BTO RESEARCH REPORT 774

Farming in Project Landscapes
Turtle Dove Monitoring Project, 2024 Report

Ashton-Butt, A., Gillings, S., Thurston, L., Wells, F., Wetherhill, A. & Newson, S.E.

RECOMMENDED CITATION: Ashton-Butt, A., Gillings, S., Thurston, L., Wells, F., Wetherhill, A.S. & Newson, S.E. 2024. Farming in Protected Landscapes. Turtle Dove Monitoring Project, 2024 Report. BTO Research Report 774, BTO, Thetford.

Graphs and mapping by S. Gillings

Cover design by M.P. Toms

Cover photo by L. Cutting

SUMMARY

Background Static acoustic recorders were deployed between May and mid-August 2024, to provide extensive acoustic data for the Stour Valley Farmer Cluster. The priority was to detect the Red-listed Turtle Dove but recording was configured to assess presence of a range of taxa. This report provides an overview of the survey coverage and main results.

Coverage Over 2024, 10 different locations across the Stour Valley Farmer Cluster were surveyed. Recording was undertaken on 31 different days between between May and mid-August, amounting to a total of 202 days of recording effort across sites.

Results The main target species, Turtle Dove, was found at one site, Bombose Farm, holding territory for 21 days in 2024. Additionally, presence was confirmed for a further 73 bird species over the ten sites. 191,213 ultrasonic recordings were collected which, following analyses and validation, were found to include 46,386 detections of ten bat species, and 295 detections of three small terrestrial mammal species. Four bush-cricket species and an audible moth species were also detected.

1. BACKGROUND

Turtle doves have suffered a c.98% decline in their UK breeding population since the 1960s, with an estimated breeding population now of only 3,600 territories (Woodward *et al*. 2020). In recognition of this, 2021–24 saw a moratorium on hunting in France, Spain and Portugal. Anecdotal evidence (RSPB pers. comm) suggests that the moratorium combined with the provision of bespoke feeding plots and supplementary feeding in their remaining breeding areas could improve the breed prospects of this species. In the 1950s, it was not uncommon for Turtle Dove to raise three broods of chicks per year. Food resources in breeding areas are now identified as one of the limiting factors. This is the background and motivation for Defra DV21 project to create and maintain Turtle Dove habitat across a wide range of farms in the Stour Valley Farm Cluster farmer members area.

This project aims to trial passive acoustic monitoring as an effective tool for assessing the status of Turtle Doves at these sites Because of the very low number of Turtle Dove remaining, it is not expected that Turtle Dove will be found at many sites in the Stour Valley Farmer Cluster farmer members area in 2024. Acoustic could provide a good means of assessing Turtle Dove presence owing to the long deployment that the technology allows, giving us a better chance of detecting rare species than might be possible from short duration visits by human surveyors. The technology also allows us to assess the presence of other species and species groups within the project area.

2. AIMS AND OBJECTIVES

The main aim of the Farming in Protected Landscapes: Turtle Dove Monitoring Project (DV44) was to use passive acoustic monitoring to survey for the presence of Turtle Doves in the Stour Valley Farmer Cluster farmer members area. Ten of fourteen farms that are providing supplementary feeding / foraging plots (DV21 Turtle Dove project) were surveyed during the spring / early summer of 2024. Whilst the focus was on Turtle Dove, other bird species will also be identified.

In addition to recording birds, by using recording equipment that can also record in the high frequency (ultrasonic) range, the project has an additional secondary objective to improve understanding of the status, distribution and timing of occurrence of bats, bush-crickets and small mammal species in the study region.

Stour Valley Farmer Cluster farmer members area.

All maps in this report use the maptiles R package (Giraud 2023) with data copyright OpenStreetMap contributors.

3. METHODS

Planning, liaison with farmers, deployment of recording equipment, collation of audio recordings and processing through the BTO Acoustic Pipeline were undertaken by SWT (LT and FW). Acoustic identification verification, data analysis and reporting were undertaken by BTO (SEN, AW, SG and AAB). Classifier development was undertaken by BTO (SEN and SG).

3.1 Static recorder protocol

Our protocol enabled farms in the Stour Valley Farmer Cluster farmer members area to deploy passive real-time recorders which they left outside to record birds during the day, and to automatically trigger and record the calls to a memory card every time a bat passes, a mouse squeaks, or bush-cricket stridulates during the night.

Acoustic recorders (the Song Meter Mini Bat), were placed out to record over three discrete recording sessions of seven consecutive days at each location. Multiple days of recording increase the chance of recording species if present and are likely to smooth over stochastic and weather-related variation, whilst also being easy to implement logistically (once a recorder is on site, it is easy to leave it in situ for multiple days and nights). The three survey sessions (9-16 May, 12-19 June and 5-13 August) ran between the beginning of May to mid-August to cover the breeding season of Turtle Dove, as well as covering the breeding season for bats, and the peak period of activity for bush-crickets.

The recorders were programmed to cycle between bird recording using an acoustic microphone, and recording bats, small mammals and bush-crickets with an ultrasonic microphone. For bird recording, a sample rate of 22,050 Hz was used, with recording blocks of one minute in every fifteen minutes from sunrise to sunset. For bats, a sample rate 256,000 Hz and a high pass filter of 13,000 Hz which defined the lower threshold of the frequencies of interest for the triggering mechanism. Ultrasonic recording was set to continue until no trigger is detected for a 2 second period up to a maximum of 5 seconds and activated to trigger between sunset until sunrise the following day. The recorders were mounted on 2 m poles to avoid ground noise and reduce recordings of reflected calls and deployed at least 1.5 m in any direction from vegetation, water or other obstructions. Locations for recording varied a little across the plots and weeks of sampling, but acoustic recorders were always deployed to record on fixed Turtle Dove foraging plots.

3.2 Processing recordings and species identification

Monitoring on this scale with automated passive real-time recorders can generate a very large volume of recordings, efficient processing of which is greatly aided by a semi-automated approach for assigning recordings to species. Audible recordings and ultrasonic recordings require different methods of analysis and verification as detailed in the following sections.

3.2.1 Audible (bird) recordings

At the end of a recording session, the files recorded by the acoustic recorder (uncompressed wav format), along with associated information on where the recording was carried out were processed as follows. All audible / bird recordings were saved onto an external hard drive for later processing by BTO, or processed using the BTO's Acoustic Pipeline http://bto.org/pipeline. BTO created a 'beta' multi-species farmland bird classifier, with a main focus on detecting Turtle Dove. After each week of recording, all audio files were processed using this classifier. The classifier works by splitting recordings into 3 second clips and assigning a 'confidence score' that each species is present in the clip. Confidence scores range between 0 and 1, with generally higher scores indicating more confidence the species is present. Confidence scores are non-linearly related to accuracy, and the relationship can vary between species and even between sites and through time, so manual verification (so-called 'human in the loop') is essential. The classifier was configured to save to the cloud all putative Turtle Dove detections with a confidence score of 0.5 or greater so that these could be checked later. Any detections of other species with a confidence score of 0.9 or greater were also saved. At the end of the season, all putative Turtle Dove detections were manually verified by one observer (SG) by inspecting spectrograms and playing recordings, assigning the status True (the clip contains a Turtle Dove), False (the clip does not contain a Turtle Dove) or Unknown (the clip contains sounds but they cannot be safely confirmed or rejected as Turtle Dove vocalisations). In addition to producing a list of definitive Turtle Dove detections, by comparing the proportion of True versus False/Unknown detections for varying confidence scores, this analysis also allows for an evaluation of the classifier's performance.

As the BTO Acoustic Pipeline farmland bird classifier was still in development, and as there might have been other species (e.g. woodland birds) of interest to farmers, we also processed all recordings through BirdNet, another machine-learning based acoustic classifier developed by Cornell University. BirdNET was configured to return all detections with a confidence score of at least 0.01 and no spatial or temporal species filters were applied. Positive identifications of each species, for each site and week of recording were then manually verified by one observer (AW). This was done by selecting 100 detections (or as many as possible if fewer detections) of each species and farm with the highest confidence scores. These were checked until at least one true positive detection was found. Vocal activity of bird species was not assessed as the accuracy (proportion of true to false positives) and detectability (proportion of true positives to false negatives) can differ considerably between species and between sites, and there was not the resources in this project to quantify these measures.

3.2.2 Ultrasonic recordings

For the ultrasonic / bat processing, the farm or SWT staff using the BTO Acoustic Pipeline had their own online user account, and desktop software through which they could upload recordings directly to the cloud-based BTO Acoustic Pipeline for processing. This system captures the metadata (name and email address of the person taking part, the survey dates and locations at which the acoustic recorders were deployed), which are matched automatically to the results. Once a batch of recordings is processed, the user is emailed automatically, and the raw results are then downloadable through the user account as a csv file. These provisional results are provided with the caveat that additional auditing of the results and recordings must be carried out to manually confirm identifications.

The ultrasonic processing through the BTO Acoustic Pipeline applies machine learning algorithms to classify sound events in the uploaded recordings. The classifier allows up to four different "identities" to be assigned to a single recording, according to probability distributions between detected and classified sound events. From these, species identities are assigned by the classifier, along with an estimated probability of correct classification. Specifically this is the false positive rate, which is the probability that the Pipeline has assigned an identification to the wrong species. However, we scale the probability, so that the higher the probability, the lower the false positive rate. To give an example, given a species identification with a probability of 0.9, there is a 10% chance that the identification is wrong. Our recommendation, which is supported in Barré *et al.* (2019), is that identifications with a probability of less than 0.5 (50%) are discarded. However, manually auditing of a sample of recordings (wav files) that are below this threshold, was carried out to be confident that we were losing very little by doing this.

For bats and small mammals where we were interested in producing a measure of activity, we manually checked all the recordings of a species. With the exception of the most common species, Common Pipistrelle *Pipistrellus pipistrellus* and Soprano pipistrelle *Pipistrellus pygmeaus*, we checked a random sample of 1,000 recordings to quantify the error rate in the dataset. For bush-crickets and audible moths where there can be a large number of recordings, often of the same individual, we instead focus on producing an inventory of species presence instead, where the three recordings with the highest probability for each site and night were selected for auditing.

Verification of species identification was carried out by SN through the manual checking of spectrograms using software SonoBat (http://sonobat.com/) which was used as an independent check of the original species identities assigned by pipeline. The spectrograms shown in this report, were also produced using SonoBat. All subsequent analyses use final identities upon completion of the above inspection and (where necessary) correction steps.

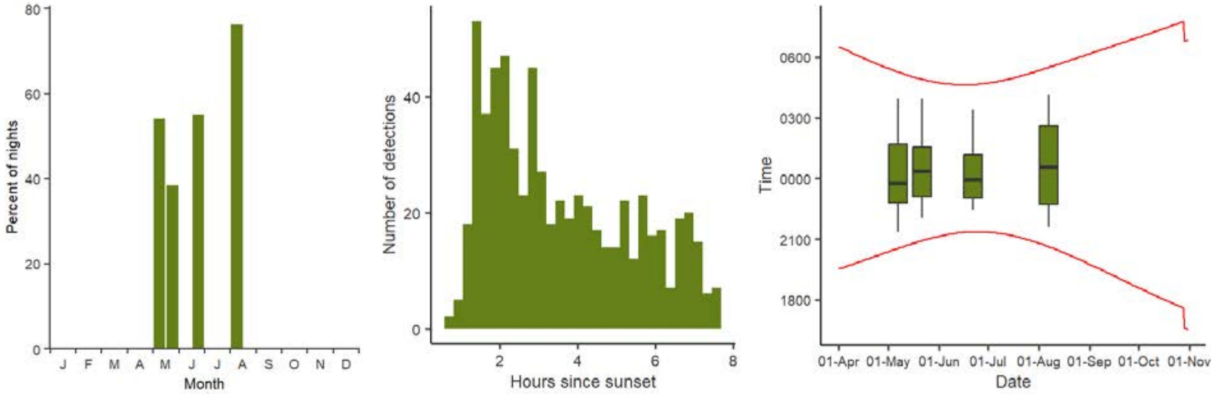
3.3 Temporal patterns of activity

For Turtle Dove, as the BTO Acoustic Pipeline results were checked in full it is possible to use these to assess seasonal and temporal patterns of detection. For other bird species we can only assess seasonal patterns at a crude level as we only checked sufficient detections to confirm presence by week.

For bats and small terrestrial mammals, we examine how activity varied by time of night and by season. Nightly activity was determined for each half-month period and presented according to the percentage of survey nights on which each bat species was detected. Activity through the night was analysed by first converting all bat pass times to time since sunset based on the location and date and calculated using the R package suncalc (Thieurmel &

Elmarhraoui, 2019) and then assessing the frequency distribution of passes relative to sunset for the whole season and in half-month periods. By looking at nightly activity in this way, it allows us to visualise general patterns in activity for a species according to time of night and season, accepting that activity on any given night will be influenced by weather and potentially other factors.

To explain the figures in the following results section, we show an example below for Natterer's Bat. The left plot shows the percentage of nights on which the species was detected every half-month through the season, showing the periods of main activity for this species. If present, pale grey bars represent periods with fewer than 10 nights of recording where accuracy of the reporting rate may be low. The middle plot shows the overall spread of recordings with respect to sunset time, calculated over the whole season. The right plot shows the spread of recordings with respect to sunset and sunrise times (red lines) summarised for each half-month through the season. For this last seasonal plot, the individual boxplot show quartiles (lower, median and upper) with lines extend to 1.5 times the interquartile range, and small dots show outliers.



3.4 Spatial patterns of activity and distribution

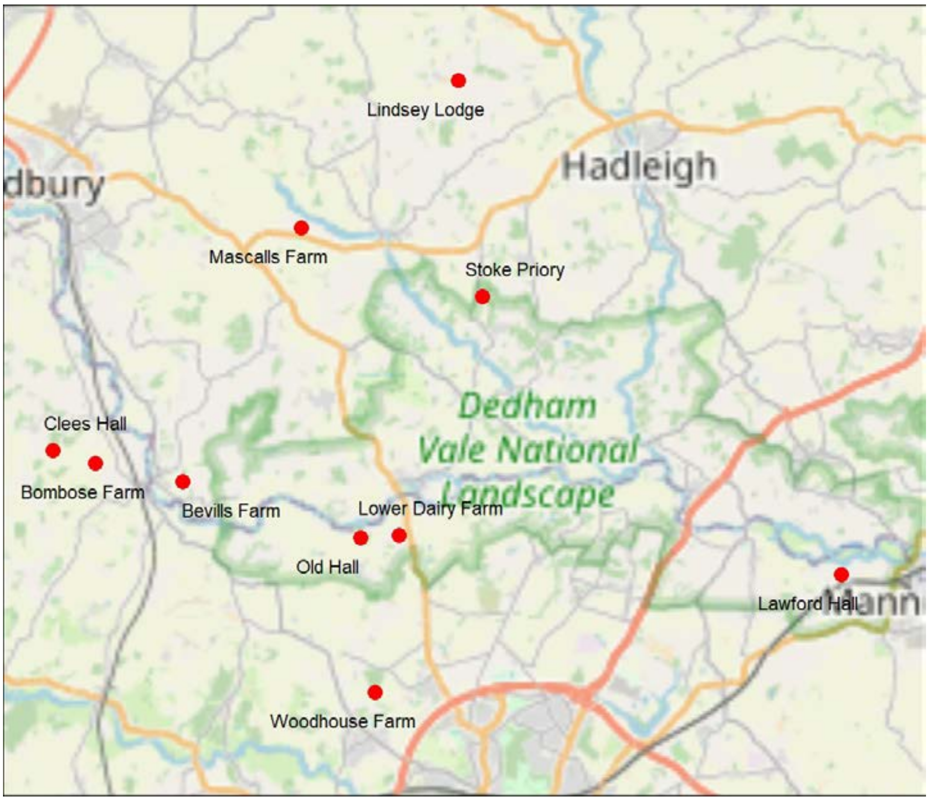
For bush-crickets and audible moths, the results focus on species presence. For bats and small mammals, we present activity where dots are scaled according to the total number of recordings of this species at each location. Activity here represents usage of an area, which will be a combination of species abundance, and time spent in the area.

4. RESULTS

4.1 Survey coverage

During 2024, fixed Turtle Dove foraging plots on 10 farms were surveyed. The distribution of these are shown below. Collectively across all these sites, 202 days of recording effort was conducted. The recording effort spanned 31 different days and 3 months. Unfortunately, subsequent to field recording, some of the media storage hardware used by SWT to store data prior to verification became corrupted and some recordings were unrecoverable. For this reason there is only partial coverage of the second recording period for audible results.

Map of the study area showing locations where detectors were deployed in 2024.



4.2 General results

Processing of audible recordings using the BTO Acoustic Pipeline resulted in the detection of Turtle Dove at one site, Bombose Farm, on 15 dates. A further 89 species were possibly detected but these data have not been manually verified. Processing of the early and late periods using BirdNET produced a provisional set of 10,782 bird identifications of over 150 species. Manual checking confirmed the presence of 74 bird species over the ten sites. As in the BTO Acoustic Pipeline analysis, BirdNET detected Turtle Dove at one site, Bombose Farm.

In addition to the audible data, 191,213 ultrasonic recordings were collected which, following analyses and validation, were found to include 46,386 bat recordings, and 295 small terrestrial mammal recordings. In addition, four bush-cricket species and one species of audible moth species were recorded (see table below). Following validation, the presence of at least ten bat species, three small mammal species (or species groups e.g. shrew species), four bush-cricket species and one audible moth species can be confirmed.

In the following tables, we consider conservation status of birds according to Birds of Conservation Concern 5 (Stanbury *et al*. 2021) which assigns species to a Red List and Amber list according to measured population declines and range contractions. For other species groups we use categories from the IUCN Red List of Threatened Species (www.iucnredlist.org/): Critically Endangered, Endangered, Vulnerable, Near Threatened, and Data Deficient.

Species detected, number of recordings of each species following validation, summary of the scale of recording and conservation status of species.

Birds

Species	No. of different locations (% of total)	Conservation status
Black-headed Gull, *Chroicocephalus ridibundus*	1 (10%)	Amber
Blackbird, *Turdus merula*	10 (100%)	
Blackcap, *Sylvia atricapilla*	10 (100%)	
Blue Tit, *Cyanistes caeruleus*	10 (100%)	
Bullfinch, *Pyrrhula pyrrhula*	3 (30%)	Amber
Buzzard, *Buteo buteo*	9 (90%)	
Canada Goose, *Branta canadensis*	3 (30%)	
Carrion Crow, *Corvus corone*	9 (90%)	
Cettis Warbler, *Cettia cetti*	3 (30%)	
Chaffinch, *Fringilla coelebs*	7 (70%)	
Chiffchaff, *Phylloscopus collybita*	10 (100%)	
Coal Tit, *Periparus ater*	4 (40%)	
Collared Dove, *Streptopelia decaocto*	7 (70%)	
Common Gull, *Larus canus*	1 (10%)	Red
Coot, *Fulica atra*	3 (30%)	
Cuckoo, *Cuculus canorus*	8 (80%)	Red
Dunnock, *Prunella modularis*	10 (100%)	Amber
Firecrest, *Regulus ignicapilla*	1 (10%)	
Garden Warbler, *Sylvia borin*	6 (60%)	
Goldcrest, *Regulus regulus*	6 (60%)	
Golden Plover, *Pluvialis apricaria*	1 (10%)	
Goldfinch, *Carduelis carduelis*	10 (100%)	
Great Spotted Woodpecker, *Dendrocopos major*	7 (70%)	
Great Tit, *Parus major*	10 (100%)	
Green Woodpecker, *Picus viridis*	10 (100%)	
Greenfinch, *Chloris chloris*	8 (80%)	Red
Grey Heron, *Ardea cinerea*	4 (40%)	
Grey Wagtail, *Motacilla cinerea*	2 (20%)	Amber
Greylag Goose, *Anser anser*	7 (70%)	Amber
Herring Gull, *Larus argentatus*	6 (60%)	Red
Hobby, *Falco subbuteo*	2 (20%)	
House Martin, *Delichon urbicum*	6 (60%)	Red
Jackdaw, *Coloeus monedula*	10 (100%)	
Jay, *Garrulus glandarius*	7 (70%)	
Kestrel, *Falco tinnunculus*	3 (30%)	Amber
Kingfisher, *Alcedo atthis*	2 (20%)	
Lapwing, *Vanellus vanellus*	1 (10%)	Red
Lesser Black-backed Gull, *Larus fuscus*	2 (20%)	Amber
Lesser Whitethroat, *Curruca curruca*	7 (70%)	
Linnet, *Linaria cannabina*	7 (70%)	Red
Little Owl, *Athene noctua*	4 (40%)	
Long-tailed Tit, *Aegithalos caudatus*	10 (100%)	

Species	No. of different locations (% of total)	Conservation status
Magpie, *Pica pica*	9 (90%)	
Mallard, *Anas platyrhynchos*	3 (30%)	Amber
Marsh Tit, *Poecile palustris*	3 (30%)	Red
Mistle Thrush, *Turdus viscivorus*	4 (40%)	Red
Moorhen, *Gallinula chloropus*	4 (40%)	Amber
Nightingale, *Luscinia megarhynchos*	4 (40%)	Red
Nuthatch, *Sitta europaea*	5 (50%)	
Pheasant, *Phasianus colchicus*	8 (80%)	
Pied Wagtail, *Motacilla alba*	6 (60%)	
Raven, *Corvus corax*	4 (40%)	
Red-legged Partridge, *Alectoris rufa*	8 (80%)	
Red Kite, *Milvus milvus*	2 (20%)	
Reed Bunting, *Emberiza schoeniclus*	3 (30%)	Amber
Robin, *Erithacus rubecula*	9 (90%)	
Rook, *Corvus frugilegus*	9 (90%)	Amber
Sand Martin, *Riparia riparia*	2 (20%)	
Skylark, *Alauda arvensis*	8 (80%)	Red
Song Thrush, *Turdus philomelos*	9 (90%)	Amber
Sparrowhawk, *Accipiter nisus*	1 (10%)	Amber
Stock Dove, *Columba oenas*	9 (90%)	Amber
Swallow, *Hirundo rustica*	5 (50%)	
Swift, *Apus apus*	1 (10%)	Red
Tawny Owl, *Strix aluco*	1 (10%)	Amber
Treecreeper, *Certhia familiaris*	7 (70%)	
Tufted Duck, *Aythya fuligula*	1 (10%)	
Turtle Dove, *Streptopelia turtur*	1 (10%)	Red
Whitethroat, *Curruca communis*	9 (90%)	Amber
Willow Warbler, *Phylloscopus trochilus*	1 (10%)	Amber
Woodpigeon, *Columba palumbus*	10 (100%)	Amber
Wren, *Troglodytes troglodytes*	10 (100%)	Amber
Yellow Wagtail, *Motacilla flava*	2 (20%)	Red
Yellowhammer, *Emberiza citrinella*	7 (70%)	Red

Bats

Species (/call type)	No. of recordings following validation	No. of different locations (% of total)	Conservation status
Barbastelle feeding buzzes, *Barbastella barbastellus*	5	2 (20%)	Vulnerable
Barbastelle social calls, *Barbastella barbastellus*	1	1 (10%)	Vulnerable
Barbastelle, *Barbastella barbastellus*	1590	10 (100%)	Vulnerable
Brown Long-eared Bat social calls, *Plecotus auritus*	3	3 (30%)	
Brown Long-eared Bat, *Plecotus auritus*	1209	10 (100%)	
Common Noctule feeding buzzes, *Nyctalus noctula*	111	8 (80%)	
Common Noctule social calls, *Nyctalus noctula*	3	3 (30%)	
Common Noctule, *Nyctalus noctula*	2592	10 (100%)	
Common Pipistrelle feeding buzzes, *Pipistrellus pipistrellus*	2231	10 (100%)	
Common Pipistrelle social calls, *Pipistrellus pipistrellus*	1259	10 (100%)	
Common Pipistrelle, *Pipistrellus pipistrellus*	27040	10 (100%)	
Daubenton's Bat social calls, *Myotis daubentonii*	6	2 (20%)	

Species (/call type)	No. of recordings following validation	No. of different locations (% of total)	Conservation status
Daubenton's Bat, *Myotis daubentonii*	108	10 (100%)	
Leisler's Bat, *Nyctalus leisleri*	213	10 (100%)	Near threatened
Nathusius' Pipistrelle, *Pipistrellus nathusii*	1	1 (10%)	Near threatened
Natterer's Bat feeding buzzes, *Myotis nattereri*	1	1 (10%)	
Natterer's Bat, *Myotis nattereri*	645	10 (100%)	
Serotine feeding buzzes, *Eptesicus serotinus*	9	4 (40%)	Vulnerable
Serotine social calls, *Eptesicus serotinus*	2	1 (10%)	Vulnerable
Serotine, *Eptesicus serotinus*	1240	10 (100%)	Vulnerable
Soprano Pipistrelle feeding buzzes, *Pipistrellus pygmaeus*	879	10 (100%)	
Soprano Pipistrelle social calls, *Pipistrellus pygmaeus*	1091	10 (100%)	
Soprano Pipistrelle, *Pipistrellus pygmaeus*	6147	10 (100%)	

Small mammals

Species	No. of recordings following validation	No. of different locations (% of total)	Conservation status
Brown Rat, *Rattus norvegicus*	255	2 (20%)	
Common Shrew, *Sorex araneus*	3	1 (10%)	
Eurasian Pygmy Shrew, *Sorex minutus*	37	5 (50%)	

Bush-crickets

Species	No. of different locations (% of total)	Conservation status
Dark Bush-cricket, *Pholidoptera griseoaptera*	8 (80%)	
Long-winged Conehead, *Conocephalus fuscus*	5 (50%)	
Roesel's Bush-cricket, *Roeseliana roeselii*	6 (60%)	
Speckled Bush-cricket, *Leptophyes punctatissima*	8 (80%)	

Moths

Species	No. of different locations (% of total)	Conservation status
Bird Cherry Ermine, *Yponomeuta evonymella*	6 (60%)	

Bird species recorded on each farm in week 1 (Early) or week 3 (Late) or on both visits (Both). Farms: BEVI = Bevills Farm, BOMB = Bombose Farm, CLEE = Clees Hall, LAWF = Lawford Hall, LIND = Lindsey Lodge, LOWD = Lower Dairy Farm, MASC = Mascalls Farm, OLDH = Old Hall, STOK = Stoke Priory, WOOD = Woodhouse Farm.

