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A CRITICAL ASSESSMENT OF THE PRESENCE OF *BARBASTELLA BARBASTELLUS* AND *NYCTALUS NOCTULA* IN IRELAND WITH A DESCRIPTION OF *N. LEISLERI* ECHOLOCATION CALLS FROM IRELAND

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ABSTRACT **-** *Nyctalus noctula* and *Barbastella barbastellus* were first reported from Ireland in 1997, however these reports were based solely on echolocation call data. Since then, neither species have been reported again or confirmed as a resident species in Ireland. In this study the status of these two species in Ireland was assessed. For *B. barbastellus*, the woodlands in the area where it was previously reported from, in the Lough Derg region, were surveyed by walked transects using Pettersson D1000X bat detectors and through passive monitoring using the SD1 Anabat detector and the Pettersson D1000X over three nights. Out of 1011 recordings, no calls of *B. barbastellus* were encountered. For *N. noctula*, 98 *Nyctalus* sp. calls recorded from five squares (30 km^2) on the east coast of Ireland, during a car based monitoring scheme were analysed (peak frequency and call duration). These were compared to 220 reference calls of *N. leisleri* from Dartry and Phoenix Park, County Dublin, Ireland and published data on *N. leisleri* and *N. noctula* calls from Britain. All Irish calls recorded from Dartry Park, Phoenix Park and the car transect squares fell within the known parameters range of *N. leisleri* but also overlapped with the higher frequency and shortest duration calls of *N. noctula*. However, no Irish calls overlapped with the lower frequency range and longest call duration of *N. noctula*, indicating that this latter species was probably not recorded in the Irish dataset. The results of this study are discussed in relation to the difficulty of reporting a bat species presence based on echolocation calls alone and the suitability of Ireland for both species.

Key words: distribution, detection, Chiroptera, species presence, Ireland

RIASSUNTO **-** ***Verifica della presenza di* Barbastella barbastellus *e* Nyctalus noctula *e descrizione delle ecolocalizzazioni di* N. leisleri *in Irlanda*.** La presenza di *Nyctalus noctula* and *Barbastella barbastellus* in Irlanda è stata segnalata nel 1997, sulla base dell'analisi di ecolocalizzazioni. Da allora, essa non è stata ulteriormente confermata. Per accertare la presenza di *B. barbastellus* nell'area di Lough Derg, sono stati effettuati transetti con bat detector (Pettersson D1000X) e registrazioni da punti fissi per un periodo di tre notti (SD1 Anabat e Pettersson D1000X). Su un totale di 1011 registrazioni, nessuna è risultata attribuibile a *B. barbastellus*. Per *N. noctula*, 98 *Nyctalus* sp. ecolocalizzazioni registrate in 5 quadrati (30 km^2) distribuiti sulla costa orientale dell'isola sono state analizzate (frequenza massima e durata) e confrontate con i dati disponibili in letteratura sulle ecolocalizzazioni delle due specie e con 220 ecolocalizzazioni di *N. leisleri* (Dartry e Phoenix Park, Contea di Dublino). I valori dei diversi parametri di tutte le ecolocalizzazioni concordano con quelli riferiti a *N. leisleri*, benché in parte si sovrappongano a quelli noti per *N. noctula*. Nel complesso i risultati suggeriscono che quest'ultima specie non sia presente in Irlanda e vengono discussi in relazione alla difficoltà di accertare la presenza di una specie in base alle sole ecolocalizzazioni e alla vocazionalità dell'isola per entrambe le nottole.

Parole chiave: distribuzione, accertamento della presenza, Chiroptera, Irlanda

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INTRODUCTION

To date, nine species of bat have been confirmed as resident in Ireland, namely *Myotis nattereri, M. daubentonii, M. mystacinus, Pipistrellus pipistrellus, P. pygmaeus, P. nathusii, Nyctalus leisleri, Plecotus auritus* and *Rhinolophus hipposideros* (Marnell et al. 2009). These nine species have been confirmed by capture of individuals and the presence of maternity roosts. Recently, Boston et al. (2010) reported on the search for *M. brandtii*, but concluded that there is currently insufficient data to confirm that this species is resident in Ireland. The other two species that have been reported in Ireland are *Nyctalus noctula* and *Barbastella barbastellus*, each reported based on echolocation calls from a single locality, Phoenix Park, County (Co.) Dublin on the east coast for the former and Portumna forest, Co. Galway in the west for the latter. These two records were obtained in 1997 (K. Mc Aney personal communication 1999) and first mentioned as personal communications from I. Ahlén and H.J. Baagøe and I. Ahlén, respectively, in the atlas of European Mammals (Mitchell-Jones et al. 1999). Based on Mitchell-Jones et al. (1999), subsequent publications have considered the two species to be present in Ireland (e.g. Dietz et al. 2009; C. Dietz personal communication 2010). However, to date, these two records have not been confirmed, as the species identification was only based on echolocation calls and no individuals have been captured nor have breeding sites been found for either species. This could potentially be due to the roosting behaviour of both species, since they generally roost in trees as opposed to buildings, so they may have been overlooked (Boonman 2000; Russo et al. 2004). However, the erection and monitoring of 60 Schwegler bat boxes in Portumna forest park for the last 11 years has failed to find any *B. barbastellus* in the woodland despite annual surveys (Teesdale 2006; K. Mc Aney personal communication 2010). Previous studies carried out in Ireland have not been able to confirm the presence of either species despite numerous surveys totalling hundreds of recording hours (e.g. Daubenton's bat waterway monitoring scheme; Aughney et al. 2009; Batlas project). Since 2003, Bat Conservation Ireland has been monitoring bats using a car-based transect scheme (Roche et al. 2009). Currently, 28 survey squares (30 km^2) are monitored annually and *N. leisleri* is the third most frequently encountered bat with 2715 calls recorded between 2003 and 2008 (Roche et al. 2009). A number of the survey squares are located on the east coast of Ireland close to the location of the original 1997 *N. noctula* record. A similar car-based scheme has been piloted in Britain where *N. noctula* and *B. barbastellus* have been successfully recorded using this methodology (Russ et al. 2008).

