

First records of *Nyctalus noctula* social calls in Portugal

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Abstract. The common noctule (*Nyctalus noctula*) is a large and fast flying Palaearctic migratory bat. The range of the species distribution extends in longitude from the Iberian Peninsula to Japan and in latitude from North Africa to the southern part of the Scandinavian countries. However, in the southern part of its distribution range, most of the potential maternity colonies are unknown or found only sporadically. This note presents the first records of *N. noctula* social calls in Portugal. In fact, two types of *N. noctula* social calls (C1 and D1) were recorded and identified at a site in the Sabor river valley in northern Portugal, which are usually associated with mating roosts. Therefore, these new data may contribute to improve and update the knowledge of the location of potential new mating, swarming and hibernation sites, as well as of the mating season length and behavioural patterns of this migratory species throughout its European range.

***Nyctalus noctula*, social calls, bat swarming, Portugal**

Introduction

The common noctule, *Nyctalus noctula* (Schreber, 1774), is a large and fast flying Palaearctic bat, with broad rounded ears, rufous-brown fur, which is slightly darker on the dorsum, and has long narrow wings covered with short hair on the underside of the membrane close to the body (Dietz et al. 2009). Little is known about its preferred foraging habitats and how the resource quality determines the occurrence of its colonies, mainly due to technical difficulties in studying a bat that roosts in almost inaccessible high tree holes (Iain & Racey 2007) or high crevices in buildings and bridges (Dietz et al. 2009).

The range of the species distribution extends in longitude from the Iberian Peninsula to Japan and in latitude from North Africa to the southern part of the Scandinavian countries (Dietz et al. 2009). However, in the southern part of its distribution range, most of the potential maternity colonies are unknown or found only sporadically (Alcade 2008, Camprodon & Guixé 2013). In Western and Central Europe, the southern border of the known distribution of nursery colonies lies around 48–49° N (central France, northwestern Switzerland, southeastern Germany, Czech Republic and Poland) (Görföl et al. 2009). South of this line, only isolated observations of breeding *N. noctula* are available, namely from the Iberian Peninsula (Ruedi et al. 1998, Alcalde 2008, Camprodon & Guixé 2013), Italy and France (Petit et al. 1999), Bulgaria and northern Greece (Dietz et al. 2009), Austria (Spitzenberger 2007) and Slovakia (Kaňuch & Čelúch 2004). In Portugal no maternity colonies were reported and the confirmed records of this species are very rare, based on few isolated observations (Palmeirim 1979, LEA 2009, ICNB 2010, Barros 2012) mostly obtained in the north of the country (Fig. 1). *Nyctalus noctula* is a typical migratory bat, which begins the migration from early September until late autumn, mainly in the southwestern