Species	BEVI	BOMB	CLEE	LAWF	LIND	LOWD	MASC	OLDH	STOK	WOOD
Black-headed Gull						Late				
Blackbird	Both	Both	Early	Early	Both	Early	Both	Both		Both
Blackcap	Both	Both	Early	Early	Both	Both	Both	Both	Both	Both
Blue Tit	Both	Both	Both	Early	Both	Both	Both	Both	Both	Early
Bullfinch	Early	Both					Early			
Buzzard	Both		Both	Late	Both	Both	Both	Both	Both	Late
Canada Goose			Early					Both		Early
Carrion Crow	Both	Both	Both	Late	Both	Both	Both	Both	Both	
Cettis Warbler	Early						Early			Both
Chaffinch	Late		Early	Early	Early		Both	Early		Early
Chiffchaff	Both	Both	Both	Both	Both	Both	Both			Both
Coal Tit	Both		Late				Late			Early
Collared Dove	Both	Both	Late		Both	Late	Both			Both

Species	BEVI	BOMB	CLEE	LAWF	LIND	LOWD	MASC	OLDH	STOK	WOOD
Common Gull										Late
Coot	Early	Late								Late
Cuckoo	Early	Early	Early		Early	Early	Early	Early	Early	
Dunnock	Both	Both	Both	Early	Both		Both	Both	Both	
Firecrest								Both		
Garden Warbler	Early					Early	Early	Early	Early	Early
Goldcrest	Late		Both	Early			Early	Both	Both	
Golden Plover		Late								
Goldfinch	Both	Both	Early	Early	Both		Both	Late	Early	Both
Great Spotted Woodpecker	Both		Both			Both	Late	Both	Both	Both
Great Tit	Both	Both	Both	Early	Both	Both	Both	Both	Both	Both
Green Woodpecker	Both	Both	Both	Late	Both	Both	Both	Both	Both	Both
Greenfinch	Both	Both	Both	Early	Both	Late				Early
Grey Heron			Late		Early	Early		Both		
Grey Wagtail			Early							Early
Greylag Goose		Both			Early	Both	Both	Both	Early	Early
Herring Gull	Late				Both	Late	Late	Both	Late	
Hobby			Late					Both		
House Martin	Late	Early	Late		Late	Late	Late			
Jackdaw	Both	Early	Both	Both	Both	Both	Both	Both	Both	Both
Jay	Both	Early	Late				Late	Both	Both	Both
Kestrel					Both		Late			Early
Kingfisher	Late	Late								
Lapwing	Early									
Lesser Black-backed Gull					Late			Late		
Lesser Whitethroat	Late	Early	Early			Late	Both		Both	Early
Linnet	Late	Both	Both		Late	Both	Both		Both	
Little Owl	Both		Late			Both		Late		
Long-tailed Tit	Both	Both	Both	Late	Both	Both	Early	Both	Both	Both
Magpie	Both	Both	Both	Late	Both	Both		Both	Both	Both
Mallard		Both	Both		Early					
Marsh Tit			Late					Late	Late	
Mistle Thrush			Both			Early	Early			Early
Moorhen	Both	Both				Late				Both
Nightingale		Early		Early			Early		Both	
Nuthatch	Early	Early	Late						Late	Late
Pheasant		Both	Both		Both	Both	Both	Both	Both	Both
Pied Wagtail		Both		Early	Late	Late	Both			Early
Raven		Early	Early		Early				Late	
Red-legged Partridge		Early	Both		Early	Both	Early	Early	Early	Early
Red Kite		Early					Early			
Reed Bunting						Late	Both	Late		
Robin	Both	Both	Both	Both	Both	Both	Early	Both		
Rook	Late		Both	Both	Both	Both	Both	Both	Both	Both
Sand Martin		Early			Late					
Skylark		Early	Early		Early	Early	Early	Early	Early	Early
Song Thrush	Both	Early	Early		Early	Both	Early	Early	Early	Both

Species	BEVI	BOMB	CLEE	LAWF	LIND	LOWD	MASC	OLDH	STOK	WOOD
Sparrowhawk			Late							
Stock Dove	Both	Both	Both		Both	Early	Early	Both	Early	Both
Swallow	Late	Both	Late			Both	Both			
Swift								Early		
Tawny Owl									Early	
Treecreeper	Late		Both		Late	Late			Late	Both
Tufted Duck		Late								
Turtle Dove		Both								
Whitethroat	Early	Early	Early	Early	Early	Both	Both	Both	Both	
Willow Warbler										Late
Woodpigeon	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
Wren	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
Yellow Wagtail							Late	Late		
Yellowhammer	Early	Both			Both	Both	Both	Both	Both	

Number of species recorded by species group.

	Number of species
All birds	74
Birds of Conservation Concern 5 (BOCC5) - Red-listed	15
Birds of Conservation Concern 5 (BOCC5) - Amber-listed	19
All bats	10
IUCN Red Listed Threatened Species - Near threatened	2
IUCN Red Listed Threatened Species - Vulnerable	2
All small mammals	3
All bush-crickets	4
All moths	1

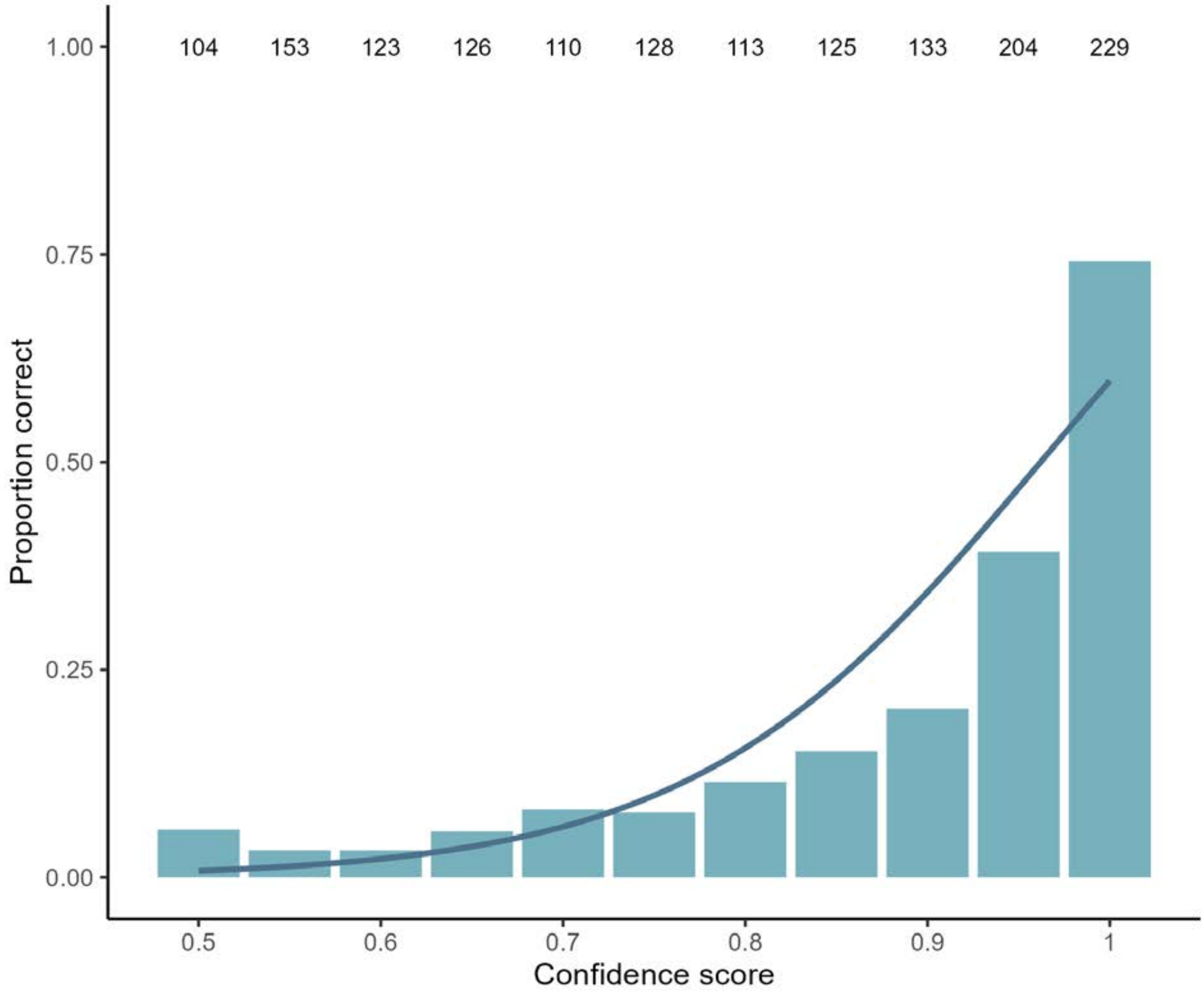
Number of species recorded by species group on each farm

	Clees Hall	Lower Dairy Farm	Bombose Farm	Woodhouse Farm	Lawford Hall	Bevills Farm	Lindsey Lodge	Old Hall	Mascalls Farm	Stoke Priory
All birds	39	41	23	45	43	40	44	47	47	43
BOCC5 - Red-listed	7	4	2	8	7	7	7	10	7	8
BOCC5 - Amber-listed	9	11	5	10	10	11	9	11	10	11
All bats	9	10	9	9	9	9	9	9	9	9
IUCN - Near threatened	1	2	1	1	1	1	1	1	1	1
IUCN - Vulnerable	2	2	2	2	2	2	2	2	2	2
All small mammals	1	0	2	0	1	0	2	1	1	0
All bush-crickets	4	4	0	2	4	3	2	4	3	1
All moths	0	1	0	1	1	0	1	1	1	0

4.3 Turtle Dove results

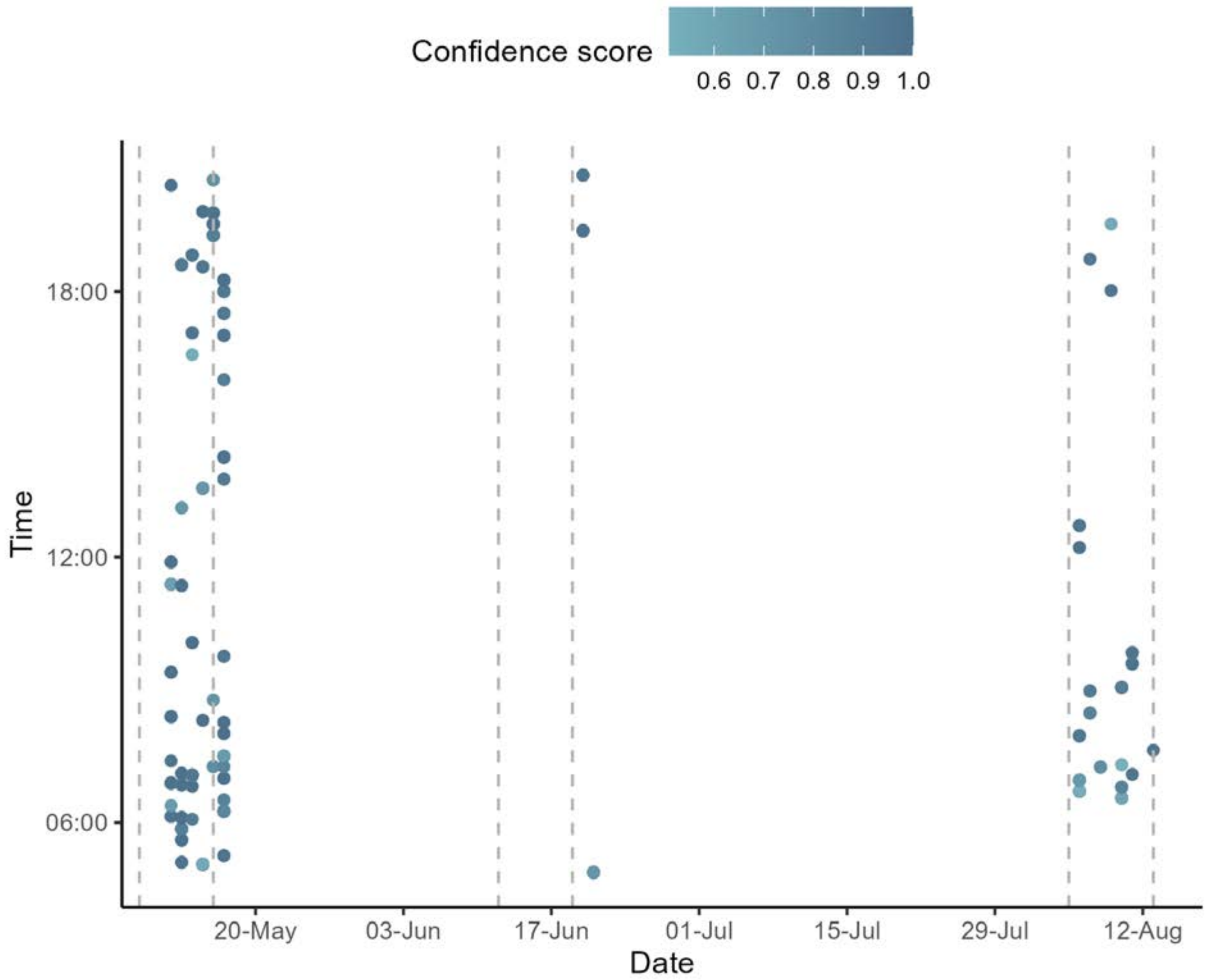
Audible data processed through the BTO Acoustic Pipeline returned 1,548 putativeTurtle Dove detections with a confidence score of 0.5 or greater. Having set a low score threshold we expect many of these to be false positives. Manual checking resulted in 320 confirmed Turtle Dove detections, all from one site, Bombose Farm. By comparing the percentage of clips that were correct with the confidence score returned by the classifier, we can see how accuracy relates to confidence score. As expected, for low confidence scores a low proportion of checked clips were true, and with increasing score, an increasing proportion of clips were true. Where true Turtle Dove clips had low scores, this was usually due to only a short section of call falling within the 3 second clip, or because there were other birds vocalising at the same time and partially obscuring the Turtle Dove song.

Relationship between accuracy and confidence score for BTO Acoustic Pipeline Turtle Dove classifier



As we manually checked all the Turtle Dove detections from the Acoustic Pipeline it is possible to investigate their temporal spread. The following figure shows how all but three detections were in the first and third recording period. In spring, Turtle Dove detections were spread throughout the data, though with a higher concentration in the morning and evening. Later in the season activity was much reduced and more focused in the morning. The true positive detections with a low confidence score (paler dots) usually occurred on the same day as multiple high-scoring detections, so it unlikely that setting a more stringent score threshold would have resulted in a significant reduction in this signal (but would have helped to eliminate a greater proportion of the false positive detections).

Date and times of Acoustic Pipeline detections of Turtle Dove at Bombose Farm



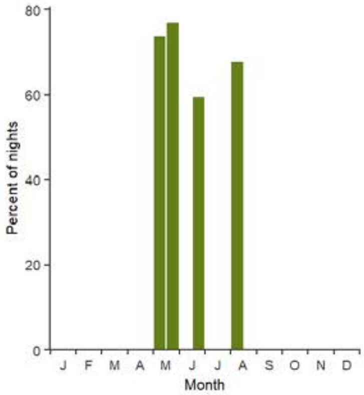
4.4 Bat species

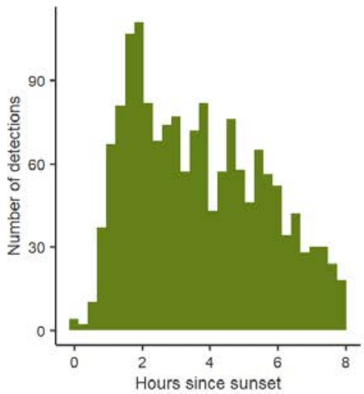
Barbastelle

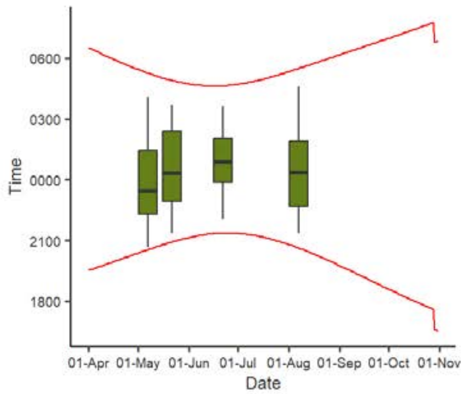
Barbastelle *Barbastella barbastellus* was recorded on 30 nights, from 10 locations, giving a total of 1,590 recordings.

Spatial pattern of activity

Seasonal and nightly activity







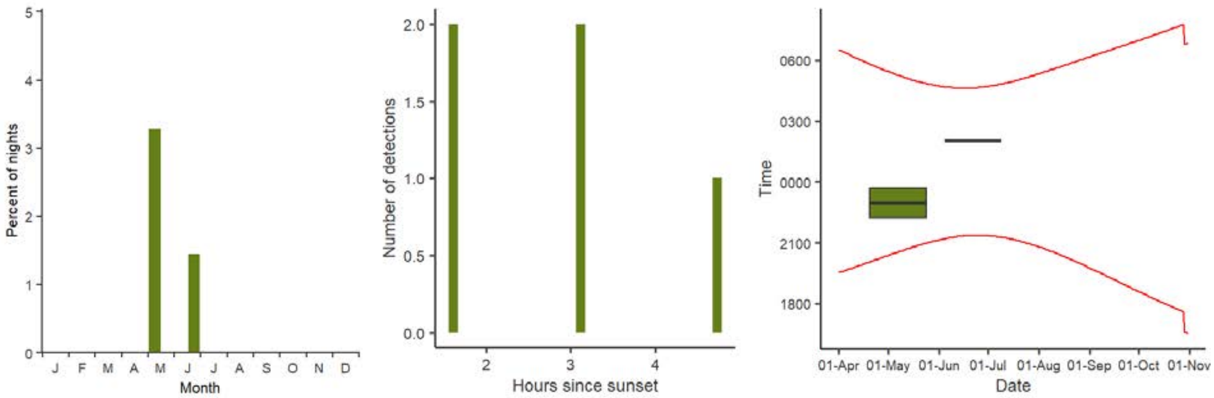
Barbastelle was recorded on every farm in 2024. Whilst Suffolk is believed to be a stronghold for this red-listed species, 1,590 recordings of Barbastelle was notable. A Clees Hall there were over 50 recordings of Barbastelle a night, with a peak of 117 recordings on one night. 78 recordings of Barbastelle were also collected from one night at Woodhouse Farm, and up to 54 Barbastelle recordings from one night at Stoke Priory.

Barbastelle feeding buzzes

Barbastelle feeding buzzes *Barbastella barbastellus* were recorded on three nights, from two locations, giving a total of 5 recordings.

Spatial pattern of activity

Seasonal and nightly activity



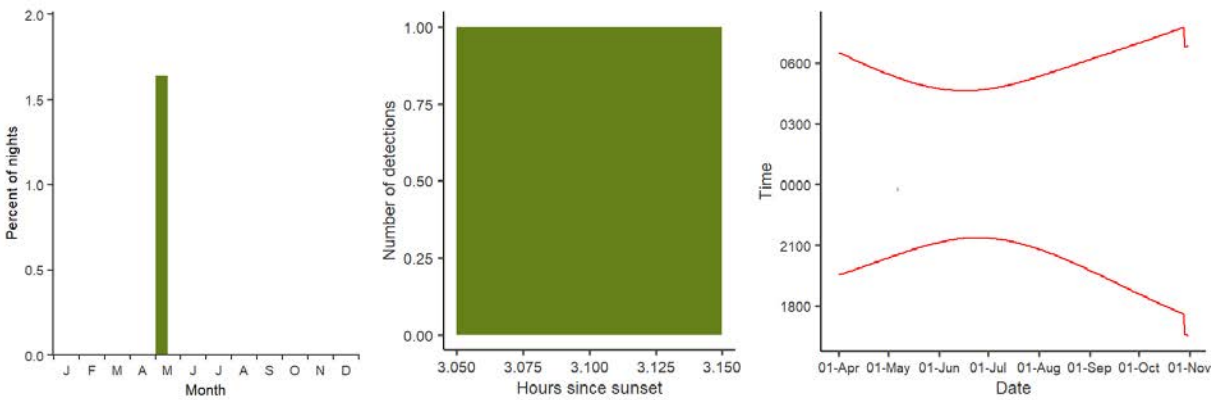
Barbastelle feeding buzzes were recorded from two farms, Lower Diary Farm and Lawford Hall. As with many bat species, the feeding buzz of a Barbastelle bat is a rapid series of brief echolocation calls that ends a bat's approach to prey. In addition to knowing that Barbastelle is present on these two farms, we also know here that this species was activity feeding at these.

Barbastelle social calls

Barbastelle social calls *Barbastella barbastellus* were recorded on one night, from one location, giving a total of 1 recordings.