Since Fenton and Bell (1981) and Ahlén (1981), echolocation calls have been widely and successfully used to identify bat species using different classification methods such as discriminant function analyses, neural networks, synergetic algorithms, etc. (Vaughan et al. 1997; Parsons and Jones 2000; Parsons 2001; Russo and Jones, 2002; Obrist et al. 2004; Preatoni et al. 2005; Papadatou et al. 2008). Similarly to direct identification by trained listeners, these classification methods 'compare' a suite of measurements (e.g. time and frequency parameters) from calls of individuals, whose species identity is unknown, to reference calls from identified individuals, and then, based on similarity, assign the unknown calls to a species or species group. Species misidentification can happen when two or more species have very similar calls (e.g. *Myotis* species) or when reference and unknown echolocation calls are not from the same location and species show echolocation call variation across their range (e.g. O'Farrell et al. 2000). Therefore, the description of a species' echolocation calls as well as their variation across space is required for accurate species identification. When foraging, *N. noctula* and *N. leisleri* switch between two distinguishable call types (Waters et al. 1995; Parsons and Jones 2000), the first signal consists of a low bandwidth, long duration shallow frequency modulated (FM) call and the second has a higher bandwidth call with shorter duration (more broadband FM). *N. noctula* is reported to alternate between the two call types more frequently than *N. leisleri*, which is rarely mentioned as doing so (Zingg 1988; Zbinden 1989; Waters et al. 1995; Parsons and Jones 2000; Russo and Jones 2002; Obrist et al. 2004; Papadatou et al. 2008). Acoustically, these two species are frequently separated in the field by differences in the frequency of maximum energy (F_{peak}) of their echolocation calls. As in many other bat species (e.g. Parsons 1997; Barclay et al. 1999; Gillam and McCracken 2007; Russo et al. 2007; Soisook et al. 2008), there is geographic variability in echolocation call parameters within *N. leisleri* across Europe. Average F_{peak} of *N. leisleri* has been reported to vary from 25.5 kHz in England to 31.7 kHz in Greece with intermediate values being reported from Italy, Switzerland and England (Zingg 1988; Waters et al. 1995; Vaughan et al. 1997; Parsons and Jones 2000; Russo and Jones 2002; Obrist et al. 2004; Papadatou et al. 2008). Although this variation could partly be explained by different recording situations (e.g. emergence *vs.*

foraging) of bats flying in different habitats (e.g. open *vs.* semi-cluttered), recording of bats in similar situations and habitats in Greece, France and Ireland confirmed the existence of large variations due to the bats themselves (Puechmaille unpublished data). Similarly, characteristics of echolocation calls of *N. noctula* vary geographically across Europe (Zbinden 1989; Vaughan et al. 1997; Parsons and Jones 2000; Russo and Jones 2002; Obrist et al. 2004; Papadatou et al. 2008), but, on average, its F_{peak} is lower than in *N. leisleri*. This important geographic variation in both species' echolocation calls renders uncertain species identifications without local reference calls. Therefore, given that the only record of *N. noctula* in Ireland is from echolocation calls, knowledge on echolocation calls of *N. leisleri* from Ireland is of paramount importance, although rarely reported.

B. barbastellus also emits two alternating call types. Type 1 calls are broadband sweeping from 36 kHz to 28 kHz with a mean F_{peak} of 32.8 kHz while type 2 calls have a narrow band FM component with starting frequency of 45 kHz followed by a broadband FM component ending on average at about 32 kHz with a mean F_{peak} of 40 kHz (Denzinger et al. 2001). In contrast to *Nyctalus* species, echolocation calls of *B. barbastellus* show little variation across Europe (Parsons and Jones 2000; Russo and Jones 2002; Obrist et al. 2004) and are quite distinctive from echolocation calls of any other European bat species (Ahlén and Baagøe 1999), so that reliable species identification can be done from good quality echolocation call recordings (Ahlén 2003; Pētersons et al. 2010; C. Corben personal communication 2009; Puechmaille unpublished data).

If these species are indeed resident in Ireland, then there is a legal obligation to monitor and protect them. *N. noctula* and *B. barbastellus* are currently listed as Annex IV of the EU Habitats Directive, while *B. barbastellus* is also listed as Annex II, thus requiring the designation of Special Areas of Conservation (92/43/EEC).