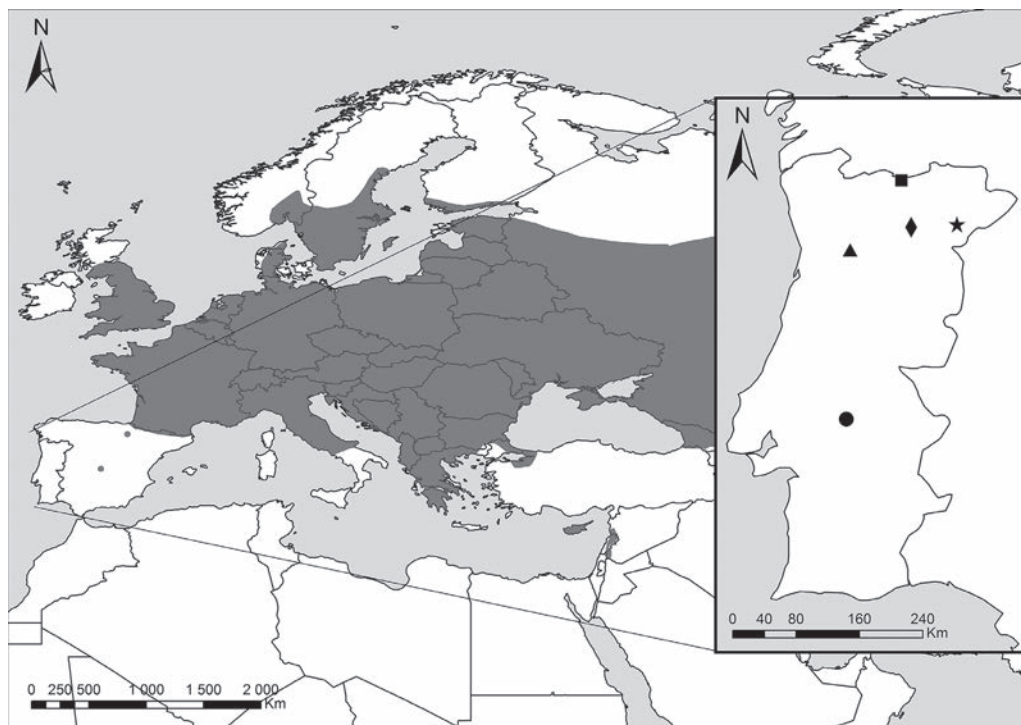


Fig. 1. The expected distribution range (shaded area) of *Nyctalus noctula* in Europe (IUCN 2014) and isolated records of the species occurrence in Portugal (black square – Barros 2012, black triangle – ICNB 2010, black lozenge – LEA 2010, black circle – Palmeirim 1979) and our records described in the present paper (black star).

direction. The bats return in the opposite direction (northeastern) between mid-March and mid-April (Weid 2002). This migratory process, from the nursery roosts to hibernating places, can cover distances of more than 1000 km (Gebhard & Bogdanowicz 2004), with reproduction areas being located mostly in northeastern and northern Central Europe. Conversely, the winter and mating areas are mostly found in south and southern Central Europe (Dietz et al. 2009).

In contrast to echolocation bat calls, used for flight orientation (Siemers & Kerth 2006), the social calls are more important for communication between individuals (Schöner et al. 2010). In fact, these intentionally emitted vocalizations exhibit lower frequencies and higher structural variability which allows longer detection ranges and individual coding of more information (Pfalzer & Kusch 2003). Social calls are used in several intraspecific interactions (Pfalzer & Kusch 2003), such as attracting or repelling other individuals from feeding or roost/mating sites (Barlow & Jones 1997). However, the extent in which free-ranging bats use social calls of conspecifics or of other bat species for roost finding is largely unknown (Schöner et al. 2010). In the Northern Hemisphere, from late summer to early autumn, a considerable number of bat species meet in roosts, where the social calls are very frequent as a part of mating behaviour (Rivers et al. 2006, Piksa 2008, Glover & Altringham 2008). This phenomenon was described in the 1960s and was defined as a swarming behaviour (Davis 1964). In the mating season of *N. noctula* (between

early September and late autumn), the males call out loudly at the roost entrance, flying around from time to time in order to drive away other males and/or to attract females, showing a clear swarming behaviour (Dietz et al. 2009).

Material and Methods

During a routine bat census, carried out at a site in the Sabor river valley in northern Portugal (41° 17' N, 06° 52' W) on 12 September 2013, between 21:30 and 22:30 (2 hours after sunset), many bats flying around roost entrances were seen and heard (in human hearing range frequencies and by bat detector acoustic records). These bats were emitting social calls continuously near structural gaps of a high (75 m) and long (560 m) bridge of the IC5 national highway, which were used for roosting. During 30 minutes of monitoring more than thirty tracks were recorded, each of them with at least one social call.

The Sabor river valley is characterized by typical Mediterranean vegetation, dominated by evergreen forests of *Quercus suber* and *Q. rotundifolia* and deciduous forests of *Q. pyrenaica* and *Q. faginea*.

Social calls were detected with a bat detector (Pettersson Elektronik® AB Mod. D240X, Uppsala) switched to the frequency division mode. When a social call was detected and recorded, the time expansion (10×) was triggered and a 1.7 s sequence of each social call was sampled. The corresponding sample of 17 s was then downloaded and transferred to a digital record (Zoom H2 Handy Recorder). The social calls were identified by using the sound editing software BatSound 3.3.1®. A sampling frequency of 44.1 kHz, with 16 bits/sample and a 1024 FFT (Fast Fourier transformation), was applied for the *N. noctula* identification/confirmation.

For the discrimination of social call types, the start frequency (SF), the end frequency (EF), the frequency of maximum energy (FMaxE), the pulse duration (PD) and the inter-pulse interval (IPI) were used as pulse variables. The parameters for each variable were compared with those described in Pfalzer (2002) and Pfalzer & Kusch (2003).

