a solution that everyone is happy with. And I also gained a very good mark for my project.

References

Barlow, K. (1997) The diets of two phonic types of the bat *Pipistrellus pipistrellus* in Britain. *Journal of Zoology*, 243(3) pp. 597-609. doi: 10.1111/j.1469-7998.1997.tb02804.x

Davidson-Watts, I. and Jones, G. (2005) Differences in foraging behaviour between *Pipistrellus pipistrellus* (Schreber, 1774) and *Pipistrellus pygmaeus* (Leach, 1825). *Journal of Zoology*, 268(1) pp. 55-62. doi: 10.1111/j.1469-7998.2005.00016.x

Davidson-Watts, I., Walls, S. and Jones, G. (2006) Differential habitat selection by *Pipistrellus pipistrellus* and *Pipistrellus pygmaeus* identifies distinct conservation needs for cryptic species of echolocating bats. *Biological Conservation*, 133(1) pp. 118-127. doi: 10.1016/j.biocon.2006.05.027

English Heritage. (2007) *Paradise Preserved An introduction to the assessment, evaluation, conservation and management of historic cemeteries* [eBook] [Online] https://content.historicengland.org.uk/images-books/publications/paradise-preserved/paradise_preserved_20081010174134.pdf/

Kowarik, I., Buchholz, S., von der Lippe, M. and Seitz, B. (2016) Biodiversity functions of urban cemeteries: Evidence from one of the largest Jewish cemeteries in Europe. *Urban Forestry & Urban Greening*, 19 pp. 68-78. doi: 10.1016/j.ufug.2016.06.023

Law, B., Park, K. and Lacki, M. (2015) 'Insectivorous Bats and Silviculture: Balancing Timber Production and Bat Conservation.' In Voight, C. C. and Kingston, T. (eds.) *Bats in the Anthropocene: conservation of bats in a changing world*. Cham: Springer, pp. 105-150.

Lintott, P., Bunnefeld, N. and Park, K. (2015) Opportunities for improving the foraging potential of urban waterways for bats. *Biological Conservation*, 191 pp. 224-233. doi: 10.1016/j.biocon.2015.06.036

Nicholls, B. and Racey, P. (2006) Habitat selection as a mechanism of resource partitioning in two cryptic bat species *Pipistrellus pipistrellus* and *Pipistrellus pygmaeus*. *Ecography*, 29(5) pp. 697-708. doi: 10.1111/j.2006.0906-7590.04575.x

Swift, S. (1998) *Long-eared bats*. London: Poyser.

Swift, S. (2009) Roosting and foraging behaviour of Natterer's bats (*Myotis nattereri*) close to the northern border of their distribution. *Journal of Zoology*, 242(2) pp. 375-384. doi: 10.1111/j.1469-7998.1997.tb05809.x

Swift, S. (2016) Conversation with Dr Sue Swift, exact date unknown.

UK Beetle Recording. (2019) *Scarabidae*. [Online]
<https://www.coleoptera.org.uk/family/scarabaeidae>

Wickramasinghe, L., Harris, S., Jones, G. and Vaughan, N. (2003) Bat activity and species richness on organic and conventional farms: impact of agricultural intensification. *Journal of Applied Ecology*, 40(6) pp. 984-993. doi: 10.1111/j.1365-2664.2003.00856.x

Wickramasinghe, L., Harris, S., Jones, G. and Vaughan Jennings, N. (2004) Abundance and Species Richness of Nocturnal Insects on Organic and Conventional Farms: Effects of Agricultural Intensification on Bat Foraging. *Conservation Biology*, 18(5) pp. 1283-1292. doi: 10.1111/j.1523-1739.2004.00152.x

[Return to contents page](#)

The status of Nathusius' pipistrelle *Pipistrellus nathusii* in North East Scotland: Breeding or Migratory status?

Katie Barr; School of Biological Sciences, University of Aberdeen

katie.barr.15@aberdeeen.ac.uk

Abstract

The ecological and life history information gathered in this study is crucial to understanding the Nathusius' pipistrelle population in the North East of Scotland and is of high biological importance. Nathusius' pipistrelle is regarded as a resident breeding species in Britain and Ireland. However, there is controversy surrounding the topic and it is yet to be confirmed whether the Aberdeenshire population is following similar patterns as the rest of Britain and Ireland. Various methods of analysis have been used across a wide range of studies in order to decipher the status of the species, including capturing and handling, echolocation analysis and most recently DNA metabarcoding. A study was carried out using static bat detectors at five waterbodies in Aberdeenshire, Scotland in June, July and August 2018. Presence/absence of Nathusius' pipistrelle was measured for eleven days in each of the months sampled. The aim was to investigate if the North East population of Nathusius' pipistrelle is migratory or residential and breeding. Key results show that Nathusius' pipistrelle are present in Aberdeenshire in June, July and August. The species was present eight out of the eleven days sampled in June, all eleven days in July and nine days in August, across all five sites. However, there was no significant difference of probability of occurrence between the three summer months. There was a significant difference of probability of occurrence between locations despite the close proximity of the five lochs. A non-significant month effect leads to the conclusion that the Aberdeenshire population is probably breeding with a supporting migratory influx; the species clearly have strong preferential habitat selection. Information gathered from this study may help understand the ecology and behaviour of the species and has widened knowledge of the North East population; however it cannot be confirmed that the population is breeding and more definitive work is required on this topic.

Key words

Migration, North East Scotland, probability of occurrence, Nathusius' pipistrelle, species diversity.

Introduction

The known range of Nathusius' pipistrelle has increased significantly over the previous few years (Lundy *et al.*, 2010), however, it is yet to be determined if this is due to sampling efforts or range expansion of the species (JNCC, 2007). Sampling efforts have increased for many reasons, the public perception of bats is more positive encouraging more engagement in conservation of the species. Moreover, technological advances in the equipment used to detect bats has allowed for ease of identification and capture (Kunz and Fenton, 2005). Therefore, historic trends are difficult to interpret and generally unknown across the UK. It is important to understand the Nathusius' pipistrelle ecology and behaviour in order to help with conservation efforts in the UK. Climate change has been suggested to be a major driver of the range expansion we are observing and is expected to further impact the distribution in the future (BCT, 2018; JNCC, 2017).

Nathusius' pipistrelle are said to exhibit plasticity in that they react to climate change by adjusting their breeding ranges (Ancillotto *et al.*, 2016). The *Pipistrellus* genus are crucial to most ecosystems and are referred to as 'indicator species' helping identify environmental stress. This statement highlights the importance of studying bats, they are pollinators, seed dispersers and insect pest controllers (JNCC, 2017). If populations decline dramatically this could be detrimental to many systems across the country. Observation of the species can pinpoint habitat requirements, behaviour and distribution helping with conservation efforts (Nathusius' pipistrelle in Great Britain and Ireland, 2014).

Scotland is home to nine different bat species, five being common and the other four referred to as rare or only occurring in certain areas of the country; the Nathusius' pipistrelle being one of the rarest bats (Scottish Wildlife Trust, 2018). Nathusius' pipistrelle is regarded as a priority species under the EUROBATS agreement, despite this it has been poorly studied up until now (Nathusius' pipistrelle in Great Britain and Ireland, 2014). Nathusius' pipistrelle is the largest and rarest of the *Pipistrellus* in the UK weighing 6-16g and a wingspan of 22-25cm. Occurring in central and eastern Europe, migrating to western Europe for overwintering, it is a relatively common species in mainland Europe. Despite its small size, it is capable of long-distance migrations between summer and winter roosting sites (Strelkov, 1969). Nathusius' pipistrelle are long-distance migrants, using multiple short flights rather than one long sustained one. Females depart before the males and young staggering migration population size. They leave northern and central Europe in July to return to areas of Germany, Austria, Switzerland and the Netherlands to hibernate (Fleming *et al.*, 2003). The population trend of the species in Britain and Ireland is unknown, however it is likely that the population increases in late winter and decreases at the start of spring due to migration (PTES, 2018). The current status of Nathusius' pipistrelle in Britain is undefined, this is partly due to records of the species being so infrequent at first. More work has been carried out on the species and three maternity colonies were discovered, one in Lincolnshire and two in County Antrim (Russ, 2001). Recently the species has received a lot more attention and there was a national Nathusius' pipistrelle survey launched in 2014 by the Bat Conservation Trust to increase population data.

If previous studies and modelling is correct and the species is experiencing habitat expansion, it is possible that they will be present in areas they were not previously. Nathusius' pipistrelle are frequently recorded at waterbodies feeding on medium-sized flying insects such as aquatic flies, midges and mosquitoes. In addition to this they are also found in woodland edges and wetlands (BCT, 2010). Habitat preference of the species could change as they are being pushed out of their usual habitat due to climate changes. Other aspects of habitats may be affected due to range expansion of Nathusius' pipistrelle, presence of a new species may disrupt species diversity and distribution of other British bat species at certain locations due to the pressures of competition and niche occupations.

Previously, studies on animal species diversity have shown a positive correlation between habitat heterogeneity and animal species diversity, known as the habitat heterogeneity hypothesis (Tews *et al.*, 2004). Locations which boast such an assortment of vegetation would be predicted to have high bat species diversity. Additionally, in several studies species are linked to 'keystone structures' that determine animal species diversity by their presence (Tews *et al.*, 2004). Bat species in Aberdeenshire also exhibit this phenomenon with the

keystone structures of waterbodies and woodland (Walsh and Harris, 1996). Where these structures are present and in abundance, it would be expected to be an area of interest to bat species and result in high diversity.

Previous studies have failed to establish whether the species is present throughout summer or if it is purely a migrant just visiting in autumn and winter (Russ *et al.*, 1998). It requires more work and is the basis of this study. The most beneficial thing would be long running studies to examine the patterns of the species in Aberdeenshire.

Aims and objectives

This study examined the patterns in the incidence of *Nathusius' pipistrelle* across the summer months at five freshwater locations by recording echolocation calls to provide insight into the population occurrence and distribution in Aberdeenshire. Ultimately to answer the question, is the North East population breeding or is it migratory. Echolocation data collected will contribute to answering the question through analysis of number of calls per day, presence or absence of calls in each given day and comparison to other species calls recorded. It is important to generate data for the North East population to further understand the species in the area and put in place conservation methods to help the future of this species. Hypotheses to be tested were:

Hypothesis 1: Does the probability of occurrence of *Nathusius' pipistrelle* differ with location or month

Hypothesis 2: Does bat species diversity differ between the five locations across the three months sampled

Hypothesis 3: Does *Nathusius' pipistrelle* follow a similar occurrence pattern as the more common, breeding bat species, common pipistrelle *P. pipistrellus*?

Methodology

The study was carried out using static bat detectors over three summer months, at five coastal sites in Aberdeenshire. The response variables are presence and absence of *Nathusius' pipistrelle* and the predictors are location and month. Minimum sample period was 11 days in each month in order to collect at least six clear days of weather. Work is based on a relatively limited sample of one year and although five sites were worked at, some data were unavailable due to technical issues.

Sampling Design

Detectors

Five song meter SM2+ static bat recorders, borrowed from the Scottish Natural Heritage (SNH) were used in this study. The detectors record echolocation calls made by passing bats that can be left unattended while they record. The SM2+ recorders can be left for up to three days due to battery life constraints. Other methods of recording bats would be using a handheld detector such as the Echo Meter Touch, surveillance and capturing bats using harp traps. However, these techniques either require a licence or are time consuming therefore not suitable due to time constraints of small sample period. Detectors were set up at the start of each sampling month according to the quick start guide provided in the boxes. The

microphones were mounted onto 3m poles to avoid as much ground noise as possible and capture optimum numbers of bat calls. The detectors were set up to record 15 minutes before sunset and 1.5 hours after sunset, similarly 1.5 hours before sunrise and 15 minutes after sunrise, this is the protocol for surveying bats and was to accommodate for early risers (Collins, 2016). The boxes were set up and taken down every month for security reasons but were set up in the exact same way each time. Batteries and SD cards were replaced every three nights at each site taking an average of three hours and covering 61 miles.

Location Choice

Data collection was carried out in June, July and August due to *Nathusius' pipistrelle* being most active in the summer months, reproducing and feeding (BCT, 2018). Bat detectors were placed at five loch side locations along the coast of North East Scotland, Aberdeenshire all with a clear view. The locations were selected to replicate a study on *Nathusius' pipistrelle* by Stark in 2017. Stark (2017) selected lochside, coastal locations because *Nathusius' pipistrelle* are found in areas close to large freshwater bodies and woodland edges (BCT, 2010). Furthermore, the position of detectors was also based on this study and placed in the same OS grid reference (Table 1). For all locations permission was

Table 1: Locations used for sampling including brief description of surroundings, distance from coast and OS grid references for the placement of detectors.

