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# Quantification of the Edible Dormouse *Glis glis* (Linnaeus, 1766) Calling Activity for Biodiversity Surveys: Comparison of Core and Peripheral Populations

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**Abstract:** The edible dormouse *Glis glis* is known to emit typical calls during the night. These calls were used in various studies for the detection of species presence or habitat occupancy as well as for quantifying abundance estimates. However, to date, we lack rigorous data on the quantification of the call activity throughout the night and within-season changes in calling activity. To fill this gap, we compared the calling activity of the edible dormouse in core and peripheral populations using voice recorders. During the summer when dormice are active, we deployed voice recorders at three sites with high dormice densities in the Czech Republic and three localities with low densities in Lithuania. We found that calling activity during night varied considerably but seasonally it peaked in August. It was lower in July and lowest in September. Rainy or windy nights significantly reduced call frequencies. Edible dormice started calling around sunset and the intensity increased within two hours, with a peak 4–6 hours after sunset. The frequency of calling decreased before sunrise. Call frequencies per hour were slightly lower in Lithuania. The duration of calls ranged from 1 to 1147 seconds and was significantly shorter at the Lithuanian sites. Our study shows that edible dormice call at a high rate even in peripheral populations and offers promising support for biodiversity surveys and acoustic monitoring.

**Key words:** Acoustic survey, voice recorders, nocturnal activity

# Introduction

Rodents of the family Gliridae emit a wide variety of vocal signals, both ultrasound and audible for humans (Hutterer & Peters 2001, Rossolimo et al. 2001, Ancillotto et al. 2014, Holden-Musser et al. 2016). In contrast to some dormouse species, which use mainly ultrasonic communication (Ancillotto et al. 2014, Ancillotto & Russo 2016), acoustic signals of the edible dormouse (*Glis glis*) are easily audible to humans (Morris 2011). However, it is surprising that only the calling activity of the edible dormouse during the mating period has been described, with nothing written in older publications about vocalisation in this species during the post-mating season (Donaurov et al. 1938, Ognev 1947, Koenig 1960, Vietinghoff-Riesch 1960, Storch 1978, Airapetyants 1983). Only in the last decade of the 20th century, attention was drawn to the calling activity of the edible dormouse in the post-mating period (Hoodless & Morris 1993, Jurczyszyn 1994, Rodolfi 1994, Jurczyszyn 2023). Its vocal behaviour was used for assessing population densities (Hoodless & Morris 1993, Jurczyszyn 1994),

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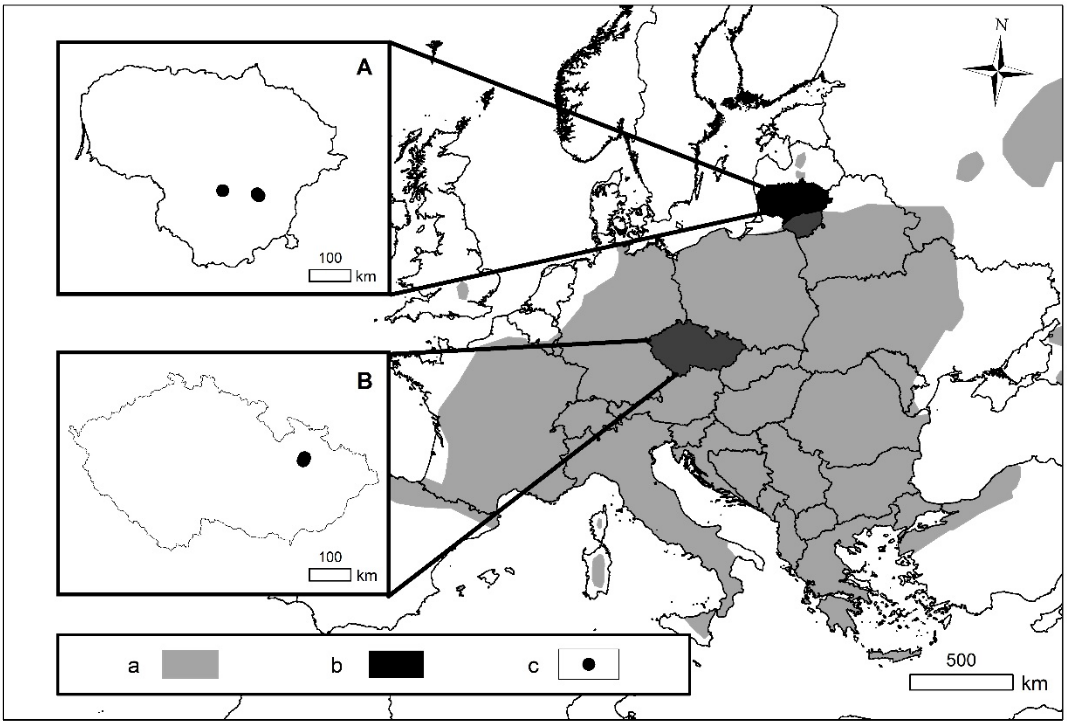