Spatial pattern of activity

Seasonal and nightly activity



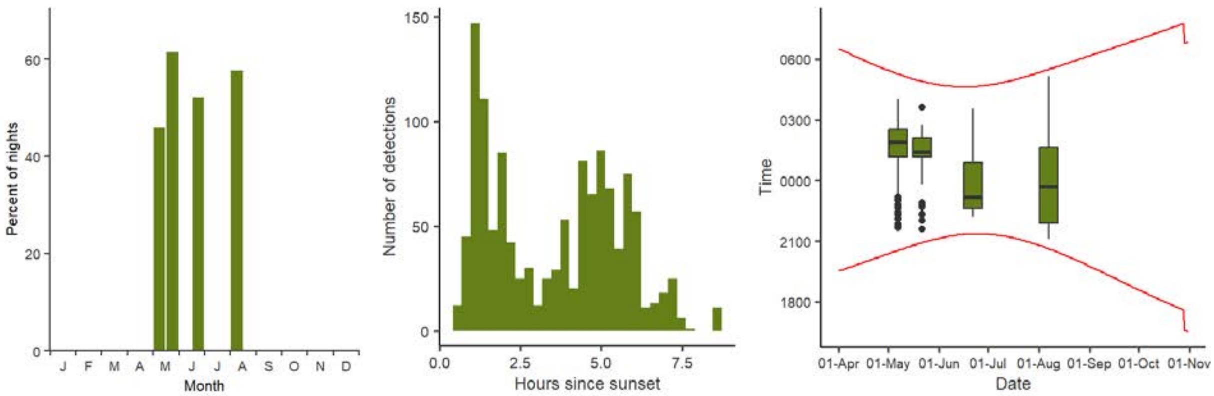
Barbastelle social calls were represented by a single triggered recording from Bevills Farm. It is difficult to infer too much from a single recording, but social calls in this species are rarely recorded far from a roost. This species favours broad-leaved woodland with lots of trees with crevices for roosts and dense areas for foraging.

Serotine

Serotine *Eptesicus serotinus* was recorded on 28 nights, from 10 locations, giving a total of 1,240 recordings.

Spatial pattern of activity

Seasonal and nightly activity



Serotine was recorded on every farm in 2024. This species is associated with open pasture for foraging. There were 241 recordings from one night at Woodhouse Farm, and over 50 recordings a night from Old Hall, with a peak of 166 recordings on one night.

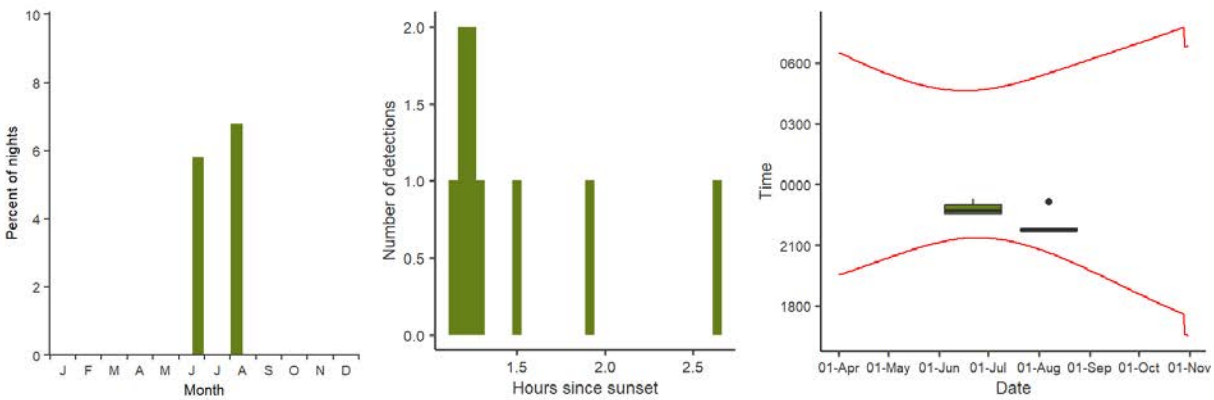
Acoustically, it is normally straightforward to distinguish Serotine from *Nyctalus* species, of which Common Noctule and Leisler's Bat are the most likely confusion species here. In contrast to Serotine, *Nyctalus* species often show strong alternating frequencies in the calls within a sequence. Leisler's Bat often shows sharp frequency changes within a sequence of over 2 kHz, where such changes would be unusual for Serotine. One situation where it can be more difficult to distinguish Serotine/*Nyctalus* is in high clutter, but *Nyctalus* normally do not stay long in high clutter, so it would be exceptional to find consecutive steep calls of these species.

Serotine feeding buzzes

Serotine feeding buzzes *Eptesicus serotinus* were recorded on five nights, from four locations, giving a total of 9 recordings.

Spatial pattern of activity

Seasonal and nightly activity



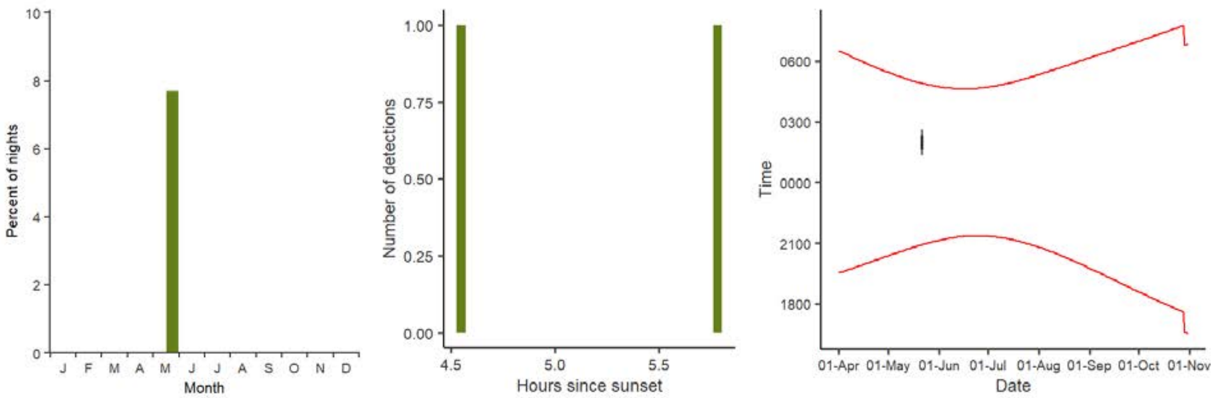
Serotine feeding buzzes. A small number of recordings with feeding buzzes, provides some behavioural information that Serotine is actively feeding at Lower Diary Farm, Woodhouse Farm, Lindsey Lodge and at Mascall Farms.

Serotine social calls

Serotine social calls *Eptesicus serotinus* were recorded on one night, from one location, giving a total of 2 recordings.

Spatial pattern of activity

Seasonal and nightly activity



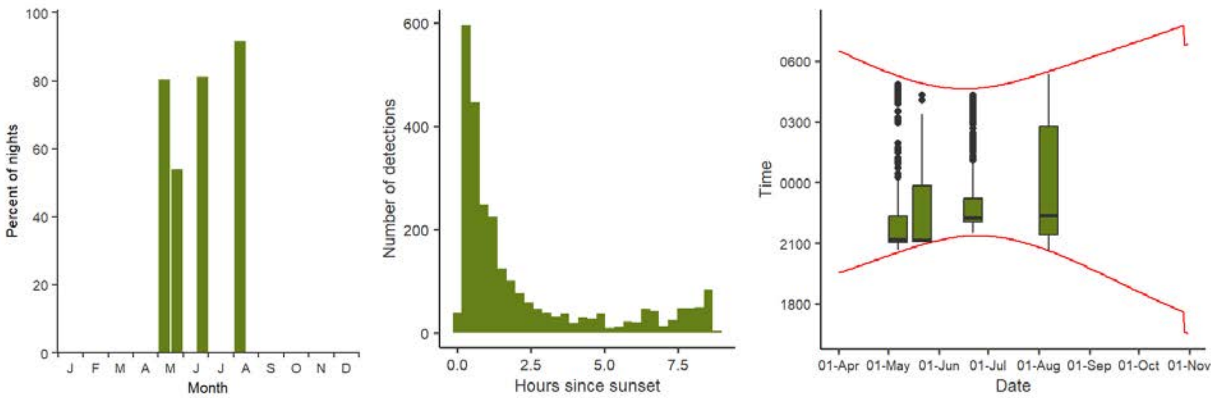
Serotine social calls were represented by two recordings from Old Hall. It is difficult to infer too much from two recordings, but considering the number of recordings with echolocation calls from Old Hall, and that social calls in this species are rarely recorded far from a roost, it suggests that a Serotine roost may have been close by.

Common Noctule

Common Noctule *Nyctalus noctula* was recorded on 28 nights, from 10 locations, giving a total of 2,592 recordings.

Spatial pattern of activity

Seasonal and nightly activity



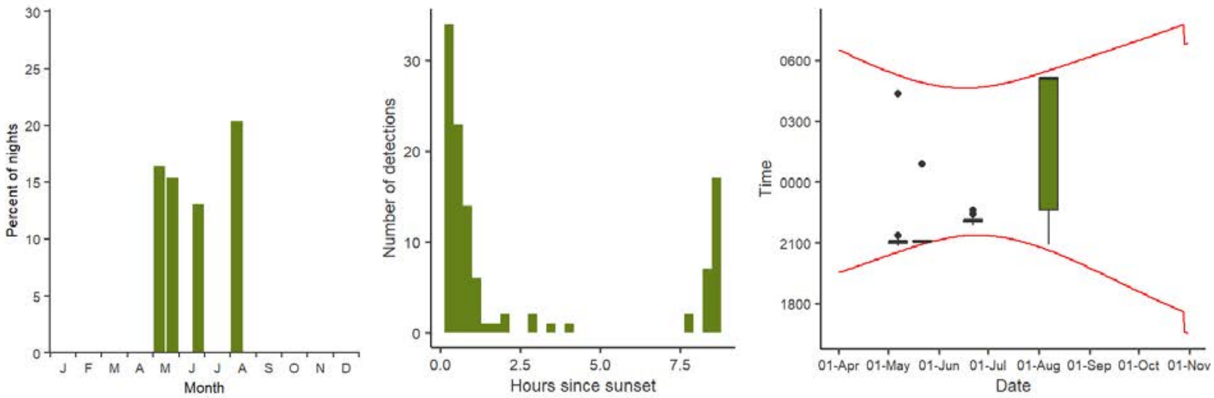
Common Noctule was recorded on every farm in 2024. Particularly notable were over a hundred recordings a night over five nights at Old Hall, with a maximum of 162 recordings in one night. See Identification appendix 3 for further information on the sound identification of Noctule and how it compares with the closely related Leisler's Bat.

Common Noctule feeding buzzes

Common Noctule feeding buzzes *Nyctalus noctula* were recorded on 20 nights, from eight locations, giving a total of 111 recordings.

Spatial pattern of activity

Seasonal and nightly activity



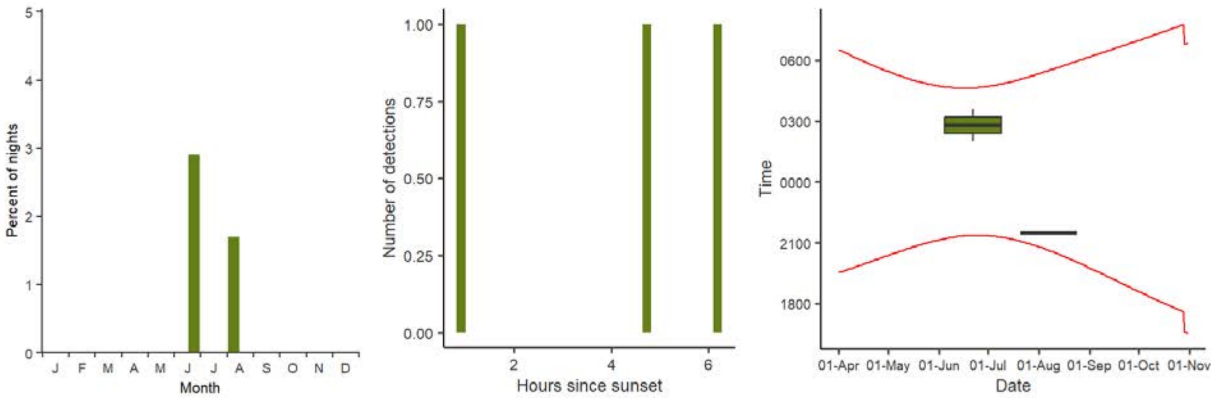
Common Noctule feeding buzzes were recorded on eight farms. The highest level of Noctule feeding activity was at Old Hall, with a total of 61 recordings with feeding buzzes, with up 30 recordings a night from Woodhouse Farm.

Common Noctule social calls

Common Noctule social calls *Nyctalus noctula* were recorded on three nights, from three locations, giving a total of 3 recordings.

Spatial pattern of activity

Seasonal and nightly activity



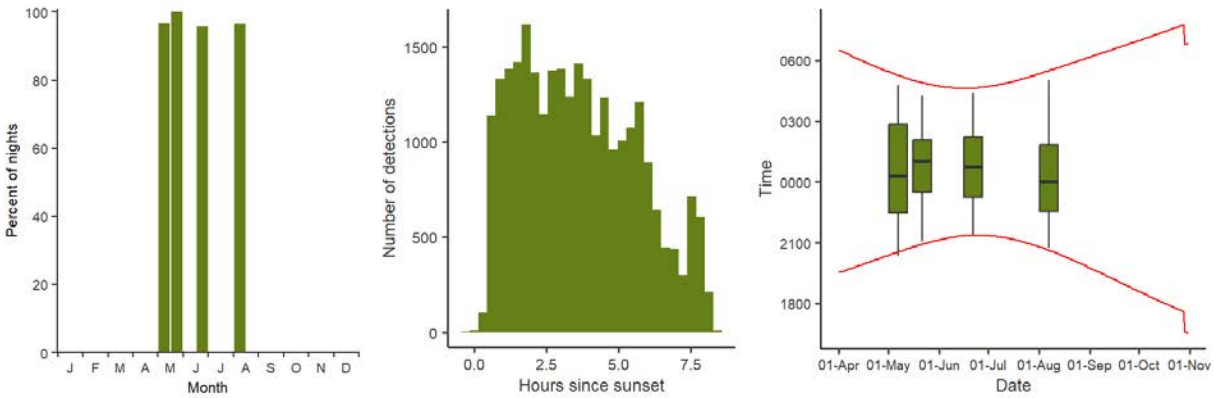
Common Noctule social calls. There were three recordings with Common Noctule social calls, one recording each from Old Hall, Lawford Hall and from Lower Diary Farm. Common Noctule social calls can be recorded in proximity to a roost, but it is difficult to infer much from only three recordings.

Common Pipistrelle

Common Pipistrelle *Pipistrellus pipistrellus* was recorded on 31 nights, from 10 locations, giving a total of 27,040 recordings.

Spatial pattern of activity

Seasonal and nightly activity



Common Pipistrelle. With a total of 27,044 recordings, Common Pipistrelle was by far the most commonly recorded bat species on every farm.

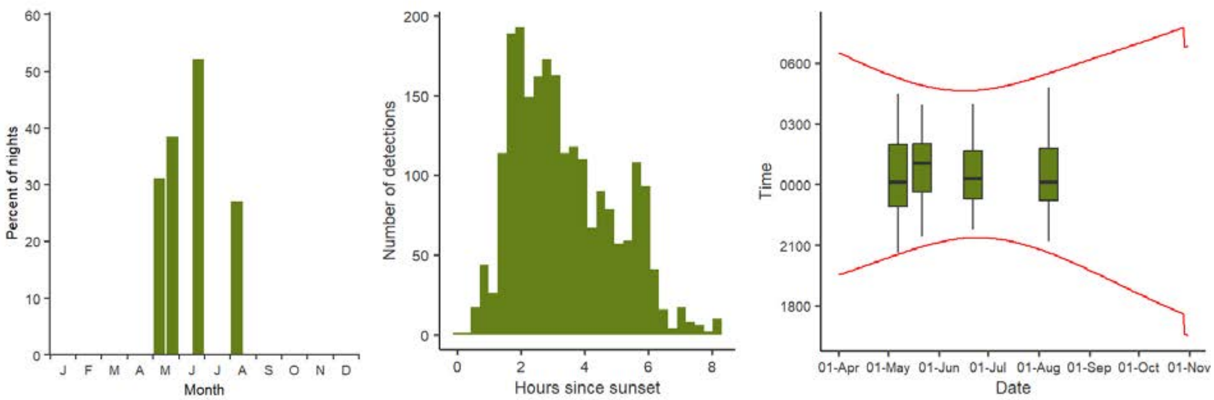
Common Pipistrelle is normally straightforward to identify acoustically, but particular care is needed given calls at the low or high frequency end of the range for this species, which could be mis-identified as Nathusius' Pipistrelle or Soprano Pipistrelle respectively. For these it is important to consider the call duration, and not just the peak or end frequency of the calls.

Common Pipistrelle feeding buzzes

Common Pipistrelle feeding buzzes *Pipistrellus pipistrellus* were recorded on 28 nights, from 10 locations, giving a total of 2,231 recordings.

Spatial pattern of activity

Seasonal and nightly activity



Common Pipistrelle feeding buzzes were recorded on every farm, with a maximum of 850 feeding buzzes recorded on one night at Lawford Hall.

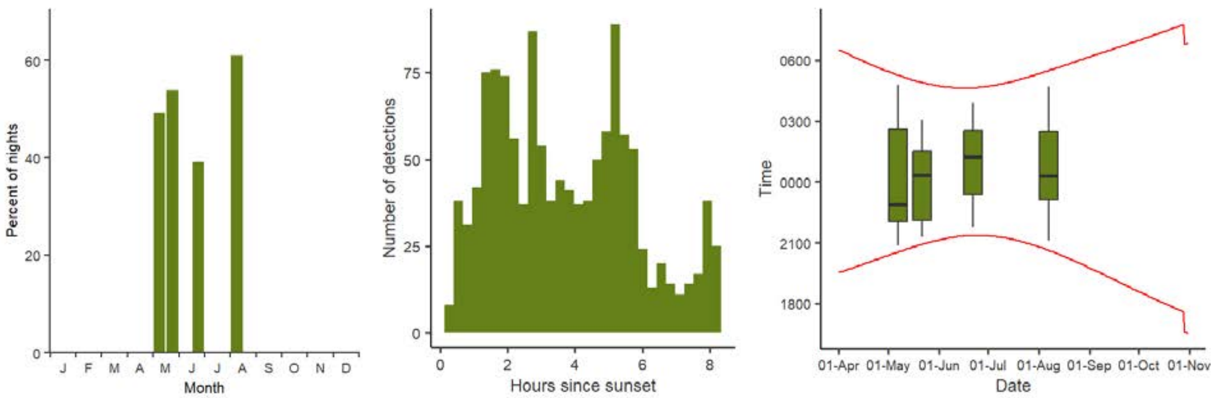
This is the first year that our bat classifiers have specifically identified Common Pipistrelle feeding buzzes. As illustrated above, there were peaks in feeding activity towards the start of the night and a clear increase in feeding activity towards the end of the night before returning to the roost.

Common Pipistrelle social calls

Common Pipistrelle social calls *Pipistrellus pipistrellus* were recorded on 29 nights, from 10 locations, giving a total of 1,259 recordings.

Spatial pattern of activity

Seasonal and nightly activity



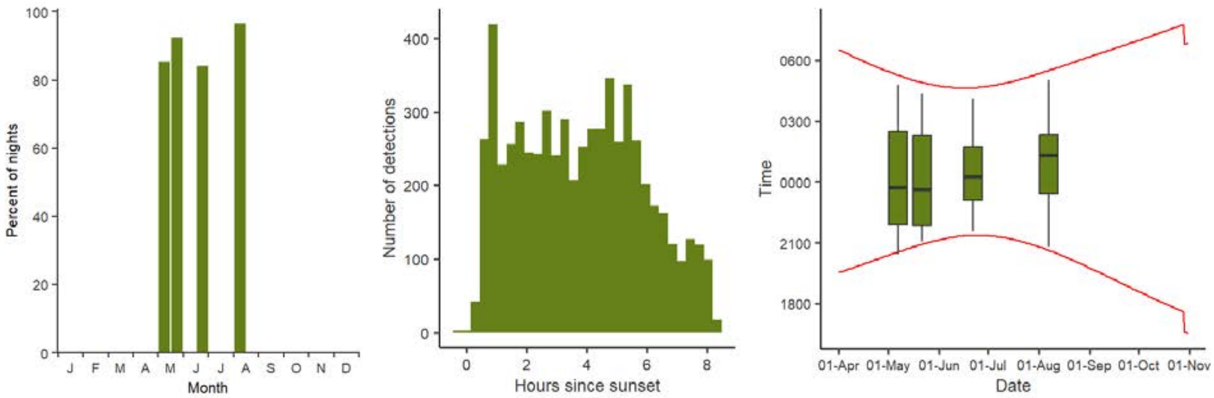
Common Pipistrelle social calls. This is the first year that we have specifically identified Common Pipistrelle social calls. A range of social calls are produced by Common Pipistrelle, but most common are social trills often comprising of four calls. These can be produced in flight at any time of year, but as perhaps suggested by the above, there is normally an increase in the percent of nights recording Common Pipistrelle social calls during the late summer, and not recorded here, into the autumn mating period.

Soprano Pipistrelle

Soprano Pipistrelle *Pipistrellus pygmaeus* was recorded on 31 nights, from 10 locations, giving a total of 6,147 recordings.

Spatial pattern of activity

Seasonal and nightly activity



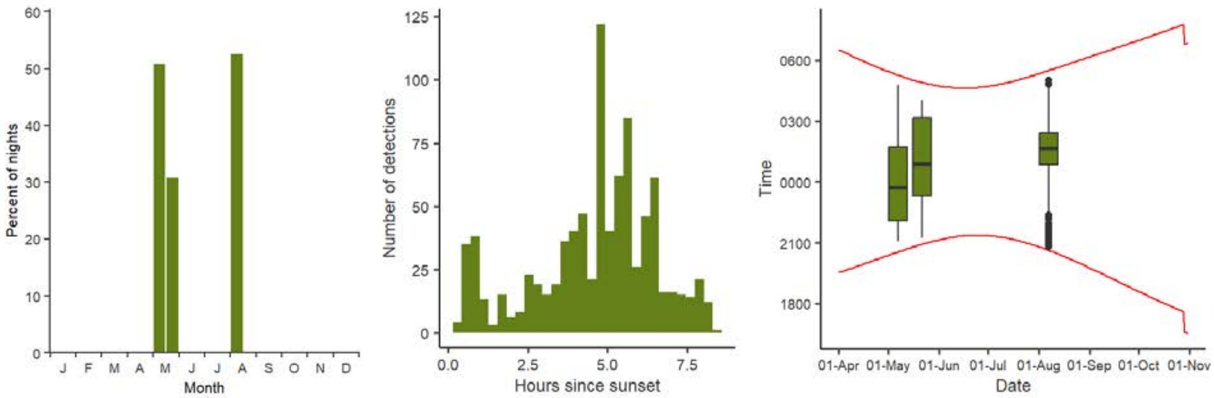
Soprano Pipistrelle was the second most commonly recorded bat species on all farms, with a total of 6,146 recordings across the survey. A maximum of 745 recordings of Soprano Pipistrelle were recorded from Lawford Hall on one night.

Soprano Pipistrelle feeding buzzes

Soprano Pipistrelle feeding buzzes *Pipistrellus pygmaeus* were recorded on 19 nights, from 10 locations, giving a total of 879 recordings.

