Survey Guidelines – Social Calls of Bats (British Isles)

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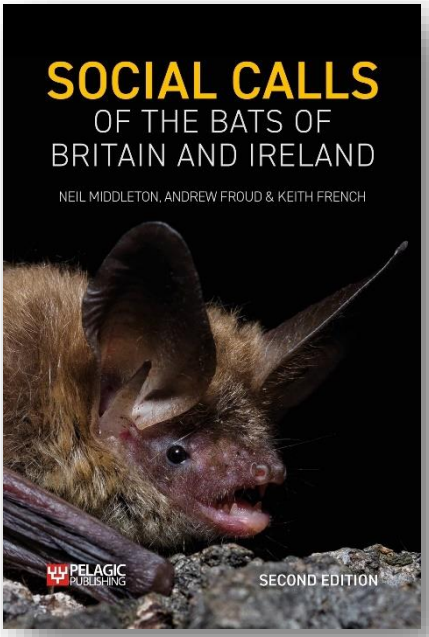

We produce here an adapted pdf version of relevant material originally created for, and available within the *Social Calls of the Bats of Britain and Ireland (2nd Edition)*, published by Pelagic Publishing (Exeter, UK) in 2022.

The purpose of this stand-alone document is to make these guidelines as accessible as reasonably possible, beyond those who have purchased the book. In doing so, however, there are certain aspects that could not be catered for, e.g. reproduction of the figures contained within the book. As such, please appreciate that what we are providing here, is with the best of intentions, and by all means should you wish to reference this work, irrespective of whether you purchased the book, you have our permission to do so.

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Survey Guidelines (Bat Social Calls)

Introduction

In so many aspects of bat-related work (and indeed for other species) there are documented guidelines that support effective methods to carry out surveys, in order to achieve sought after information. Here we provide guidelines for the gathering and interpretation of social acoustic information, reflecting the information contained elsewhere within the *Social Calls of the Bats of Britain and Ireland, 2nd Edition*. All of this with a view to improving the interpretation of behaviour, and, in the case of consultancy-lead projects relating to development activities, to make more informed decisions about any current or potential impacts occurring at a particular site, at a particular time.

These guidelines are written very much with a British Isles audience in mind, and as such may not be directly transferrable in whole or in part, for any or all species, to other countries in Europe. Having said this, those in areas beyond the scope of this document may find such approaches appropriate, after taking account of any local differences in behaviour, and what is suggested here should be adapted accordingly.

What we have produced is designed to be used purely in relation to collecting and interpreting social calls of bats, and to be read in conjunction with material contained elsewhere in the book (e.g. Chapters 6 and 8). As well as this, other survey guidelines exist in relation to many other aspects of bat work, for example; *Bat Surveys for Professional Ecologists: Good Practice Guidelines* (Collins, 2016). If using a combination of approaches taken from different sources, we would suggest that, first and foremost, common sense, based on a good level of knowledge relating to the matter in question, should always prevail. Guidelines are only guidelines after all, and therefore should not be used as a reason against adopting a better (or equally suitable) approach when experience is telling you that a different course of action for any particular species, or at any specific site, may be equally or more effective. Conversely, as is always the case, less experienced people should seek input from more experienced people when any doubt exists as to how to proceed effectively, safely and appropriately at an individual case level.

Benefits and approach

Looking at things in a logical order, we start off with Table 1.1, which outlines areas where the gathering of social calls may be helpful in identification to species level, either in conjunction with, or in the absence of, echolocation sequences.

Table 1.2 then considers each genus and determines the likely behavioural/site use information that may be obtained if social call activity is recorded. Here we also give an opinion on the most suitable placement of equipment in order to gather such data on a genus by genus basis. The table also cross-references each of the groups to any specific information (available in the Appendix) that should be taken account of, over and above the seasonal survey methods described in Table 1.3. In order to support the information given in Tables 1.1 to 1.3 we have included examples of survey equipment positioning (Figures 1.1 and 1.2).

In Table 1.4 we outline some other considerations to bear in mind while carrying out such surveys. Many of the points made in Table 1.4 are based on the experiences of the authors (and others) who have on occasions had to learn the hard way, and we very much hope that by providing these further thoughts we will help to reduce the risk of errors or wasted effort occurring during the survey activities of others.

Finally, we offer an example case study of how the gathered data could be used to establish approximate locations of mating roosts, in conjunction with the number of active territories likely to be present.

Table 1.1 Usefulness in gathering and interpreting social call data, relative to the presence or absence of other acoustic data (i.e. echolocation). Areas of greatest benefit are shaded.

Genus	Usefulness in ID to species level in conjunction with echolocation data	Usefulness in ID to species level in the absence of echolocation data
Rhinolophus	Not of any great benefit, as echolocation is easily identifiable to species level.	Social calls rarely recorded away from roosts. Most social call activity recorded within roost settings, and as such echolocation data would normally be available.
Myotis	Echolocation alone is often difficult to identify diagnostically to species level. Presence of species-specific social calls can provide considerably more confidence in species identification.	Very useful away from roosting locations, as on occasions social calls may be evident without echolocation (or with poorly recorded, unworkable sequences), and therefore species identification can often be confirmed, or narrowed down.
Nyctalus	Echolocation alone in edge/closed settings is often difficult to identify diagnostically to species level. Presence of species-specific social calls provide considerably more confidence in species identification.	Certain social calls may be evident without echolocation information being available (e.g. male advertisement calls). As such, social calls can prove very useful in confirming identification to species level.
Vespertilio	Often essential, as echolocation is often difficult to safely separate from some other species (e.g. Leisler's bat).	Very useful, as male advertisement calls are diagnostic and often recorded without echolocation being present.
Pipistrellus	**Soprano pipistrelle/Common pipistrelle** Usually not required as echolocation can be safely allocated to species level. In areas of echolocation overlap, can be beneficial in confirming species. **Nathusius' pipistrelle/Kuhl's pipistrelle** Essential where distribution overlaps, as echolocation calls for these can be similar, and thus often not safely separated.	Very useful, as Type D calls can be emitted without echolocation being produced (or evident from recordings). Type D calls can often be allocated to species level, without the need for echolocation to be recorded, especially so for Nathusius' pipistrelle and Kuhl's pipistrelle.
Eptesicus	Species-specific social calls are not commonly encountered in flight and away from known roosts. If calls are recorded, then they can help in differentiating this species from *Nyctalus* when bats are in edge/closed environments.	Not recommended as only limited data available, and it is rare for currently known diagnostic social calls to be recorded without echolocation being present.
Plecotus	Echolocation may be faint/heavily attenuated, and not diagnostic. Social calls would often give confidence that *Plecotus* was present, even to species level (i.e. brown long-eared bat) where grey long-eared is not thought to be present.	Very useful, as certain social calls can be allocated safely to *Plecotus*, and in many areas where grey long-eared bat does not occur, therefore as a consequence, allocated safely to brown long-eared bat.
Barbastella	Usually not required as echolocation can often be safely allocated to species level.	Not recommended as only limited data available.
Important note: The information provided above is generalised, and based on normal, expected behaviours for each of the groups. Exceptions to what is shown may occur, and you should always bear in mind that our knowledge and understanding of all aspects of bat acoustics is still developing, and over time elements of what is described here may need updating.		