The aim of this study was to follow up on the 1997 records of *N. noctula* and *B. barbastellus* and try to determine the presence of these two bat species. The status of *N. noctula* was assessed through the analysis of calls recorded in the last five years from eastern Ireland and the status of *B. barbastellus* was assessed through both active and passive detector surveys carried out in June 2010 in Portumna forest and two other woodland sites on the shores of Lough (lake) Derg.

MATERIALS AND METHODS

1. *B. barbastellus*

The presence of the species was investigated in three woodland sites (Portumna forest, Rosturra forest and Raheen forest) in the vicinity of Lough Derg (Fig. 1) between the 15th and the 17th of June 2010. The first site was selected as it was the source of the 1997 *B. barbastellus* record and the two other sites were chosen as they represented suitable woodlands within proximity of Portumna forest.

1.1 Site descriptions

Portumna forest is located in Co. Galway on the northern shore of Lough Derg, adjacent to the town of Portumna (Fig. 1). It is

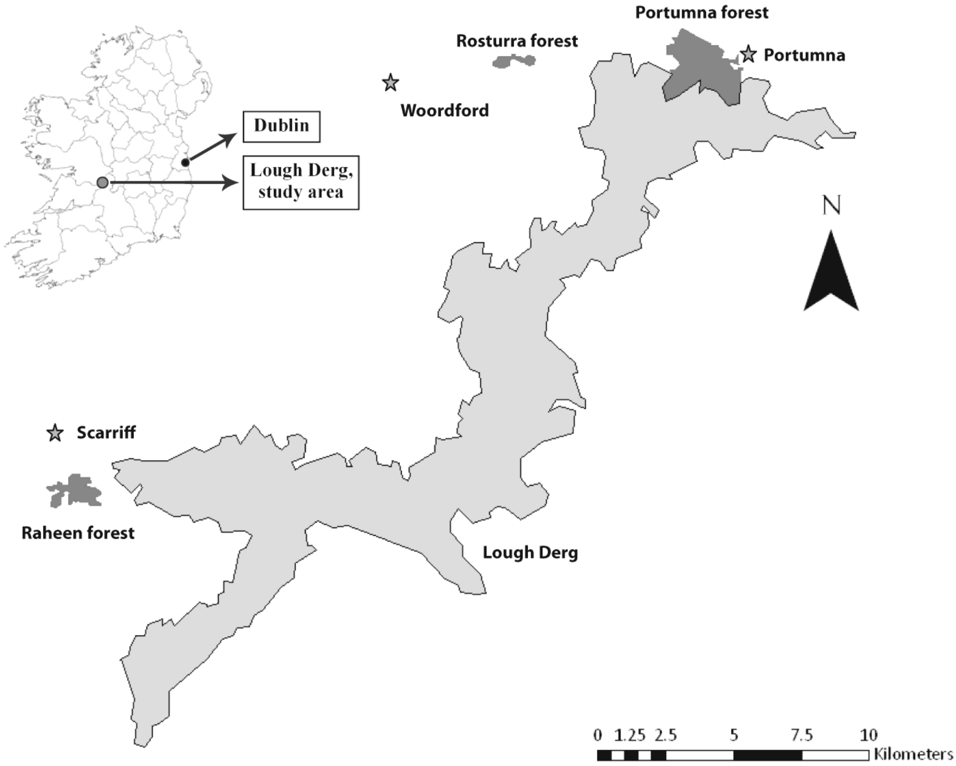

Figure 1 - Location of the study sites in Ireland with details of the Lough Derg region.

approximately 600 ha in size. The main canopy tree species are conifers, including *Pinus sylvestris*, *Larix* sp. and *Picea abies*. However, there are also some broadleaf stands with mature *Quercus* sp., and *Fagus sylvatica*. Native woodland (which in Ireland includes mainly broadleaves such as *Q. robur, Q. petraea, Fraxinus excelsior, Alnus glutinosa* and various *Salix* spp., among others) mainly occurs on the lake shore and northern edge of the forest.

Raheen forest is located in Co. Clare, 2 km south of Scarriff village (Fig. 1). It is approximately 128 ha in size. This forest consists of stands of very mature *Quercus* spp. and mixed broadleaves (native and non-native) and conifer stands of varying age.

Finally, Rosturra forest is located in Co. Galway, 4.2 km northeast of Woodford village (Fig. 1). This 39 ha semi-natural woodland consists of mature tree stands dominated by *Q. petraea* and cleared areas planted with a mixture of native tree and shrub species.

1.2 Survey methodology

Portumna and Raheen forests were surveyed using walked transects and passive monitoring, while only passive monitoring was carried out in Rosturra forest. Three transect routes were walked in Portumna (4, 3.4 and 4.3 km) over two nights, while one transect route was walked in Raheen forest (3.9 km) in one night. Each route was mapped using an Etrex GPS (Garmin). Transects were walked at a constant pace, from 40 minutes after sunset until 00:30 am. All bat activity was manually recorded in real time on hearing using D1000X detectors (Pettersson Elktronik AB) set with a pre-recording time of 2 seconds so as not to miss any bat pass. Headphones were used with heterodyne mode in one channel and frequency division in the other. The detector was tuned at 35 kHz so as to maximize the possibility of hearing *B. barbastellus* echolocation calls. The heterodyne channel was used to detect bats in the range of 30 to 40 kHz approximately, while the frequency division channel was used to detect any bat (but with less sensitivity). Two D1000X detectors were left at sites adjacent to transects to passively monitor Portumna and Raheen forests while transects were walked. All three forests were passively monitored for one night each using a frequency division SD1 Anabat detector (Titley Electronics). The Anabat was placed in a protective case and erected in a suitable tree 4-6 m off the ground and was set to automatically record from 21:30 till 05:30. Sunset and sunrise time for the period of the survey were 21:47 and 04:57, respectively. Weather conditions during the survey period were dry with night time temperatures ranging between 15-20°C. The month of June 2010 was the hottest recorded in Ireland for 40 years (www.met.ie).