Results

The social calls of *Nyctalus noctula* are the most variable among all Palaearctic bat species (Weid 1994), with 11 types of social calls already described (B, C, D, E, F, G, H, I, J, and K) (Pfalzer 2002), also considered as 4 main types (A, B, C, and D) with some variations among the types

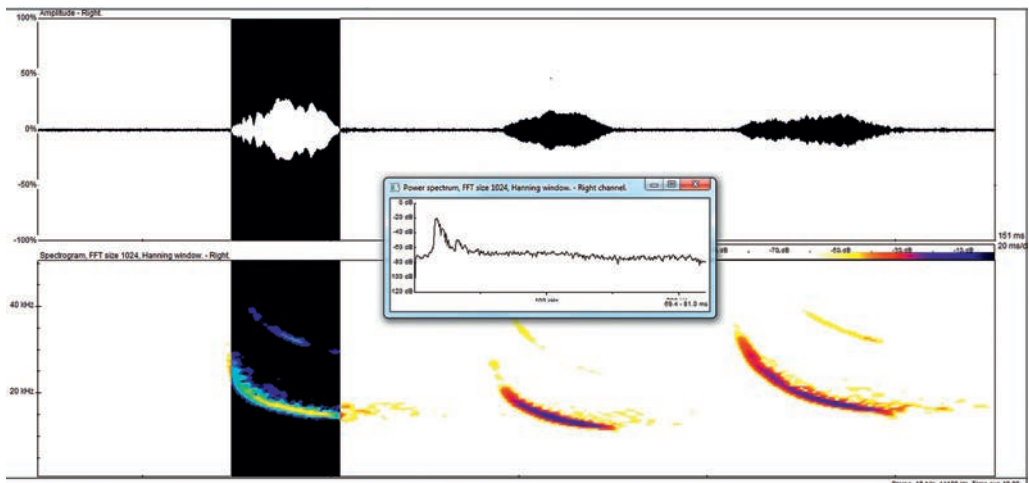


Fig. 2. Oscillogram, spectrograms and power spectrum of the recorded C1 type social call of *Nyctalus noctula*. Sabor River Valley, 12 September 2013.

Table 1. Mean values of the pulse variables analysed. SF – start frequency; EF – end frequency; FMAX – frequency of maximum energy; D – duration

social call	SF [kHz]	EF [kHz]	FMAX [kHz]	D [ms]
type D	14.6	38.03	17.42	14.2
type G	10.3	19.17	13.60	125.2

C (C1, C2 and C3) and D (D1 and D2) (Pfalzer & Kusch 2003). Although in the ultrasound analysis, some social calls of *N. noctula* can overlap with those of *Nyctalus lasiopterus*, two types of *N. noctula* social calls (C1 and D1) were clearly identified taking into account the description criteria by Pfalzer (2002) and Pfalzer & Kusch (2003). The *N. noctula* occurrence was confirmed by capturing two individuals (F. Amorim, pers. comm.), during the same month of 2013, by using the mist netting procedure in a more accessible bridge roost on the same highway, near the site (less than 1 km) of our acoustic records.

The analysis of the recorded C1 type social calls revealed a frequency modulation (FM) structure around the frequency of maximum energy (FMaxE) and the final part of the pulse tended to an almost constant frequency (CF). The relatively high calls had one or more harmonics in the spectrogram (Fig. 2). The frequency of maximum energy was significantly higher in the range of human hearing with a mean of 17.42 kHz and a frequency interval covering a range of about 38–14 kHz (EF and SF, respectively). The duration of each pulse of this type of social call was characterized by the mean value of 14.2 ms (Table 1) with a mean inter-pulse interval of 28.9 ms.