Table 1.2 Ability to determine site use for genus through the gathering of social call data, along with placement of survey equipment and species-specific considerations.

Genus	Specific site use determinable through the gathering of social calls	Most useful placement of survey equipment? (See Table 1.3)	Specific survey methods available
Rhinolophus	Presence of roosting bats Maternity roost Mating roost	Roost (internal)*	See Appendix, Table A.1, in conjunction with Table 1.3
Myotis	Presence of roosting bats Autumn swarming behaviour, also leading to potential hibernation sites Mating roost (some species)	In flight – away from roost* Roost (internal)* Roost (external)*	See Appendix, Table A.2, in conjunction with Table 1.3
Nyctalus	Presence of roosting bats Mating roost/territory	In flight – away from roost* Roost (external)*	See Appendix, Table A.3, in conjunction with Table 1.3
Vespertilio	Presence of roosting bats Mating roost/territory	In flight – away from roost* Roost (external)*	See Appendix, Table A.4, in conjunction with Table 1.3
Pipistrellus	Presence of roosting bats Mating roost/territory	In flight – away from roost* Roost (external)*	See Appendix, Table A.5, in conjunction with Table 1.3
Eptesicus	Presence of roosting bats Unable to allocate current data to prescribed behaviours/site use	In flight – away from roost* Roost (external)*	See Appendix, Table A.6, in conjunction with Table 1.3
Plecotus	Presence of roosting bats Mating roost Autumn swarming behaviour, also leading to potential hibernation sites	In flight – away from roost* Roost (external)* Roost (internal)*	See Appendix, Table A.7, in conjunction with Table 1.3
Barbastella	Presence of roosting bats Autumn swarming behaviour, also leading to potential hibernation sites	Roost (external)*	See Appendix, Table A.8, in conjunction with Table 1.3

*Refer to Table 1.3 for a full definition of these terms

Important notes:

(i) When carrying out other recognised survey methods, it may be desirable to consider how to adapt the approach in order to cater for the potential presence of social call behaviour.

(ii) The regular emission of social calls from bats 'In flight/away from roost' overnight or at dawn at a discrete location, can often be indicative of a roosting location in the vicinity.

(iii) Presence of roosting bats could also, in some circumstances, be established through encountering 'roost chatter', albeit such call sequences on their own are usually unlikely to help in identification to species level.

Table 1.3 Survey methods relating to the collection of social call data and establishing associated behaviour.

Ideal survey period (shaded) **Shaded inserts:** **Red: Maternity** **Blue: Mating**	**In flight – away from roost** **(Survey equipment placed away from known roosts)**	**Roost (external)** **(Survey equipment placed outside, within acoustic range of roost)**	**Roost (internal)** **(Survey equipment placed inside roost)**
March **April** **May** **June** **July** **August** **September** **October** **November**	Appropriate for short-term (e.g. single session) or long-term (multiple nights) survey periods **Equipment:** Handheld detector: Yes Static detector: Yes Infrared camera: No Set up equipment in suitable location **Weather conditions:** Dry / >8°C / Wind <F3 **Start time:** 30 mins after sunset **End time:** 180 mins after sunset, or continuing thereafter, until no later than sunrise	More appropriate for short-term (e.g. single session) surveys **Equipment:** Handheld detector: Yes Static detector: Yes Infrared camera: Yes Set up equipment in suitable location relative to roost access points (see Figure 1.1) **Weather conditions:** Dry / >8°C / Wind <F3 **Start time:** 30 mins before sunset (120 mins after sunset for autumn swarming) **End time:** 180 mins after sunset (300 mins after sunset for autumn swarming), or continuing thereafter, until no later than 30 mins after sunrise Best results often obtained during the night, or at dawn, when bats return to roost	More appropriate for long-term (multiple nights) survey periods **Equipment:** Handheld detector: No Static detector: Yes Infrared camera: ?? Set up equipment in suitable area within roost (see Figure 1.2) **Weather conditions:** Not applicable **Start time:** 60 mins before sunset **End time:** 60 mins after sunrise
December **January** **February**	Not normally effective as bats would be expected to be hibernating within a roost	Not normally effective as bats would be expected to be hibernating within a roost	Careful consideration required due to issues regarding disturbance during hibernation Long-term static deployment only, activated throughout 24 hour period

Notes

(i) Double check genus-specific survey methods (see Table 1.2 and Appendix).

(ii) Infrared/thermal imaging technology can be very useful for establishing precise roosting locations, number of bats and specific calls recorded relative to behaviour.

(iii) Bat roosts are protected from disturbance, and as such you should always consider the legal and licensing implications when carrying out surveys within or in close vicinity to roosts.

(iv) Any survey activity carried out within or near a roosting location may impact upon natural behaviour. You should always seek to carry out activities in such a way whereby what you are recording/observing is unaffected by your activities.