1.3 Sound analysis

All calls recorded from the D1000X were analysed using the software BatSound, version 4 (Pettersson Elktronik AB). Whenever possible, calls were identified to species, except for *Myotis* species which were just identified to genus. All calls recorded from the Anabat were analysed using the software AnalookW version 3.7o (written by Chris Corben). *Pipistrellus* calls were only identified to genus from Anabat recordings while real time recordings obtained with the D1000X were identified to species level whenever possible. Real-time recordings of *Pipistrellus* species were identified to species level based on F_{peak}. Generally, individuals with F_{peak} <50 kHz were classified as *P. pipistrellus* while those with F_{peak} >52 kHz were classified as *P. pygmaeus* and intermediate ones (50 kHz <F_{peak} <52 kHz) as *Pipistrellus* spp. The discrimination between *P. pipistrellus* and *P. nathusii* without social calls is not straightforward and to be conservative, we identified *Pipistrellus* species with F_{peak} >40 kHz as *P. pipistrellus* although this might include some high frequency *P. nathusii* (Russ 1999).

2. *Nyctalus noctula*

The presence of this species was investigated through the analysis of echolocation calls of *Nyctalus* sp. from stationary positions in (1) Phoenix Park (the source of the 1997 record of *N. noctula*) and Dartry Park (Co. Dublin) and (2) the archived recordings of Bat Conservation Ireland car-based monitoring scheme (Roche et al. 2009).

2.1 Survey methodology

Real time recordings were obtained from Phoenix Park (11th of June 2006) and Dartry Park (13th of August 2006 and 6th of June 2007). Recordings were made with a D1000X at dusk while bats were foraging 10-20 meters above grassland. Bats were visually observed while recorded, which corroborated the identification of the species recorded. Recordings were typically 10-20 seconds long and captured the range of calls emitted by individuals while foraging in the open. A total of 220 calls were analysed from six recordings, which represented the range of calls emitted by the bats on these three evenings.

Ninety-eight good quality calls from 2005 to 2009 were selected from five (J06, N77, O04, S78, T05) of the 28 squares where the car-based monitoring scheme is operated (Fig. 5). Good quality calls were defined as calls with a good signal to noise ratio, allowing a clear identification of the start and end of the call. The five squares are located in the east and north east of the island and square O04 includes locations within 5 km of the site of the original *N. noctula* record. These eastern squares were chosen due to their proximity to Britain where *N. noctula* occurs. Within each survey square, 20, 1.6 km transects separated by a 3.2 km gap were driven at a constant speed (24 km/h) and bat echolocation calls were recorded using a Tranquility Transect (Courtpan Electronics) time expansion detector and minidisk (Roche et al. 2009). The maximum Doppler shift in frequency created by the car movement (24 km/h) can be estimated to be less than 0.5 kHz for a frequency of 25 kHz. Therefore, direct comparisons can be made between stationary and car-transect data.

Data gathered from Phoenix Park and Dartry Park allowed for the characterization of Irish *N. leisleri* echolocation calls, while data obtained *via* the car transects covering large areas of Eastern Ireland aimed at collecting a representative range of calls from *Nyctalus* sp. that could then be compared to *N. leisleri* calls.

2.2 Sound analysis

All calls were processed through a Fast Fourier Transform (FFT, 1024 points, Hanning window) in BatSound version 4 (Pettersson Elktronik AB) to measure F_{peak} using the power spectrum window. We determined the call duration by measuring the time between the start and the end of each call from the amplitude shown in the oscillogram window. For calls recorded in Phoenix Park and Dartry Park, call F_{peak}, start and end time were measured using the function 'Pulse Characteristics Analysis' available in BatSound. The 'mark positioning' was enabled and measurements were visually checked and corrected if necessary. Intervals between pulses (IBP) were calculated as the absolute time difference between the start of one call and the start of the following one. All calculations and graphs were done in R 2.10.1 (Ihaka and Gentleman 1996; R Development Core Team 2009).

RESULTS

1. *Barbastella barbastellus*

In Portumna forest, 637 recordings were made (Tab. 1). Calls assigned to *Pipistrellus* spp. (302) were the most frequently encountered, followed by *P. pygmaeus* (95), *P. pipistrellus* (81), *Myotis* spp. (125), *N. leisleri* (33) and *Plecotus* sp. (1). Similar results were obtained from Raheen forest where 304 recordings were made (Tab. 1). *P. pygmaeus* was the most frequently encountered species (115), followed by *P. pipistrellus* (87), *Pipistrellus* spp. (63), *Myotis* spp. (36) and *Plecotus* sp. (2). Seventy recordings were obtained from Rosturra forest (Tab. 1), with *Myotis* spp. being the most frequently encountered (34), followed by *Pipistrellus* spp. (33) and *Plecotus* sp. (3). No calls of *B. barbastellus* were recorded at any of the three sites.