Location Name	OS Grid Reference of Location	Distance from Coast (km)	Location Description
Meikle Loch	NK028310	2.59	Rural location with few buildings surrounding. Small adjacent loch (Little Loch) to the north west. Small woodland area on the north edge and between the two lochs.
Sand Loch	NK035285	0.52	Little urbanisation, coastal location surrounded by dunes and grassland. Little to no woodland areas nearby.
Corby Loch	NJ9248814320	3.94	Rural location with small quarry adjacent. Small adjacent loch (Lily Loch) to the south. Shrubbery and low woodland scattered around loch edge.
Inchgarth Reservoir	NJ899027	6.51	In an area of high urbanisation to the north of the loch and a major river running alongside the south edge of the reservoir. Medium density woodland surrounding the loch.
Loirston Loch	NJ939010	1.49	Adjacent to dual carriage way on the east edge with little urbanisation nearby. Patchy woodland with road works on going nearby.

gained from each landowner before any sampling took place. There were a couple issues with sampling including the detector at Inchgarth Reservoir being thrown into the water mid-July and having to wait for Scottish Water to retrieve it. Furthermore, I encountered a technical issue with the detector at Sand Loch in June, it did not record anything although it was set up in the exact same way as other detectors.

Echolocation Measurements

Recorder set up

The SM2+ detectors were set up to record in ZC (zero-crossing) this is a way of representing the most prominent frequency in a recording by calculating the points in time which a sound wave has crossed a reference amplitude a certain number of times (Wildlife Acoustics, 2018). Calls were recorded onto 32GB SD cards placed into the detector and changed every three days.

Manipulation of files

Data from the SD cards was then backed up on a hard drive and transferred onto a laptop to be manually identified using the Kaleidoscope viewer 4.5.5 software (Wildlife Acoustics, 2018). The software allowed for the files to be sorted into two separate folders, calls and noise. When in Bat Analysis Mode the programme can identify and isolate noise files. If they do not meet the signal parameter criteria they will be isolated as noise files, making analysis of calls a faster process (Wildlife Acoustics, 2019). Each recording was identified individually looking at frequency, more specifically character frequency (Fc) on the Kaleidoscope viewer analysis tab. Once all recordings were identified and labelled, total number of calls for each species in each recording were counted and added to an excel sheet ready for analysis.

Determination of species

Each species has its own range allowing them to be identified looking solely at frequency, exceptions are abnormal social calls. Nathusius' pipistrelle calls are similar to other *Pipistrellus* calls, hockey stick shaped but have a lower frequency of 32-40kHz. The common pipistrelle echolocation call has a frequency range of 42-50kHz and the soprano pipistrelle *P. pygmaeus* 50-80kHz. Other species identified were the Daubenton's bat *Myotis daubentonii*, ranging from 35-80kHz but has a characteristic of nearly vertical lines extending over a wide range of frequencies (Russ, 2012).

Data Analysis

First data were pooled on Microsoft Excel (16.15) to determine whether Nathusius' pipistrelle was present or absent for each sampling day across all sites and the total number of calls per day at each site. To summarise data all hours recorded were considered in analysis and there was no breakdown of dusk and dawn recordings. The probability of occurrence was calculated by dividing the number of days Nathusius' pipistrelle was recorded (event) by the total number of days sampled. Output from this indicated that the probability of occurrence was a binary variable.

Data were explored on Minitab 18 (Minitab Inc., 2017) to reveal characteristics in the data set. Exploration highlighted the large number of species detected and the uneven variance across sites. Furthermore, exploration helped with the selection of the correct model for analysis of presence/absence of Nathusius' pipistrelle across the sites for each month. A

binary logistic regression was used as it describes the data and explains the relationship between one dependent binary variable and one or more nominal, ordinal, interval or ratio-level independent variables (Statistics Solutions, 2018). Probability of occurrence was the response, month and location were categorical predictors. Two separate models were run, one for month and one for location because of the small sample size. Due to the nature of the data it wasn't possible to get a valid model to fit for the month, therefore analysis was presented graphically using boxplots. The total number of calls per day for Nathusius' pipistrelle was analysed on Minitab, however similar issues were experienced with the data and again it was analysed graphically using boxplots.

Recordings of common pipistrelle were explored in a similar fashion to the methods used for Nathusius' pipistrelle. The probability of occurrence was calculated and a binary logistic regression was conducted with species and month as predictors, however the model showed overdispersion, probably due to small sample size. Therefore, results are presented graphically.

The Shannon's diversity index was calculated using the total number of calls per species over the eleven days of sampling for each loch by month. To gain insight into the pattern of diversity among locations and month I used one sample T-tests. These tests compared the diversity index for each location for each month against the mean diversity index. The mean diversity index ($\bar{x}=0.695$) was calculated by adding up all Shannon diversity index outputs of all locations across all three months divided by the total number of outputs.

Results

Probability of Occurrence

Nathusius' pipistrelle were present at all five locations sampled in this study (Figure 1) and probability of occurrence differed across the locations (Chi square= 33.60, df= 4, $p<0.001$). This brings forward the idea that there is something else impacting the probability of occurrence, not just location.

Probability of occurrence appears similar across the three months samples (Figure 2). No valid statistical analysis model was identified to allow a statistical comparison.

Number of calls represents the total number of calls recorded per day, assuming one call is one individual. Meikle Loch exhibits the highest total number of calls for Nathusius' pipistrelle across the three months in comparison to the other locations (Figure 3). Number of Nathusius' pipistrelle calls per day has been presented graphically in boxplot form. When looking at Figure 3, it shows that there is variation within the locations with Meikle Loch in particular being considerably different to the latter four locations.

There was a lot of overlap of boxes when looking at month versus number of calls suggesting there is little similarity therefore there is no difference in number of calls across the three months (Figure 4). Additionally, there is much more variation in the number of calls as time progressed over summer.

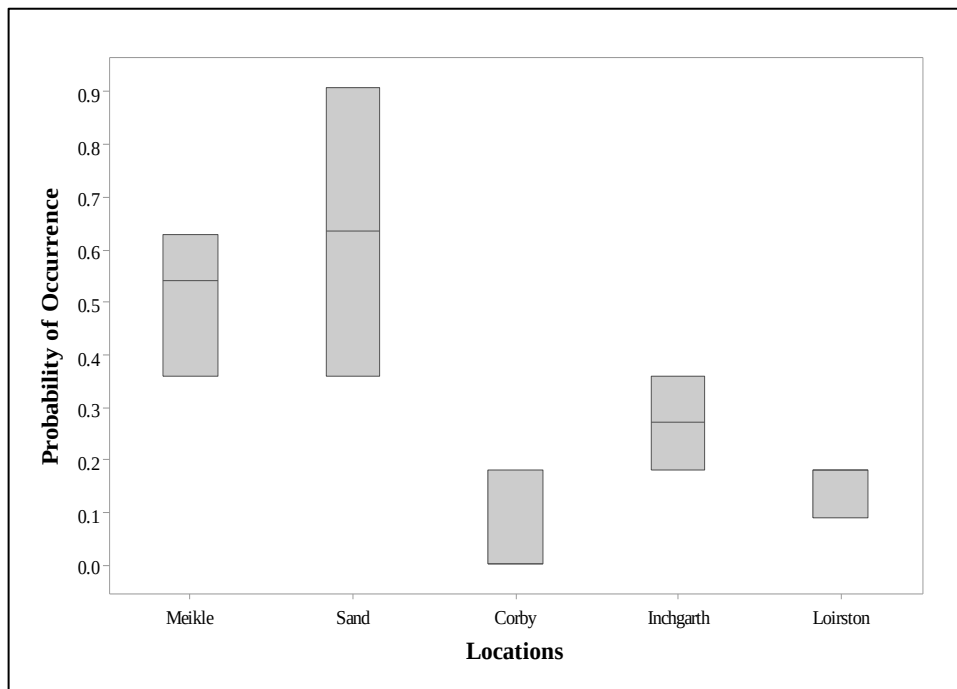


Figure 1: Boxplot representing the probability of occurrence of Nathusius' pipistrelle at each location. Probability of occurrence refers to the probability of the event occurring, Nathusius' pipistrelle being present, within the number of trials. The line in the box represents the median. Boxes where median line is not clearly visible; Corby Loch the median lies at the bottom of the box and for Loirston Loch it lies at the top. Plot is based on a sample size of N=13.

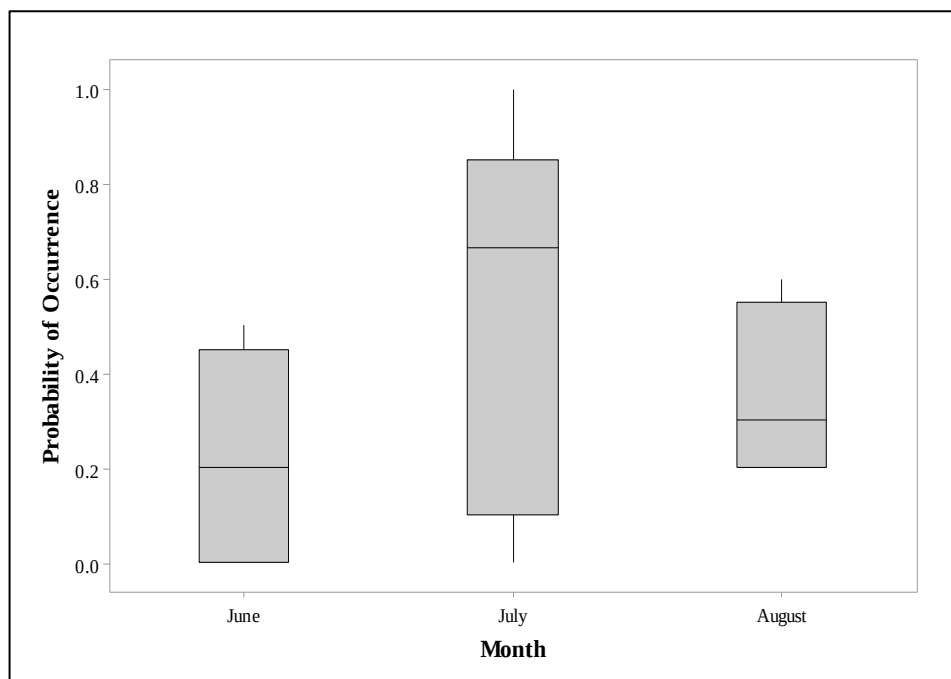


Figure 2: Boxplot representing the probability of occurrence of Nathusius' pipistrelle across the three months sampled. Probability of occurrence refers to the probability of the event occurring, Nathusius' pipistrelle being present, within the number of trials. The line in the box represents the median. Plot is based on a sample size of N=13.

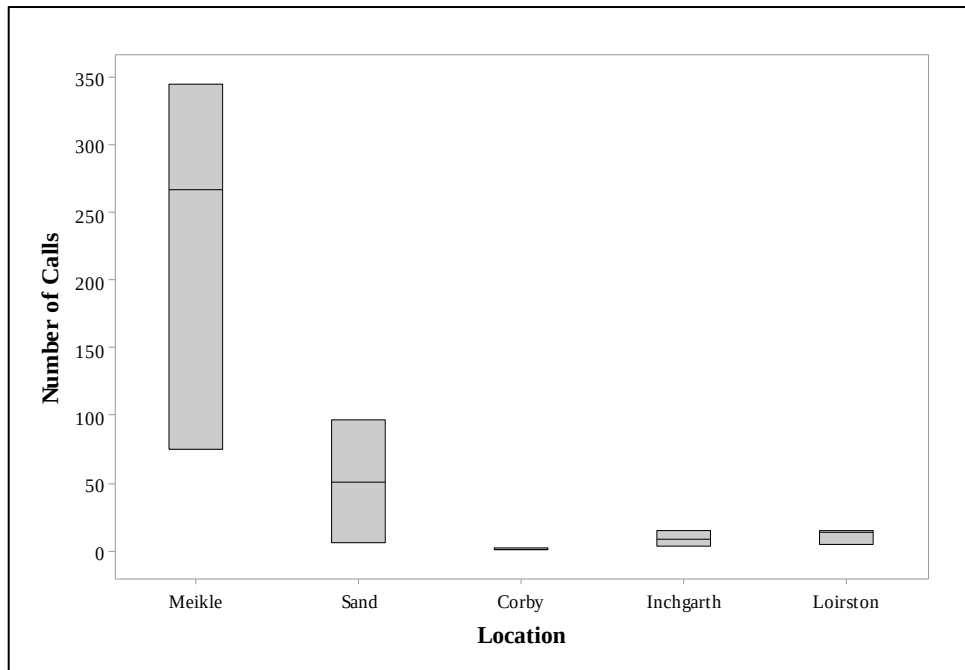


Figure 3: Boxplot representing the number of calls of Nathusius' pipistrelle at each location. The line represents the median. Number of calls is the total number of calls recorded per day, sample size N=134.