**Fig. 1.** Edible dormouse distribution range (a) and study areas (b): A – Lithuania and B – Czechia with study sites (c) where voice recorders were deployed.

abundance (Sergio et al. 2007, Ratajac et al. 2022) and distribution (Capizzi et al. 2003, Mortelliti et al. 2009, Lang 2010, Adamík et al. 2019).

While many researchers successfully used dormouse vocalizations for various research projects, we still need a deeper understanding of their functions and seasonal patterns. As indicated by Holden-Musser et al. (2016), much work remains to be done to understand how dormice communicate.

Jurczyszyn (1994, 2023) made the first attempts to quantify seasonal and sex-specific patterns in calling intensity among edible dormice. Thus, while we know that the species regularly uses vocalizations during the summer, there is a considerable gap in understanding whether there are seasonal or site-related differences in calling activity. Our study aimed to obtain new data by comparing the acoustic activity of the edible dormouse at field sites in the Czech Republic and in Lithuania. The Czech sites were located in areas within the core population, while the Lithuanian sites were situated at the patchy edge of the species' distributional range.

# Materials and Methods

### Study sites

Our study was conducted in two study areas: a core population with very high densities of edible dormice in the Czech Republic compared to peripheral populations with low densities in Lithuania (Fig. 1). In each area, we selected three sites for the deployment of voice recorders. In the summer of 2017, three voice recorders were deployed at the sites in the Czech Republic, near Dlouhá Loučka: Krmelec (49.8302N, 17.2146E), Sutrak (49.8602N, 17.2369E) and Ucapa (49.8720N, 17.2427E). Similarly, in the summer of 2020, three voice recorders were deployed at three sites in Lithuania, in Vilnius and Kaišiadorys districts: Airėnai (54.8382N, 24.9121E), Dūkštos (54.8162N, 24.9494E) and Rumšiškės (54.879N, 24.1558E).

All three Czech sites are part of a large forested landscape in the Nízký Jeseník Mountains. Managed mixed forest stands prevail here with a majority of broadleaved tree species. The first study site, Sutrak, was in a 90-100-year-old forest with beech (*Fagus sylvatica*) and sessile oak *Quercus petraea* as dominant tree species (65% and 20%, respectively). The understory is poorly developed as the old trees form a closed canopy. The second site, Ucapa, is a 100-year-old beech forest (80%) with a rich understory of young beech trees. Voice recorders at the first and second sites were placed at 1.5 m height underneath a nest box. The third site, Krmelec, is a 130-year-old patch surrounded by 30 to 100 year-old stands. Beech comprises 40% and sessile oak 30% of the trees. The voice recorder was placed at 3 m height under the roof of a wooden shelter used to store food for deer. This site is unusual as edible dormice frequently used this shelter and call frequencies were unusually high. Thus, we treated this site separately for analyses of call frequencies. All three sites were within a similar altitudinal range (420–445 m a. s. l.). Edible dormice are very abundant at all three sites (Mašková & Adamík 2012).