Spatial pattern of activity

Seasonal and nightly activity



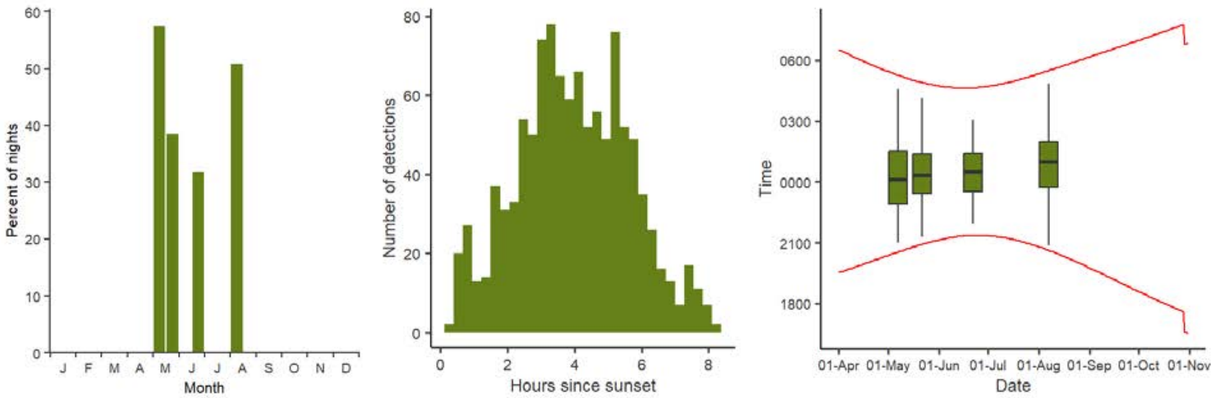
Soprano Pipistrelle feeding buzzes were recorded on every farm, with a maximum of 443 feeding buzzes recorded from one night at Bevills Farm. This is the first year that our bat classifiers have specifically identified Soprano Pipistrelle feeding buzzes.

Soprano Pipistrelle social calls

Soprano Pipistrelle social calls *Pipistrellus pygmaeus* were recorded on 26 nights, from 10 locations, giving a total of 1,091 recordings.

Spatial pattern of activity

Seasonal and nightly activity



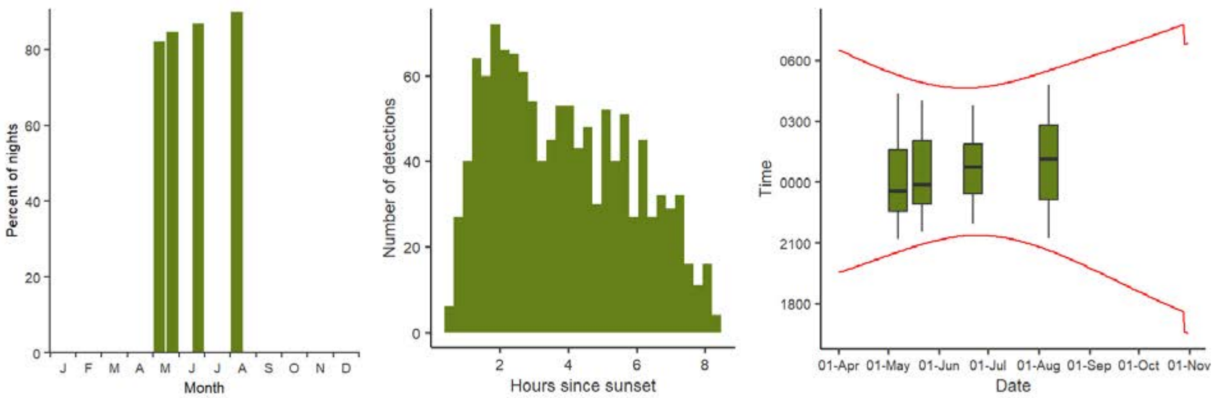
This is the first year that we have specifically identified Soprano Pipistrelle social calls. A range of social calls are produced by Soprano Pipistrelle, but most common are social trills often comprising of three calls.

Brown Long-eared Bat

Brown Long-eared Bat *Plecotus auritus* was recorded on 31 nights, from 10 locations, giving a total of 1,209 recordings.

Spatial pattern of activity

Seasonal and nightly activity



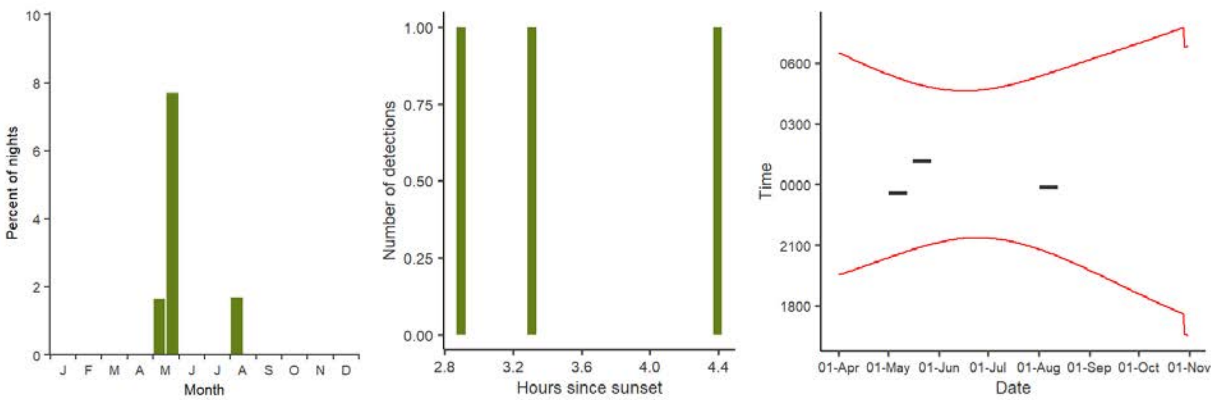
Brown Long-eared Bat was recorded from every farm. A maximum of 35 recordings a night was recorded at Clees Hall.

Brown Long-eared Bat social calls

Brown Long-eared Bat social calls *Plecotus auritus* were recorded on three nights, from three locations, giving a total of 3 recordings.

Spatial pattern of activity

Seasonal and nightly activity



Brown Long-eared Bat social calls. This is the first year that our bat classifiers have specifically identified Brown Long-eared Bat social calls. In our categorisation of social calls for Brown Long-eared Bat, we have not included calls often defined as Type C social calls (Middleton *et al.* 2022) that are likely to have an echolocation and a social function. By excluding Type C social calls, the remaining social calls are more likely (but not exclusively) to be recorded in the vicinity of a roost. With just a single recording containing Brown Long-eared Bat social calls from each of three farms, it is difficult to infer too much from these results.

4.5 Small terrestrial mammal species

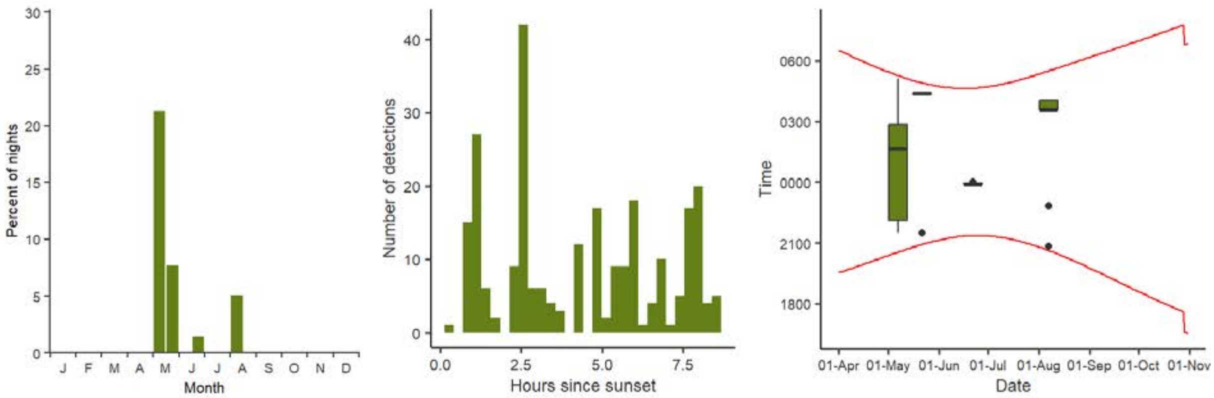
In this section we look at the recordings that we can assign to small terrestrial mammals.

Brown Rat

Brown Rat *Rattus norvegicus* was recorded on 12 nights, from two locations, giving a total of 255 recordings.

Spatial pattern of activity

Seasonal and nightly activity



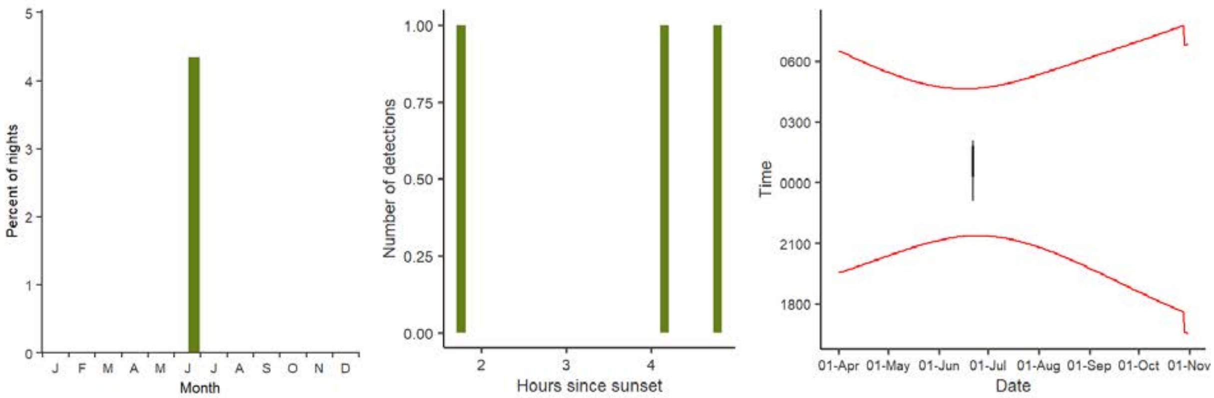
Brown Rat is a highly vocal species that is relatively easy to detect using an ultrasonic microphone and is regularly recorded incidentally during static bat detector surveys (Newson & Pearce 2022). This species was only recorded from two farms in 2024, of which the maximum number of recordings a night was 43 from Bevills Farm and a maximum of 40 recordings a night from Old Hall.

Common Shrew

Common Shrew *Sorex araneus* was recorded on three nights, from one location, giving a total of 3 recordings.

Spatial pattern of activity

Seasonal and nightly activity



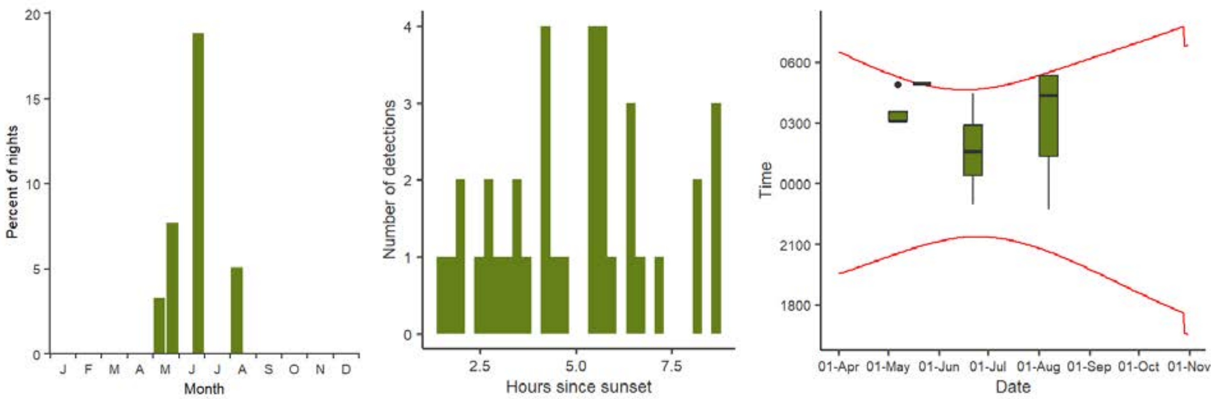
Common Shrew was recorded from a single farm, Lawford Farm in 2024. Common and Pygmy Shrew produce calls that are notably different from those of Rodents in having multiple harmonics that when played slowed down, produces a warbling sound. In most cases it is possible to separate Common Shrew and Pygmy Shrew, the former producing quite simple calls with much less variability in frequency and call structure than the latter. In the case of Common Shrew, the first harmonic (i.e. the fundamental) of the call (if present) ends at around 10 kHz, while the often stronger second harmonic ends at double the frequency to the first (i.e. about 20 kHz). Up to three further harmonics may be recorded, depending on how close the shrew is to the microphone. The complex calls of the Pygmy Shrew, in contrast, often include five or more harmonics, where no two calls in a single recording being quite the same. For more information on the sound identification of shrews, see Newson *et al*., (2021) and Middleton *et al*., (2024).

Eurasian Pygmy Shrew

Eurasian Pygmy Shrew *Sorex minutus* was recorded on 14 nights, from five locations, giving a total of 37 recordings.

Spatial pattern of activity

Seasonal and nightly activity



Pygmy Shrew was recorded more widely than Common Shrew (five farms) during the project. As discussed in the previous section (and see Newson *et al*., 2021; Middleton *et al*. 2024), it is normally straightforward to distinguish this species acoustically from Common Shrew.

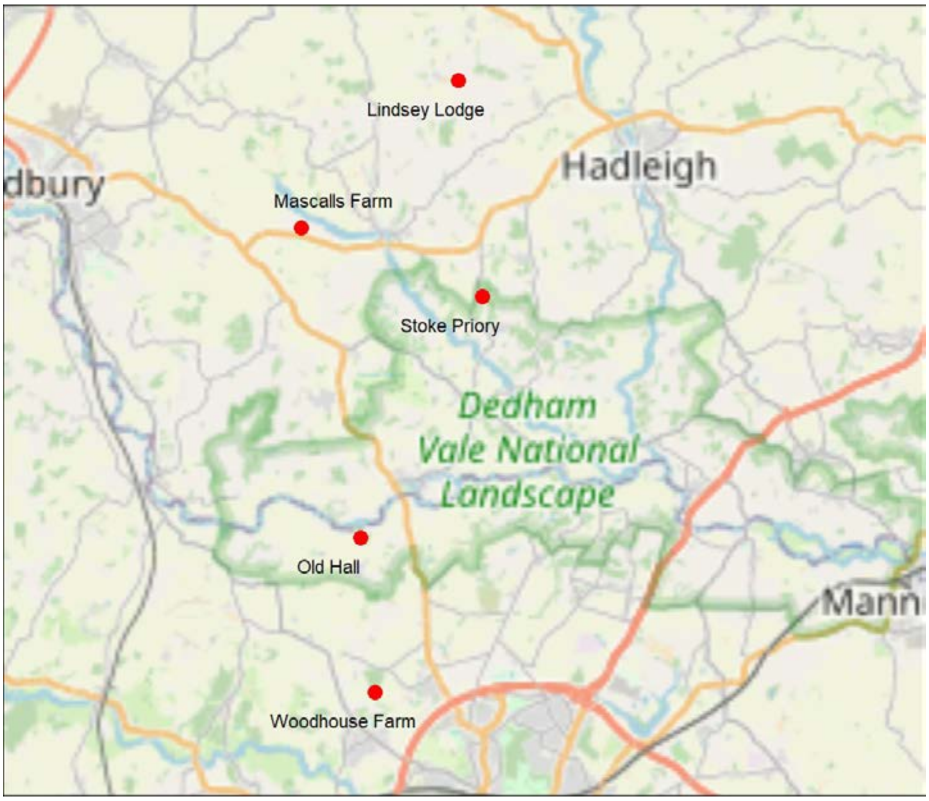
4.6 Bush-crickets

Being stationary, and calling for long periods, the number of recordings is not an informative measure of abundance. For this reason, bush-cricket data are shown as presence information rather than activity information.

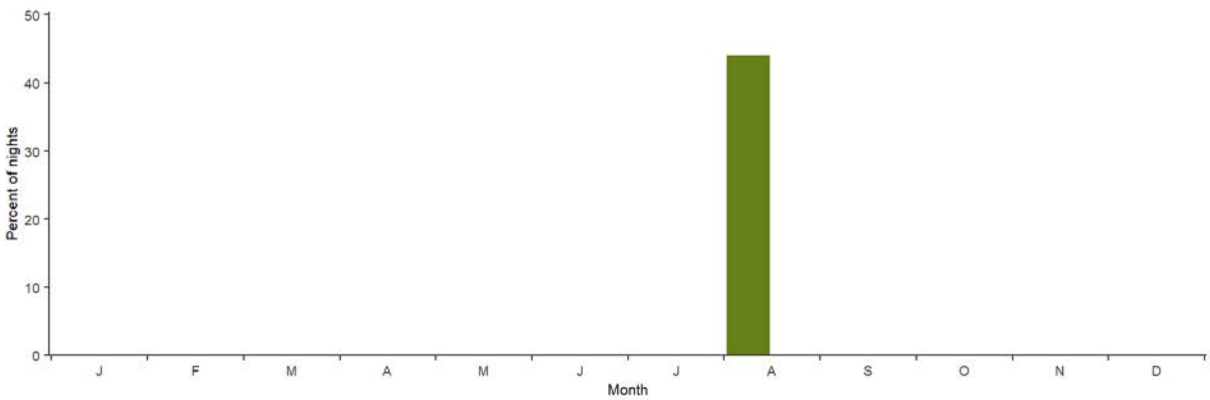
Long-winged Conehead

Long-winged Conehead *Conocephalus fuscus* was recorded on eight nights, from five locations.

Spatial pattern of detections



Seasonality

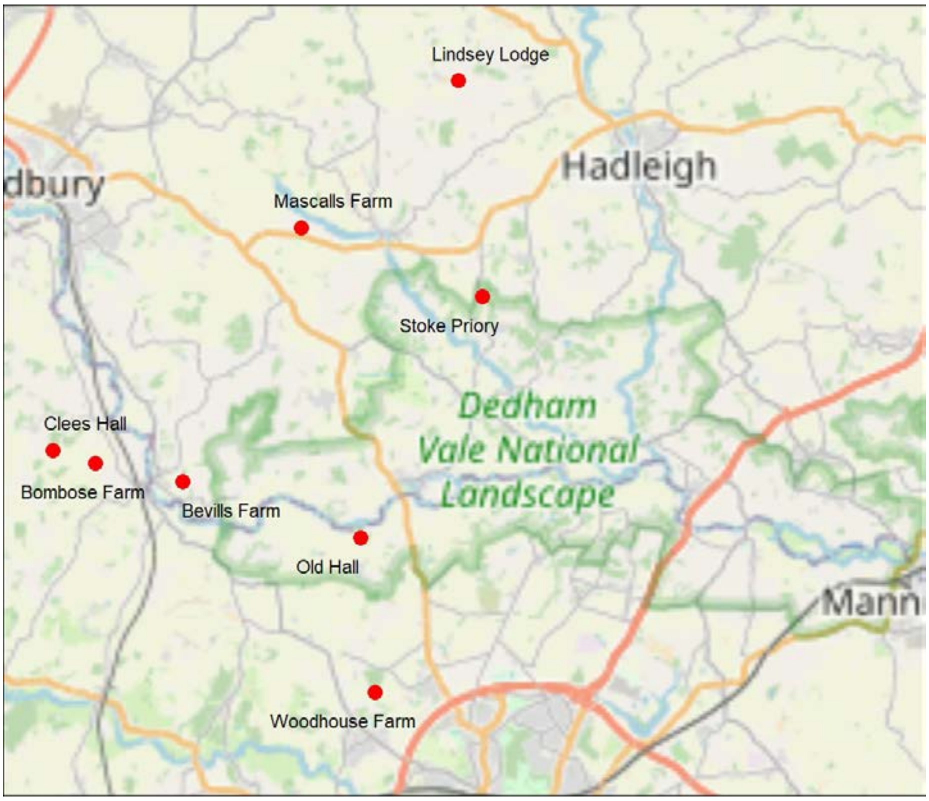


Long-winged Conehead was recorded from eight farms in August. Long-winged Conehead produces ‘calls’ with a peak frequency about 26 kHz. It is most similar acoustically to Short-winged Conehead (Middleton 2020), which has not yet been recorded in the survey area, but Long-winged Conehead produces three-syllable calls (two short calls, pause, followed by one longer duration call).

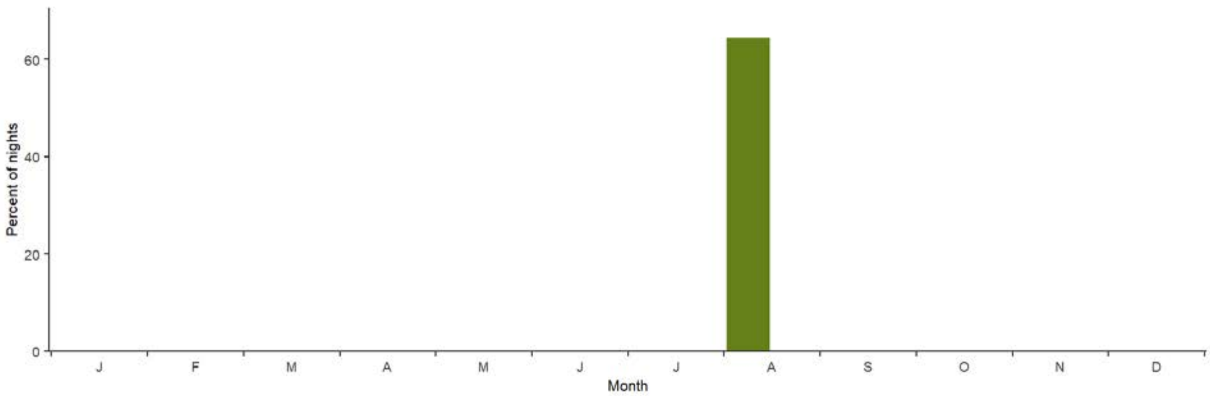
Speckled Bush-cricket

Speckled Bush-cricket *Leptophyes punctatissima* was recorded on eight nights, from eight locations.

Spatial pattern of detections



Seasonality

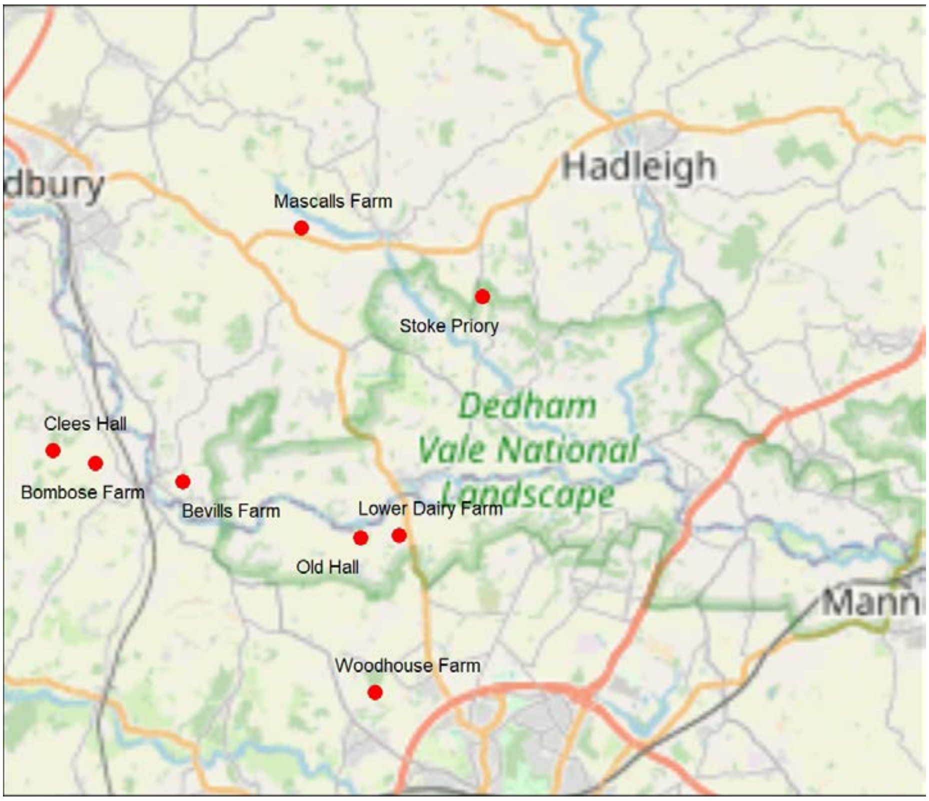


Speckled Bush-cricket were recorded from eight of the ten farms in August. Speckled Bush-cricket produces distinctive multiple syllable calls. There are normally at least five of these, which are isolated, short and are at high frequency, 30-40 kHz. In this species, the female also calls in response to the male, but the calls normally comprise a shorter call sequence.