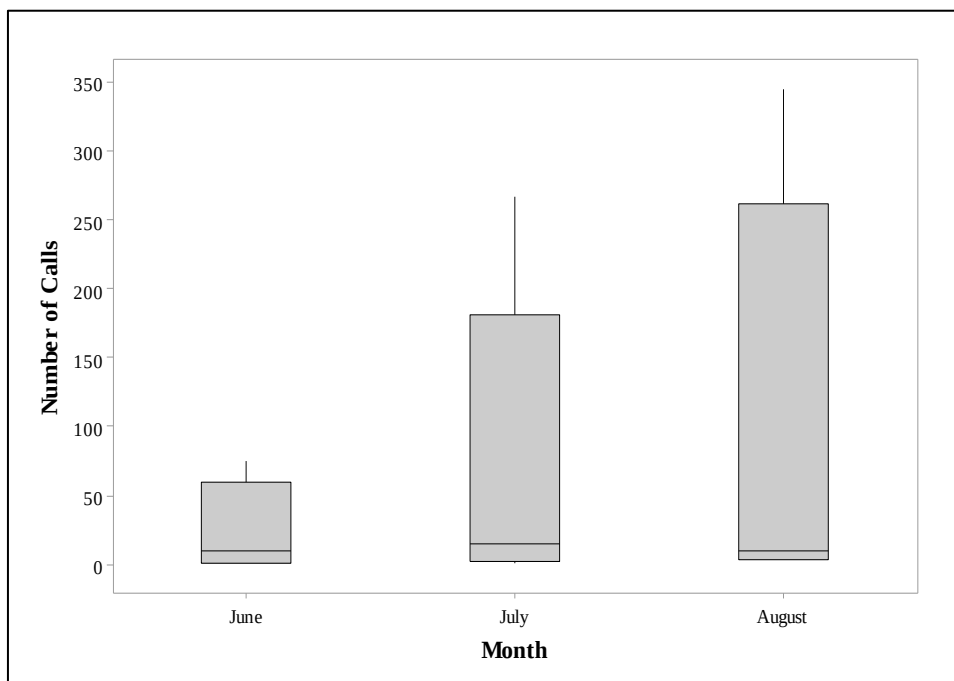


Figure 4: Boxplot representing the total number of calls of Nathusius' pipistrelle across the three months sampled. The line represents the median. Number of calls is the total number of calls recorded per day, sample size N=134.

Species Diversity

In this study there were four species recorded in total; common pipistrelle, soprano pipistrelle, Nathusius' pipistrelle and Daubenton's bat. The higher the index the more diverse the community is, Table 2 shows Meikle Loch was the most species diverse location

across all three months. One sample T-test output shows that months are no different to the mean ($\bar{x}=0.695$) with all p values $p>0.05$. However, the one sample T-test outputs for the different locations shows that Meikle Loch is significantly different from the mean ($t=5.72$, $df=4$, $p<0.05$).

Table 2: Results of the Shannon's diversity index for all the species recorded over the three month period at each location. Total number of sample days was 33 for each site with the exception of Sand Loch (22) and Inchgarth Reservoir (13). Asterisk stand for days where recording did not take place due to technical issues.

Month	Meikle	Sand	Corby	Inchgarth	Loirston
June	1.11	*	0	0.64	0.72
July	0.92	0.92	0	0.67	0.71
August	1.09	0.91	0.34	*	1.01

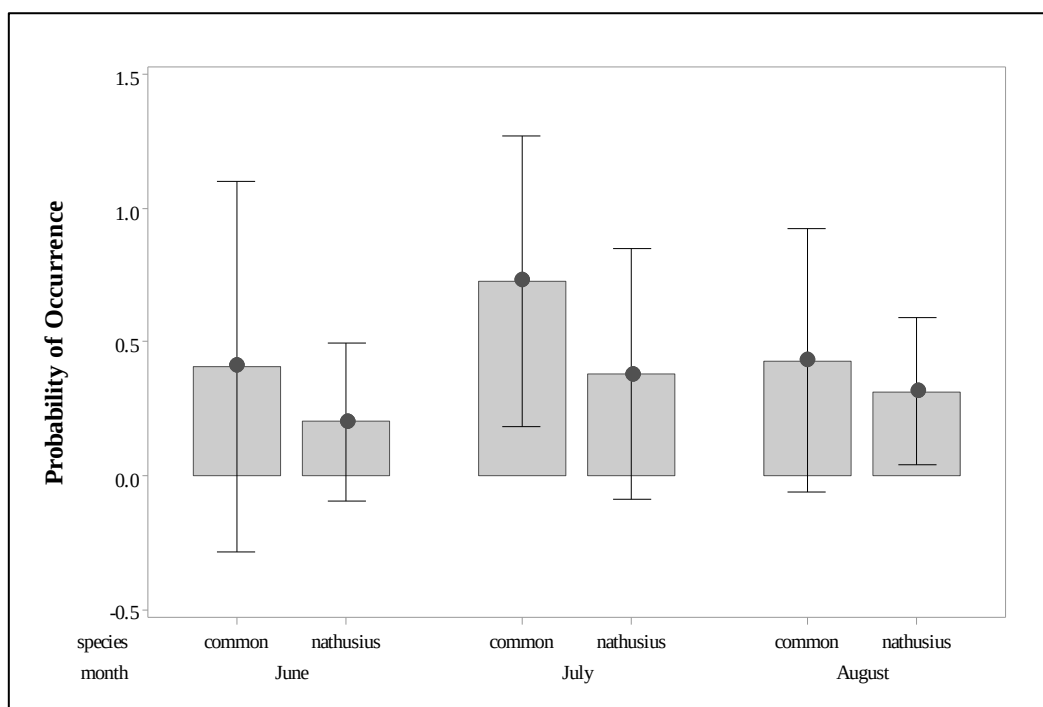


Figure 5: Interval plot of probability of occurrence for *Nathusius' pipistrelle* and common pipistrelle with a 95% CI for the mean. The error bars highlight the amount of variance within the data.

Comparison of Nathusius' pipistrelle with known breeding species

Analysis shows that species differ with fewer *Nathusius' pipistrelle* relative to common pipistrelle (Figure 5). However, it suggests that there is too much variation, that you cannot conclude that there is a difference between the two. Moreover, output highlights that

Nathusius' pipistrelle follows similar patterns to common pipistrelle over June, July and August with July being the peak month for probability of occurrence (Figure 6).

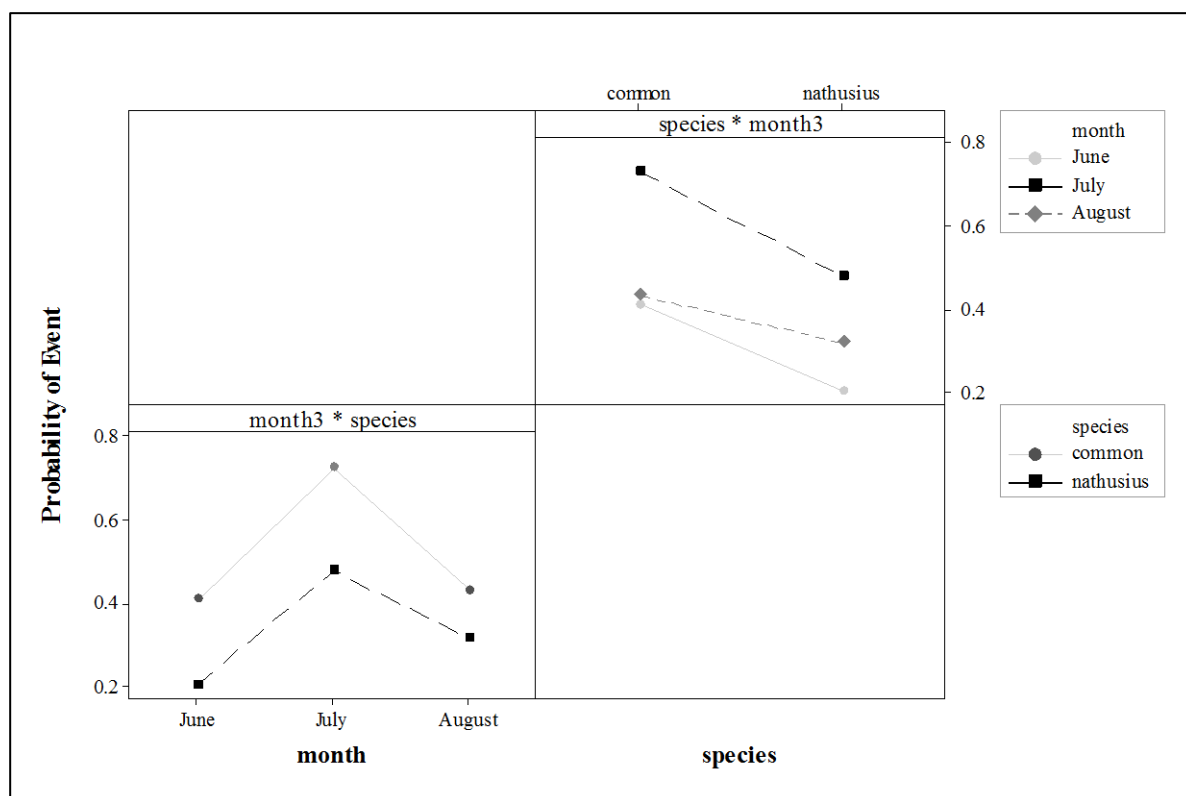


Figure 6: Interaction plot for probability of event with fitted probabilities. Showing the interaction between species and month and vice versa.

Discussion

Migratory or Breeding

Nathusius' pipistrelle have previously been described as a vagrant species in the UK, occurring out with its previously considered normal range of Northern and central Europe (Lundy *et al.*, 2010). However, more recent studies confirm that Nathusius' pipistrelle is a migratory species in Great Britain with small maternity colonies known in England and Ireland (BCT, 2010).

The females migrate in a south-westerly direction to mate with males during early autumn and in late autumn they move further in the same direction to hibernate (Russ, 2001). Due to the warmer summer experienced this year in Europe, this may have delayed the response of females migrating. This would have a knock-on effect on the migration the species make for hibernation, this infers there is a change in species status occurring. As discussed, in theory, this conclusion may not be reliable due to the sampling period not covering the months September, October and early November. Nonetheless, Nathusius' pipistrelle is said to be a migratory species but some individuals do remain all year and breed in the UK (BCT, 2010). This could indeed be the case for the North East population. It would be wrong to disregard the migratory status of this species in the UK. It is possible that the resident breeding population is accompanied by a migratory influx as well. A study used stable isotope analysis to examine Nathusius' pipistrelle fur samples to confirm the origin of the individuals. They found that at least 40% of their UK samples had moved a substantial

distance suggesting they were migratory originating from outside of the UK. However, some samples did show that they were resident and had not travelled since the last moult the previous summer (BSG Ecology, 2014).

These findings contradict previous studies, in particular Speakman (1991) concluded that Nathusius' pipistrelle were exhibiting species migratory patterns. Limited calls were captured over summer, with none in July. Since then there has been a small number of Nathusius' pipistrelle maternity colonies identified in England and Northern Ireland, but not yet Scotland. On the same token, this study infers that the North East population is breeding due to the non-significant month effect. If the North East population was migratory you would expect month to significantly impact the probability of occurrence. More specifically you would observe a difference in August in comparison to June and July due to the main migration period occurring in late summer/autumn (Lundy *et al.*, 2010). Results show high variation in the number of calls as time progressed over summer, with the month of August showing the highest variance. This could be due to the irregular nature of male Nathusius' pipistrelle social calls to attract females passing by the roost at the beginning of the autumn mating season (Russ and Racey, 2007).