The recorded D1 type social calls were very remarkable in the time expansion mode (10X) with a reminiscent and penetrating “purr” trill and chirping sounds, reminding a nightjar (*Caprimulgus europaeus*) vocalization, in the audible mode of the detector. This type of social calls is characterized by frequencies ranging between 10 and 19 kHz with the frequency of maximum energy around 14 kHz. The most notable characteristics of this type of social call are its modulated sinusoidal form (Fig. 3) and its extensive pulse duration (always above 100 ms, in our case with the mean of 125 ms, Table 1). This type of social calls was emitted always in the presence of two or more

Table 2. Mean values of the pulse variables analysed for the complex social call recorded. FMAX – frequency of maximum energy; SF – start frequency; EF – end frequency; PD – pulse duration; IPI – inter-pulse interval

part	pulse	FMAXE [kHz]	SF [kHz]	EF [kHz]	PD [ms]	IPI [ms]
A	1	17.0	25.9	13.9	12.5	–
	2	14.5	27.8	11.3	13.7	27.9
	3	18.4	35.2	14.8	17.1	29.5
mean		16.6	29.6	13.3	14.4	28.7
B	4	19.4	29.8	27.6	26.8	48.3
	5	14.1	19.7	10.7	10.8	48.9
	mean	16.8	24.8	19.2	18.8	48.6
C	6	15.1	19.1	10.9	3.7	27.9
	7	16.1	16.9	10.8	3.9	12.3
	8	16.4	18.3	11.2	3.4	12.9
	9	15.7	19.1	10.9	4.2	12.0
mean		15.8	18.4	11.0	3.8	16.3

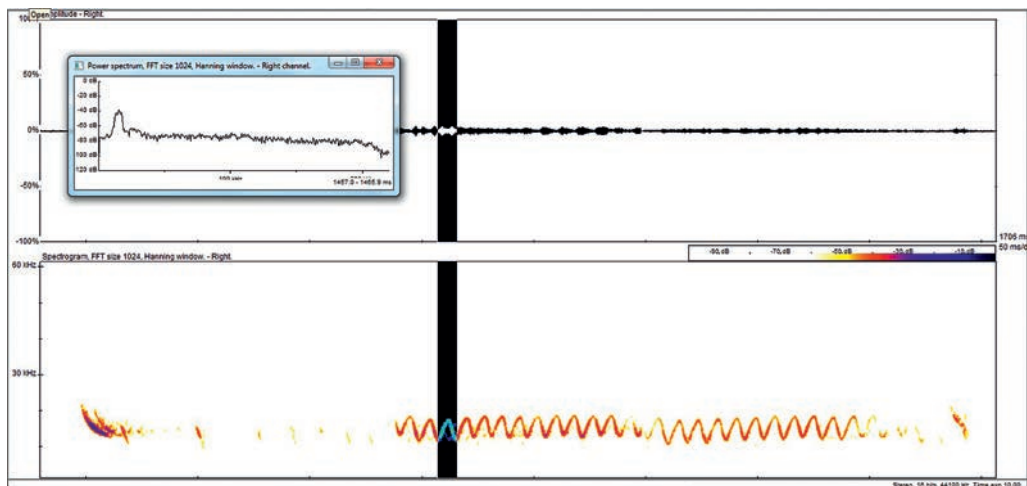


Fig. 3. Oscillogram, spectrogram and power spectrum of the recorded D1 type social call of *Nyctalus noctula*. Sabor River Valley, 12 September 2013.

other individuals. Besides the typical social calls described by Pfalzer (2002) and Pfalzer & Kusch (2003). We recorded also other social calls which were more complex composed of three different parts: the first one with three pulses similar to the C1 type social calls, with frequencies covering