In Lithuania, the first site (Airėnai) is situated along the Neris River valley in the Neris Regional Park, Vilnius district. The mixed forest stand where dormice occur covers ca. 75 ha, at 110 m a. s. l. This site differs from the other known edible dormouse habitats in Lithuania because as oak trees are absent here. Lime (*Tilia cordata*), elm (*Ulmus glabra*), grey alder (*Alnus glutinosa*), aspen (*Populus tremula*) and ash (*Fraxinus excelsior*) dominate the canopy, with hazel (*Corylus avellana*), dwarf honeysuckle (*Lonicera xylosteum*), bird cherry (*Padus avium*) and elder (*Sambucus nigra*) present in the understory. The second site (Dūkštos) is situated in a continuous forest area (ca. 400 ha, 110 m a. s. l.), where mixed forest stands of various ages prevail. Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*), birches (*Betula* spp.), pedunculate oak (*Quercus robur*) and grey alder dominate the canopy layer, with hazel, alder buckthorn (*Frangula alnus*), rowan (*Sorbus aucuparia*), dwarf honeysuckle and bird cherry in the understory. The third site at Rumšiškės (60 m a. s. l.) is situated along the Nemunas River valley, in the Kauno Marios Regional Park. The site is part of a ca. 500 ha forest where mature stands of mixed forest prevail. Dominant trees are Scots pine, Norway spruce, birches and pedunculate oak, with hazel, dwarf honeysuckle, alder buckthorn and rowan in the understory. All the three voice recorders were hung on trees at 2–3 m above the ground. Edible dormice were already known to occur in all three sites, at very low population densities (Juškaitis & Augutė 2015).

**Acoustic survey**

We deployed Olympus DM-650 voice recorders at the three Czech sites. They were in continuous operation mode from July to September 2017. In 2020, the same three recorders were deployed from July to September at the Lithuanian sites. Voice recorders were protected from adverse weather by installing them in specially-made boxes with a protective roof and an opening for the microphone and wind shield (Samson WS-1). The sampling rate was set at 44.1 kHz 32-bit. The recorders were equipped with 16 or 32 GB SD cards. To ensure long operation times of several weeks, each recorder was powered by 3.4 Ah rechargeable 12 V batteries.

**Data processing and analysis**

A typical edible dormouse call is a short squeak between 2–16 kHz of about 0.3–0.5 sec (Fig. 2).

We refrained from using automatic detection of calls from the large data archive as our preliminary work showed a high rate of missed detections. Instead, we focused on precise detections of all calling events. Processing data from every night over two seasons would be very time-consuming; therefore, we used subsets of data. For each site, we selected three five-night periods, always between the $18^{th}$ and

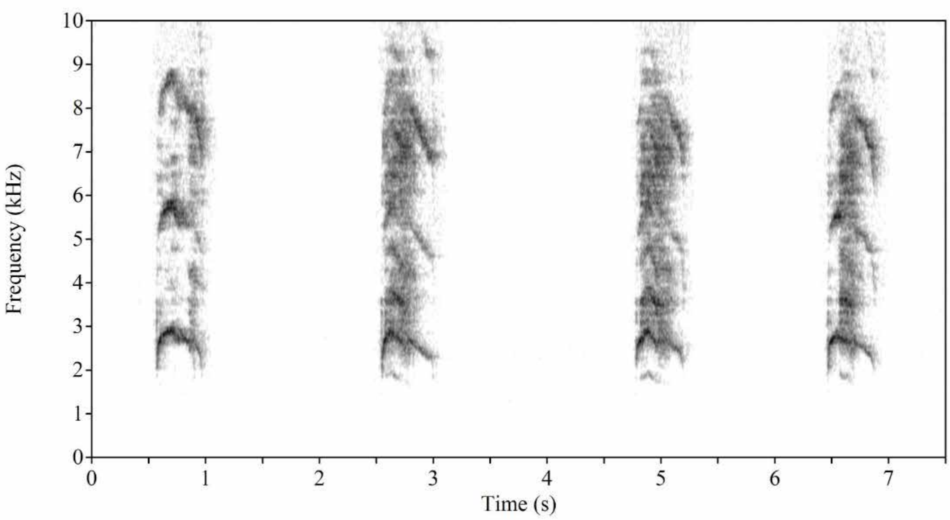


**Fig. 2.** Spectrogram of four typical calls of the edible dormouse. Visualisation was made using Praat and GIMP 2.10.32 programmes.