It is thought that the milder winters experienced in the UK may push certain species of bats to disregard their migratory behaviour (Russ *et al.*, 1998). Milder weather makes the pressure to migrate to avoid extreme weather less of a crucial behaviour. Climate change seems to be imposing a substantial impact on the world and its fauna in recent years and will continue to over the next few years (Visser, 2008). Climate change may affect Nathusius' pipistrelle and other bat species found in the UK. Research has shown that climate change may increase food availability and promote faster development of young but it may also disrupt hibernation and reduce disease tolerance (Sherwin *et al.*, 2013). In conjunction with this, several studies have generated models to make predictions on the impact climate change could have on European bats. Results show that temperate species such as Nathusius' pipistrelle were more tolerant than other European species of temperature increases, although under certain scenarios of a global intensive use of fossil fuel, the European bat species diversity suffered significantly (Rebelo *et al.*, 2010). Moreover, large-scale landscape development due to human activity may account for the change in migratory behaviour observed. This statement touches on the fact that many migratory species have specific habitat requirements, the rapid decline of these habitats may drive them to areas they have not been seen before (Flaquer *et al.*, 2009).

Limitations to this investigation is the small sample size, limiting the analysis and quality of results. On reflection, 11 days of observation per month was sufficient to capture monthly trends. However, extension of the time period is necessary and sampling from May through to October could reveal more about breeding and migratory behaviours. In addition to this, repetition of the study over several years would build a better picture of the annual pattern Nathusius' pipistrelle is exhibiting in Aberdeenshire.

Location Effects

On the contrary there is a significant location effect on probability of occurrence of Nathusius' pipistrelle. This indicates that either a single feature or a combination of features of the different locations are impacting the probability of occurrence. Each location varied in

characteristics, ranging from a heavily urbanised to rural surroundings. Furthermore, habitats surrounding the lochs differed among the locations. *Nathusius' pipistrelle* are thought to have a habitat preference for riparian habitats with broadleaved and mixed woodland but always near water (Collins, 2016). Out of the five locations, Inchgarth Reservoir most closely provided this preferred habitat.

It could be possible that there is a *Nathusius' pipistrelle* maternity roost present at Meikle Loch or nearby. Breeding roosts are usually located in crevices such as cracks in walls, under gutters and fissures in rocks and tree hollows (BCT, 2010.) From observation, there are suitable locations for a roost at all sites but more localised features are at Meikle Loch. Further studies such as examination of social calls of the male *Nathusius' pipistrelle*, could give more information about the location of breeding roosts. The males emit a characteristic call at regular intervals while flying in the vicinity of the roost or while at the roost itself (Gerell-Lundberg and Gerell, 1994).

Results do suggest that there must be something else impacting the probability of occurrence as location does not account for all the variation in the model. Factors such as surface area of waterbody, number of months the site holds water, distance from the coast and site topography are all said to affect the use of these habitats by bats (Salvarina, 2016).

Species Diversity

As previously discussed *Nathusius' pipistrelle* has a habitat preference, but is it possible the species is following similar patterns to other bat species found in North East Scotland in terms of habitat selection and feeding behaviour. A previous study carried out in Aberdeenshire revealed that other species in the region have a similar habitat preference to *Nathusius' pipistrelle* in terms of broadleaved woodland and presence of a waterbody. However, Daubenton's bats were found to utilise rivers more than open water in comparison to the *Pipistrellus* (Downs and Racey, 2006). Results from this study indicate that Meikle Loch has the highest species diversity. It has been shown that productivity affects species richness (Waide *et al.*, 1999), it is possible that Meikle Loch has high productivity therefore resulting in high species evenness and richness. At first look, Meikle Loch had a standout feature of an adjacent waterbody (small loch) to the north west joined by a small burn (JNCC, 2008). Previous studies have shown that there is a positive relationship with bat occurrence and linear landscape features such as tree lines and forest corridors. This due to a number of reasons such as protection, food abundance and navigation (Hein *et al.*, 2009). It could be a possibility that the bats are using this as a corridor between the two waterbodies for optimum feeding intake. However, looking at Corby Loch, it shares similar characteristics in that it also hosts a small adjacent waterbody (Lily Loch). This site has been described to have rich insect fauna displaying a good progression of open water to woodland (Aberdeen City Council, 2013). Despite this, there were very little species recorded at this location throughout the sampling period. This may be as a result of the nearby working quarry and newly developed dual carriageway. Studies have shown that there is a barrier effect associated with major roads and reduced foraging, making bats more reluctant to be in that area (Altringham and Kerth, 2016).

Water quality of the waterbodies adds another level of complexity when investigating bat distribution. Impact differs depending on the individual practices of the farms and what

agrochemicals are used. Higher nitrate levels can lead to eutrophication of waterbodies causing algal blooms which can in turn disrupt the food web (Conley *et al.*, 2009). An increase in nitrogenous materials can be the causation of a sudden abundance of flying insects (Racey *et al.*, 1998). The water quality of the locations could impact the species diversity due to the differences in diet composition and preference. Select species can take advantage of the insects more tolerant to changes in water quality (Salvarina, 2016). Meikle Loch is a eutrophic waterbody supporting limited aquatic vegetation (JNCC, 2008), it is surrounded by agricultural land resulting in an increased nitrate level in the waterbody due to run off from the fields (USGS, 2017). This could be a strong factor that contributes to the high species diversity observed at this particular location. Although open habitats associated with intensive farming and agriculture are avoided by most bat species (Newson *et al.*, 2017), surrounding agricultural land could still be of benefit. It has been shown that grass margins that have been put in place to protect watercourses from agrochemicals also increase invertebrate abundance (McHugh *et al.*, 2018).

In light of this, you must consider what conditions need to be present to allow for such diversity of species to occur at one location at any given time. Lisón and Calvo (2013) demonstrated this, highlighting the *Pipistrellus* species in particular. They concluded that the species need to develop mechanisms of niche partitioning to avoid competition allowing them to live in sympatry. Therefore, locations with higher species diversity must be supporting the different bat species with abundance of possible niche selection. Nonetheless, it is important to take into consideration that the same habitat feature can have a different effect on different species at different locations (Salvarina, 2016).

Sand Loch displayed relatively high species diversity, which is surprising due to the habitat composition of this location. Sand Loch has surrounding dunes and very little woodland which is considered to be poor habitat for most bat species. It could be possible that so many bats were recorded at this site because they are following a south westerly path, and not necessarily feeding; the lochs may create a network of habitats, connecting the coast through the Ythan estuary, Sand Loch and Meikle Loch to more inland habitats.

Moderately high species diversity was observed at Loirston Loch, studies have shown that Nathusius' pipistrelle distribution has been positively related to woodland and small areas of urbanisation (Lundy *et al.*, 2010). Small areas of urbanisation are favoured by *Pipistrellus* due roost potential in a majority of buildings (Lintott *et al.*, 2016). This location is a mix of Meikle Loch and Inchgarth Reservoir, supporting most bat species with optimal urbanisation levels and woodland. The downfall of this location was the neighbouring dual carriageway which, as previously discussed, negatively impacts bat presence.

The format in which recordings were viewed resulted in the detector only picking up the loudest noise, therefore if two bats were passing the microphone the quieter bat would be missed out. Therefore, the full range of species present at each location at any given time was misrepresented. Furthermore, the echolocation software Kaleidoscope, tended to falsely identify social calls of *Pipistrellus* species for other species such as Leisler's bat *Nyctalus leisleri* or noctule *N. noctula*. This could impact the species composition of sites resulting in false diversity index outcomes.

Comparison with common pipistrelle

It is possible that *Nathusius' pipistrelle* may be following similar patterns to an already known breeding species, common pipistrelle. This speculation supports the statement that North East *Nathusius' pipistrelle* population is indeed breeding. However, more in depth study of this is required to draw a conclusion from this as other factors may be contributing to the similar pattern observed. Although they may be following similar patterns of probability of occurrence over the three months there is a clear difference in species with fewer *Nathusius' pipistrelle* recorded relative to common pipistrelle. Common pipistrelle is a more established species in the region, they are the commonest and most widespread British bat species. The species has only been identified separate from soprano pipistrelle in the 1990's (BCT, 2010), there is estimated to be 1,280,000 in Great Britain alone.

In addition, similar patterns observed may result in strong competition for food resources. Both species feed using the 'aerial hawking' method, where echolocation is used as a means of catching their prey. Moreover they also have similar prey choice, with Diptera and Lepidoptera comprising the major prey categories (Krüger *et al.*, 2014). The expansion of the common pipistrelle resulted in competition for food becoming stronger, thus contributing to the decline of the lesser horseshoe bat *Rhinolophus hipposideros*. This could be similar circumstances for *Nathusius' pipistrelle* in Aberdeenshire, it is more at risk due to its small population size and the limited information we have on the species. Due to common pipistrelle and *Nathusius' pipistrelle* having similar feeding habits and diet you would expect them to have similar preference for similar habitats (Lisón and Calvo, 2013). Common pipistrelle is suggested to be a generalist therefore able to thrive in a wide variety of environments, explaining the higher probability of occurrence (Davidson-Watts *et al.*, 2006). Common pipistrelle populations have significantly increased since 1999, this expansion could be putting pressure on other species due to niches, already being occupied by common pipistrelle (JNCC, 2017). Arlettaz *et al.* (2000) demonstrated the outcome of similar interaction of common pipistrelle and lesser horseshoe bat.

Results show a peak in probability of occurrence in July, although not a significant difference it is likely due to the breeding timeline of both common pipistrelle and *Nathusius' pipistrelle* being similar. The females give birth to young in June or early July and after three or four weeks the young are able to fly, accounting for the influx of individuals recorded (BCT, 2010). The low probability of occurrence of both species in June, if breeding, is likely to be due to females who are pregnant in May and June only leave their roost once each night (Swift, 1980).

To conclude the status of *Nathusius' pipistrelle* in the North East of Scotland is challenging to study and there are many difficulties gathering the data resulting in it being limited, representing the key issue in bat research. However, understanding of the species in the area has increased considerably. The key conclusions of this study highlights the plasticity of *Nathusius' pipistrelle* and the further diversification we may observe in the species and indeed other European bat species. It is probable that the Aberdeenshire population is residential and breeding, with a supporting influx of a migratory population and have a clear significant habitat preference. Nevertheless, findings of this experiment cannot be confirmed solely from the information gathered. More in depth study is required to come to a reasonable conclusion.

Acknowledgements

Thanks go to Robert Raynor and the SNH for their support and providing me with the SM2+ bat detectors. Further thanks to Aileen Salway from the North East Scotland Bat Group who provided me with the basics in bat echolocation identification and the group itself were all so welcoming. Additionally, I would like to thank all landowners that allowed me to carry out sampling on their land: RSPB, SNH, Scottish Water, Malcolm Smith and the Aberdeen and District Angling Association. Finally, I would like to also thank my supervisor, Professor Michelle Pinard, for all the help and patience throughout this process.

References

- Aberdeen City Council (2013) Aberdeen City Local Nature Conservation Sites. [Online] https://www.aberdeencity.gov.uk/sites/default/files/2017-09/2013_LNCS_Booklet_LR_0.pdf [Accessed 29th November 2018].
- Altringham, J. and Kerth, G. (2016) 'Bats and roads.' In Voight, C. C. and Kingston, T. (eds.) *Bats in the Anthropocene: conservation of bats in a changing world*. Cham: Springer, pp. 35-62.
- Ancillotto, L., Santini, L., Ranc, N., Maiorano, L. and Russo, D. (2016) Extraordinary range expansion in a common bat: the potential roles of climate change and urbanisation. *The Science of Nature*, 103(3-4) p. 15.
- Arlettaz, R., Godat, S. and Meyer, H. (2000) Competition for food by expanding pipistrelle bat populations (*Pipistrellus pipistrellus*) might contribute to the decline of lesser horseshoe bats (*Rhinolophus hipposideros*). *Biological Conservation*, 93(1) pp. 55-60.
- Barlow, K.E. and Jones, G. (1996) *Pipistrellus nathusii* (Chiroptera: Vespertilionidae) in Britain in the mating season. *Journal of Zoology*, 240(4) pp. 767-773.
- Bat Conservation Trust (2010) *Common pipistrelle species Factsheet*. [Online] https://cdn.bats.org.uk/pdf/About%20Bats/commonpipistrelle_11.02.13.pdf?mtime=20181101151257 [Accessed 30th November 2018].
- Bat Conservation Trust (2018) *A year in the life of a bat*. [Online] <https://www.bats.org.uk/about-bats/a-year-in-the-life-of-a-bat> [Accessed 21st November 2018].
- Bat Conservation Trust (2018) *Nathusius' Pipistrelle Survey*. [Online] <https://www.bats.org.uk/our-work/national-bat-monitoring-programme/surveys/national-nathusius-pipistrelle-survey> [Accessed 10th November 2018].
- Bat Conservation Trust (2010) *Nathusius' Pipistrelle species Factsheet*. [Online] https://cdn.bats.org.uk/pdf/About%20Bats/nathusiuspipistrelle_11.02.13.pdf?mtime=20181101151301 [Accessed 10th November 2018].