2. *Nyctalus noctula*

Two hundred and twenty *N. leisleri* echolocation calls from Phoenix Park and Dartry Park were studied (Tab. 2). These calls included search phase echolocation as well as approach phase calls and feeding buzzes (Simmons et al. 1979). In many species, feeding buzzes can be divided into "buzz I" and "buzz II", the start of the latter being characterized by an abrupt drop in frequency (e.g. Surlykke et al. 1993). F_{peak} of search phase calls was typically in the range of 20.5-25.5 kHz and often showed

Table 1 - Summary of the number of times each species or group of species were recorded during the surveys at Portumna, Raheen and Rosturra. Sounds of *Pipistrellus* spp. recorded with the Anabat system were not identified to species level and are, therefore, all included in the *Pipistrellus* spp. field, hence data were not available (N/A) for *P. pygmaeus* and *P. pipistrellus* separately (An: Anabat, T: Transect, D: D1000X, Tot: Total).

	Portumna						Raheen					Rosturra	
	An	T1	T2	T3	D1	Tot	An.	T1	D1	D2	Tot	An	Tot
Pipistrellus spp.	231	53	12	6	0	302	34	0	29	0	63	33	398
P. pygmaeus	N/A	58	26	11	0	95	N/A	7	105	3	115	N/A	210
P. pipistrellus	N/A	50	21	10	0	81	N/A	0	87	0	87	N/A	168
Myotis spp.	97	12	11	5	0	125	2	2	15	17	36	34	195
Nyctalus leisleri	0	14	15	4	0	33	0	1	0	0	1	0	34
Plecotus sp.	0	0	0	0	1	1	1	1	0	0	2	3	6
Tot	328	187	85	36	1	637	37	11	236	20	304	70	1011

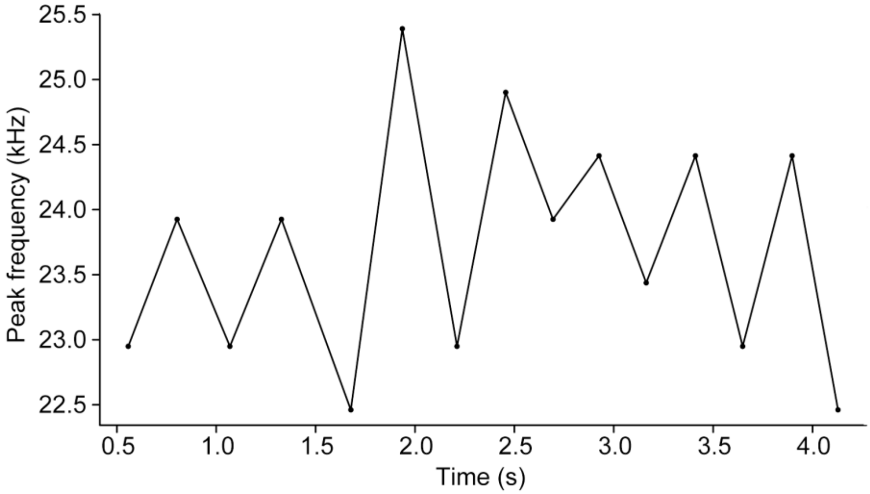

Figure 2 - Typical pattern of search phase echolocation calls of *N. leisleri* in the open.

a pattern of frequency alternation (see Fig. 2 and Tab. 2). Intervals between pulses averaged 227.4 ms with a maximum of 376 ms. Approach phase calls were characterized by a higher F_{peak}, typically between 25.5 to 30.3 kHz, a shorter duration and a higher repetition rate (Fig. 3 and Tab. 2). Feeding buzz I reached the highest F_{peak} we recorded in the species (Tab. 2 and Fig. 4). F_{peak} of feeding buzz II was approximately 7 kHz lower than in buzz I (Tab. 2). All four types of calls can be found on one sequence produced by the same individual. Some of the recordings from which calls were

Table 2 - Characteristics of echolocation calls of *N. leisleri* in Ireland recorded from a stationary position (columns 1 to 4) and comparison with the car transect data (last column) in Ireland. Average, standard deviation (SD), minimum (min.) and maximum (max.) values are presented for each parameter ([1]frequency with maximum energy; [2]call duration; [3]interval between pulses). IBP was not measured for the Car Transect data (N/A) as most recordings (300 ms long) only contained a single call.