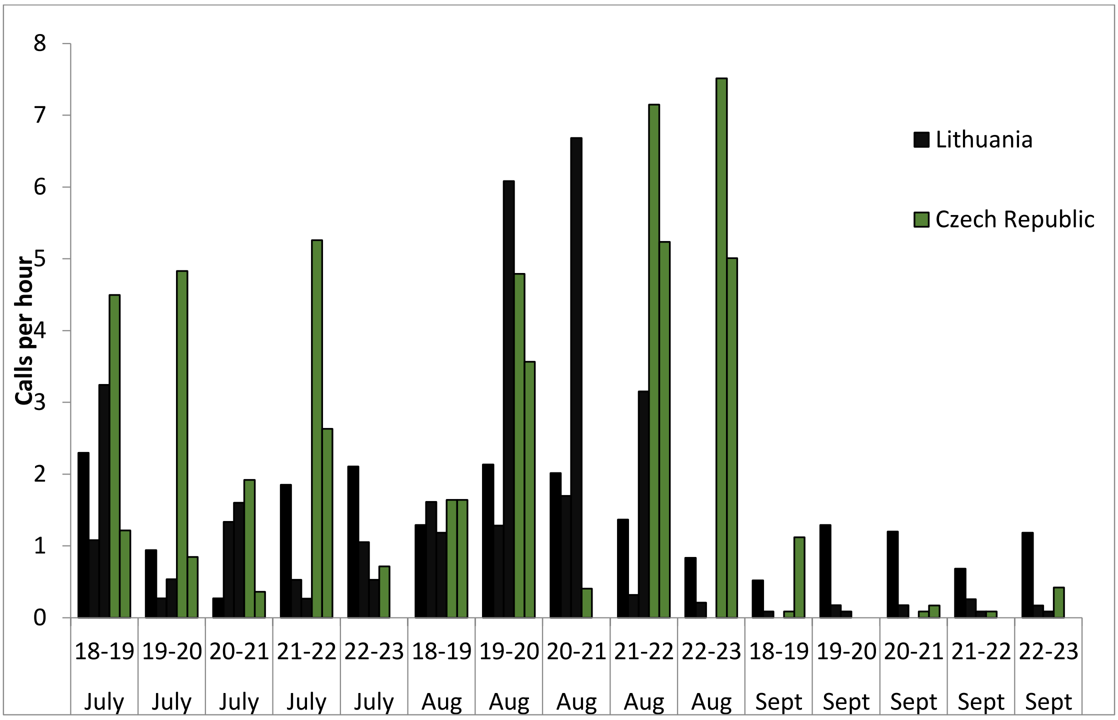


**Fig. 3.** Seasonal changes in night-time calling activity (number of calls per hour) of the edible dormouse at two Czech and three Lithuanian sites.

23rd day of the month in July, August and September. Thus, the dataset consists of call activity processed for each of the six sites for 15 nights. All voice records (1107.5 hours) were processed manually by one person (JB) using the program 'Audacity'. For this purpose, we used a 1 sec time window with a frequency scale from 0 to 20 kHz. We were searching for the specific dormice spectrograms (Fig. 2) of their callings and at the same time listening to them. Dormice usually vocalise in bouts of several calls within a variable period. We intended to quantify the duration of individual calls and frequency of their repetition. For the latter, we set an arbitrary criterion of 30 sec. Thus, if there was a period of silence longer than 30 sec, we quantified the calls as two separate bouts. As dormice are strictly nocturnal, it is crucial to express the timing of events relative to sunset at a particular location and date (Nouvellet et al. 2012). For this reason, we express the timing of all activities relative to sunset. Call frequencies are given as number of calls per hour. For each night, we checked for rain or wind. These were detected from a voice recorder and validated by reference to nearby meteorological stations. For each night, we express the amount of time of windy or rainy weather at each location.