BSG Ecology (2014) *Bat Migration Research Report, Stable Isotope Analysis of Nathusius' Pipistrelle Fur Samples*. [Online] https://www.bsg-ecology.com/wp-content/uploads/2015/09/SIA_APPR_271114.pdf [Accessed 3rd December 2018].

Collins, J. (ed.) (2016) *Bat Surveys for Professional Ecologists: Good Practice Guidelines* (3rd edn.). London: Bat Conservation Trust.

Conley, D.J., Paerl, H.W., Howarth, R.W., Boesch, D.F., Seitzinger, S.P., Havens, K.E., Lancelot, C. and Likens, G.E. (2009) Controlling eutrophication: nitrogen and phosphorus. *Science*, 323(5917) pp. 1014-1015.

Davidson-Watts, I., Walls, S. and Jones, G. (2006) Differential habitat selection by *Pipistrellus pipistrellus* and *Pipistrellus pygmaeus* identifies distinct conservation needs for cryptic species of echolocating bats. *Biological conservation*, 133(1) pp. 118-127.

Downs, N.C. and Racey, P.A. (2006) The use by bats of habitat features in mixed farmland in Scotland. *Acta Chiropterologica*, 8(1) pp. 169-185.

Flaquer, C., Puig-Montserrat, X., Goiti, U., Vidal, F., Curcó, A. and Russo, D. (2009) Habitat selection in Nathusius' pipistrelle (*Pipistrellus nathusii*): the importance of wetlands. *Acta Chiropterologica*, 11(1) pp. 149-155.

Fleming, T.H., Eby, P., Kunz, T.H. and Fenton, M.B. (2003) Ecology of bat migration. *Bat Ecology*, 156 pp. 164-65.

Gerell-Lundberg, K. and Gerell, R. (1994) The mating behaviour of the pipistrelle and the Nathusius' pipistrelle (Chiroptera)-A comparison. *Folia Zoologica*, 43(4) pp. 315-324.

Hein, C.D., Castleberry, S.B. and Miller, K.V. (2009) Site-occupancy of bats in relation to forested corridors. *Forest Ecology and Management*, 257(4) pp. 1200-1207.

JNCC. (2008) *Information Sheet on Ramsar Wetlands (RIS)*. [Online] <http://jncc.defra.gov.uk/pdf/RIS/UK13061.pdf> [Accessed 24th November 2018].

JNCC, Bat Conservation Trust. (2017) *The state of the UK's bats 2017. National Bat Monitoring Programme Population Trends*. [Online] https://cdn.bats.org.uk/pdf/State_of_UKs_Bats_2017-2.pdf?mtime=20181101151557 [Accessed 27th November 2018].

JNCC. (2007) *Second Report by the UK under Article 17 on the implementation of the Habitats Directive from January 2001 to December 2006*. [Online] www.jncc.gov.uk/article17 [Accessed 5th January 2019].

Krüger, F., Clare, E.L., Symondson, W.O., Keiřs, O. and Pētersons, G. (2014) Diet of the insectivorous bat *Pipistrellus nathusii* during autumn migration and summer residence. *Molecular Ecology*, 23(15) pp. 3672-3683.

- Kunz, T.H. and Fenton, M.B. (eds.) (2005) *Bat ecology*. Chicago: University of Chicago Press.
- Lintott, P.R., Barlow, K., Bunnefeld, N., Briggs, P., Gajas Roig, C. and Park, K.J. (2016) Differential responses of cryptic bat species to the urban landscape. *Ecology and evolution*, 6(7) pp. 2044-2052
- Lisón, F. and Calvo, J.F. (2013) Ecological niche modelling of three pipistrelle bat species in semiarid Mediterranean landscapes. *Acta Oecologica*, 47 pp. 68-73.
- Lundy, M., Montgomery, I. and Russ, J. (2010) Climate change-linked range expansion of Nathusius' pipistrelle bat, *Pipistrellus nathusii* (Keyserling and Blasius, 1839). *Journal of Biogeography*, 37(12) pp. 2232-2242.
- McHugh, N.M., Bown, B.L., Forbes, A.S., Hemsley, J.A. and Holland J.M. (2018) Use of agri-environment scheme habitats by pipistrelle bats on arable farmland. *Aspects of Applied Biology*, 139 pp. 15-22.
- Minitab Inc. (2017) Minitab Statistical Software. Pennsylvania: State College.
- Nathusius' pipistrelle in Great Britain and Ireland. (2014) Life History. [Online] http://www.nathusius.org.uk/Life_History.htm [Accessed 14th November 2018].
- Newson, S.E., Evans, H.E., Gillings, S., Jarrett, D. and Wilson, M.W. (2017) *A survey of high risk bat species across southern Scotland*. Scottish Natural Heritage Commissioned Report, No. 1008.
- People's Trust for Endangered Species. (2018) *Nathusius' pipistrelle*. [Online] <https://ptes.org/get-informed/facts-figures/nathusius-pipistrelle/> [Accessed 3rd December 2018].
- Racey, P.R., Swift, S.M., Rydell, J. and Brodie, L. (1998) Bats and insects over two Scottish rivers with contrasting nitrate status. *Animal Conservation forum*, 1(3) pp. 195-202.
- Rebelo, H., Tarroso, P. and Jones G. (2010) Predicted impact of climate change on European bats in relation to their biogeographic patterns. *Global Change Biology*, 16(2) pp. 561-576.
- Russ, J. (2012) *British bat calls: a guide to species identification*. Exeter: Pelagic Publishing.
- Russ, J.M. and Racey, P.A. (2007) Species-specificity and individual variation in the song of male Nathusius' pipistrelles (*Pipistrellus nathusii*). *Behavioral Ecology and Sociobiology*, 61(5) pp. 669-677.
- Russ, J.M., Hutson, A.M., Montgomery, W.I., Racey, P.A. and Speakman, J.R. (2001) The status of Nathusius' pipistrelle (*Pipistrellus nathusii* Keyserling and Blasius, 1839) in the British Isles. *Journal of Zoology*, 254(1) pp. 91-100.

Russ, J.M., O'Neill, J.K. and Montgomery, W.I. (1998) Nathusius' pipistrelle bats (*Pipistrellus nathusii*, Keyserling and Blasius 1839) breeding in Ireland. *Journal of Zoology*, 245(3) pp. 345- 349.

Salvarina, I. (2016) Bats and aquatic habitats: a review of habitat use and anthropogenic impacts. *Mammal Review*, 46(2) pp. 131-143.

Scottish Wildlife Trust. (2018) Bat to Basics. [Online]
<https://scottishwildlifetrust.org.uk/2018/09/bat-to-basics/> [Accessed 30th November 2018].

Sherwin, H.A., Montgomery, W.I. and Lundy, M.G. (2013) The impact and implications of climate change for bats. *Mammal Review*, 43(3) pp. 171-182.

Speakman, J., Racey, P., Hutson, A., Webb, P. and Burnett, A. (1991) Status of Nathusius' pipistrelle (*Pipistrellus nathusii*) in Britain. *Journal of Zoology*, 225 pp. 685-690.

Stark, J. (2017) Bats to the Future: The Occurrence and Distribution of Nathusius' Pipistrelle (*Pipistrellus nathusii*) in the North East of Scotland.

Statistics Solutions. (2018) *What is a logistic regression?* [Online]
<https://www.statisticssolutions.com/what-is-logistic-regression/> [Accessed 23rd November 2018].

Strelkov, P.P. (1969) Migratory and stationary bats (Chiroptera) of the European part of the Soviet Union. *Acta Zoologica Cracoviensia*, 16 pp. 393-440.

Swift, J.F., Lance, R.F., Guan, X., Britzke, E.R., Lindsay, D.L. and Edwards, C.E. (2018) Multifaceted DNA metabarcoding: Validation of a noninvasive, next-generation approach to studying bat populations. *Evolutionary Applications*, 11(7) pp. 1120-1138.

Swift, S.M. (1980) Activity patterns of pipistrelle bats (*Pipistrellus pipistrellus*) in north-east Scotland. *Journal of Zoology*, 190(3) pp. 285-295.

Tews, J., Brose, U., Grimm, V., Tielbörger, K., Wichmann, M.C., Schwager, M. and Jeltsch, F. (2004) Animal species diversity driven by habitat heterogeneity/diversity: the importance of keystone structures. *Journal of biogeography*, 31(1)pp. 79-92.

U.S. Geological Survey (USGS) (2017) *The USGS Water Science School, Nitrogen and water*. [Online] <https://water.usgs.gov/edu/nitrogen.html> [Accessed 8th January 2019].

University of Bristol. (2005) School of Biological Sciences, Common pipistrelle, *Pipistrellus pipistrellus*. [Online]
<http://www.bio.bris.ac.uk/research/bats/britishbats/batpages/commonpipi.htm#Morphological> [Accessed 30th November 2018].

Visser, M.E. (2008) Keeping up with a warming world; assessing the rate of adaptation to climate change. *Proceedings of the Royal Society B: Biological Sciences*, 275(1635) pp. 649-659.

Waide, R.B., Willig, M.R., Steiner, C.F., Mittelbach, G., Gough, L., Dodson, S.I., Juday, G.P. and Parmenter, R. (1999) The relationship between productivity and species richness. *Annual review of Ecology and Systematics*, 30(1) pp. 257-300.

Walsh, A.L. and Harris, S. (1996) Foraging habitat preferences of vespertilionid bats in Britain. *Journal of Applied Ecology*, 33(3) pp.508-518.

Wildlife Acoustics, Inc. (2018) Kaleidoscope Pro Analysis Software. [Online] https://www.wildlifeacoustics.com/products/kaleidoscope-pro?utm_source=global-nav&utm_medium=website&utm_campaign=kpro5-bat [Accessed 23rd November 2018].

Wildlife Acoustics, Inc. (2019) Kaleidoscope Pro 5, User Guide. [Online] <http://condor.wildlifeacoustics.com/Kaleidoscope.pdf> [Accessed 6th January 2019].

[Return to contents page](#)

Glamorgan Bat Group Area Status – Relative Abundance based on local record centre records

Aaron Davies and Matt Mott-Dowling

aarondavies_4@hotmail.com

Introduction

The following document seeks to identify the relative status of the bat populations within the area represented by the Glamorgan Bat Group; hereafter referred to as GBG. GBG covers the unitary authorities of Swansea and Neath Port Talbot. The area covered by GBG is shown in Figure 1.

The sole source of information that this assessment is drawn from is the database of bat records held by the South East Wales Biodiversity Records Centre (SEWBRc). This excludes any information held solely by National Biodiversity Network (NBN), or personal records that have not yet been submitted to SEWBRc. Revision to this database will be undertaken in subsequent years with addition of data from the SEWBRc database, NBN, existing databases that have yet to be assessed and with data collected from monitoring projects that GBG will be undertaking in the forthcoming years.