	Search phase	Approach phase	Buzz I	Buzz II	Car transect
Sample size	123	33	56	8	98
F_{peak}[1] (SD)	23.0 (1.21)	27.1 (1.09)	31.7 (1.66)	24.5 (1.46)	25.6 (2.41)
Min-max	20.50-25.50	25.6-30.3	28.7-34.7	22.5-26.4	21.6-31.7
Duration[2] (SD)	15.3 (2.28)	8.9 (2.77)	1.8 (1.02)	0.45 (0.15)	9.2 (3.13)
Min-max	8.3-20.3	3.9-15.0	0.13-4.22	0.25-0.72	3.56-17
IBP[3] (SD)	227.4 (48.4)	127.4 (61.4)	14.4 (12.9)	5.4 (0.16)	N/A
Min-max	87-376	23-255	0.48-70.26	5.07-5.49	N/A

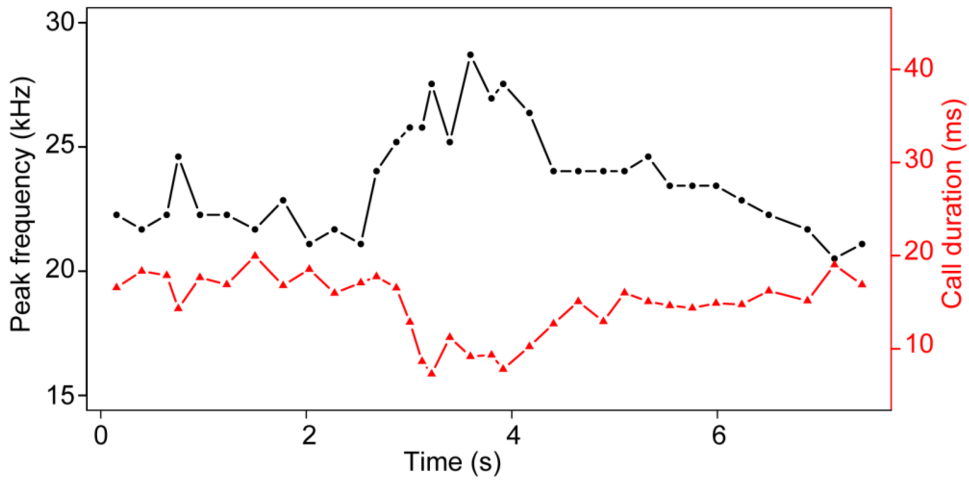

Figure 3 - Typical pattern of *N. leisleri* search phase echolocation calls followed by an 'approach like phase' sequence (middle) and returning to search phase towards the end. Circles represent peak frequency and triangles call duration.

measured also contained *N. leisleri* social calls similar to those described in Pfalzer (2002) (type B and M) and figure 5.12 in Russ (1999).

Ninety eight high quality calls were selected for the final analysis from the car-based bat monitoring squares (J06: 18, N77: 32, O04: 14, S78: 16, T05: 18). A plot of F_{peak} *vs.* call duration for the car transect calls and the reference calls described above showed a near complete overlap between the two data-

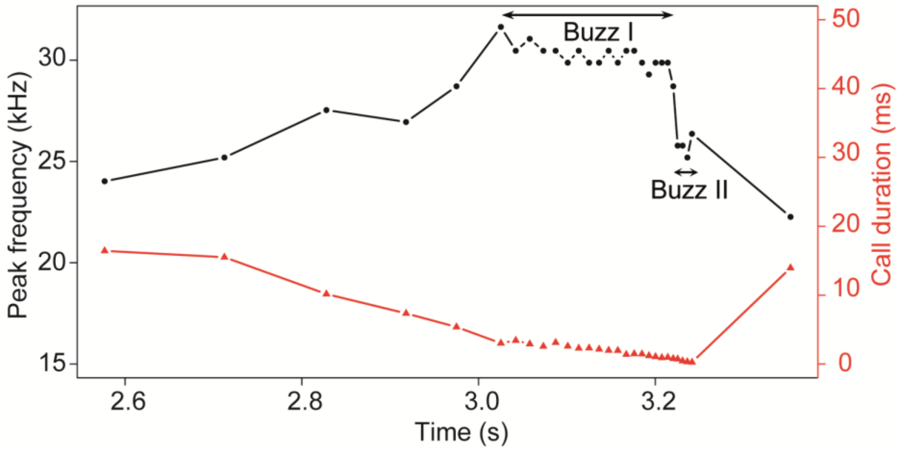

Figure 4 - Sequence of *N. leisleri* echolocation calls showing the approach phase calls and feeding buzz I and buzz II. Circles represent peak frequency and triangles call duration.