We analysed two response variables, i.e. call frequencies and call lengths. To assess the variability in frequencies of calls (response variable), we fitted a linear-mixed effect model (LMM) with country, month and weather as fixed predictors and site as a random effect. In the second LMM, we aimed to assess the variability in the duration of calls. In this model, we took call length as a response variable and country, month and timing of particular calls relative to sunset as fixed predictors, with site as a random effect. All models were fitted in the R-package lme4 using REML (Bates et al. 2015). For additional model diagnostics, we used the package performance (Lüdecke et al. 2021).

# Results

In Czechia, we recorded on average between 0 to 7.51 calls per hour (mean 2.04 ± 2.36 SD, n = 30 nights). In Lithuania, we recorded between 0 and 6.68 calls per hour (mean 1.19 ± 1.40, n = 45 nights). Call activity did not differ between the countries: b = -0.71, 95% CI [-1.92, 0.50], t = -1.17, P = 0.245. Calling activity during nights varied considerably across the season, but seasonally it peaked in August while it was lower in July (LMM estimates: b = -1.48, 95% CI [-2.23, -0.74], $t_{68}$ =-3.96, P < .001, Fig. 3) and lowest in September (b = -2.78, 95% CI [-3.53, -2.03], t =-7.41, P < .001). In July, the monthly means of calls per hour were 2.23 (n = 10 nights) in Czechia and 1.19 (n = 15) in Lithuania. In August, the means were 3.69 for Czechia and 1.99 for