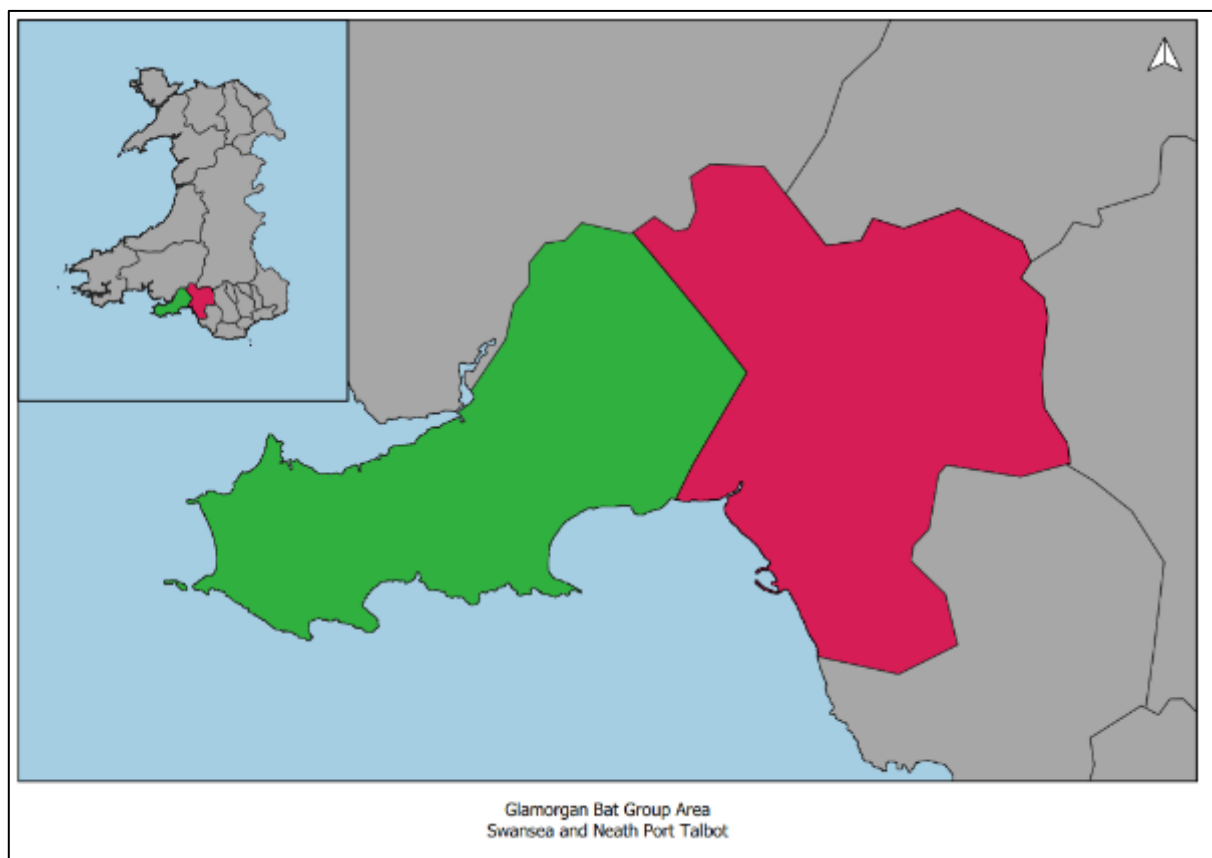


Figure 1: Glamorgan Bat Group Area.

Glamorgan Bat Group Area

Swansea is the second largest city in Wales and the regional commercial centre for South West Wales. The entire area is 379.7sq.km with approximately 69.5% considered rural and 30.5% considered urban (Swansea Council, 2020). A large proportion of the unitary

authority of Swansea is the Gower peninsula which projects westwards into the Bristol Channel and is the most westerly part of the historic county of Glamorgan. In 1956, part of the Gower peninsula became the first area in the United Kingdom to be designated an Area of Outstanding Natural Beauty (AONB).

On the south east coast of the Gower peninsula is the Limestone Coast of South West Wales Special Area of Conservation (SAC). This SAC comprises a series of Sites of Special Scientific Interest (SSSI's) stretching from Castlemartin at the western end of southern Pembrokeshire to the Bishopston Valley on the south east coast of the Gower peninsula. One of the Annex II species that are a primary reason for selection of this SAC is the greater horseshoe bat *Rhinolophus ferrumequinum*.

There are three other statutory designated sites in Swansea that are at least partly designated for bats, all of which are on the Gower peninsula. Rose Cottage, Llethrid SSSI, is an important breeding roost of the lesser horseshoe bat *R. hipposideros*. Parkmill Woodlands and Llethrid Valley SSSI has several caves within woodlands that are known hibernation sites for greater and lesser horseshoe bats in addition to whiskered bat *Myotis mystacinus* and Natterer's bat *M. nattereri*. Penrice Stables and Underhill Cottage SSSI is a composite lesser horseshoe bat roost in the grounds of the Penrice Estate, on the Gower peninsula. The breeding roosts at this site rank amongst the eight largest lesser horseshoe roosts in Wales.

Neath Port Talbot is the eighth most populous county in Wales and the third most populous county borough with an area of 442sq.km. The majority of land is upland or semi-upland in character with large portions covered by forestry with major conifer plantations in upland areas (Harris, 2012). Most of the lower lying flat land is near the coast around Port Talbot. An extensive dune system stretches along much of the coast, broken by river mouths and areas of development. The upland areas are cut by five valleys of which include: Vale of Neath, Dulais Valley, Afan Valley, Swansea Valley and Upper Amman Valley. There are currently no statutory sites in Neath Port Talbot that are designated for bats.

Methodology

Using the information solely available from SEWBReC, the bats within the confines of the GBG Study Area (Swansea and Neath Port Talbot) have been classified in terms of their relative abundance within the counties. The categories used in this classification have drawn from similar attempts to identify the relative status of bat species (Slack, 2019; Battersby, 2005). These are given in Table 1.

In Table 4, it is classified which species are known or suspected to breed and/or hibernate within the confines of the GBG. Species are classified as known to breed and/or hibernate if there are confirmed records within SEWBReC of hibernation and/or maternity sites. If there are no known maternity and/or hibernation records, then the species is either classified as suspected or unknown. It is classified as suspected if there are sufficient records of this species within the database to support the assumption that they do breed and/or hibernate in the area.

Table 1: Relative status categories assigned to Glamorgan bat populations.

Most Abundant Least Abundant	Common
	Fairly Common
	Locally distributed
	Uncommon
	Scarce
	Rare
	Very rare
	Not known to be present

Limitations, assumptions and changes to the database

It is important to note that records held by local biological record centres and local recording groups are generally collected on a voluntary basis; therefore, the absence of records does not demonstrate the absence of species, it may simply indicate a gap in recording coverage. There is also an assumption that bat calls have been correctly identified to species level. However, calls for species of the genus *Myotis* are similar in structure and have overlapping call parameters, making species identification problematic.

Some of the records held by SEWBRc are multiple counts of the same roost on different dates and years. It is considered likely that the motivation to monitor a roost is greater if the roost is larger, or if the roost is of a less common species. This includes long term projects such as the National Bat Monitoring Project (NBMP). This is thought likely to have biased the raw results presented in the Database Results section. Instances where this would be likely to impact the status category assigned to a species have been identified, acknowledged and taken into account as fully as currently possible in the interpretation.

Historically, advanced survey techniques such as harp traps and mist netting with acoustic lures have been utilised in only a very limited fashion within GBG. Therefore, it is considered that bat species that are more difficult to record using widely available survey techniques will potentially be under recorded. This is particularly the case with quieter species or for less easily identifiable species through acoustic analysis such as *Myotis* species bats.

In order to make sense of the vast amount of data held by SEWBRc, some of the data needed to be simplified. Therefore, the following changes were made to the records held in the database, prior to any analysis being undertaken:

- all negative records were ignored
- all records with a species but without a count value were assumed to be one bat
- for all counts identified as ranges within the database, the upper value was taken
- where possible all records were refined to a species or genus based on known ranges. For example, a *Plecotus* record would be defined as a brown long-eared bat *Plecotus auritus*
- all multiple species records were split to give one separate record for each species

Swansea Database Results

Following the changes identified above, the number of records, number of bats, average number of bats per record and maximum number of bats in any one record present in the January 2020 SEWBRc Database for Swansea is given in Table 2. A 1km distribution map for all bat records held by the SEWBRc database within Swansea is shown in Figure 2.

Table 2: Summary of the breakdown of records held in SEWBRc database (January 2020) for Swansea.

Species/Species Group	Total number of records	Number of Activity Records	Number of Roosting Records	Number of records for different roosts	Sum of the number of roosting bats recorded	Mean Count per Roost	Maximum count per Roost record
Common pipistrelle	737	648	89	69	374	4.2	100
Soprano pipistrelle	406	373	33	25	863	25.38	245
<i>Pipistrellus</i> species	58	52	6	6	8	1.33	3
Nathusius' pipistrelle	11	10	1	1	1	1	1
Barbastelle	1	1	0	0	1	1	1
Daubenton's bat	36	21	15	10	17	1.13	2
Natterer's bat	111	45	66	25	78	1.18	10
Brandt's bat	10	2	8	6	13	1.3	2
Whiskered bat	24	15	9	5	13	1.4	5
Whiskered/Brandt's bat	1	0	1	1	1	1	1
Noctule	214	214	0	0	0	0	0
Serotine	11	11	0	0	0	0	0
Leisler's bat	3	0	3	1	6	2	2
Brown long-eared bat	116	45	71	48	128	1.8	15
Lesser horseshoe bat	1099	130	969	127	13591	14.04	256
Greater horseshoe bat	512	61	451	52	663	1.47	16
All species combined	3350	1628	1722	376	15757	3.36	256

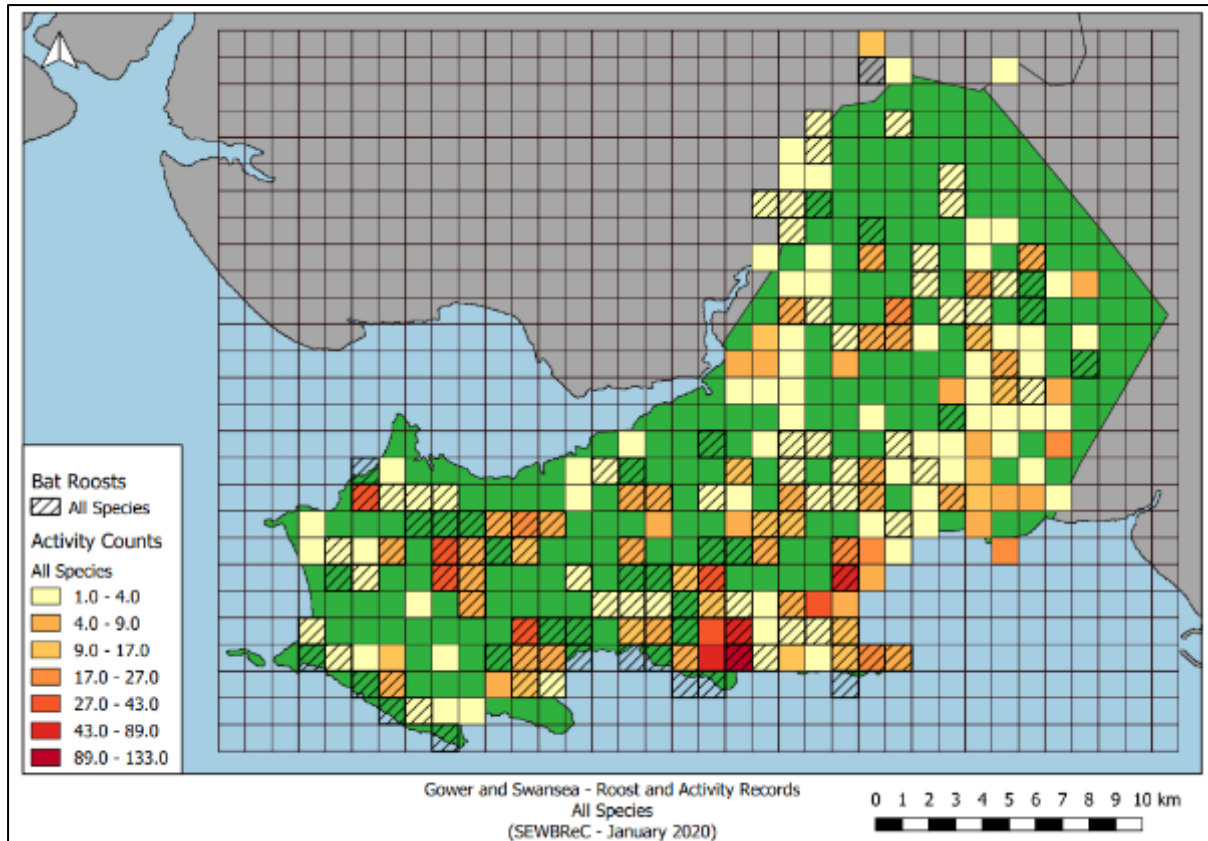


Figure 2: Swansea 1km Bat Activity and Roost Record Distribution Map (Total number of activity records for all bat species).