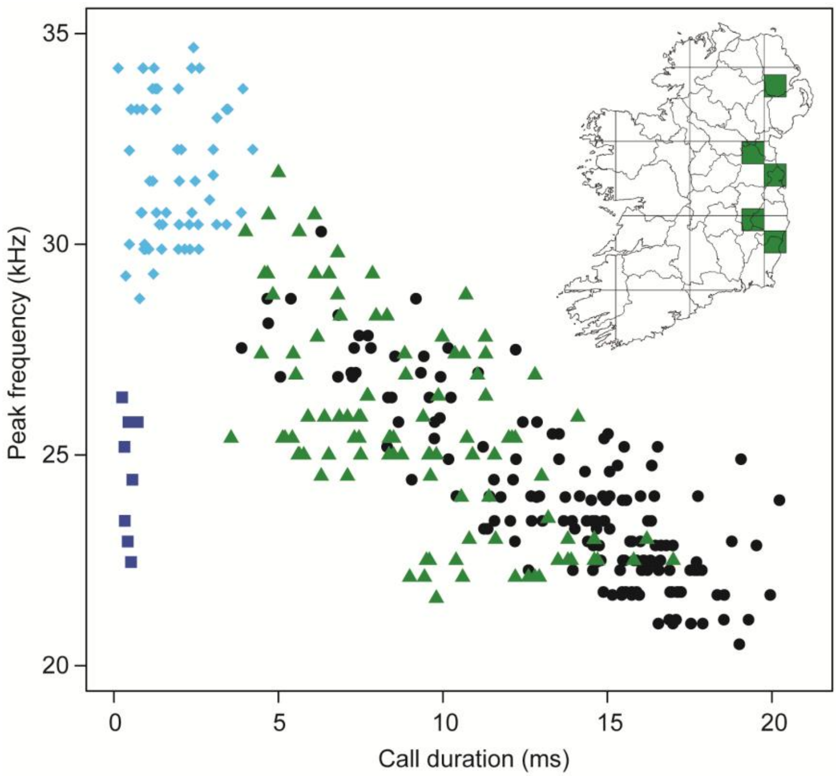

Figure 5 - Echolocation peak frequency *versus* call duration for search phase and approach phase calls (●), feeding buzz I (♦) and feeding buzz II (■) for *N. leisleri* recorded in Ireland. Triangles (▲) represent echolocation calls recorded during the car transects from eastern Ireland (squares on the map of Ireland).

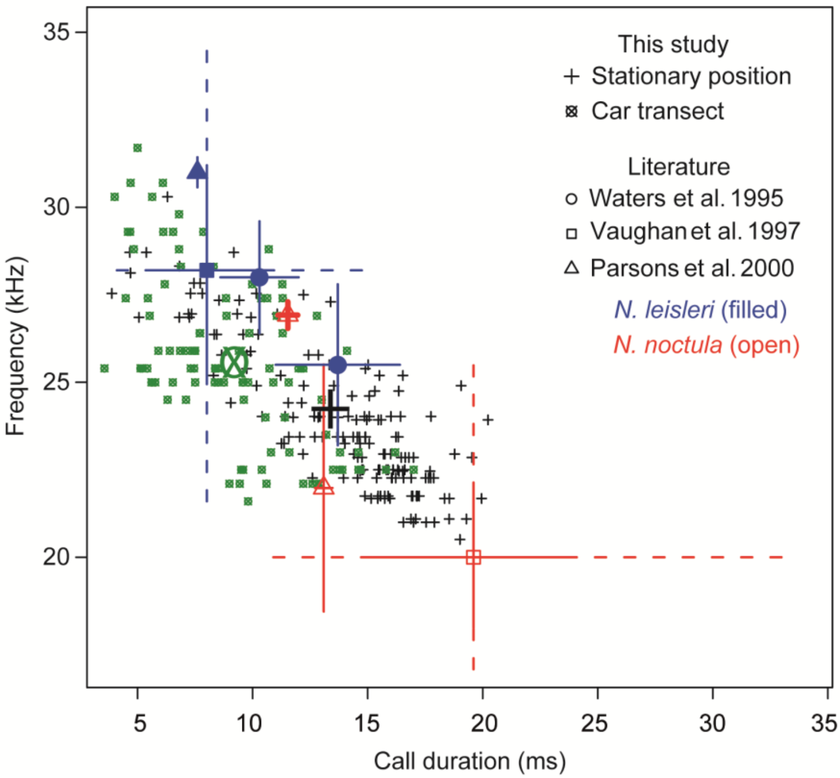

Figure 6 - Echolocation peak frequency *vs.* call duration for *N. leisleri* recorded from stationary position (+) and car transect data (¤). The average values for the two data sets are presented by their respective symbols enlarged. Published averages (large squares, triangles and circles), one standard deviation (solid line) and range (dashed line) of published *N. noctula* (open) and *N. leisleri* (filled) calls from England and Wales are also presented. For published data, different types of calls were presented whenever available in the original publication (e.g. type 1 and type 2 calls; Parsons and Jones, 2000).

sets' parameters (Fig. 5). Fig. 6 presents published data on *N. leisleri* and *N. noctula* from England and shows that although some calls from Ireland overlap with the published upper calls of British *N. noctula* (Vaughan et al. 1997; Parsons and Jones, 2000), none of the calls recorded in Ireland fall within the lower frequency range of British *N. noctula* calls (16.8-20 kHz, Vaughan et al., 1997; see also Fig. 6). F_{peak} of all 318 calls fell within the frequency range previously reported for *N. leisleri* in England while a few calls slightly exceeded, by a few milliseconds, the previous maximum duration reported (Fig. 6). Waters et al. (1995) and Parsons et al. (2000) did not include minimum and maximum values for the parameters measured but only included their standard deviation from which we could estimate the 99% confidence intervals assuming a normal distribution of the data. By doing so, our data entirely falls within the range for *N. leisleri* calls reported by those authors (data not shown). The maximum call duration reported in our data set (20.3 ms) was less than 2/3rd of the maximum reported for *N. noctula* in England (33.5 ms, Vaughan et al. 1997; see also Fig. 6).