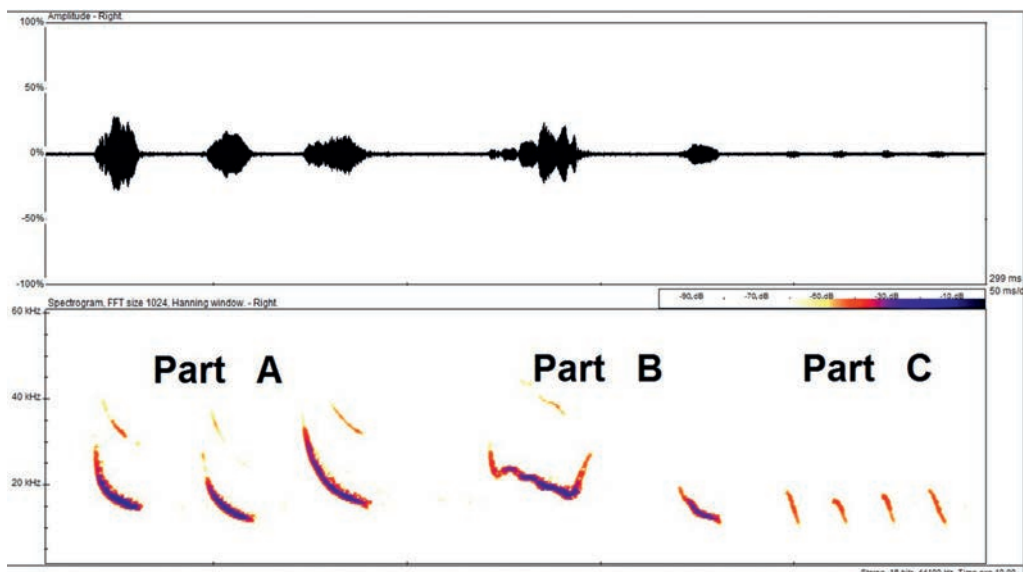


Fig. 4. Oscillogram and spectrogram of the complex social call recorded. Sabor River Valley, 12 September 2013.

a range of about 35–11 kHz (EF and SF, respectively), a FMaxE around 16 kHz and 14 ms PD, followed by a second part with a long (26–10 ms) pair of irregular pulses of the quasi-constant frequency (QCF), and finished by a third part with 4 pulses of short duration (3–4 ms) tending to FM (Fig. 4, Table 2).

Discussion

In the Iberian Peninsula, *Nyctalus noctula* reaches the southern limit of its distribution with only four records of colonies in three regions in Spain, Aranjuez in Madrid (Ruedi et al. 1998), Pamplona and Sangüesa in Navarra (Alcade 1999), Lleida (Camprodon & Guixé 2013), and few observations of individuals (Ibáñez et al. 1992). In Portugal, no colonies nor breeding activity have been reported so far and the confirmed records of this species are related exclusively to sporadic observations/captures of solitary individuals: one found dead in a wind farm (ICNB 2010), one hibernating in an abandoned train tunnel (LEA 2009), one trapped during a mist net survey (Barros 2012), two captured in a mist net (F. Amorim pers. comm.) and one in the collection of Museu Bocage (Palmeirim 1979). Emission of social calls and echolocation signals by bats swarming around the roost are a typical behaviour of many vespertilionid bats before entering the roost during the mating season, when males and females coexist (Dietz et al. 2009, Barros & Braz 2013). This behaviour was also observed in the Iberian Peninsula, where the colonies in Navarra are composed almost exclusively by males during the breeding season and by both sexes during the mating season, with females outnumbering males due to the formation of harems (Alcalde 1999).

Mating of *N. noctula* usually occurs in early autumn, but may also occur during winter, just before hibernation and mostly in the swarming hibernacula roosts. Winter roosts of *N. noctula* can be found in thick-walled tree holes, in crevices in buildings and bridges, rock crevices and in roof crevices of caves (Dietz et al. 2009). Nevertheless, the males of *N. noctula* occupy temporary roosts on migration or dispersal routes, producing calls to attract females for mating (Petit et al. 2001). In Bulgaria, hibernation of this species has already been observed in bridges with characteristics similar to those described in our study (Tilova et al. 2008).

Given the season in which these social calls were obtained and the phenology of the species, our records can be related to individuals from the south and southern Central European areas of its distribution (Dietz et al. 2009), that moved further south for mating and hibernation. However, a main question remains: is this finding only the evidence that social calls of *N. noctula* can be recorded sporadically in Portugal or does it also suggest possible existence of swarming sites, temporary mating roosts and/or potential hibernation roosts in the south-western region of its known distribution range? Therefore, further studies investigating the occupancy and type of these potential roosts may be highly interesting, if possible by using complementary methods, such as inspection of gaps in bridges in different seasons (mating and hibernation periods) and/or by capturing and marking individuals (ringing or marking with passive integrant transponders - PIT) to better understand migration patterns of these bats. Despite this question, since the C1 and D1 social calls of *N. noctula* are usually recorded in mating roosts (Pfalzer & Kusch 2003), our new data may contribute as a starting point to improve and update the knowledge of the location of potential new mating, swarming and hibernation sites, as well as of the mating season length, migratory and behavioural patterns of the species throughout its European range.

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