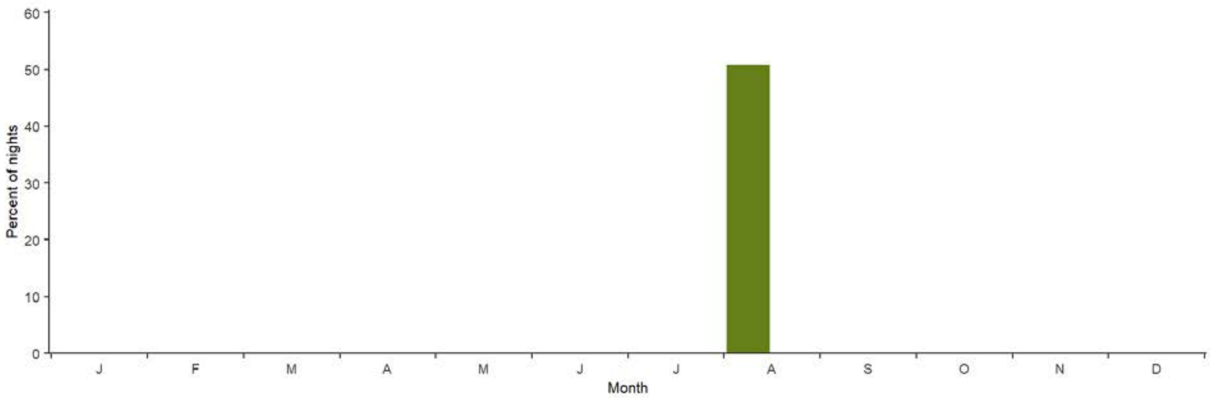
Dark Bush-cricket

Dark Bush-cricket *Pholidoptera griseoaptera* was recorded on eight nights, from eight locations.

Spatial pattern of detections



Seasonality

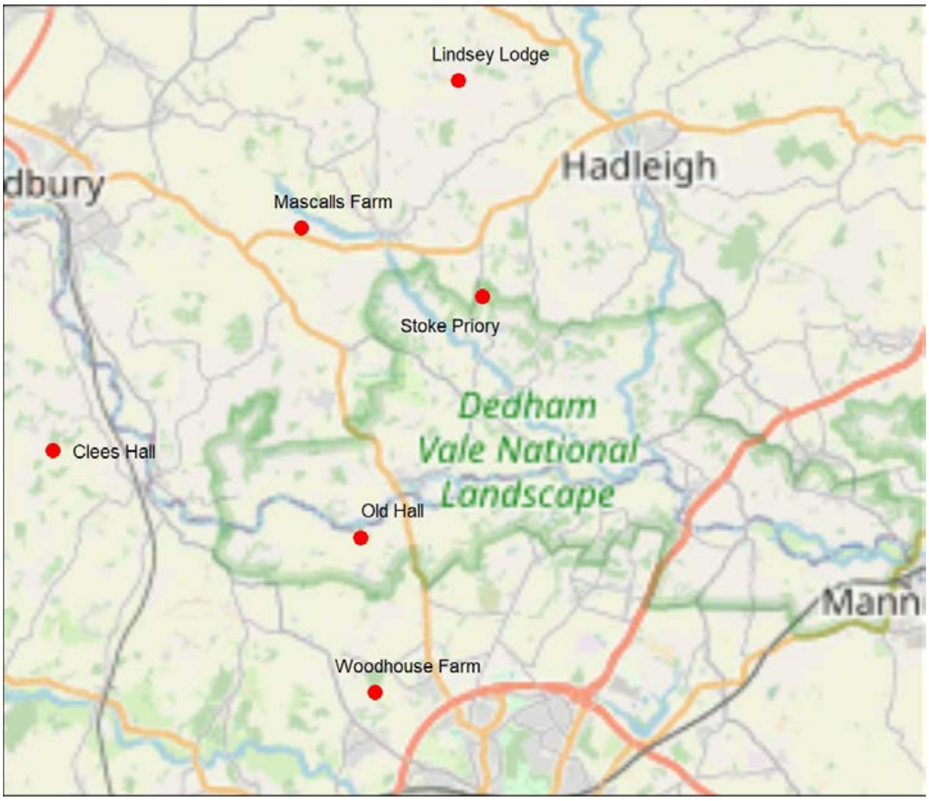


Dark Bush-cricket were recorded from eight farms in August. Dark Bush-cricket produces isolated call of 3 syllables (sometimes the first syllable is faint or missing), with a peak frequency of about 12 kHz. This species is typically active during the evening and through the night.

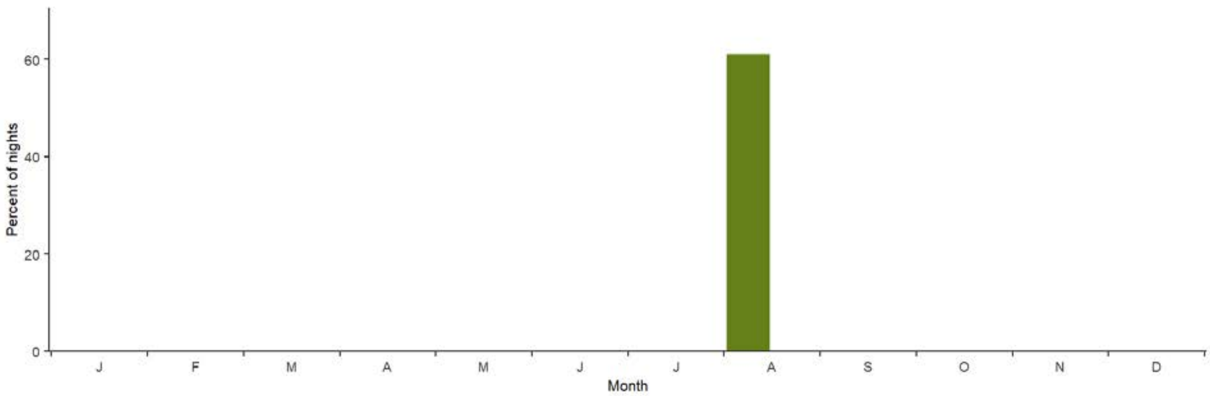
Roesel’s Bush-cricket

Roesel’s Bush-cricket *Roeseliana roeselii* was recorded on eight nights, from six locations.

Spatial pattern of detections



Seasonality



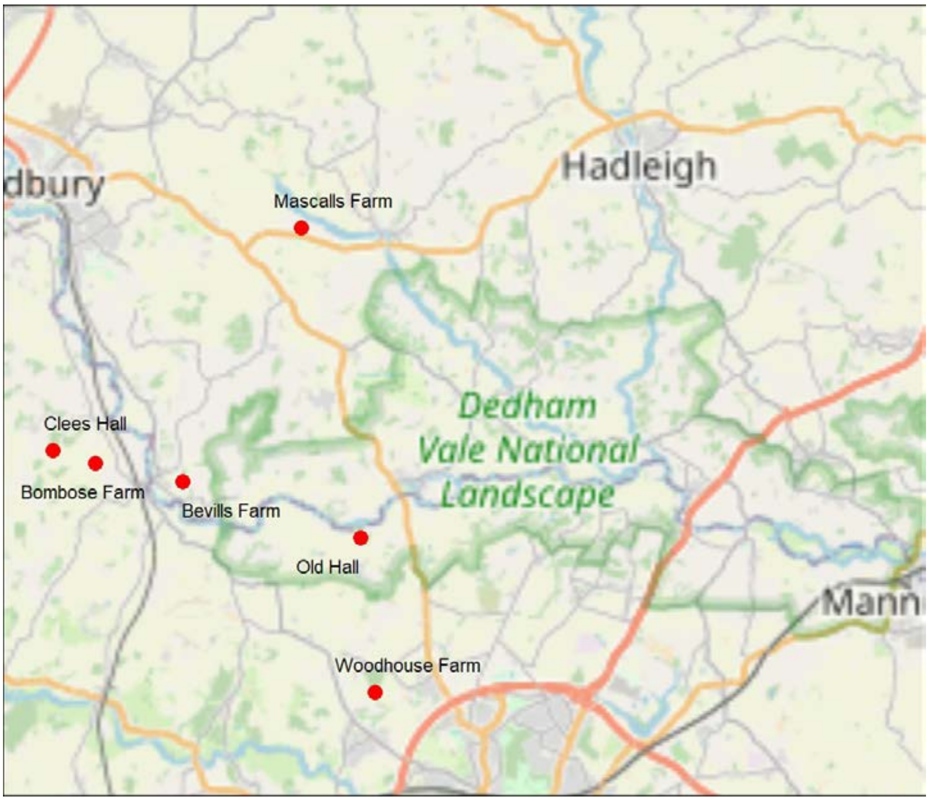
Roesel’s Bush-cricket were recorded from six farms in August. Roesel’s Bush-cricket produces ‘calls’ with a peak frequency about 20 kHz. This species is distinctive in producing simple continuous / regular ‘calls’. This species most commonly ‘calls’ between midday and mid-afternoon, but as here, it can be recorded during the evening and sometimes later in the night.

4.7 Audible moth species

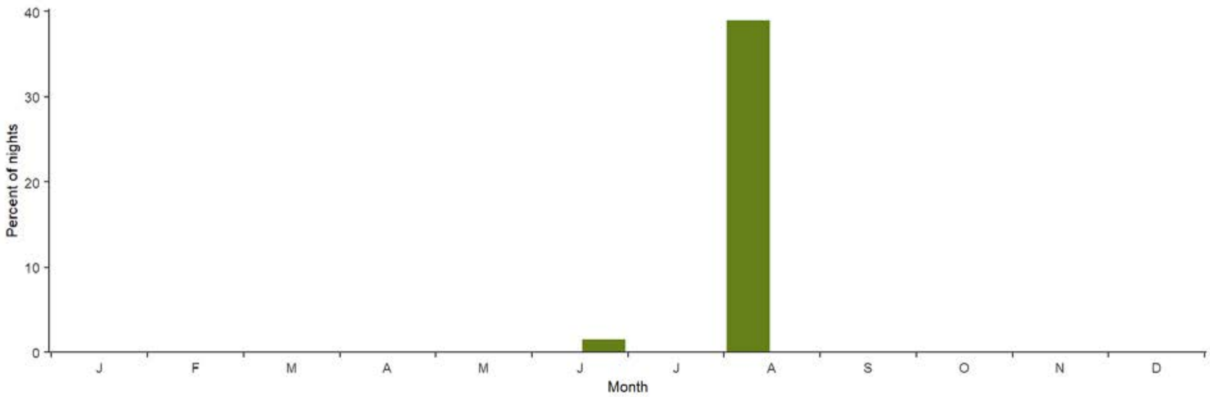
Bird Cherry Ermine

Bird Cherry Ermine *Yponomeuta evonymella* was recorded on nine nights, from six locations.

Spatial pattern of detections



Seasonality



Bird Cherry Ermine The micro-moth Bird Cherry Ermine was recorded from six farms. This species of moth is deaf itself, but it produces ultrasonic clicks when it flies, to interfere with the echolocation of bats and reduce predation. The sound produced by the Bird Cherry Ermine is very different from Green Silver-lines. Whilst we have assigned all recordings like this to this species, we can not exclude the possibility that other closely related species produce similar sounds.

5. DISCUSSION

This dataset confirms the presence of Turtle Doves at one out of ten farms in the Stour Valley Farmer Cluster alongside new insight into farm biodiversity in the cluster. The passive acoustic monitoring method used made it possible to survey multiple taxonomic groups simultaneously resulting in a total of: 74 bird species, 10 bat species, 3 small mammal, 4 bush cricket, and 1 moth species detected across the ten farms.

5.1 Turtle Dove

Results from the BTO Acoustic Pipeline for Turtle Dove are promising in showing that our provisional classifier is able to detect Turtle Doves, and with an appropriately high score threshold we can be confident of detecting the species at sites without generating high volumes of false positive detections to check. Nevertheless, we stress the need to always perform manual verification on a sample of recordings to confirm target presence. The recording protocol employed in this project involved 1 minute in 15 minute sampling through daylight hours. This was sufficient to reveal not only presence at Bombose Farm, but to show the pattern of song activity, how this was ongoing through the day at the start of the season, minimal mid-season, and then later in the season was more confined to mornings. This pattern of behaviour may be related to breeding activity (e.g. first and second broods) but further work is needed. Passive acoustic monitoring, with its long deployment duration offers tremendous potential to explore species' behaviours that are difficult to assess without intensive effort by human surveyors.

5.2 Bats and other ultrasonic species

Configuring the recorders to switch to ultrasonic recording at night provided additional data on other species groups at minimal extra cost. These data can provide the Stour Valley Farmer Cluster with valuable context to deliver biodiversity friendly farming and conservation initiatives within the National Landscape. Of particular note, was that Barbastelle, which is IUCN listed as vulnerable in England, was recorded across all 10 farms, and with a high number of recordings at a number of sites (1,590 recordings in total). Unmanaged woodland with high structural and floral diversity is considered to be optimal roosting habitat for Barbastelle, although ancient woodland sites where a policy of minimum intervention is carried out to restore diversity can be of equal high value, provided that dead trees are retained (Russo *et al*. 2004, Zeale 2011, Carr *el al*. 2018). It is thought that Barbastelle's are not able to persist in woodland where intensive management and non-selective logging is conducted, although where these habitats exist around optimal roost sites, they can provide additional, albeit limited, roosting opportunities.

5.3 Recommendations

Data from 2024 indicate some of the knowledge gains that can be made by careful deployment of acoustic monitoring technology. Yet this isn't without its challenges and improvements could be made. Potential areas for improvement include:

- deploy more recorders, or move recorders around farms on a clear time table. Acoustic recorders provide information within a finite radius, with the size of that radius depending on the species: many loud and vocal birds can be detected over distances of up to 500 m, whereas some small mammals and bats can be detected less than 10 m distant. If there is interest in a wider assessment of biodiversity on farms, or if further sampling of Turtle Dove habitat is required, recording should be undertaken at points at least 250–500 m apart to maintain independence among recorders.

- careful logging of recording effort. With all biological surveys, accounting for recording effort is critical when attempting to compare data between sites or through time. Acoustic monitoring is no different. A clear protocol is needed to accurately record deployment dates and times so that effective recording effort can be calculated. For audible monitoring this is slightly less critical because files are produced throughout the deployment. However, as automated classifiers only return positive detections, it is still necessary to have some measure of recording effort (e.g. to express identifications as detections per unit recording time).

- a clear data management plan. Acoustic monitoring generates large volumes of audio files. It is easy to get muddled when working with multiple memory cards and survey locations. A clear data management plan covering how to name, organise and store files should be developed prior to recording and reviewed regularly during fieldwork to check it is fit for purpose. Audio files should be backed up regularly and logs made of which batches have been processed through the Acoustic Pipeline to avoid results duplication.

- improve BTO Acoustic Pipeline species coverage. Adding more bird species to the BTO Acoustic Pipeline is a high priority so that it can become a single tool for providing acoustic data management for multi-taxa monitoring projects.

6. ACKNOWLEDGEMENTS

We are very grateful to the farms who took part in Farming in Protected Landscapes - Turtle Dove Monitoring Project project in 2024, with a special mention to Geoffrey Probert, Chris Boast, Ben Twinn, Dora Nichols, Andrew Sturgeon, Jenny Taylor, Nick Oliver, David Lewis, John Engleheart and Tim Knighton. Lastly we would like to thank the Farming in Protected Landscapes program for funding this project. BTO Acoustic Pipeline classifiers are trained on a combination of recording sources, including those owned by BTO, those kindly shared with BTO, and open access repositories such as xeno-canto. We are grateful to all sound recordists who have made their recordings available to us. For more details see here (https://www.bto.org/our-science/products-and-technologies/bto-acoustic-pipeline/how-acoustic-pipeline-works).

7. REFERENCES

Barataud, M. 2015. *Acoustic Ecology of European Bats: Species identification, study of their habitats and foraging behaviour*. Collection Inventaires et biodiversité, Biotope Editions, Mèze et Publications scientifiques du Muséum National d'Histoire Naturelle, Paris.

Barataud, M. & Skals, N. 2018. Émissions ultrasonores de communication sociale enregistrées en canopée : attribution au lépidoptère Pseudoips prasinana (L.) (Noctuoidea ; Nolidae ; Chloephorinae) grâce à une analyse bibliographique. *Plume de naturalistes* 2, 11-22. http://www.plume-de-naturalistes.fr/wp-content/uploads/2018/11/02_BARATAUD-M_05-2018_Emissions-ultrasonores-Pseudoips-prasinana_Plume2_11-22.pdf

Barré, K., Le Viol, I., Julliard, R., Pauwels, J., Newson, S.E., Julien, J.F., Fabien, C., Kerbiriou, C. & Bas, Y. 2019. Accounting for automated identification errors in acoustic surveys. *Methods in Ecology and Evolution*.

Carr, A., Zeale, M. R. K., 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, 237-246.

Jones, J.P.G. 2011. Monitoring species abundance and distribution at the landscape scale. *Journal of Applied Ecology*, 48, 9-13.

Thieurmel, B. & Elmarhraoui, A. 2019. suncalc: Compute Sun Position, Sunlight Phases, Moon Position and Lunar Phase. R package version 0.5.0. https://CRAN.R-project.org/package=suncalc.

Middleton, N. 2020. *Is That a Bat? A Guide to Non-Bat Sounds Encountered During Bat Surveys.* Pelagic Publishing.

Middleton, N., Newson, S.E., & Pearce, H. 2024. *Sound Identification of Terrestrial Mammals of Britain & Ireland.* Pelagic Publishing.

Newson, S. E., Bas, Y., Murray, A. & Gillings, S. 2017b. Potential for coupling the monitoring of bush-crickets with established large-scale acoustic monitoring of bats. *Methods in Ecology and Evolution* 8, 1051-1062.

Newson, S.E., Middleton, N., & Pearce, H. 2020. The acoustic identification of small terrestrial mammals in Britain. *British Wildlife* 32, 186-194

Newson, S.E. & Pearce, H. 2022. The potential for acoustics as a conservation tool for monitoring small terrestrial mammals. *JNCC Report* No. 708. JNCC, Peterborough, ISSN 0963-8091.

Pereira, H.M. & Cooper, H.D. 2006. Towards the global monitoring of biodiversity change. *Trends Ecology and*

Evolution 21, 123-129.

Russ, J. (ed.) 2021. *Bat calls of Britain and Europe. A guide to species identification.* Pelagic Publishing.

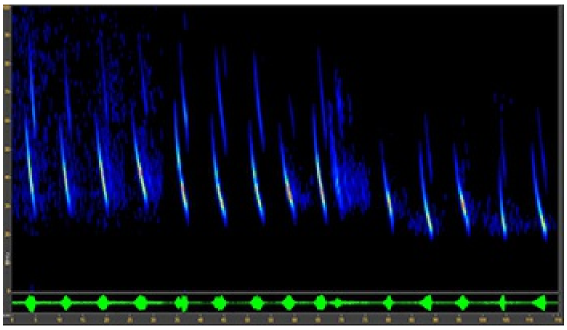
Russo, D., Cistrone, L., Jones, G., and Mazzoleni, S. 2004. Roost selection by barbastelle bats (Barbastella barbastellus, Chiroptera : Vespertilionidae) in beech woodlands of central Italy: consequences for conservation. *Biological Conservation* 117, 73-81.

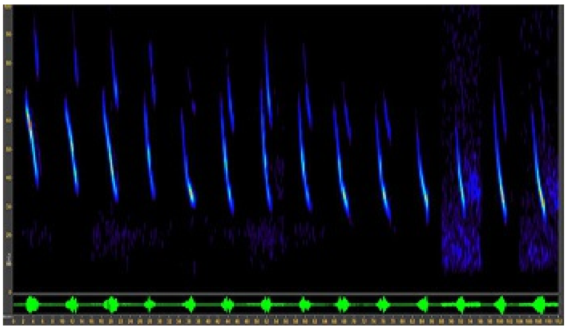
Stanbury, A., Eaton, M., Aebischer, N., Balmer, D., Brown, A., Douse, A., Lindley, P., McCulloch, N., Noble, D., and Win I. 2021. The status of our bird populations: the fifth Birds of Conservation Concern in the United Kingdom, Channel Islands and Isle of Man and second IUCN Red List assessment of extinction risk for Great Britain. *British Birds* 114, 723-747. Available online at https://britishbirds.co.uk/content/status-our-bird-populations.

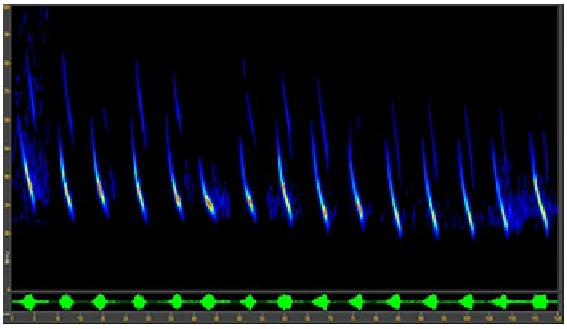
Woodward, I., Aebischer, N., Burnell, D., Eaton, M., Frost, T., Hall, C., Stroud, D.A. & Noble, D. 2020. Population estimates of birds in Great Britain and the United Kingdom. *British Birds* 113, 69–104.

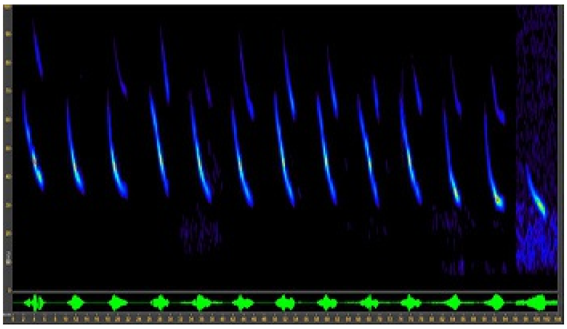
Zeale, M. R. K. 2011. Conservation biology of the barbastelle *Barbastella barbastellus*: applications of spatial modelling, ecology and molecular analysis of diet. PhD thesis, University of Bristol, United Kingdom.