DISCUSSION

Barbastella barbastellus

This study could not confirm the presence of this species in the Lough Derg region. However, it is important to note that all known Irish species were recorded during survey work except *Rhinolophus hipposideros*, whose range does not extend that far east (Kelleher 2004) and *P. nathusii,* which has been only recently confirmed to be a resident species in Ireland (Russ and Montgomery 1998), breeding only in the north east (Russ et al. 2001). *Plecotus auritus*, which emits "quiet" echolocation calls, similar to *B. barbastellus* (Russ 1999) was also recorded at each site surveyed, indicating the thoroughness of this acoustic survey. *Myotis daubentonii* can emit a social call that overlaps in call structure with the type 2 call of *B. barbastellus* (Denzinger et al. 2001; call of type A in Pfalzer 2002). Therefore, it cannot be excluded that the reported recording from 1997 may have been from *M. daubentonii* social calls; however, we were unable to get access to the unpublished 1997 collected data to investigate this possibility.

B. barbastellus is vulnerable throughout Europe (Temple and Terry 2007) and is highly specialised in its habitat requirements, generally occurring in mature broadleaved and mixed woodland with large, mature trees and a well developed understory (Sierro 1999; Eriksson et al. 2004; Russo et al. 2004, 2005, 2010; Hillen et al. 2009; Rebelo and Jones 2010). Its diet is dominated by Lepidoptera (Sierro and Arlettaz 1997), indicating a very specialised niche. The question then arises, is Ireland suitable from a climatic and habitat perspective for this species? Recent predictive modelling for the distribution of *B. barbastellus* in Europe shows suitable climatic conditions in the east coast and midlands (including the Lough Derg region) of Ireland (Rebelo 2009). Nevertheless, this model does not consider habitat variables (e.g. forest cover), which would be an important factor for the presence of the species (H. Rebelo personal communication 2010). Currently Ireland has a very reduced forest cover (Gallagher et al. 2001), although there is currently suitable forest habitat on the east coast, particularly in Co. Wicklow (Perrin et al. 2006). Ireland's forest cover was reduced to less than 1% by the nineteenth century (McCracken 1971). Therefore, it is possible that this species occurred here in the past but became extinct due to habitat loss. Although *B. barbastellus* is not known for long distance flights (Hutterer et al. 2005), other slow flying species such as *M. mystacinus* and *P. auritus* managed to colonise Ireland after the last glacial maximum. An investigation of the subfossil bat bones of Irish caves would be required to test if *B. barbastellus* also reached Ireland in the same period.

2. *Nyctalus noctula*

The analyses of our data set suggest that *N. noctula* is absent from Ireland

and show that the lower echolocation calls of Irish *N. leisleri* compared to British conspecifics could complicate correct species identification without local reference calls. When the call dataset from Dartry/Phoenix Park and the car transect squares were compared to the published call parameters for peak frequency and call duration for *N. leisleri* in England (Waters et al. 1995; Vaughan et al. 1997; Parsons and Jones 2000), they were found to fall within the known call range for this species (see also Russ 1999). However, our study reveals that *N. leisleri* from Ireland use on average a lower F_{peak} than *N. leisleri* from Britain and we hypothesise that this lower F_{peak} could be explained by the absence of *N. noctula* in Ireland. This would give *N. leisleri* the possibility to exploit the niche occupied by *N. noctula* in the continent and Britain and would potentially lead to more prey being available, which could explain why *N. leisleri* is common in Ireland (O'Sullivan 1994). Further work should however be carried out to test this hypothesis. Irish *N. leisleri* calls do partly overlap with the published call parameters for *N. noctula* but a large space parameter (F_{peak} < 20 kHz and call duration > 21 ms, see Fig. 6) was missing from the Irish data set when compared to the published range of *N. noctula* echolocation calls in Britain (Vaughan et al. 1997; Parsons and Jones 2000). We hypothesize that if *N. noctula* were present in Ireland, then the Irish *Nyctalus* sp. call dataset would contain calls of longer duration and lower F_{peak}. We were unable to get access to the 1997 unpublished original data set identified as *N. noctula* to investigate how it compares to the Irish *N. leisleri* echolocation calls.

If *N. noctula* is absent from Ireland it is unlikely to be due to Ireland's island status, given that this species is a long distant migrant (Hutterer et al. 2005). Therefore, the Irish Sea, particularly between south western Scotland and north eastern Ireland (approx. 20 km) should not have been a barrier for colonisation. The potential distribution of *N. noctula* in Europe has not been modelled, but, similarly to *B. barbastellus*, this species is reliant on woodland for foraging (Mackie and Racey 2007) and roosting, with a heavy reliance on woodpecker holes (Boonman 2000). Woodpeckers (*Dendrocopos major*) became extinct in Ireland in historical times due to deforestation (D'Arcy 1999) so *N. noctula* might have occurred in Ireland in the past, and became extinct along with woodpeckers due to loss of habitat. However, the "re-colonization" of the eastern coast of Ireland by *D. major* in the last few years (O'Halloran 2009) might create favourable roosting conditions for *N. noctula* and favour their colonisation from Britain. Furthermore, current policies promoting re-forestation and afforestation with broadleaf trees might also help to create habitats suitable for both species.

Although it is impossible to prove the absence of a species (e.g. Puechmaille et al. 2009), there is currently insufficient evidence to state that *N. noctula* and *B. barbastellus* occur in Ireland. Further surveys should be carried out in Irish woodlands to determine the status of both species, which, for the moment, should not be considered as present or resident in the island. We would also recommend that species should only be considered as present in a country or landmass if there are undeniable data to support such a statement.

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