Neath Port Talbot Database Results

Following the changes identified above, the number of records, number of bats, average number of bats per record and maximum number of bats in any one record present in the January 2020 SEWBReC Database for Neath Port Talbot is given in Table 3. A 1km distribution map for all bat records held by the SEWBReC database within Neath Port Talbot is shown in Figure 3.

Table 3: Summary of the breakdown of records held in SEWBReC database (January 2020) for Neath Port Talbot.

Species/Species Group	Total number of records	Number of Activity Records	Number of Roost Records	Number of records for different roosts	Sum of the number of roosting bats recorded	Mean Count per Roost record	Maximum count per roost record
Common pipistrelle	380	316	64	38	203	5.34	26
Soprano pipistrelle	189	160	29	22	751	28.88	374
<i>Pipistrellus</i> species	226	148	78	66	527	6.756	140
Nathusius' pipistrelle	10	7	3	2	5	1.66	2
Barbastelle	1	1	0	0	0	0	0
Daubenton's bat	24	22	2	2	15	7.5	14
Natterer's bat	30	30	0	0	0	0	0
Brandt's bat	2	1	1	1	1	1	1
Whiskered bat	10	7	3	3	4	1.33	2
Whiskered/Brandt's bat	1	0	1	1	1	1	1
Noctule	129	123	6	4	29	4.83	13
Serotine	5	3	2	2	3	1.5	2
Leisler's bat	2	2	0	0	0	0	0
Brown long-eared bat	48	27	21	13	32	1.6	7
Lesser horseshoe bat	18	6	12	5	117	9.5	58
Greater horseshoe bat	6	3	3	2	4	1.33	2
All species combined	1081	823	228	162	1744	4.03	374

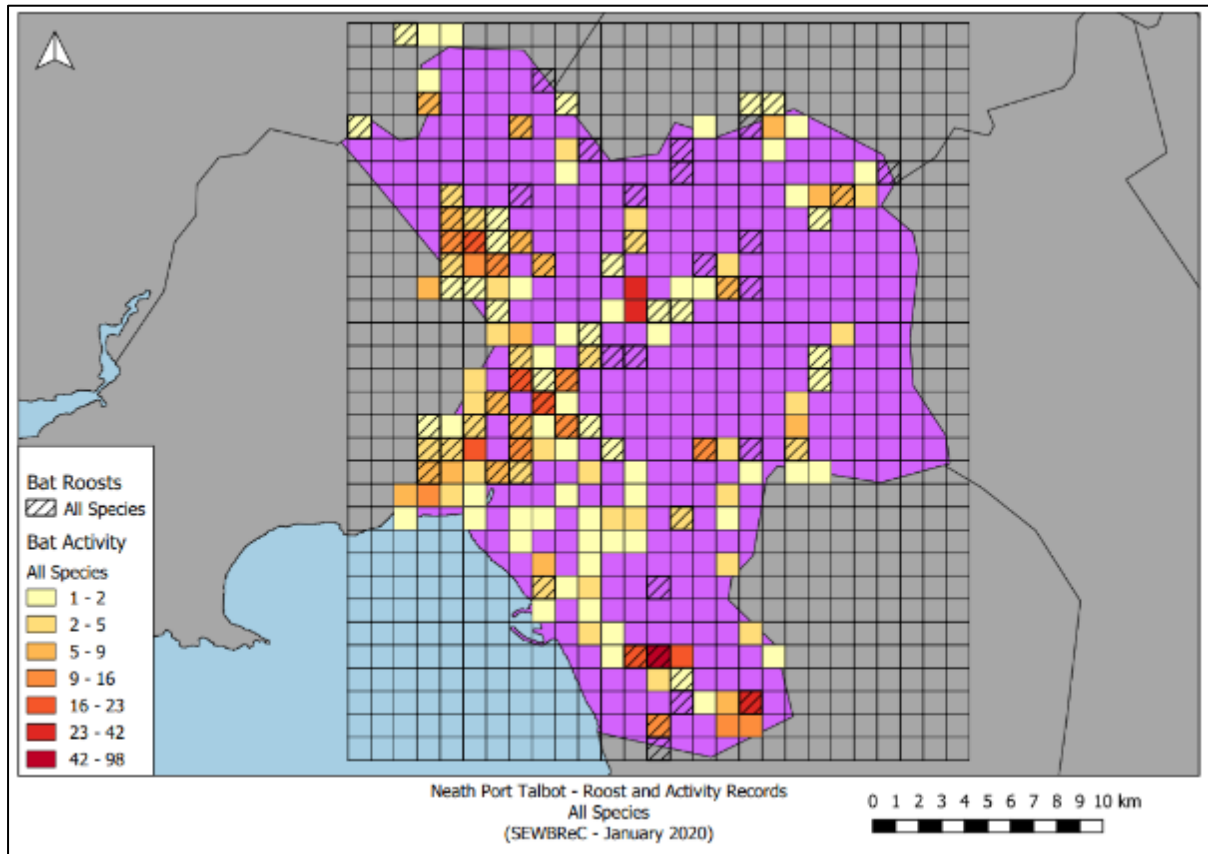


Figure 3: Neath Port Talbot 1km Bat Activity and Roost Record Distribution Map (Total number of activity records for all bat species).

Discussion

Breeding and hibernating bats

Looking at SEWBRc database records solely, which is data collected from various sources including data from historic roost monitoring projects, it allows us to identify species known or suspected to breed and/or hibernate within Swansea and Neath Port Talbot. However, it is important to note that this first assessment excludes NBN records which have not been inputted into the SEWBRc database and excludes records held by local bat specialists that have not yet submitted their records. Therefore, further records from GBG, input from NBN, and other sources, will further determine what species are present within the GBG area and what their status is. These will be added to a second draft of this report.

In total, 14 species have been recorded within the GBG area. Ten species known or suspected to breed and/or hibernate regularly within Swansea with nine species in Neath Port Talbot. These are shown in Table 4.

Table 4: Species known or suspected to breed and/or hibernate in Swansea and Neath Port Talbot.

Species	Breeding known or suspected in Swansea	Hibernation known or suspected in Swansea	Breeding known or suspected in Neath Port Talbot	Hibernation known or suspected in Neath Port Talbot
Common pipistrelle	Known	Known	Known	Suspected
Soprano pipistrelle	Known	Known	Known	Suspected
Nathusius' pipistrelle	Unknown	Unknown	Unknown	Unknown
Barbastelle	Unknown	Unknown	Unknown	Unknown
Daubenton's bat	Suspected	Known	Known	Suspected
Natterer's bat	Known	Known	Suspected	Suspected
Brandt's bat	Unknown	Known	Unknown	Unknown
Whiskered bat	Unknown	Known	Suspected	Suspected
Noctule	Suspected	Suspected	Suspected	Suspected
Serotine	Unknown	Unknown	Unknown	Unknown
Leisler's bat	Unknown	Unknown	Unknown	Unknown
Brown long-eared bat	Known	Known	Known	Suspected
Grey long-eared bat	Unknown	Unknown	Unknown	Unknown
Lesser horseshoe bat	Known	Known	Known	Known
Greater horseshoe bat	Known	Known	Suspected	Known

Following consideration of the information available the relative status of Swansea and Neath Port Talbot bat populations is shown in Table 5.

Table 5: The relative status of Swansea and Neath Port Talbot's bat populations.

Species	Relative population status within Swansea	Relative population status within Neath Port Talbot
Common pipistrelle	Common	Common
Soprano pipistrelle	Common	Common
Nathusius' pipistrelle	Very rare	Very rare
Barbastelle	Very rare	Very rare
Daubenton's bat	Uncommon but widespread	Uncommon but widespread
Bechstein's bat	Not known to be present	Not known to be present
Natterer's bat	Locally distributed	Uncommon but widespread
Brandt's bat	Very rare	Very rare

Species	Relative population status within Swansea	Relative population status within Neath Port Talbot
Whiskered bat	Uncommon	Very rare
Alcathoe bat	Not known to be present	Not known to be present
Noctule	Fairly common	Fairly common
Serotine	Very rare	Very rare
Leisler's bat	Very rare	Very rare
Brown long-eared bat	Fairly common	Fairly common
Grey long eared bat	Not known to be present	Not known to be present
Lesser horseshoe bat	Fairly common	Locally distributed
Greater horseshoe bat	Fairly common	Very rare

The common pipistrelle *Pipistrellus pipistrellus* and soprano pipistrelle *P. pygmaeus* were considered to be the only relatively common species. For Swansea, the sum of the bats recorded (Table 2) was highest for lesser horseshoe bats and greater horseshoe bat counts were comparatively similar to both common and soprano pipistrelle bat species. However, it is acknowledged that the high number of *Rhinolophus* species bats recorded was at least partly a result of a large monitoring project that was begun in the 1970's. The presence of well-studied large colonies is considered likely responsible for skewing the data. Therefore, whilst concentrations of *Rhinolophus* species bats may be greater than *Pipistrellus* species at a local level, particularly around large roosts, they are considered likely less abundant at a county level.

The species with the highest mean number of bats reported per record in both counties was the soprano pipistrelle. This tallies with soprano pipistrelle maternity roosts being known to be relatively large (Jones and Barlow, 1999). Limited hibernation records for *Pipistrellus* species bats were held within the database for both counties.

In the specific case of the *Rhinolophus* species, their echolocation calls are unlikely to be confused with any other British bat species, but as the calls are highly focused, detection of bats at distances over 5m is unlikely (Barataud, 2015). This may partly explain why, even though there were large numbers of roost records for Swansea, there were comparatively few activity records. It is also important to note that only a small proportion of lesser horseshoe bat records had been submitted since 2010 with most submitted before 2000. This suggests that NBMP data has not been inputted to the SEWBRc database so is therefore not a true reflection of records collected in the last twenty years. This is not the case for *Rhinolophus* records for Neath Port Talbot. Compared to Swansea, there were very few records for *Rhinolophus* species, but all were since the year 2000.

Natterer's bats *Myotis nattereri* were considered to be locally distributed within Swansea and uncommon but widespread within Neath Port Talbot. Brown long-eared bats were considered fairly common. These bats are species which use woodland extensively and have relatively quiet calls in this habitat. As a result, they are likely to be underrepresented within this database as many tree roosts will go undetected, as would most echolocation calls from bats flying within the canopy. The detection range of *Plecotus* in woodlands is approximately 5m which is one of the lowest ranges of all species identified as present within Swansea. The detection range of Natterer's bat is also low with a range within

50 woodland of 8m, so the same limitations apply. Natterer's bats, however, were the most recorded *Myotis* species, although in Neath Port Talbot these all related to activity records with no roost records.

Daubenton's bat *M. daubentonii* were considered uncommon but widespread due to the low levels of records within the database for this species. It is considered that this species is likely more common than records suggest. The low level of records for Daubenton's bats were surprising as this species tends to be recorded in locations where they aggregate (i.e. at key foraging sites) and are often distinctive enough to identify at species level without the use of bat detectors. However, it is also considered that this species is likely under-recorded in non-riparian habitats, particularly in woodland habitats, as call parameters are similar to other *Myotis* species (Mathews *et al.*, 2015). There were also no confirmed maternity roosts held on the database, but it is considered very likely that they do breed within the area. Whiskered bat *M. mystacinus* were also identified as uncommon in Swansea and very rare in Neath Port Talbot. The records that are held by the SEWBReC database show that they are recorded less frequently than Daubenton's bat and Natterer's bat. These are less easily identifiable species through acoustic analysis and historically, advanced survey techniques such as harp traps and mist netting with acoustic lures have been utilised in only a very limited fashion within GBG.

Noctule bats *Nyctalus noctula* were considered to be fairly common and was considered to be present across most of both counties. However, no roost sites have been recorded in Swansea with only four recorded in Neath Port Talbot. This is considered likely due to the fact that they tend to roost in trees which are typically harder to find.

Five species, Nathusius' pipistrelle *P. nathusii*, Brandt's bat *M. brandtii*, barbastelle *Barbastella barbastellus*, Leisler's bat *N. leisleri* and serotine *Eptesicus serotinus*, were identified as very rare within both counties. Swansea records for Brandt's bat almost entirely consisted of hibernation records from the 1990's with only one roost record from 1993 for Neath Port Talbot. There were three roost records for Leisler's bat within Swansea, but these were all hibernation records from 1986. There were only two activity records within Neath Port Talbot and was considered as very rare within the county. However, it should be noted that the big bats (noctule, Leisler's bat and serotine) have calls which are sometimes very difficult to distinguish from each other in woodland, when the peak frequency is raised, and their distinctive rhythms tend to disappear. Therefore, activity records for these and other species do need to be assessed with caution, particularly when they have not been verified.