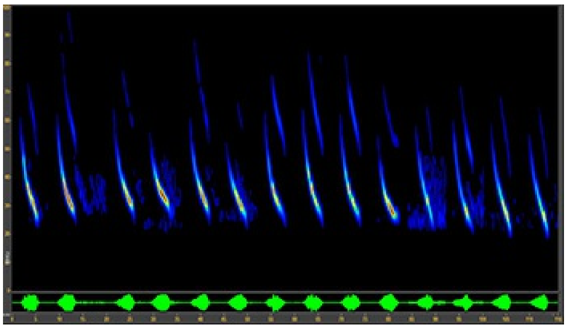
Identification appendix 1: Common Noctule *Nyctalus noctula* and Leisler's Bat *Nyctalus leisleri*

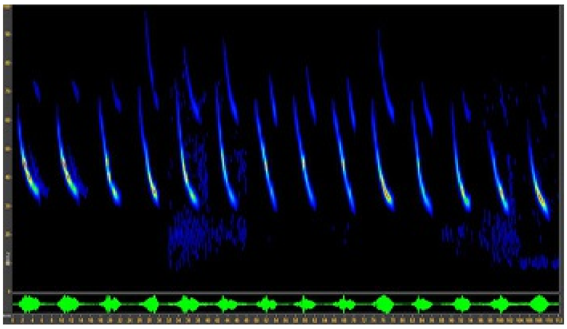

Common Noctule - call duration 1.4-3.0 ms

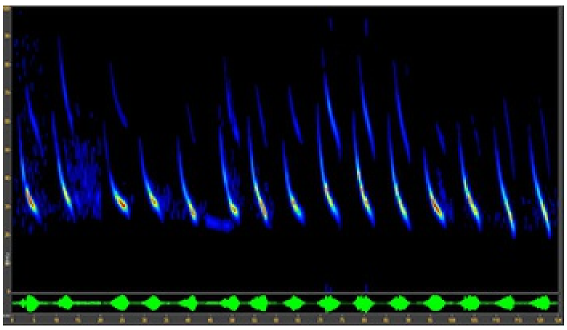

Leisler's Bat - call duration 1.4-3.0 ms

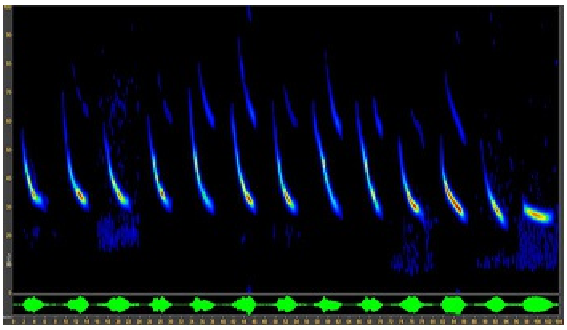

Common Noctule - call duration 3.1-3.7 ms

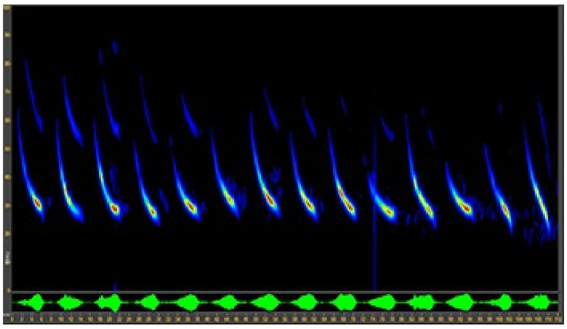

Leisler's Bat - call duration 3.1-3.7 ms

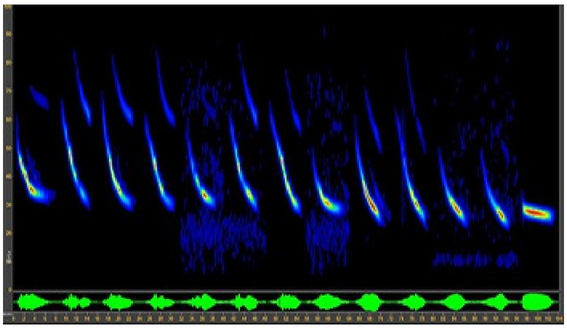

Common Noctule - call duration 3.8-4.3 ms

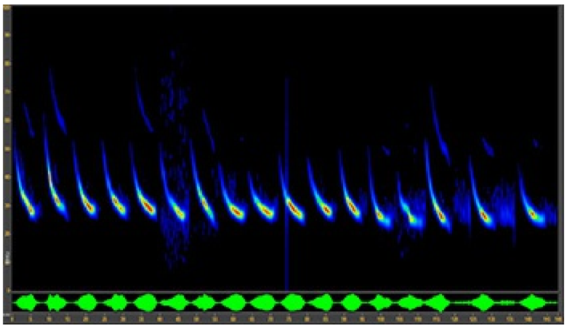

Leisler's Bat - call duration 3.8-4.3 ms

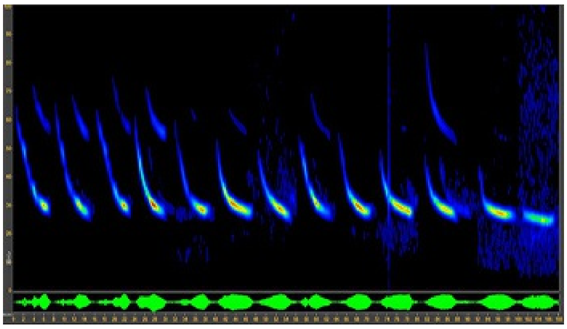

Common Noctule - call duration 4.4-4.9 ms

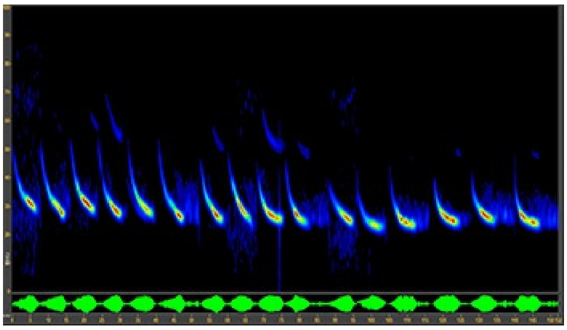

Leisler's Bat - call duration 4.4-4.9 ms

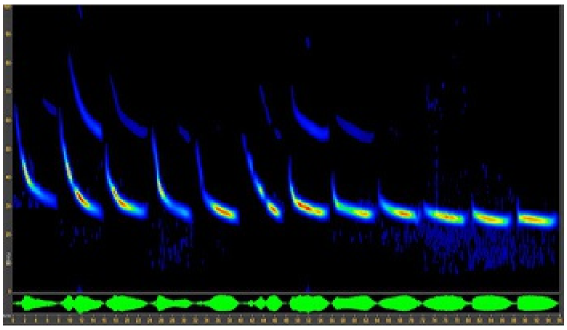

Common Noctule - call duration 5.0-5.9 ms

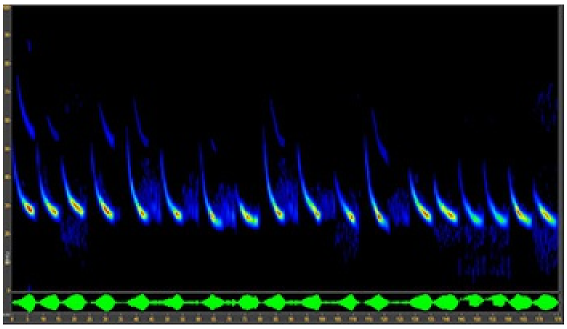

Leisler's Bat - call duration 5.0-5.9 ms

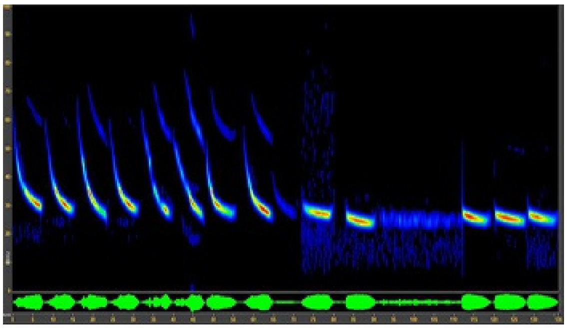

Common Noctule - call duration 6.0-6.8 ms

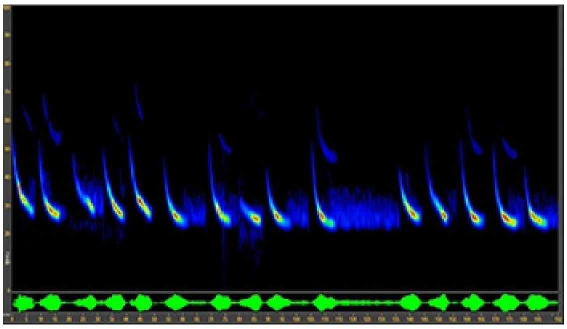

Leisler's Bat - call duration 6.0-6.8 ms

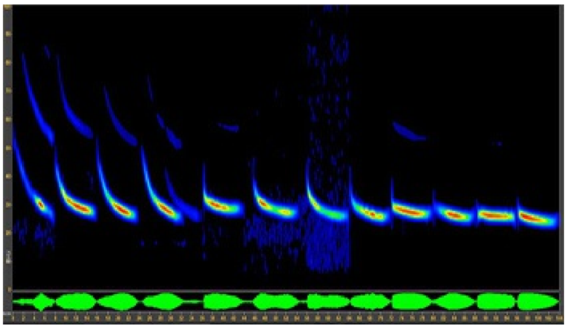

Common Noctule - call duration 6.9-7.2 ms

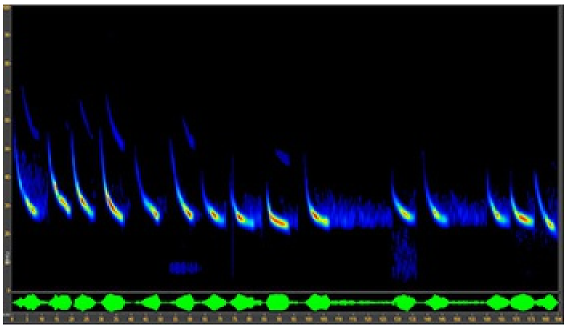

Leisler's Bat - call duration 6.9-7.2 ms

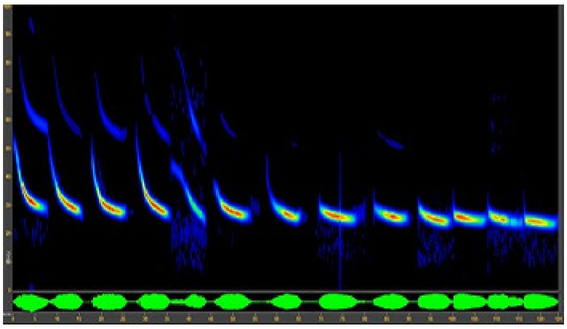

Common Noctule - call duration 7.3-7.6 ms

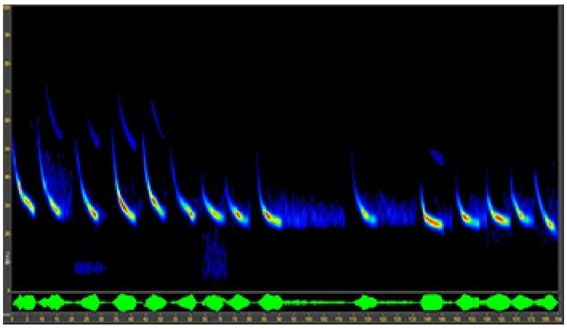

Leisler's Bat - call duration 7.3-7.6 ms

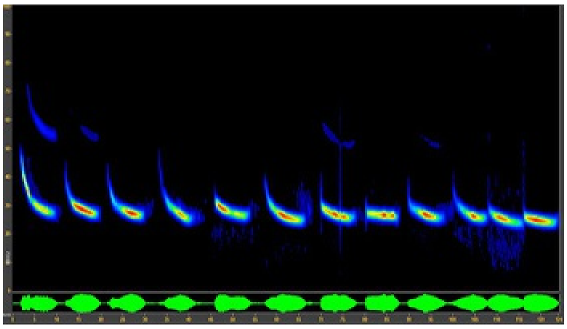

Common Noctule - call duration 7.7-7.8 ms

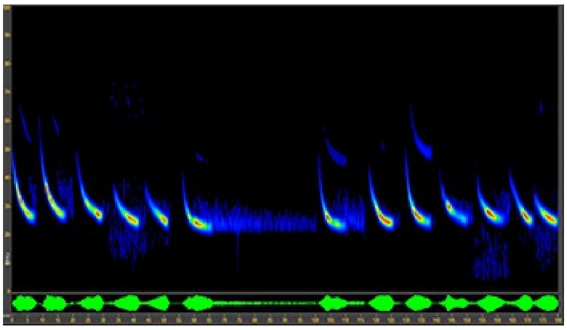

Leisler's Bat - call duration 7.7-7.8 ms

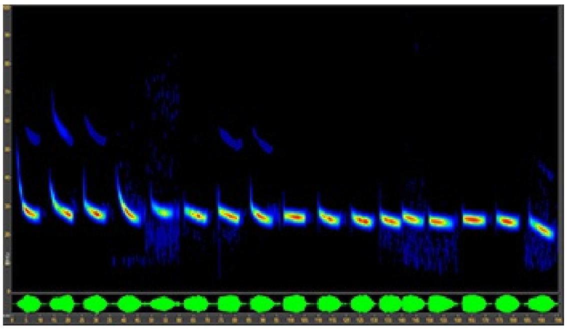

Common Noctule - call duration 7.9-8.0 ms

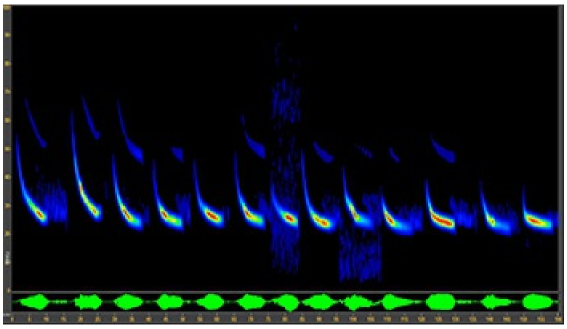

Leisler's Bat - call duration 7.9-8.0 ms

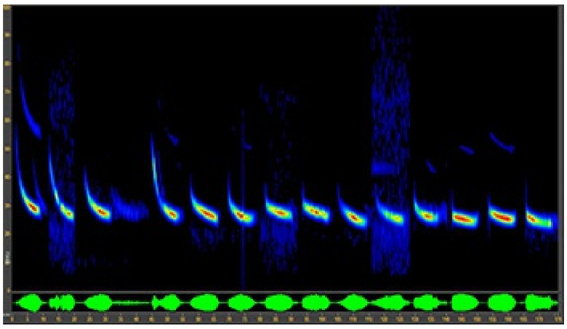

Common Noctule - call duration 8.1-8.3 ms

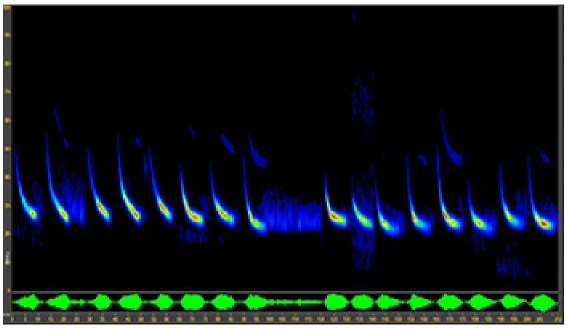

Leisler's Bat - call duration 8.1-8.3 ms

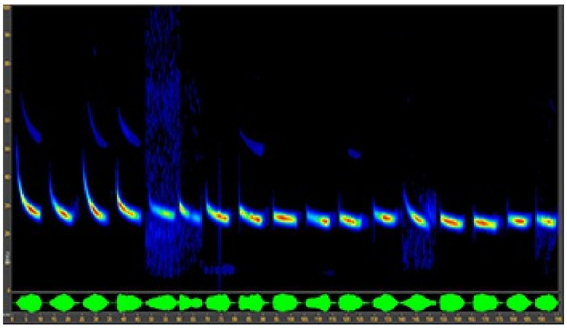

Common Noctule - call duration 8.4-8.5 ms

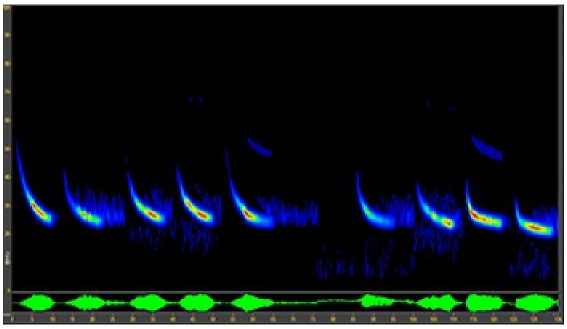

Leisler's Bat - call duration 8.4-8.5 ms

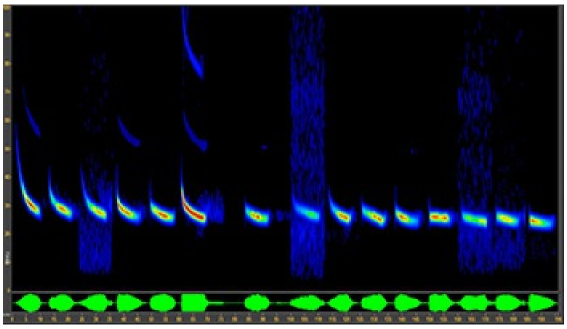

Common Noctule - call duration 8.6-8.7 ms

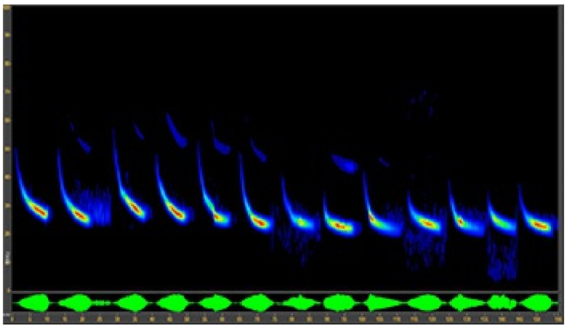

Leisler's Bat - call duration 8.6-8.7 ms

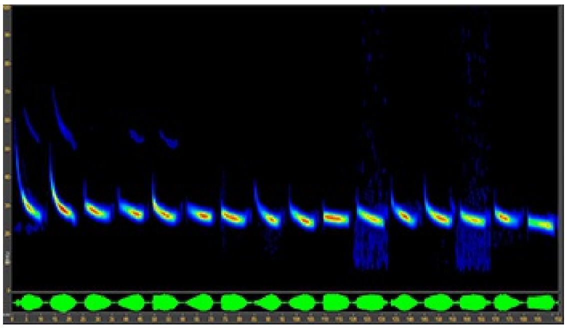

Common Noctule - call duration 8.8-8.9 ms

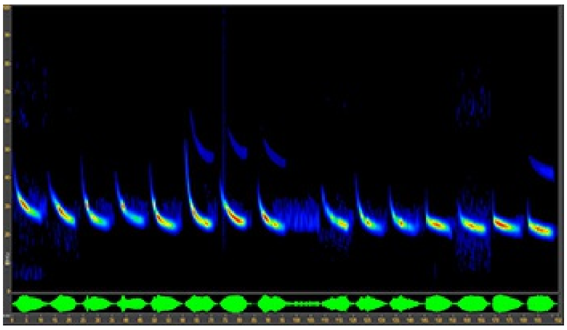

Leisler's Bat - call duration 8.8-8.9 ms

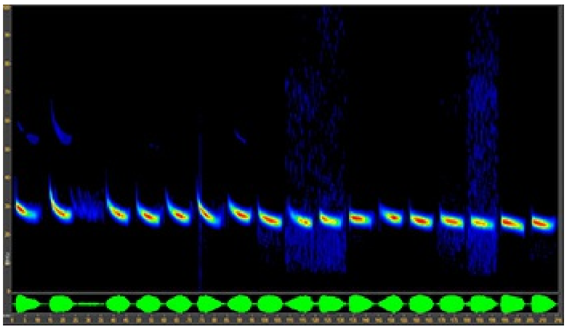

Common Noctule - call duration 9.0-9.1 ms

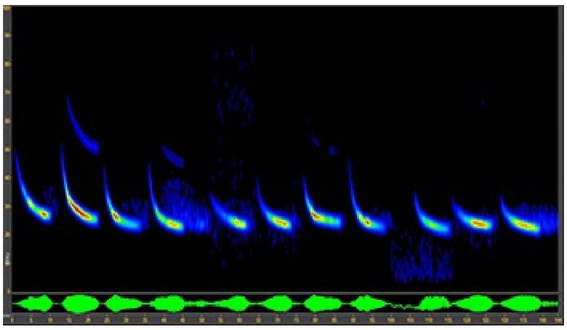

Leisler's Bat - call duration 9.0-9.1 ms

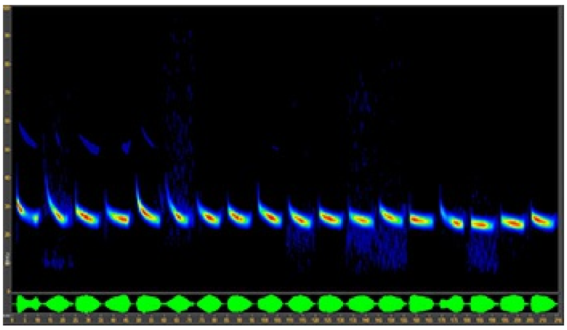

Common Noctule - call duration 9.2-9.3 ms

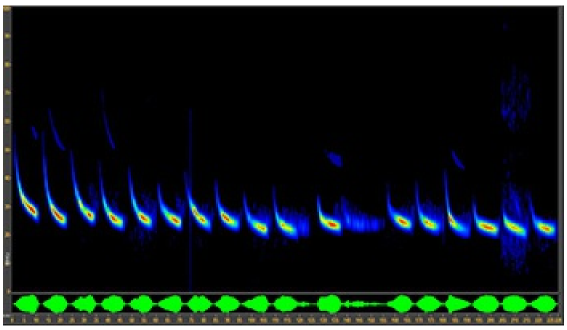

Leisler's Bat - call duration 9.2-9.3 ms

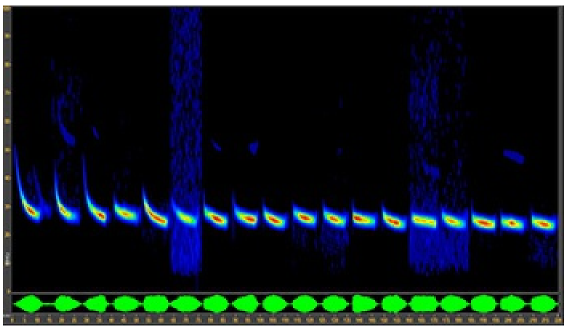

Common Noctule - call duration 9.4-9.5 ms

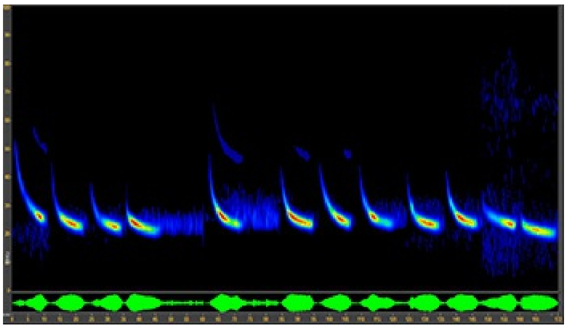