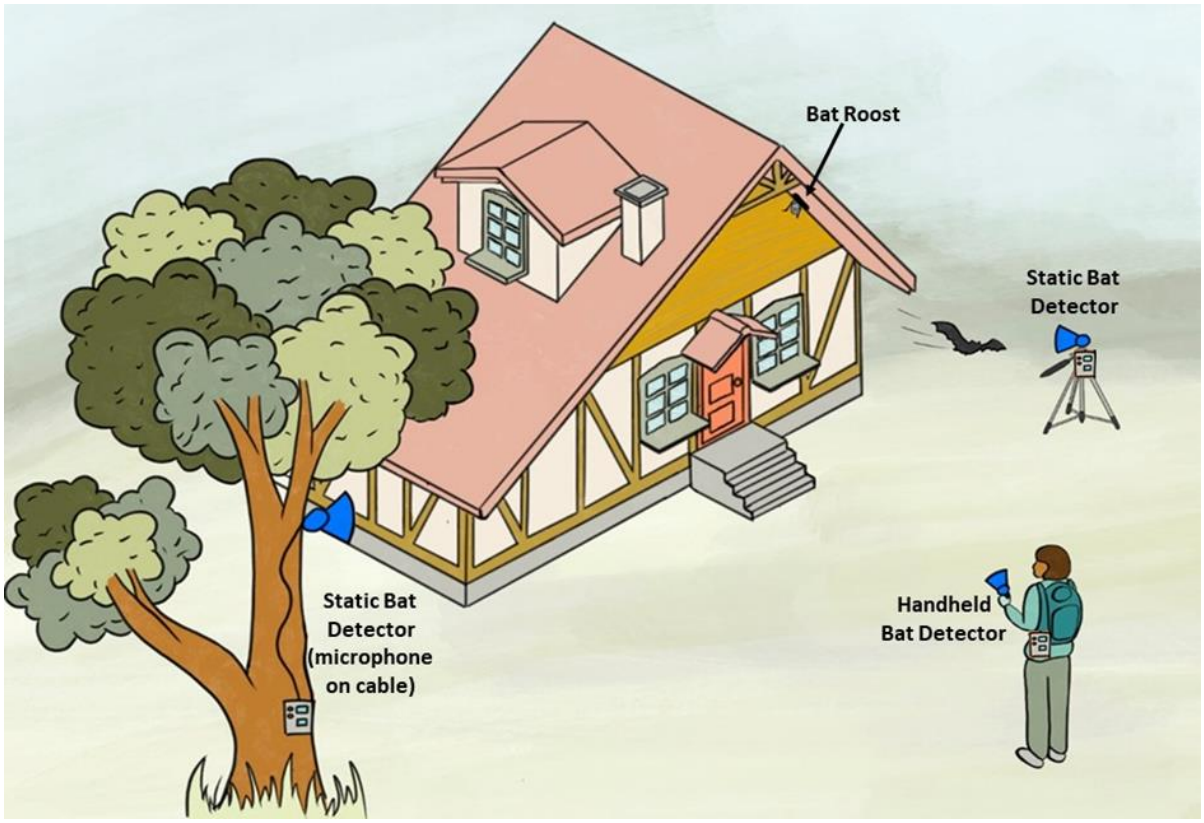

Figure 1.1 Example equipment layout for recording social calls and associated behaviour, immediately external to roost locations (artwork by A. Middleton, 2021).

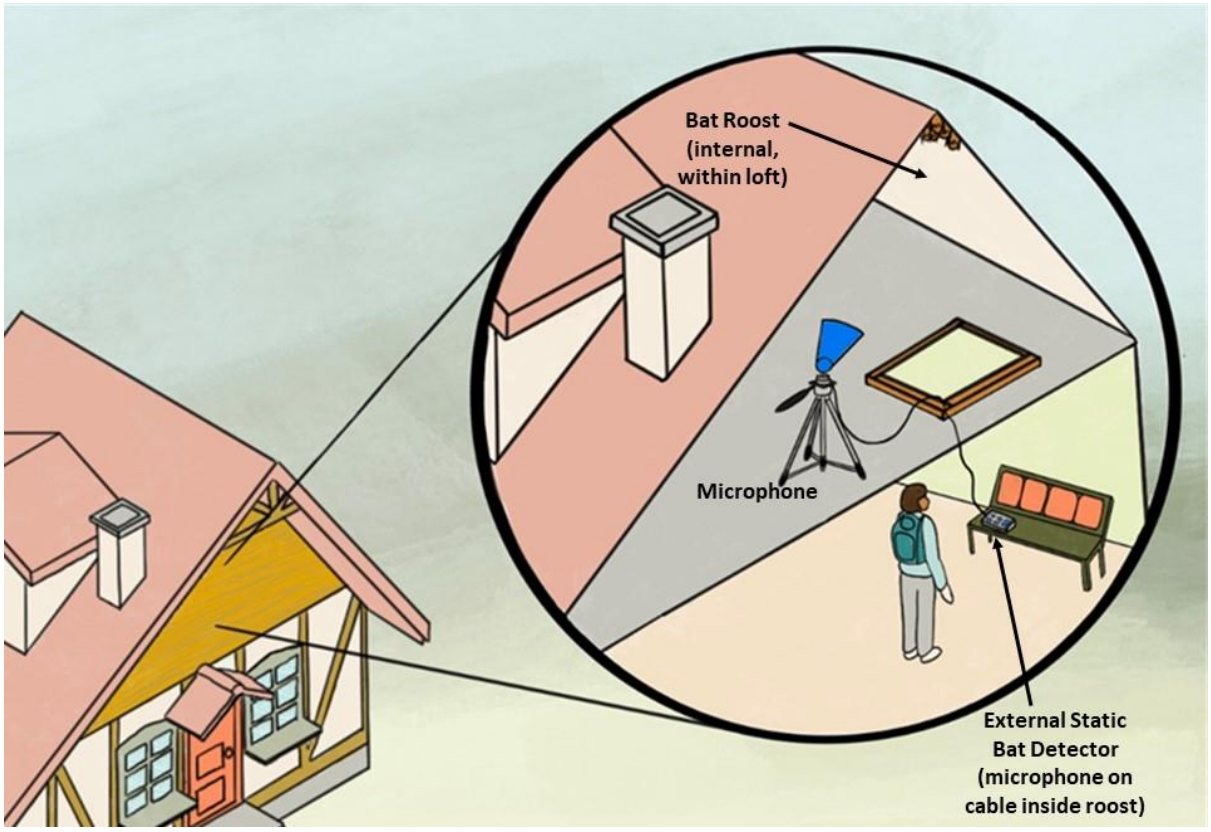

Figure 1.2 Example equipment layout for recording social calls and associated behaviour within roosts (artwork by A. Middleton, 2021).

Table 1.4 Checklist of useful additional considerations.