Three records for grey long-eared bats *P. austriacus* were found on the database for Swansea. The known distribution of this species is almost exclusively the south and south east of England, close to the coast, although there has also been a record in Pembrokeshire confirmed by molecular analysis (Mathews *et al.*, 2018). Personal communication with one of the surveyors who submitted one of the records found that this was an error on the database and that the record was for brown long-eared bat. It is considered that this is the same for all three records so therefore all were changed to records for brown long-eared bats within this assessment.

Most likely future status changes

Only one record from 1982 for barbastelle in Swansea exists on the SEWBrEC database. However, it is the authors knowledge that there have been a small number of other records for this species in certain areas of Swansea and Neath Port Talbot that are currently missing from the SEWBrEC database. One activity record for barbastelle was found within the Neath Port Talbot database which was a record from the International bat night undertaken in 2015 at Margam Park where lots of surveyors visited the site to collect records. It is considered that further targeted surveys for this species, within suitable habitat may find more records and possible breeding colonies.

The use of advanced survey techniques such as harp traps, mist nets and acoustic lures will likely expand and increase the records of certain bat species and increase our understanding of their distribution and abundance. It is considered that widely available survey techniques previously used are not sufficiently adept at picking up certain species, therefore, targeted research projects looking at *Myotis* and other species such as barbastelle would be beneficial. It is also considered that a focus on bat tree surveys would also identify several more roosts, especially for noctule bats.

The addition of GBG records that have not yet been added to the SEWBrEC database will further increase our understanding of bat species and their statuses within the GBG area. Assessing records held by other databases such as NBN, will also increase our understanding. These will be added to a second draft of this report.

References

Barataud, M. (2015) *Acoustic ecology of European bats. Species Identification and Studies of Their Habitats and Foraging Behaviour*. Meze: Biotope Editions.

Battersby, J. (ed.) (2005) *UK Mammals: Species Status and Population Trends. First Report by the Tracking Mammals Partnership*. Peterborough: JNCC/Tracking Mammals Partnership.

Harris, K. (2012) *Information – Area profiles*. [Online]
https://www.neathporttalbothousing.co.uk/index.php?section=accommodation&option=area_profile_page

Jones, G. and Barlow, K.E. (1999) Roosts, echolocation calls and wing morphology of two cryptic species of *Pipistrellus pipistrellus*. *Zeitschrift für Säugetierkunde*, 64 pp. 257-268.

Mathews, F., Kubasiewicz, L.M., Gurnell, J., Harrower, C.A., McDonald, R.A. and Shore, R.F. (2018) *A Review of the Population and Conservation Status of British Mammals. A report by the Mammal Society under contract to Natural England, Natural Resources Wales and Scottish Natural Heritage*. Peterborough: Natural England.

Slack, G. (2019) South Yorkshire Bat Status. *Northern Bats*, 4 pp. 1-6.

Swansea Council (2020) *Swansea in figures - key facts about Swansea*. [Online]
<https://www.swansea.gov.uk/keyfacts>

[Return to contents page](#)

Brandt's bat in Bridgend

Jessica Dangerfield, Hal Starkie, Neil Price and Mike Shewring

jessicadangerfield@outlook.com

Introduction

The *Myotis* genus of bats is poorly recorded owing to the difficulties in discerning species by acoustic methods. In Wales many of the *Myotis* are also considered much rarer when comparing population estimates with those in England (Wray *et al.*, 2008). The *Myotis* species include Bechstein's bat *Myotis bechsteinii*, a rare woodland species and Alcahloe bat *M. alcathoe*, only recently recognised as resident in the UK in 2010 (Jan *et al.*, 2010) and more recently documented in Wiltshire, England (Wiltshire Bat Group, 2019) for the first time. Woodlands are important habitats used by all *Myotis* species (Dietz and Kiefer, 2016), with some of our rarer species exhibiting a stronger reliance on the woodland environment than others.

Existing Data (or lack thereof!)

A desk study undertaken with the South East Wales Biological Records Centre (SEWBRc) in 2018 found a serious paucity of species specific records for all *Myotis* (Figure 1), with one notable exception: Daubenton's bat *M. daubentonii*. A total of 499 records for *Myotis* were received for the three counties (Cardiff, Vale of Glamorgan and Bridgend). Of these records, only 294 were identified to species level (61 records in Bridgend, 197 records in Cardiff, 36 records in Vale of Glamorgan). The vast majority of the records relate to Daubenton's bat (with the majority of the data derived from the National Bat Monitoring Programme (NBMP) waterway surveys) or 'unidentified *Myotis*'. When excluding data for Daubenton's bat and 'unidentified *Myotis*' records there are only 76 records for species specific *Myotis* across all three counties. Only a single record is returned for Brandt's bat *M. brandti* bat and this record is located in Cardiff County (with no records of this species occurring in the Vale of Glamorgan or Bridgend). This record is derived from acoustic data and therefore may not be reliable. No records for Bechstein's bat or Alcahloe bat exist in any of the three counties. Forty-five records for Natterer's bat *M. nattereri* and 30 records for whiskered bat *M. mystacinus* exist. Excluding the NBMP survey data, the remaining *Myotis* records largely arise from surveys of built structures. Very little data exists of these species in the woodland environment.

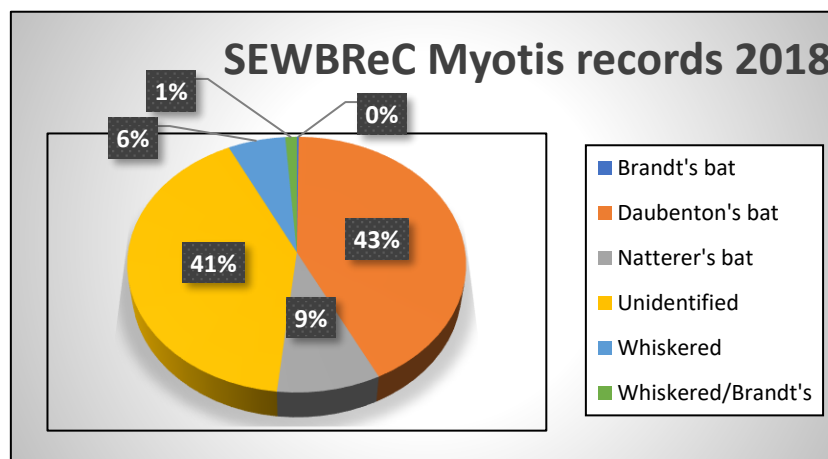


Figure 1: *Myotis* records returned in SEWBRc 2018 data search.

The Woodland *Myotis* Project

To address this lack of data Cardiff, Vale of Glamorgan and Bridgend Bat Groups have formed a collaborative project to target woodland habitats across the three counties in an effort to generate species specific records and establish the presence/absence of *Myotis* species and distribution in the counties. The project looks to survey ten woodland sites across the three counties. Examples of varying woodland habitats have been selected including plantation on ancient woodland, ancient broadleaved woodland, mixed woodland, wet woodland and broadleaved secondary woodland. Previous acoustic work undertaken by the Bat Group had already identified a number of sites with high *Myotis* activity that we were keen to include in the study. The methodology employed has involved a set-up comprising two harp traps with acoustic lures (AT100 and Sussex Autobat) and two mist nets, with surveys commencing from around sunset to approximately five hours after sunset.

Preliminary Results

Following the first successful year (2019) of running this project a total of ten surveys have been undertaken at five of the selected sites. A total of 152 bats have been caught through the project including 30 *Myotis* species bats (Figure 2).

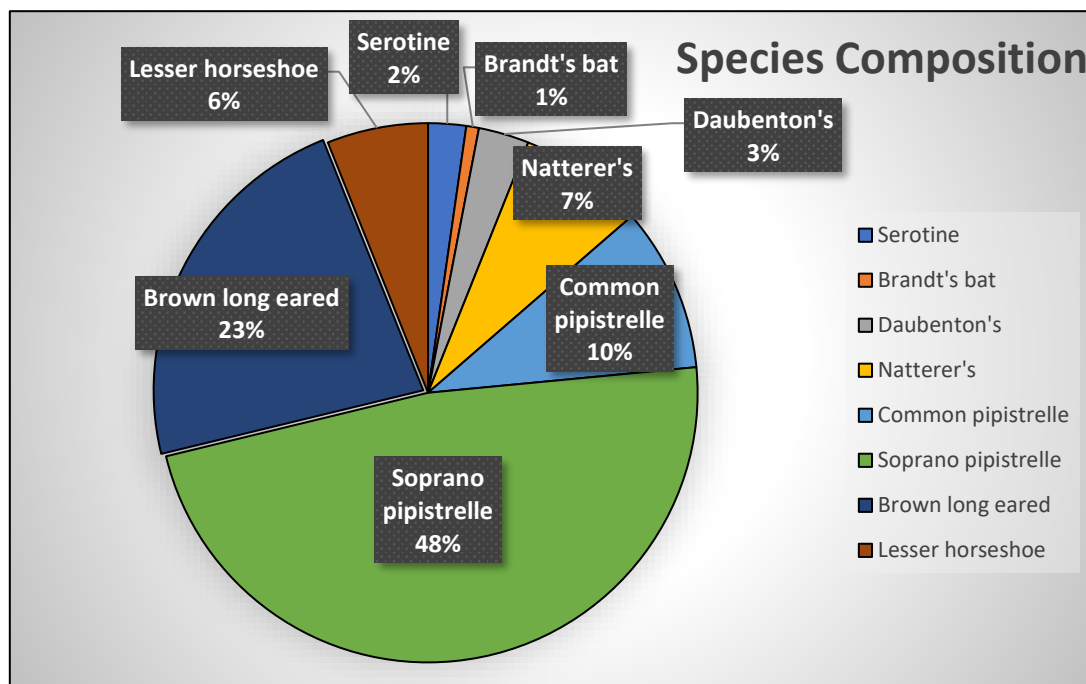


Figure 2: Species caught throughout project (all sites/surveys pooled).

Although only around 20% of our total catch has been the target species, we have contributed considerably to the knowledge and records base for these under-recorded species in this area. In the first year of running this project we have increased the number of records significantly compared to data produced from non-targeted surveys possessed by SEWBRc. Most notably, increasing the number of known records for Brandt's bat by 100%, whiskered bat by 50% and Natterer's bat by 20% (Table 1). Additionally, the large by-catch of non-target species has provided an excellent opportunity for training Bat Group members

in handling and identification. To date the project has had over 30 volunteers assisting with surveys.

Table 1: All SEWBRcC (on request in 2018) data versus one season of data collection through targeted project and percent increase in species specific *Myotis* records.

Species	2018	2019	% Increase
Brandt's bat	1	1	100
Daubenton's bat	212	4	2
Natterer's bat	45	10	22
Whiskered bat	30	15	50
Bechstein's bat	0	0	-
Alcathoe bat	0	0	-

Our most exciting result to date is the discovery of the first Brandt's bat in Bridgend county (and likely only reliable record for this species across the three counties). A male Brandt's bat (Figure 3) was caught at one of our sites in August along with several whiskered bats at the same location. Although the project is very much still in its early days we hope that in addition to increasing the number of records for under recorded bat species, we are also able to start to understand how the bats' use of these woodlands change throughout the year and identify important sites and work with landowners and managers to ensure the protection of these sites into the future.



Figure 3: Male Brandt's bat caught in August 2019.

References

Wray, S., Wells, D., Long, E. and Mitchel-Jones, T. (2010) Valuing bats in Ecological Impact Assessment. *In Practice*, 70 pp. 23-25.

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

Jan, C. M. I., Frith, K., Glover, A. M., Butlin, R.K., Scott, C. D., Greenaway, F., Ruedi, M., Frantz, A.C., Dawson, D.A. and Altringham, J.D. (2010) *Myotis alcathoe* confirmed in the UK from mitochondrial and microsatellite DNA. *Acta Chiropterologica*, 12(2) pp. 471-483(13).

Wiltshire Bat Group. (Keith Cohen and Dani Linton) (2019) Conversation with Jess Dangerfield, 29th June.

[Return to contents page](#)