Leisler's Bat - call duration 9.4-9.5 ms

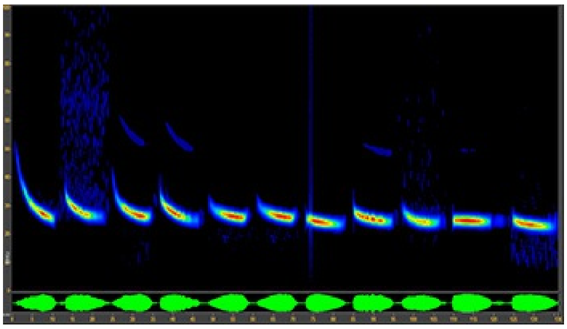

Common Noctule - call duration 9.6-9.7 ms

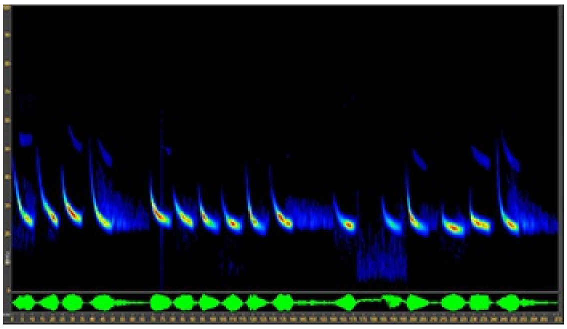

Leisler's Bat - call duration 9.6-9.7 ms

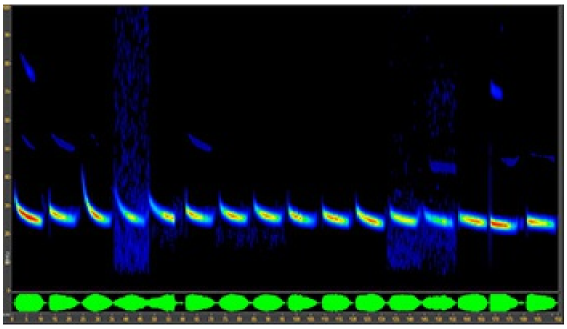

Common Noctule - call duration 9.8-9.9 ms

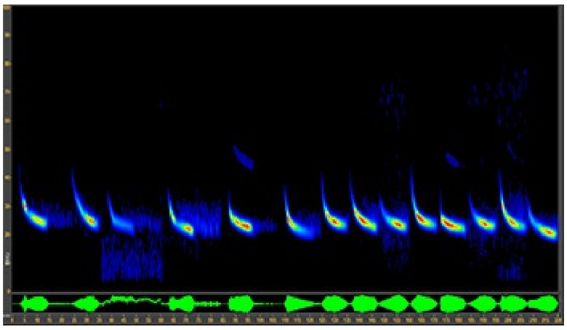

Leisler's Bat - call duration 9.8-9.9 ms

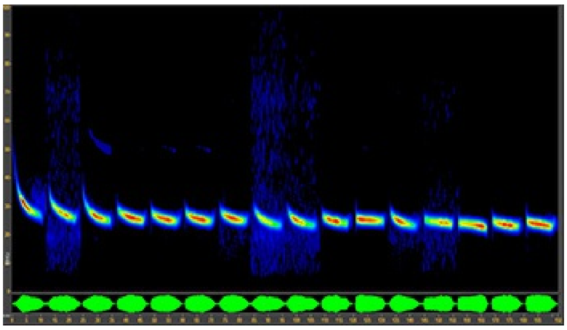

Common Noctule - call duration 10.0-10.1 ms

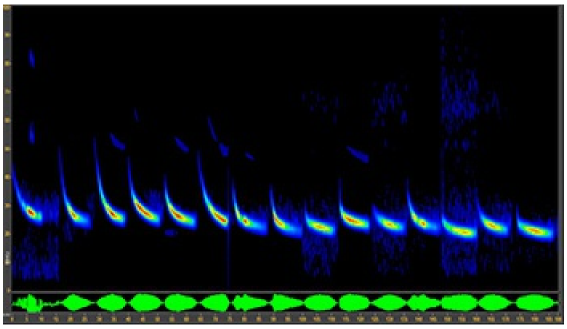

Leisler's Bat - call duration 10.0-10.1 ms

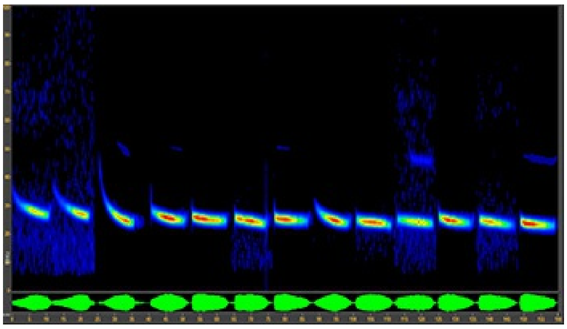

Common Noctule - call duration 10.2-10.3 ms

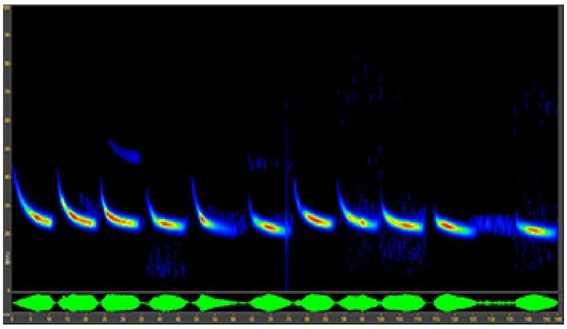

Leisler's Bat - call duration 10.2-10.3 ms

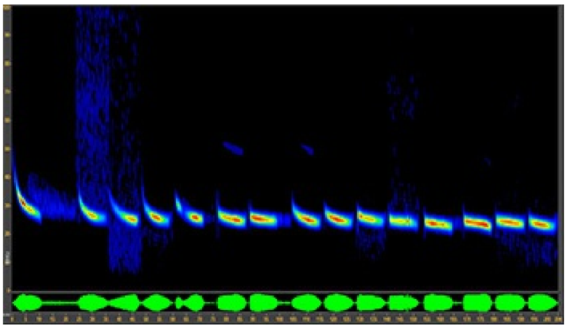

Common Noctule - call duration 10.4-10.5 ms

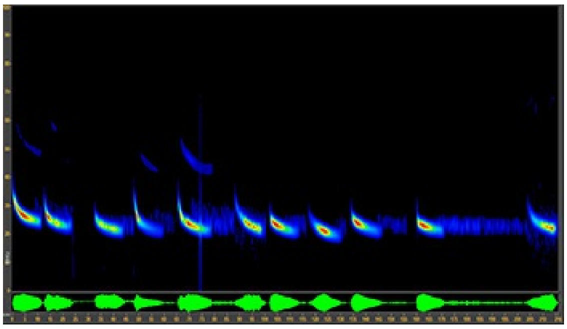

Leisler's Bat - call duration 10.4-10.5 ms

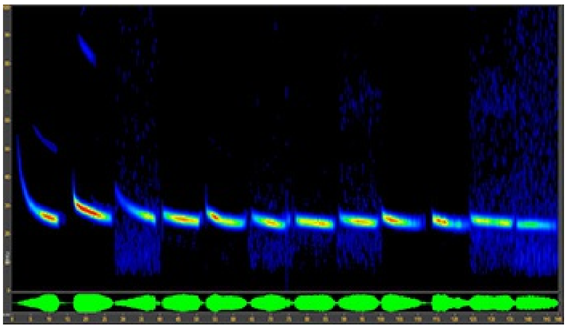

Common Noctule - call duration 10.6-10.7 ms

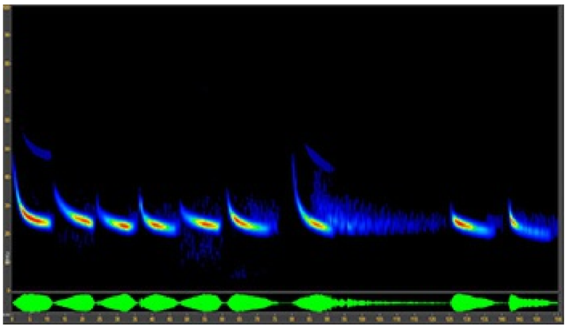

Leisler's Bat - call duration 10.6-10.7 ms

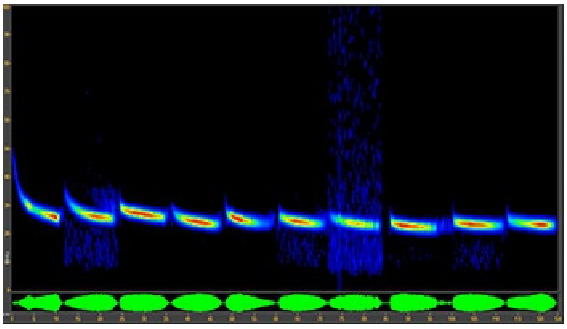

Common Noctule - call duration 10.8-10.9 ms

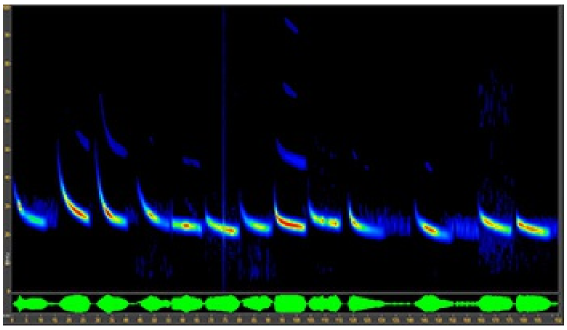

Leisler's Bat - call duration 10.8-10.9 ms

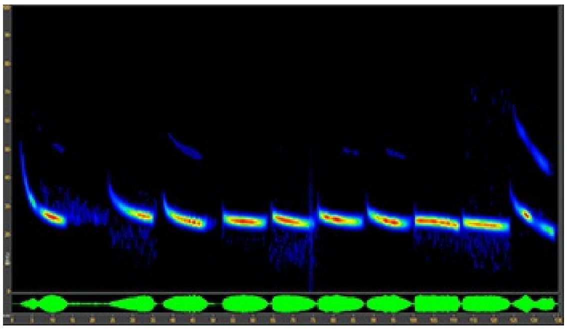

Common Noctule - call duration 11.0-11.1 ms

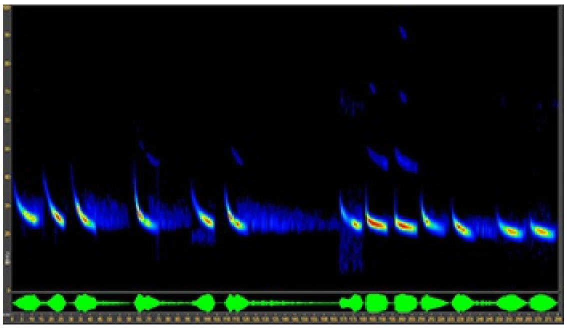

Leisler's Bat - call duration 11.0-11.1 ms

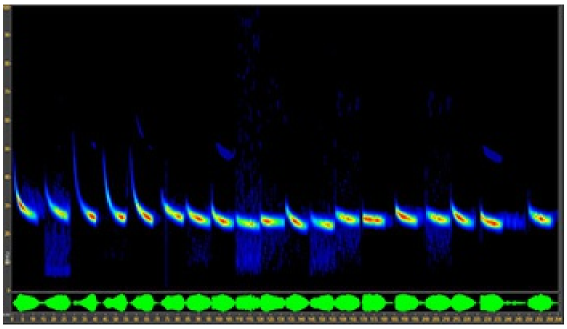

Common Noctule - call duration 11.2-11.3 ms

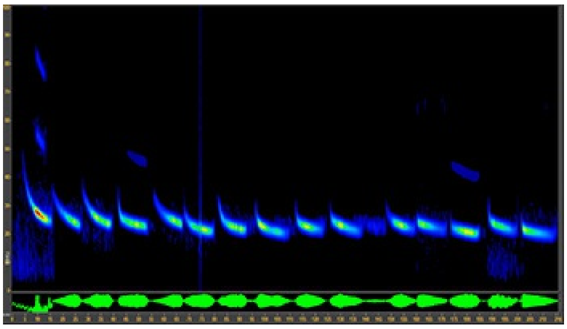

Leisler's Bat - call duration 11.2-11.3 ms

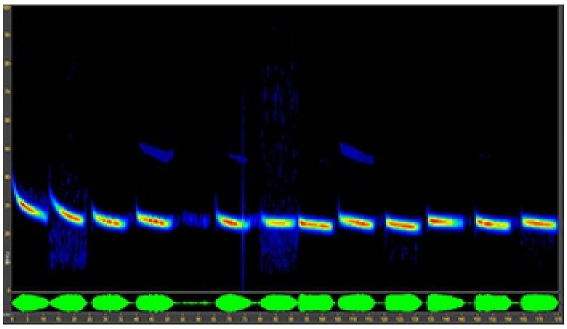

Common Noctule - call duration 11.4-11.5 ms

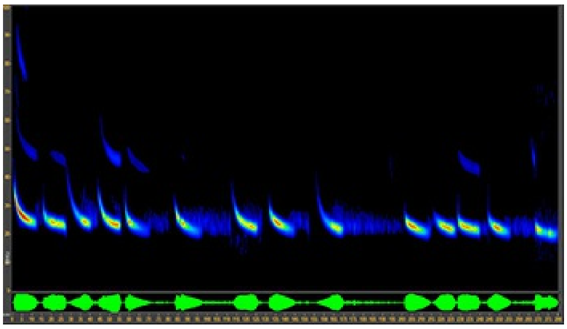

Leisler's Bat - call duration 11.4-11.5 ms


Common Noctule - call duration 11.6-11.7 ms

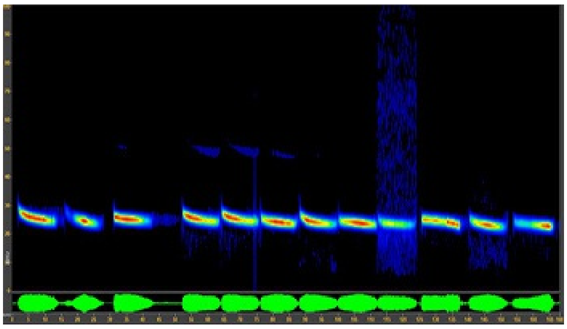

Leisler's Bat - call duration 11.6-11.7 ms


Common Noctule - call duration 11.8-11.9 ms

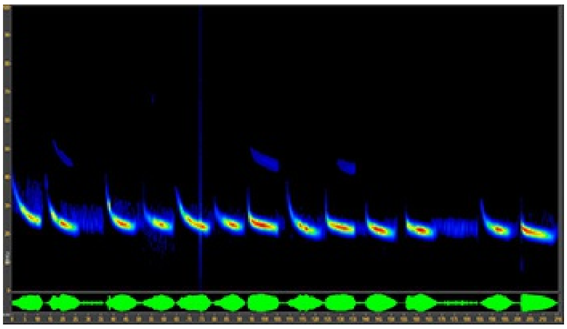

Leisler's Bat - call duration 11.8-11.9 ms



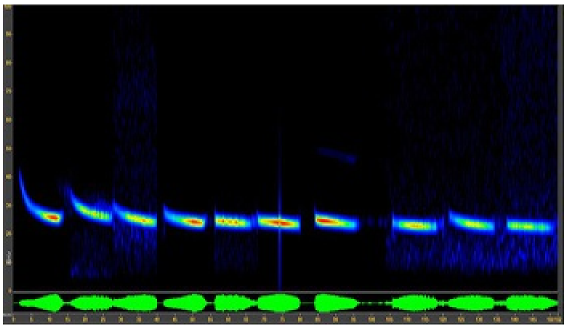
Common Noctule - call duration 12.0-12.2 ms



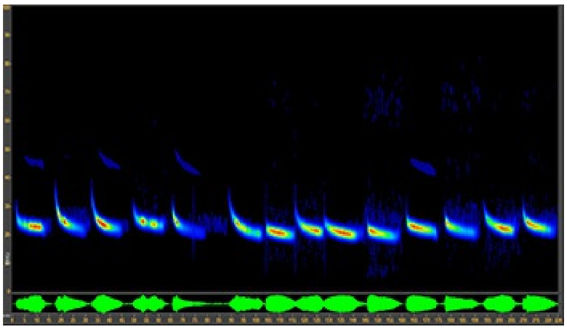
Leisler's Bat - call duration 12.0-12.2 ms



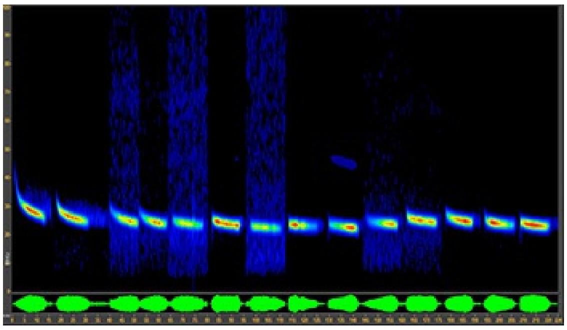
Common Noctule - call duration 12.3-12.4 ms



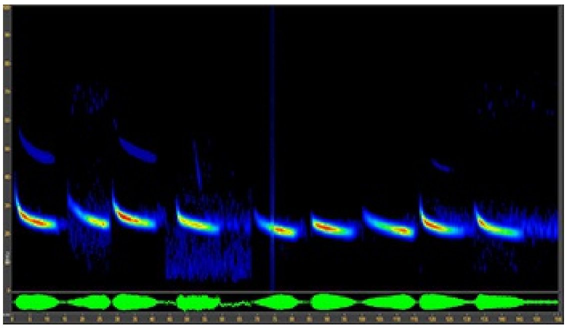
Leisler's Bat - call duration 12.3-12.4 ms



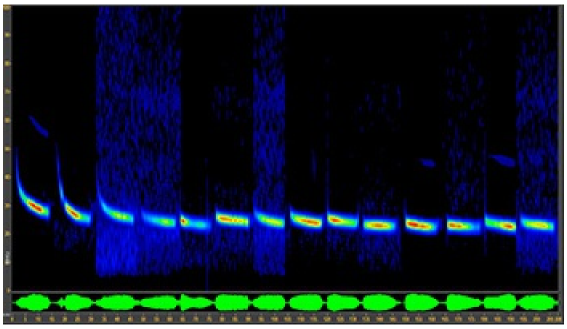
Common Noctule - call duration 12.5-12.7 ms



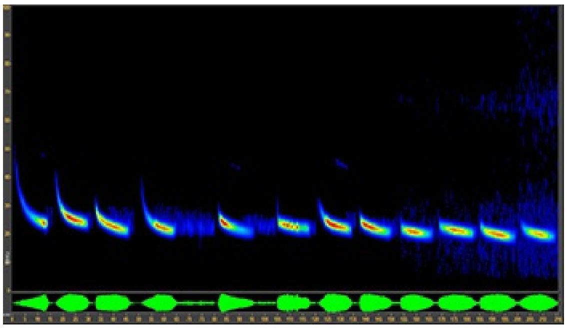
Leisler's Bat - call duration 12.5-12.7 ms



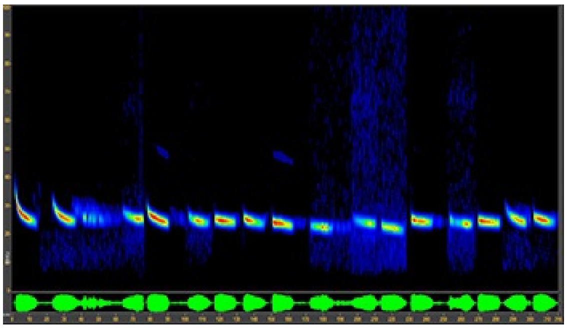
Common Noctule - call duration 12.8-12.9 ms



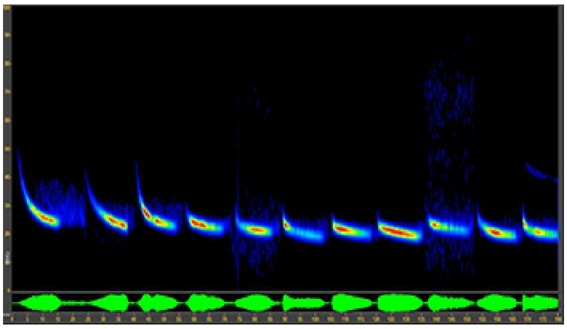
Leisler's Bat - call duration 12.8-12.9 ms

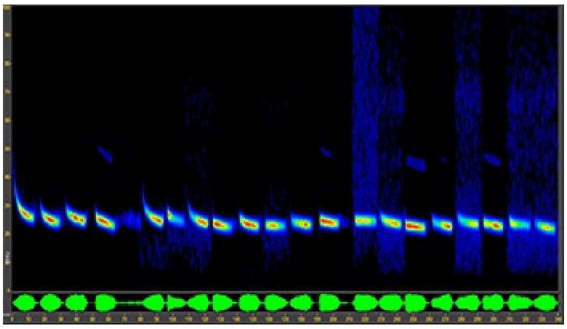


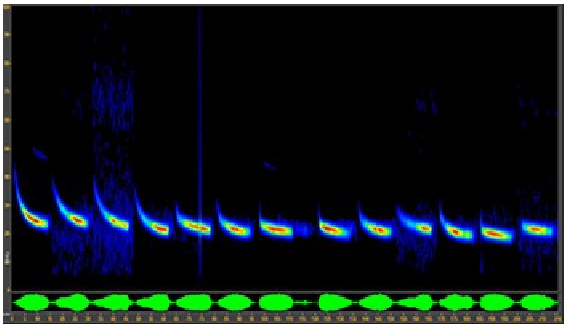
Common Noctule - call duration 13.0-13.1 ms

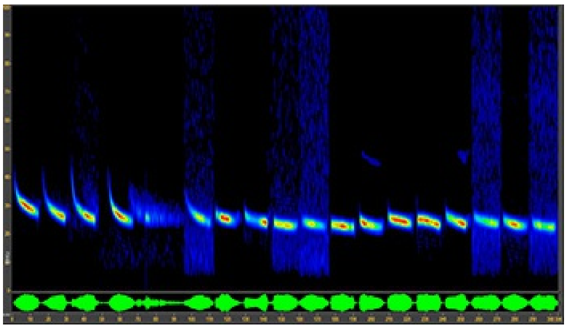


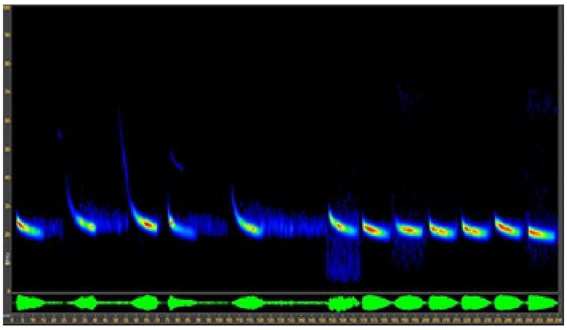
Leisler's Bat - call duration 13.0-13.1 ms