Equipment	Additional considerations
Handheld devices Full spectrum or Time expansion (×10) system recommended for social calls	Surveyor should be positioned quietly, and settled at a distance which is within acoustic range, but not directly in front of the roost access point. Position detector away from (>2 m) reflective surfaces, in order to minimise occurrence of echoes/distortion, and thus improving recording quality. Social calls are often relatively louder than echolocation, meaning that sensitivity thresholds may benefit from being adjusted, so as to improve recording quality. Torchlight should be minimised, and not directed towards roost features or bats. When bats are active outside the roost, disturbance should be minimised and preferably eliminated (e.g. no noise or artificial light). Good note taking, in real time, is beneficial. A dictaphone (or detector that allows voice notes to be recorded) allows this to be done without taking attention away from activity. Ensure all equipment is calibrated accurately in terms of time and date, so as to aid future cross-referencing of data/notes.
Static devices Full spectrum system recommended for social calls	If only one machine, then position it within acoustic range of roosting location. If more than one machine, consider line of acoustic sight, allowing for the different positions and angles they may be able to record from. A machine placed in adjacent suitable habitat may also be beneficial. Position detector microphone away from echo reflective surfaces. If placed within roost, consider having a microphone inside, separate from the detector outside (e.g. beneath loft hatch), so that batteries/SD cards can be changed without disturbance. This means that activity can be checked regularly without entering the roost and causing unnecessary disturbance. Also, for some systems it may be possible that set-up can be done using Bluetooth, Wi-Fi or satellite link so that status/activity can be monitored remotely. Carry out ultrasonic noise audit of site during equipment set-up in order to reduce risks of other noise sources (e.g. electrical noise) affecting recording quality etc. Consider security of devices, weather impacts and other sources of damage.
Infrared camera system **Thermal imaging camera system**	Consider specific points raised in *Infrared Survey Guidelines* (R. Crompton, in prep., anticipated in 2022) and *Thermal Imaging Survey Guidelines* (Fawcett Williams, 2020). Camera set at an appropriately productive angle to anticipated activity. Use additional support lights with infrared systems, and consider positioning these independent of camera location for better illumination and interpretation of results.
Other useful support equipment	Torch and headtorch (including spare batteries). Tripods for detector(s), camera(s), infrared spot light(s). Dictaphone, spare batteries, spare battery packs, extra pre-formatted memory cards. Trail camera – a good quality one with fast trigger reaction may be useful within roosts, or for bats returning to roosts. Weather station, or at very least basic notes on weather conditions (temperature, moon phase, cloud cover, precipitation, wind speed).

Case Study - Establishing and documenting mating roost locations and territorial boundaries

Certain genera have mating-related behaviour that lends itself nicely towards establishing the number and vicinity of mating roosts, as well as territorial boundaries possibly being defended. In our area, the genera and species (see Table 1.5) best suited for attempting to establish such information, are some of those displaying resource defence polygyny. This is due to their mating behaviour, as it can be expected that any male holding a territory will be regularly emitting Type D or Type C.d1 social calls in order to attract females into an area and/or discourage other males from entering the area.

In some respects the method and reporting outputs resulting from such an exercise are not dissimilar to those relating to a breeding bird survey for songbirds (BTO, 2020), and what follows, in spirit anyway, is an approach that would not be unfamiliar to ornithologists carrying out similar work. The method is also similar to that carried out previously by others. See, for example, the *Proceedings of the First European Bat Detector Workshop* (Limpens, 1993), and work carried out by Leif Gjerde (2004, 2017) when attempting to establish territories held by parti-coloured bat *Vespertilio murinus*.

Table 1.5 Genera and species displaying resource defence polygyny mating strategies whereby roost location and territorial mapping may be appropriate.

Genus	Species	Documented territory diameters	Ideal survey period	Relevant call type
Pipistrellus	Common pipistrelle Soprano pipistrelle Nathusius' pipistrelle	200 m* 100–200 m** Likely to be in the immediate vicinity of the roost	Late summer and throughout autumn	Type D advertisement calls emitted consistently, in flight (i.e. in a series of five or more sequences). For Nathusius' pipistrelle, calls emitted from stationary positions are of particular interest, giving strong evidence of territorial behaviour, as well as, more precisely, the mating roost location.
Nyctalus	Noctule Leisler's bat	Discrete roost site is defended, with associated territory not being far beyond this location. For in-flight social calls from Leisler's bat, 300 m*** would seem to be a reasonable maximum distance from roost location.	Late summer and throughout autumn	Type C.d1 advertisement calls emitted consistently, from a stationary position (both species) or in flight (Leisler's bat), giving strong evidence of mating roost location. In addition, Type D1 and Type D2 calls may also be indicative of territorial behaviour.

References:
* Sachteleben and von Helversen (2006)
** Lundberg and Gerell (1986)
***BCT (2013c)

In order to undertake such surveys the following approach is recommended. First of all the survey has to be carried out when you would most expect advertising males to be present and active (see Table 1.5, and genus/species-specific sections in the Appendix).

The next step is to carry out a desktop exercise, ground-truthed by a daytime assessment within the site boundary (and a buffer), noting any features that may be relevant to mating behaviour. This would include documenting the location of any potential roost locations (e.g. crevices and the like in structures and trees), as well as any landscape features that may serve as a territorial boundary for any bats present (e.g. tree lines, woodland edge, hedgerow, water features, structures, changes in topography).

Using the information gathered from the desk study and ground-truthing exercise, a map should then be created, and from this a transect route designed, catering for all such features, as previously mentioned. The transect should come within 50 m of all features, and take no longer than 30 minutes to walk at a slow pace.

The bat survey should start no later than 60 minutes after sunset, and continue until 180 minutes after sunset, with the transect being repeated at least three times (e.g. time after sunset: 60–90 minutes/110–140 minutes/150–180 minutes). The survey is repeated monthly (i.e. usually three times) throughout the mating season.

During the survey, Type D/Type C.d1 social calls are recorded on a full spectrum bat detector, along with the GPS location of each encounter (most modern full spectrum bat detectors tag recorded files with GPS information). During analysis of data each sequence of social calls is identified to species or genus, and this information, along with GPS location, is mapped. The data gathered can then be used to create a table showing what was encountered at the site (see Table 1.6).

Table 1.6 Example of data collected during mating territory survey for *Pipistrellus* species.

Date	Time	GPS location	Species	Number/Type of call sequences recorded
30/8/2021	21:15	AA 5491 8009	*P. pygmaeus*	7 – Type D
	21:17	AA 5490 8008	*P. pygmaeus*	5 – Type D
	21:55	AA 5400 8010	*P. pygmaeus*	10 – Type D
	21:57	AA 5400 8009	*P. pygmaeus*	8 – Type D
	22:01	AA 5397 8007	*P. pygmaeus*	6 – Type D

In addition to showing the data in table format, most importantly an individual map is produced for each survey session (see Figure 1.3), along with an overall ‘master’ map, for all surveys combined. If numerous species are present, performing advertisement behaviour, then separating the maps into individual species would often be beneficial.

The maps produced should include the following information, either combined or separately: transect route; location of social call encounters (species labelled); and territorial polygons for each closely associated ‘cluster’ of activity per species.

Having gathered the data and considered the mapping outputs, it should be possible, at the very least, to begin to have an opinion about what species hold territories within an area, how many territories are likely to be held, and in some instances where territorial boundaries may exist. It can then be assumed that within each territory there is at least one roosting location for the individual bat involved.

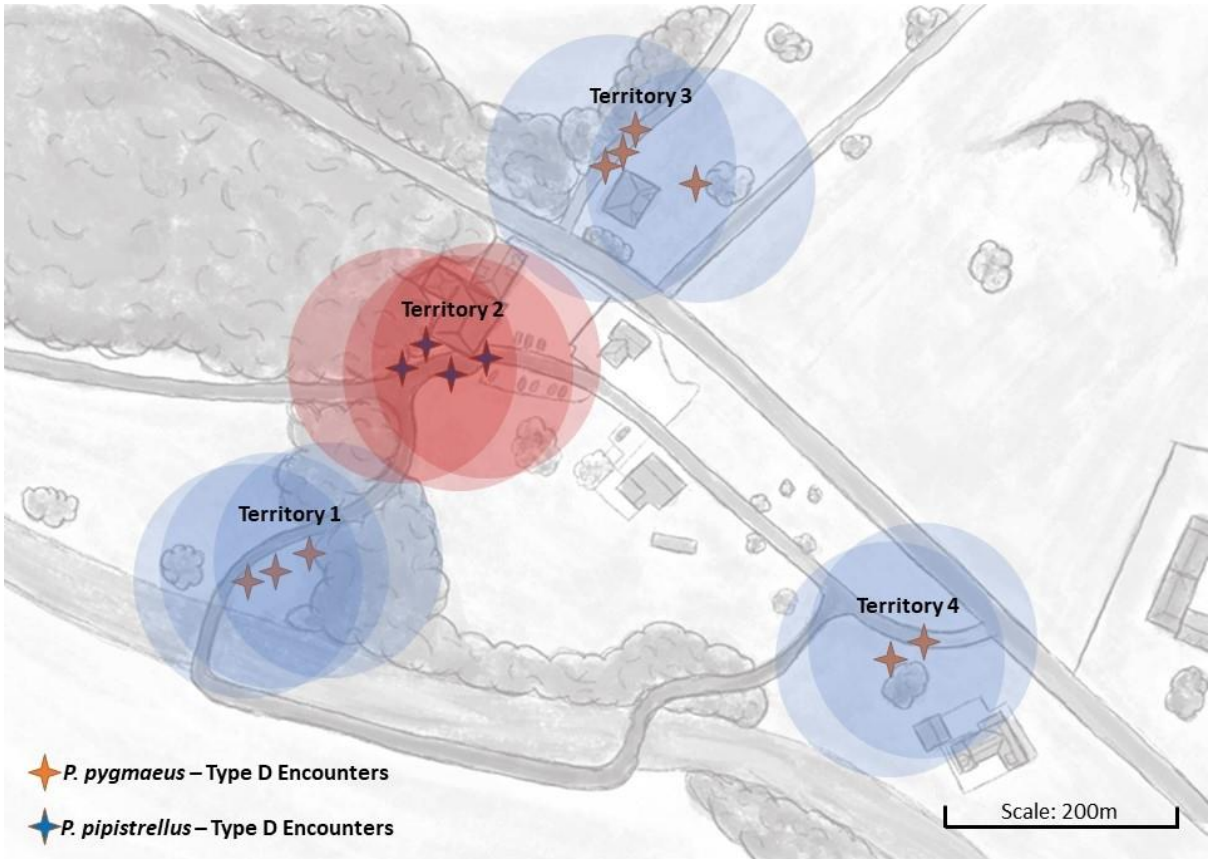

Figure 1.3 Example of territory mapping output (*Pipistrellus* species) (graphic provided by A. Middleton).

It should be borne in mind that the purpose of the exercise (assuming exact roosting locations cannot be found) is to narrow down the likely approximate location of roosts, as well as the number of territories held within a developmental footprint, and, if required, a buffer zone. The precise boundary between adjacent territories is not an essential piece of information for this purpose, as they can be combined to form a single overall area of interest, albeit within which more than one bat is noted as holding a territory.

In creating polygons there needs to be an element of case-specific logic applied, allowing for the topography of an area, the presence of landmarks, as well as the location of potential roost features. There are some useful considerations to bear in mind here, which we will now consider.

For bats emitting their advertisement calls from a stationary position (e.g. Nathusius' pipistrelle, noctule or Leisler's bat), the territory being defended may be very small (Limpens, 1993; BCT, 2013b), in that it would normally be expected that it is the specific roost feature being defended against other males, and possibly a very short distance in front of, or around, the feature itself (e.g. the flight path into the feature).

For bats emitting advertisement calls in flight, it is unlikely that any territorial boundary would be viable beyond the effective range of a bat social call. The effective range for a pipistrelle Type D call is unlikely to be as far as 200 m, and typical territories have been shown to be up to 200 m in length for common pipistrelle and soprano pipistrelle (Lundberg and Gerell, 1986; Sachteleben and von Helversen, 2006). In addition to this, the transect should have travelled no farther than 50 m from any potential roost or territorial landscape feature. On the one hand, drawing a polygon with a 100 m radius around the outer edge of a cluster of calls, presumably coming from one bat, may be deemed appropriate in many scenarios. On the other hand, a 50 m radius (or less) may be viewed as conservative. Having said this, also bear in mind that the more individuals of a certain species you have in an area, the more likely that territories would be smaller, and therefore there may very well be cases when 50 m is in fact an over-estimate. In this respect our preference would be to err on the side of caution (i.e. 100 m radius), but adjust this downwards as territorial polygons overlap. Also remember that, in reality, a

territory is unlikely to be a perfect circle centred around a roost location, indeed unlikely to be a circle at all, and any territorial representation being made is usually best adjusted, if possible, to fit in with features present on the ground that are potentially regarded by a bat as being at the edge of its patch.