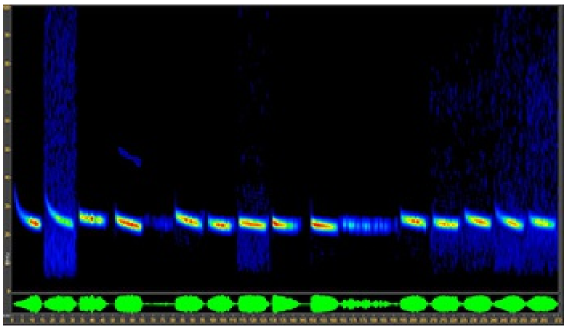

Common Noctule - call duration 13.2-13.3 ms

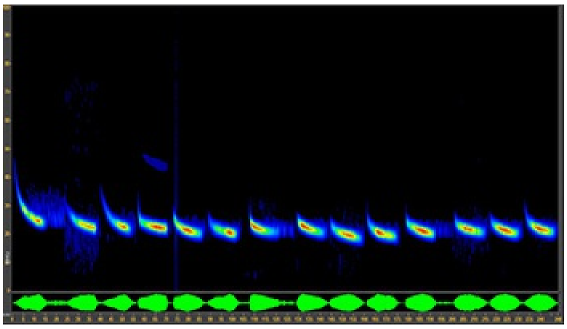

Leisler's Bat - call duration 13.2-13.3 ms

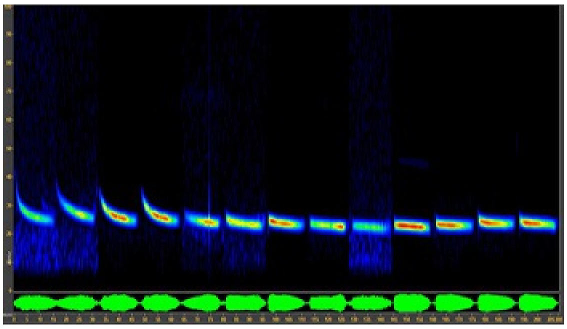

Common Noctule - call duration 13.4-13.5 ms

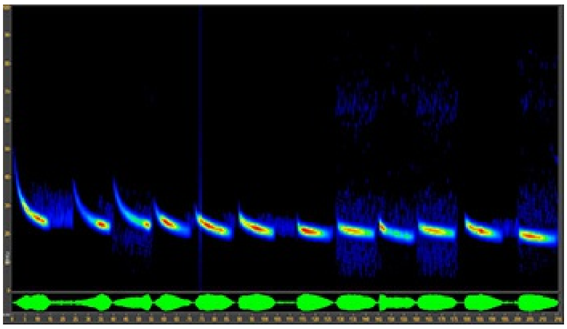

Leisler's Bat - call duration 13.4-13.5 ms

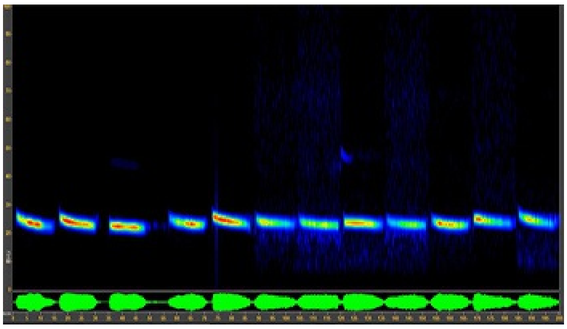

Common Noctule - call duration 13.6-13.7 ms

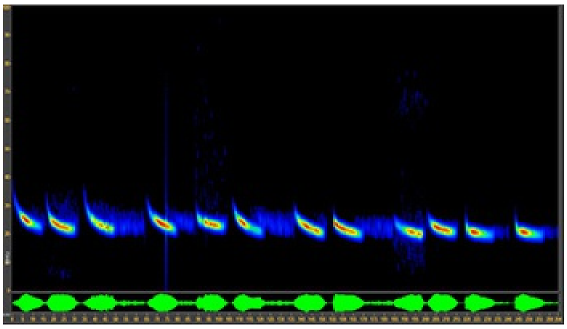

Leisler's Bat - call duration 13.6-13.7 ms


Common Noctule - call duration 13.8-14.0 ms

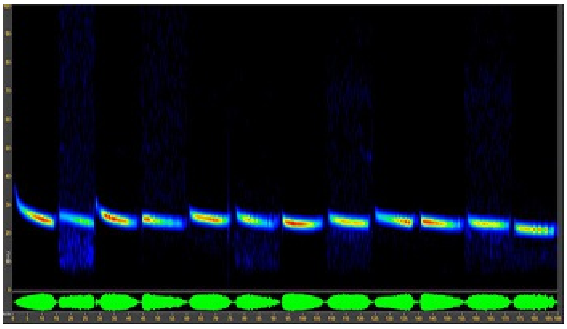

Leisler's Bat - call duration 13.8-14.0 ms


Common Noctule - call duration 14.1-14.3 ms

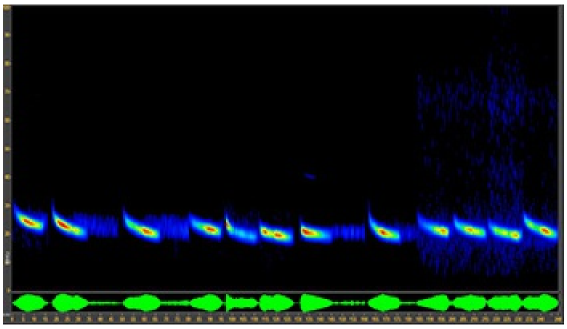

Leisler's Bat - call duration 14.1-14.3 ms



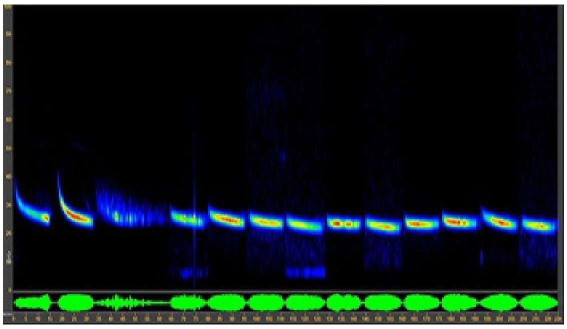
Common Noctule - call duration 14.4-14.5 ms



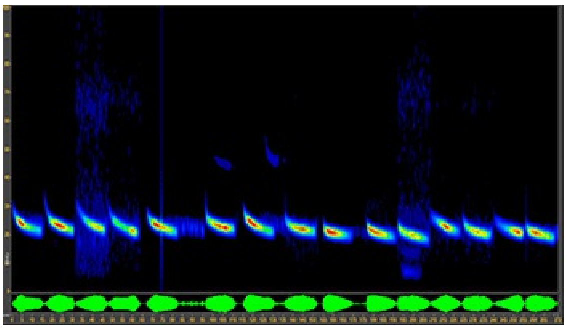
Leisler's Bat - call duration 14.4-14.5 ms



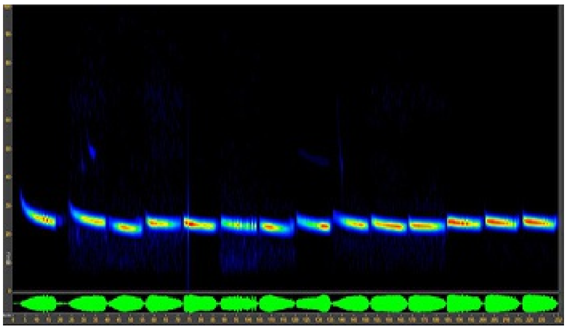
Common Noctule - call duration 14.6-14.8 ms



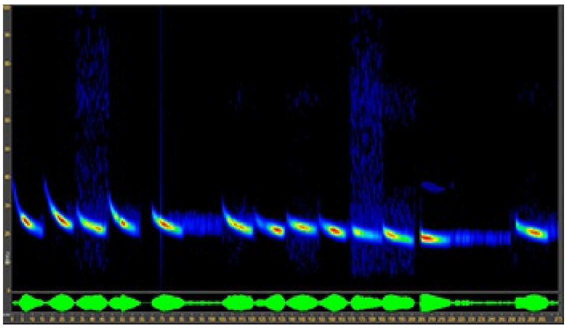
Leisler's Bat - call duration 14.6-14.8 ms



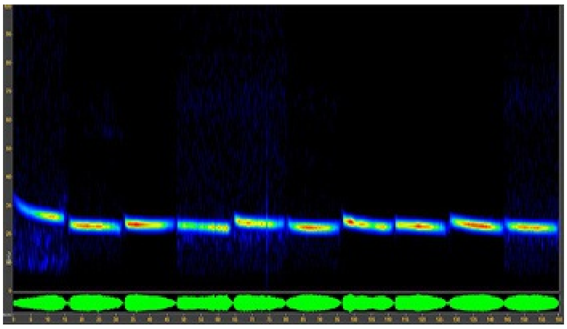
Common Noctule - call duration 14.9-15.1 ms



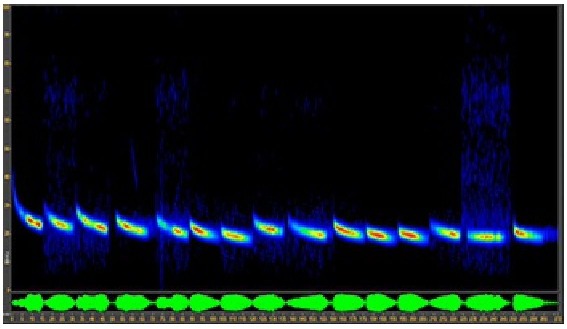
Leisler's Bat - call duration 14.9-15.1 ms



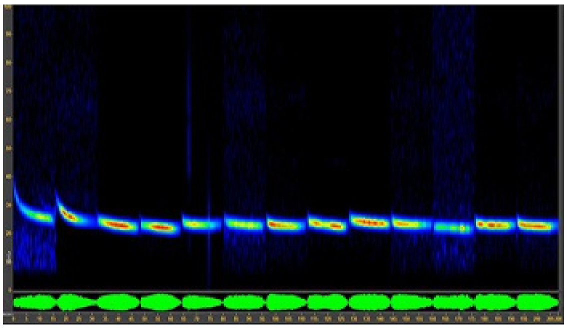
Common Noctule - call duration 15.2-15.3 ms



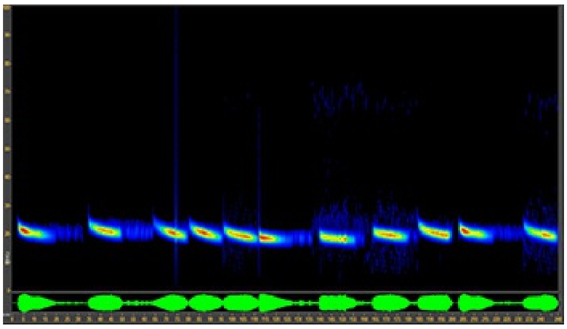
Leisler's Bat - call duration 15.2-15.3 ms

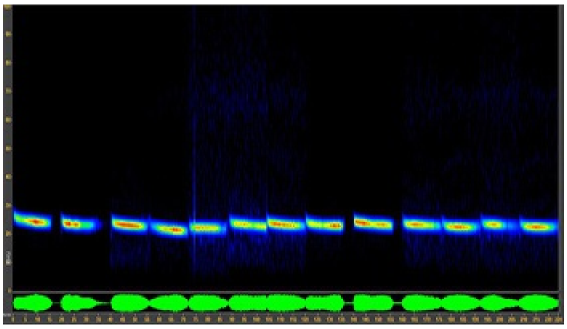


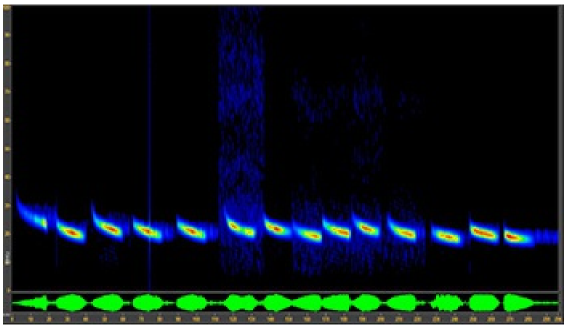
Common Noctule - call duration 15.4-15.7 ms

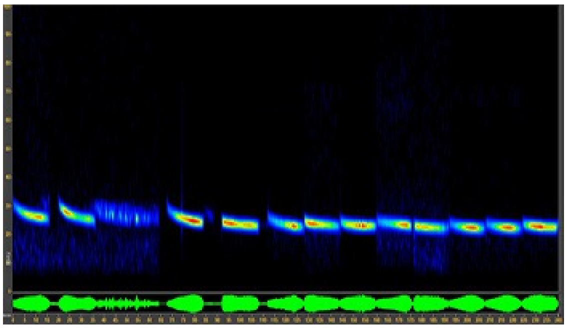


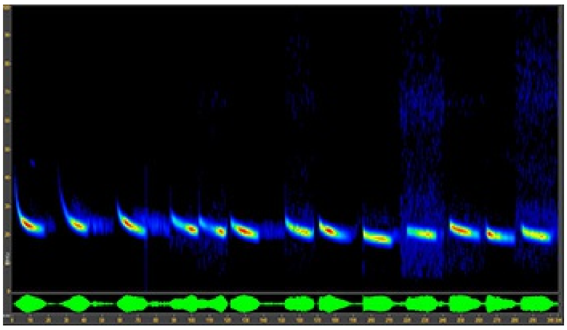
Leisler's Bat - call duration 15.4-15.7 ms

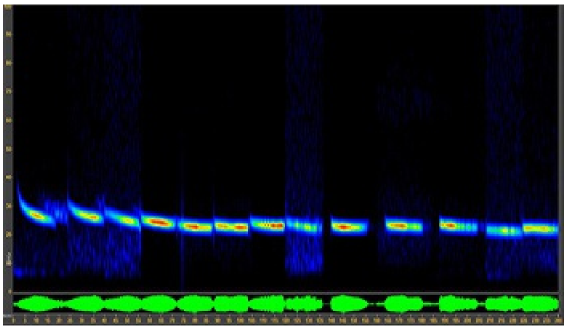

Common Noctule - call duration 15.8-16.0 ms

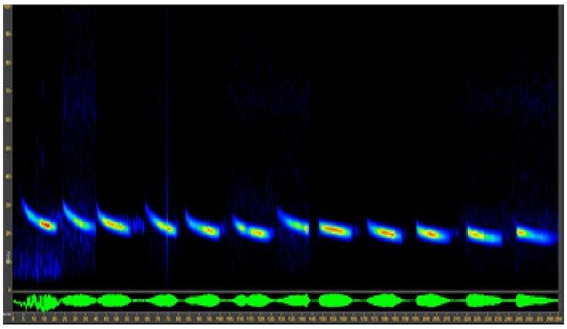

Leisler's Bat - call duration 15.8-16.0 ms

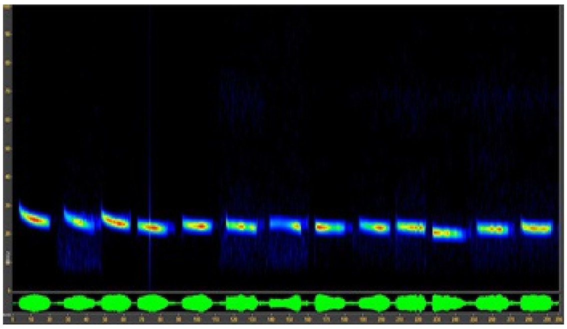

Common Noctule - call duration 16.1-16.3 ms

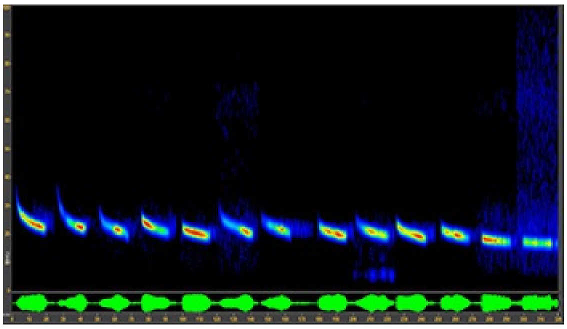

Leisler's Bat - call duration 16.1-16.3 ms

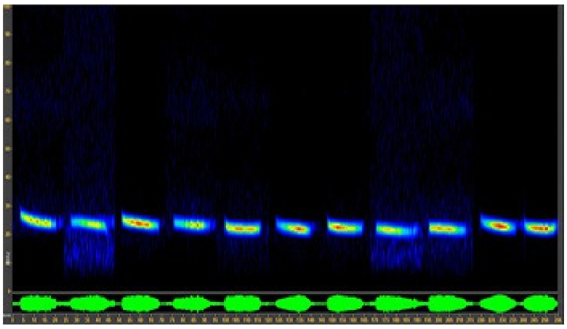

Common Noctule - call duration 16.4-16.6 ms

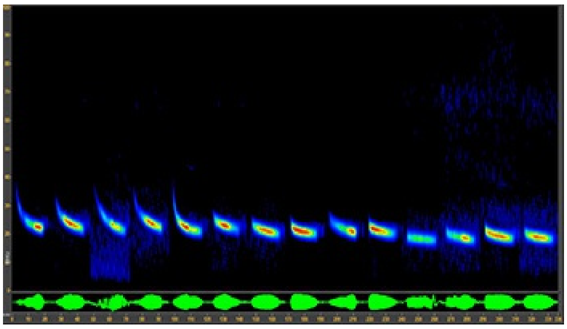

Leisler's Bat - call duration 16.4-16.6 ms

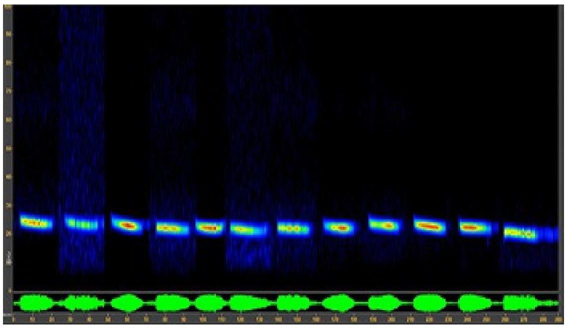

Common Noctule - call duration 16.7-17.0 ms

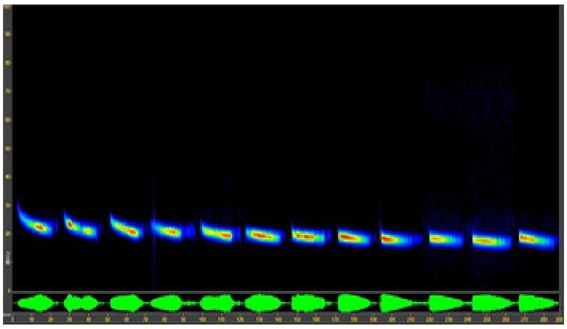

Leisler's Bat - call duration 16.7-17.0 ms

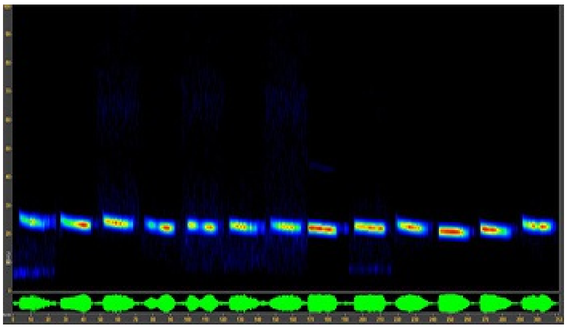

Common Noctule - call duration 17.1-17.2 ms

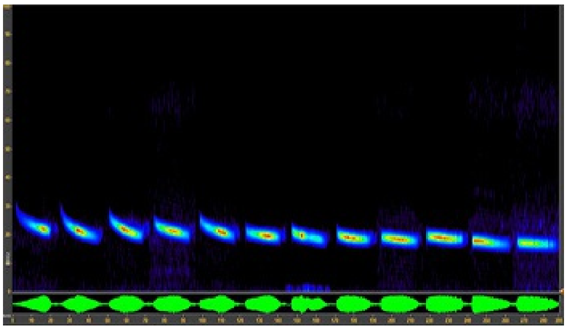

Leisler's Bat - call duration 17.1-17.2 ms

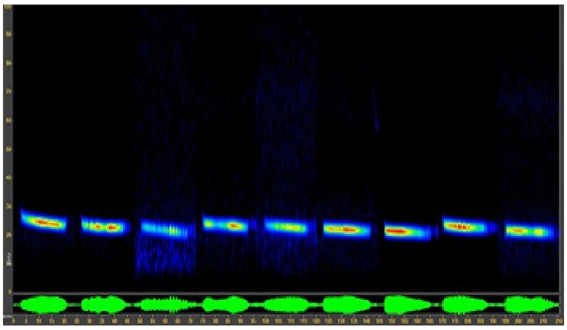

Common Noctule - call duration 17.3-17.4 ms

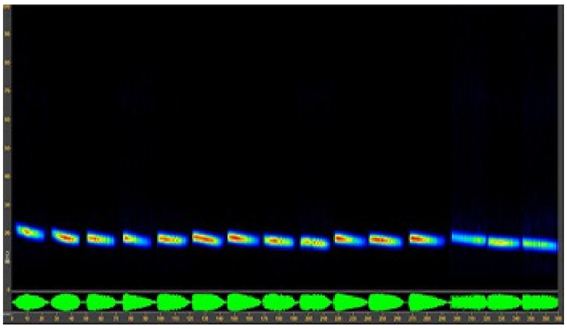

Leisler's Bat - call duration 17.3-17.4 ms

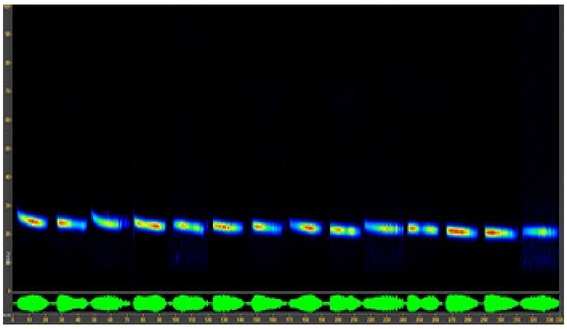

Common Noctule - call duration 17.5-18.2 ms

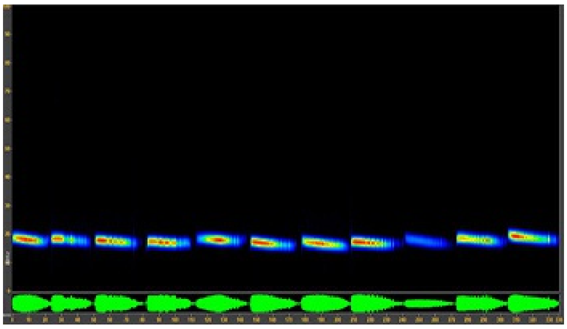

Leisler's Bat - call duration 17.5-18.2 ms


Common Noctule - call duration 18.3-18.7 ms


Leisler's Bat - call duration 18.3-18.7 ms


Common Noctule - call duration 18.8-24.0 ms


Leisler's Bat - call duration 18.8-24.0 ms


Common Noctule - call duration 24.1-31.7 ms

Leisler's Bat - no examples for this call duration

Images: Common Pipistrelle, by John Black; Barbastelle, by Chris Damant; Speckled Bush-cricket, by Mike Toms; Turtle Dove, by Edmund Fellowes.
Cover image: Turtle Dove, by Liz Cutting.

Farming in Project Landscapes – Turtle Dove Monitoring Project, 2024 Report

This report presents the main findings from survey work delivered using passive acoustic monitoring devices. Through the surveys that we support we aim to improve knowledge and understanding of species distribution and activity, covering a range of taxonomic groups, including birds, bats, small terrestrial mammals and insects. Through this approach we provide robust datasets that can be used to inform better decision-making processes.

The use of acoustic monitoring can be particularly useful for species that are rare or unexpected in the survey area, or that are traditionally regarded as too difficult to identify (such as bats in the genera *Myotis*, *Plecotus* or *Nyctalus*/*Eptesicus*). Where such species are recorded, we provide additional information to support their identification. A secondary aim of our work is to improve the wider understanding of species identification, inspiring a culture of critical thinking and the use of emerging technologies to improve the current knowledge base.

Ashton-Butt, A., Gillings, S., Thurston, L., Wells, F., Wetherhill, A. & Newson, S.E. 2024. Farming in Project Landscapes – Turtle Dove Monitoring Project, 2024 Report. *BTO Research Report* **774**, BTO, Thetford, UK.

ISBN 978-1-912642-71-7

9 781912 642717 >

BTO Birds Science People