The next thing to point out is that, for some of these species, there may be peculiarities of an individual bat's call that allows it to be recognised as an individual, or at least consider this as a possibility. During sound analysis, it is, therefore, worth paying attention to specific call structure variances occurring within clusters, to see if individuality is present and can be used to separate bats. If so, this would add to confidence in how many individuals may be present in an area, and where their territories possibly border.

When reporting such data it is important to highlight any constraints and limitations, and it is probably sensible to take an approach whereby minimum/maximum numbers of territories held are described, along with minimum/maximum territory sizes (i.e. *at best it looks like this, and at worst it looks like that*).

To finish off this subsection, it is important to recognise that in describing a specific approach, as we have done here, it is difficult to describe things perfectly using an artificial example. We recognise the approach described is not perfect, and there have been some assumptions made as to where parameters exist. For each species, it may be possible to find academic examples of typical territory sizes and/or effective range of calls in different habitats, under differing environmental conditions and in different geographical areas. Where this information is available, you should undoubtedly use such references to justify any conclusions you are making about any cases you are working on.

Appendix

Genus/Species-Specific Considerations

In this appendix we provide the genus-specific and/or species-specific survey methods that should be considered in conjunction with the information provided.

Note: The figures referred to within each table relate to figures presented within *Social Calls of the Bats of Britain and Ireland (2nd Edition)*.

A.1 Genus-specific considerations in social call survey design: *Rhinolophus* species

This genus is most productively surveyed for social call behaviour within, or immediately outside known or suspected roosting locations, in particular maternity sites and sites prone to autumn mating activity, as well as holding potential for hibernation.

Table A.1 Genus-specific social call survey considerations – *Rhinolophus* species.

Genus-specific survey period(s) and/or location(s)	Most useful social calls in determining ID to species level
Late spring/summer At entrance to, or within maternity roosts. **Late summer/autumn** At entrance to, or within autumn mating roosts, showing strong association with site being used for hibernation.	Preferrable to also have echolocation sequences, or other evidence, in order to confirm presence. Most 'in flight' social call sequences would be expected to be produced in conjunction with echolocation, and in the close vicinity to, or within, roosting locations. The presence of developmental calls during the period June to early August from within a roosting location would be evidence of maternity roost. The presence of trill calls (see figure references below) during the period September to early November from within a roosting location would be evidence of mating behaviour. **Greater horseshoe bat:** Figures 8.2.1 and 8.2.2 **Lesser horseshoe bat:** Figure 8.2.17
Genus-specific survey methods: **Maternity roosting:** Present throughout summer. Follow guidance as provided in Tables 1.1, 1.2 and 1.3 (roost external and roost internal). **Autumn mating roosts:** Best established during the period September to November. Placement of static, full spectrum detectors, operational from sunset to sunrise, for survey sessions of not less than five nights per month (September to November) is recommended.	
References for genus/species survey methods (if applicable): Greater horseshoe bat: Andrews and Andrews, 2003; Andrews *et al*., 2006, 2011 Lesser horseshoe bat: Andrews *et al*., 2017	

A.2 Genus-specific considerations in social call survey design: *Myotis* species

This genus is most productively surveyed for social call behaviour in the vicinity of known or suspected roosting locations, in particular maternity sites and sites prone to autumn swarming activity, as well as holding potential for hibernation. In addition, for some species, as described, characteristic calls can be recorded from bats away from roosting locations.

Table A.2 Genus-specific social call survey considerations – *Myotis* species.

Genus-specific survey period(s) and/or location(s)	Most useful social calls in determining ID to species level
Late spring/summer In vicinity of maternity roosts **Late summer/autumn** In vicinity of autumn swarming locations, and/or sites with potential for hibernation.	Preferrable to also have echolocation sequences, or other evidence, in order to confirm presence. In many instances, for this group, echolocation alone will not be able to be diagnostically allocated to species level. Most 'in flight' social call sequences would be expected to be produced in conjunction with echolocation. Certain call types (see figure references below) can usually be safely allocated to this species. Other social call sequences on their own (i.e. without associated echolocation or visual observation) will be difficult to safely allocate to species level, and even with the presence of echolocation will still prove problematic. **Daubenton's bat:** Figures 8.3.1, 8.3.2, 8.3.5 and 8.3.6 Can often be verified due to its low flight behaviour over calm water. 'Walking stick'/arched Type C calls can usually be safely allocated to this species, provided pond bat/non-bat sources of similar calls can be ruled out. **Natterer's bat:** Figures 8.3.18 and 8.3.20 to 8.3.25 **Whiskered/Brandt's bat:** Figures 8.3.34 to 8.3.36 and 8.3.42 to 8.3.45 Similar calls may also be present, but as yet not fully documented or understood, for other species (e.g. Alcathoe whiskered bat). As such, diagnostic identification based on purely social calls is problematic. **Bechstein's bat:** Figures 8.3.56, 8.3.57, 8.3.62 and 8.3.64 to 8.3.66 Careful consideration is required in order not to confuse with other species which may produce echolocation calls or social calls at low minimum frequencies. As well as this, distribution range and habitat should be factored into any interpretation of recordings.
Genus-specific survey methods: **Maternity roosting:** Present throughout summer. Follow guidance as provided in Tables 1.1, 1.2 and 1.3 (roost external). **Autumn swarming:** Late summer and throughout the autumn. Daubenton's bat often appears at sites earlier than other *Myotis* species, and Natterer's bat appearing later. Placement of static, full spectrum detectors, operational from sunset to sunrise, for survey sessions of not less than five nights per month (August to November) is recommended.	
References for genus-specific survey methods (if applicable): None	

A.3 Genus-specific considerations in social call survey design: *Nyctalus* species

This genus is most productively surveyed for social call behaviour in the vicinity of known or suspected roosting locations, in particular maternity sites and sites where males may be advertising during late summer and into the autumn.

Table A.3 Genus-specific social call survey considerations – *Nyctalus* species.

Genus-specific survey period(s) and/or location(s)	Most useful social calls in determining ID to species level
Late spring/summer In vicinity of maternity roosts **Late summer/autumn** In vicinity of woodland areas where males may be heard advertising.	In areas where these species' distribution does not overlap (or indeed with other 'big bat' species), echolocation and social call sequences tend to be easier to determine. For noctule, the Type C.d1 advertisement calls are usually emitted from a stationary position. For Leisler's bat, this call type can be emitted in flight or while stationary from a perched position. Type D1 and D2 social calls would normally be expected 'in flight', with echolocation being evident. Certain call types (see figure references below) are strong evidence that a species is present, although it is important that Type D2 calls are not confused with other things, for example, in the case of noctule with shrew species (Middleton, 2020). **Noctule:** Figures 8.4.1, 8.4.2, 8.4.3 and 8.4.6 **Leisler's bat:** Figures 8.4.16, 8.4.17, 8.4.19 and 8.4.20
Genus-specific survey methods: **Maternity roosting:** Present throughout summer. Follow guidance as provided Tables 1.1, 1.2 and 1.3 (roost external). **Late summer/autumn:** Refer to case study example (*Pipistrellus* species) which could be adapted for *Nyctalus* species. Placement of static full spectrum detectors, operational from sunset to sunrise, for survey sessions of not less than five nights per month (August to October) is recommended. The optimum time to encounter Type C.d1 advertisement calls is from sunset through to 180 minutes after sunset. Walked transects, with full spectrum handheld detector, in order to locate Type C.d1 calling behaviour within a discrete area, which is indicative of a territory being held, with a mating roost in close proximity. Encounters with Type D1 and Type D2 calls should also be taken into account. Such transects to incorporate the location of all potential roosts, visiting each location at least every 30 minutes, during the period from sunset through to three hours after sunset. The survey should be repeated monthly (i.e. usually three times) throughout the mating season (adapted from Andrews and Pearson, 2019).	
References for genus-specific survey methods (if applicable): Noctule – Andrews and Pearson, 2019	

A.4 Species-specific considerations in social call survey design: Parti-coloured bat

This species is probably under-recorded in the British Isles, albeit rarely occurring. The regularity with which grounded bats are encountered would suggest that many more bats go unnoticed because they are either healthy or they are grounded but not found. To survey for this species there are a few things worth noting. We are grateful to Leif Gjerde, who has given us the benefit of his experience, and his thoughts are included in Table A.4.

Table A.4 Species-specific social call survey considerations – parti-coloured bat.

Species-specific survey period(s) and/or location(s)	Most useful social calls in determining ID to species level
Late spring/summer In vicinity of maternity roosts. **Autumn/winter** In vicinity of mating territories and/or sites with potential for hibernation.	The Type D advertisement call is regarded as being diagnostic in Europe, without the need for echolocation to have been recorded. It is not unusual to record such sequences without any echolocation being produced. Echolocation alone can be problematic when identifying this bat to species level, especially in areas where Leisler's bat may be present, as well as, to some extent, areas where northern bat or serotine may also be present. Figures 8.5.1, 8.5.2, 8.5.4 and 8.5.5

Species-specific survey methods:

Maternity roosting:
Potential for encountering social call behaviour at such sites from May through to early August. Follow guidance as provided in Tables 1.1, 1.2 and 1.3 (roost external).

Autumn/winter mating behaviour:
Will typically occur from September onwards, well into December. Advertisement behaviour may occur when temperatures are well below what would normally be expected for bat activity (e.g. 0°C, and/or snow on ground), but surveying on calm, dry, milder nights (>5°C) is more useful.

Focus survey activity in areas close to large waterbodies, river valleys and estuaries, in the vicinity of tall structures (e.g. nine storeys or higher), especially where there are a number of such structures grouped closely together. Also, consider relatively shorter structures positioned prominently within wider landscape. Rock faces and cliffs should also be visited, if present in the area. There are also examples where males have been found in deciduous woodland clearings.

In the British Isles, there may be a bias in presence for this species towards the east, as it would be from this direction (i.e. bats migrating over from continental Europe) that we would expect to see seasonal movement.

For handheld bat detector surveys, start at 90 minutes after sunset, following repeated transects, every 30 minutes, until at least 3 to 4 hours after sunset, with no less than three separate surveys being carried out in optimal conditions. Tune heterodyne bat detector to 12 to 14 kHz, as well as using just your ears to pick up on audible sound and determine movement of bats associated with territorial boundaries. Engaging with local members of the public (e.g. dog walkers) may prove useful, in order to establish if they have heard any high pitched sounds while outside at night.

Placement of static full spectrum detectors, operational from sunset to sunrise, for survey sessions of not less than five nights per month (August to November) during favourable weather conditions is recommended.

References for species-specific survey methods (if applicable):
Gjerde (2004)

A.5 Genus-specific considerations in social call survey design: *Pipistrellus* species

This genus is most productively surveyed for social call behaviour in the vicinity of known or suspected roosting locations, in particular maternity sites and sites where males may be advertising during late summer and into the autumn.

Table A.5 Genus-specific social call survey considerations – *Pipistrellus* species.

Genus-specific survey period(s) and/or location(s)	Most useful social calls in determining ID to species level
Late spring/summer In vicinity of maternity roosts. **Late summer/autumn** In vicinity of woodland areas where males may be heard advertising. Although mating roosts are often associated with suitable features in trees, other suitable locations can be chosen (e.g. within the built environment).	For all species, Type D social calls would be expected 'in flight', with echolocation usually being evident. When the calls relate to advertisement behaviour, they are usually emitted in flight close to the mating roost location (e.g. a tree/structure cavity or similar). During the peak mating season male Nathusius' pipistrelle will also produce their calls from a stationary position, either from within or very close to the roosting location. Certain call types (see figure references below) provide very strong evidence of a species being present. **Common pipistrelle:** Figures 8.6.1 and 8.6.2 **Soprano pipistrelle:** Figures 8.6.12 and 8.6.13 **Nathusius' pipistrelle**: Figures 8.6.26 and 8.6.27* **Kuhl's pipistrelle**: Figures 8.6.37 and 8.6.38* *In areas where these species' distribution does not overlap, echolocation sequences alone should also help confirm presence.

Genus-specific survey methods:

Maternity roosting:
Present throughout summer. Follow guidance as provided in Tables 1.1, 1.2 and 1.3 (roost external).

Late summer/autumn (ideally from August to October):
Refer to case study example.

Walked transects, with full spectrum handheld detector, in order to locate consistent Type D advertisement behaviour within a discrete area, which is indicative of a territory being held, with a mating roost in close proximity (e.g. within 200 m). Such transects should incorporate the location of all potential mating roosts, visiting each location on at least three occasions, 30 minutes or more apart, during the period from 1 hour after sunset through to 3 hours after sunset. The survey should be repeated monthly (i.e. usually three times) throughout the mating season.

References for genus-specific survey methods (if applicable):
Sachteleben and von Helversen, 2006

A.6 Species-specific considerations in social call survey design: Serotine

This species is most productively surveyed for social call behaviour in the vicinity of known or suspected maternity sites. Not much is known about mating behaviour, as it relates to acoustics for this species, and, therefore, studies focusing specifically on this are difficult to design, with more research into the matter needed.

Table A.6 Species-specific social call survey considerations – serotine.

Species-specific survey period(s) and/or location(s)	Most useful social calls in determining ID to species level
Late spring/summer In vicinity of maternity roosts. **Late summer/autumn** In areas where bats are known to be present, and mating activity possibly taking place.	Preferrable to also have distinctive echolocation sequences, or other evidence, in order to verify presence. Most in-flight social call sequences (see figure references below) would be expected to be produced in conjunction with echolocation. Figures 8.7.1 and 8.7.2
Species-specific survey methods: **Maternity roosting:** Present throughout summer, showing good degree of stability relating to roosting locations. Follow guidance as provided in Tables 1.1, 1.2 and 1.3 (roost external). **Late summer/autumn mating roosts:** Due to lack of specific knowledge regarding the mating behaviour of this species, no guidance is provided.	
References for species-specific survey methods (if applicable): None	

A.7 Genus-specific considerations in social call survey design: *Plecotus* species

This genus would probably be most productively surveyed for social call behaviour in the vicinity of known or suspected maternity sites (both during the maternity season and at other times of the year), and, in respect of brown long-eared bat, sites prone to autumn swarming activity, as well as holding potential for hibernation.

The use of social calls for diagnostic identification of this genus is highly appropriate, and also beneficial for establishing species within our area, and indeed other parts of Europe, when the rarer grey long-eared bat is not expected, and brown long-eared bat presence can be safely established. In contrast, where the two species overlap in distribution, identification to species level should not be relied upon, albeit establishing presence at genus level (i.e. *Plecotus* sp.) is relatively straightforward.

Table A.7 Genus-specific social call survey considerations – *Plecotus* species.

Genus-specific survey period(s) and/or location(s)	Most useful social calls in determining ID to species level
Throughout the year In vicinity of maternity roosting locations. **Late summer/autumn** Brown long-eared bat: In vicinity of autumn swarming locations, and/or sites with potential for hibernation. Grey long-eared bat: In vicinity of roosts occupied during maternity season.	In-flight social call sequences can often be produced in conjunction with echolocation; however, in some scenarios, the presence of echolocation may be neither apparent nor present. In areas where distribution of the two species overlap, it is essential to also have distinctive echolocation sequences, or other evidence, in order to verify species identification, as social calls alone (e.g. Type C) are not diagnostic to species level, although can be assigned to genus. In areas where no overlap in distribution occurs, verification to species level is fairly straightforward due to distinctive Type C and Type D1 social calls (see figure references below). **Brown long-eared bat**: Figures 8.8.1, 8.8.2, 8.8.3, 8.8.4, 8.8.6 and 8.8.7 **Grey long-eared bat**: Figures 8.8.16, 8.8.17, 8.8.18, 8.8.19 and 8.8.20

Genus-specific survey methods:

Maternity roosting:
Present throughout summer, with colonies within the built environment usually holding a strong allegiance to a single roosting location.
Follow guidance as provided in Tables 1.1, 1.2 and 1.3 (roost external and roost internal).

Known roosting locations excluding maternity season:
There is good potential for bats being present, and active, albeit in lower numbers, within or in the vicinity of known established roosting locations throughout the year, especially in parts of the country which experience milder winters.

Autumn swarming:
Brown long-eared bat turns up at classic swarming locations throughout the autumn, and may be found hibernating at such locations (there is less evidence supporting this for grey long-eared bat, but this may be bias, due to scarcity in numbers). However, due to the overlap in distribution with the rare grey long-eared bat, it would be difficult to confidently identify either of these to species level where both may be present. In order to verify presence at either species level (where distribution allows), or genus level (i.e. *Plecotus* sp.), then the placement of static full spectrum detectors, operational from sunset to sunrise, for survey sessions of not less than five nights per month (August to October) is recommended.

References for genus/species survey methods (if applicable):
None

A.8 Species-specific considerations in social call survey design: Barbastelle

This species is most productively surveyed for social call behaviour in the vicinity of known or suspected roosting locations, in particular maternity sites and sites prone to autumn swarming activity, as well as holding potential for hibernation.

Table A.8 Species-specific social call survey considerations – Barbastelle.

Species-specific survey period(s) and/or location(s)	Most useful social calls in determining ID to species level
Late spring/summer In vicinity of maternity roosting locations. **Late summer/autumn** In vicinity of autumn swarming locations, and/or sites with potential for hibernation.	Preferrable to also have distinctive echolocation sequences, or other evidence, in order to verify presence. Most in-flight social call sequences would be expected to be produced in conjunction with echolocation. Many social call sequences on their own will be difficult to safely allocate to species level; however, numerous sequences similar to those described in the following figures may be of assistance in determining the probability of roosting behaviour in the vicinity: Figures 8.9.1, 8.9.2, 8.9.6, 8.9.7, 8.9.8, 8.9.9, 8.9.10, 8.9.11, 8.9.12 and 8.9.13
Species-specific survey methods: **Maternity roosting:** Present throughout summer, with colonies prone to roost switching during the period. Follow guidance as provided in Tables 1.1, 1.2 and 1.3 (roost external). **Autumn mating roosts:** Best established during the period August to October. Placement of static, full spectrum detectors, operational from sunset to sunrise, for survey sessions of not less than five nights per month (August to October) is recommended.	
References for species-specific survey methods (if applicable): Young *et al*., 2018	

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