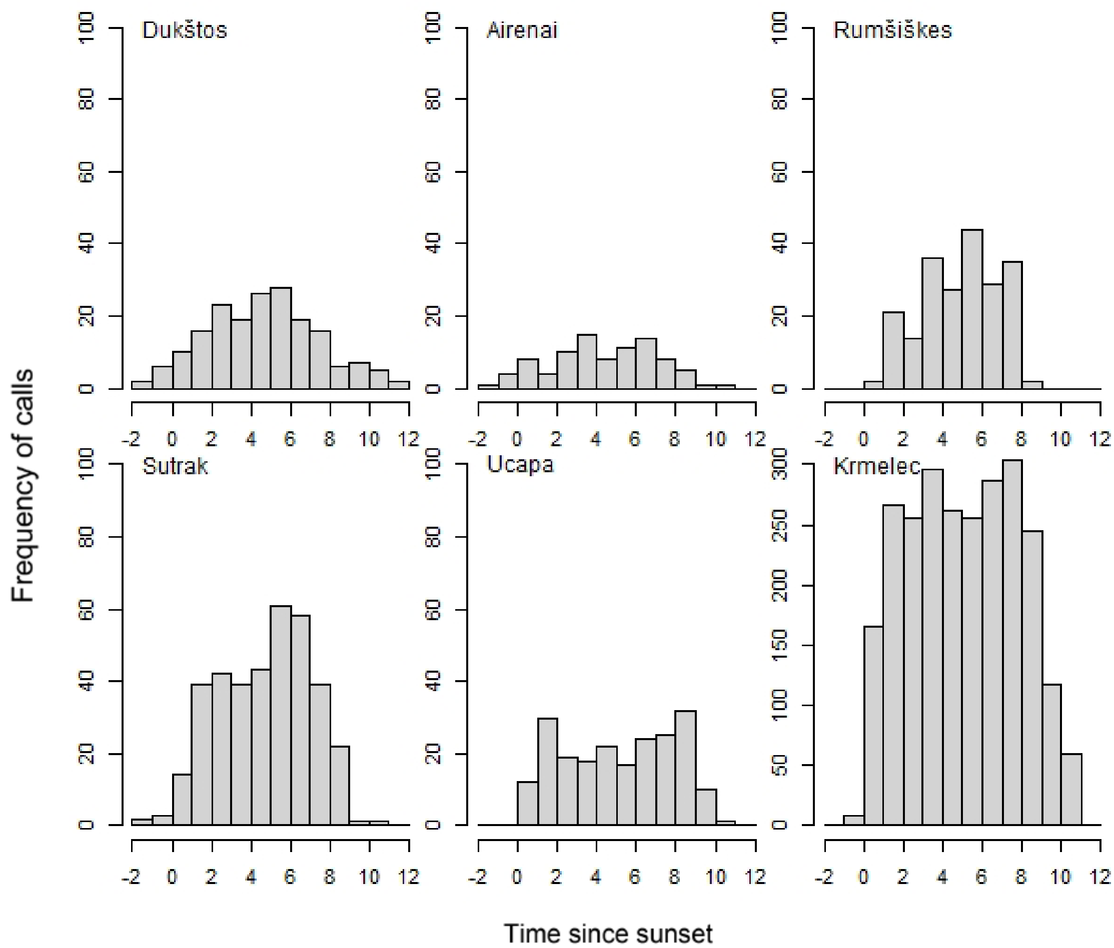


**Fig. 4.** Timing of call activity of the edible dormouse during the night at three Lithuanian (upper row) and three Czech sites (lower row). For each site, the data represent cumulative counts from 15 nights binned into hourly intervals.

Lithuania. September brought a considerable drop in calls, and interestingly in Lithuania, the dormice called slightly more often (0.40) than in Czechia (0.20). Rainy or windy nights had a significantly negative effect on call frequencies (b = -0.18, 95% CI [-0.25, -0.11], t = -5.42, $P < 0.001$). The model's conditional $R^2 = 0.56$ and the part related to the fixed effects alone (marginal $R^2$) is 0.47.

Timing of calls showed an overall similar pattern across sites and both countries (Fig. 4). Dormice started calling around sunset and the intensity increased within two hours, with a peak between 4-6 hours after sunset. Calling frequency decreased again before sunrise. In the entire dataset, edible dormice call lengths ranged from 1 to 1147 sec (mean = 43.77 ± 80.76 SD, median = 11 sec). Edible dormice had significantly shorter calls in Lithuania (mean = 10.66 ± 28.11, median = 2, n = 486) than in Czechia (mean = 48.95 ± 84.96, median = 16, n = 3098; LMM estimates: b = -33.0, 95% CI [-51.85, -14.16], t = -3.43, $P < 0.001$). Overall, the calls were longer

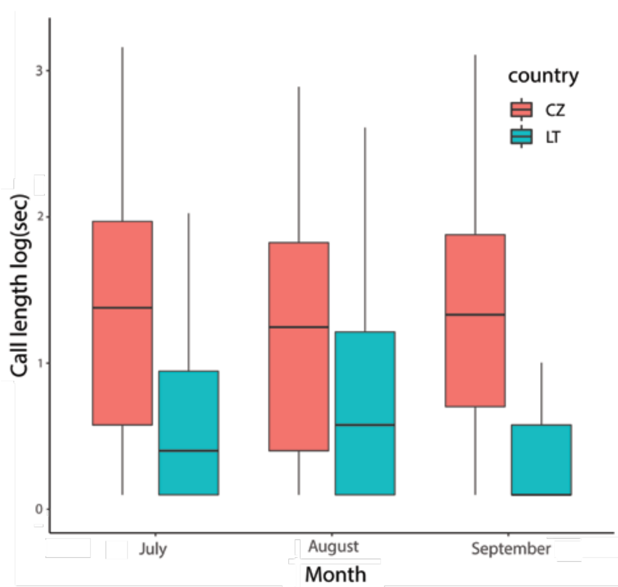


**Fig. 5.** Boxplot of seasonal and country-specific differences in lengths of calls of the edible dormouse. For clarity of presentation the call lengths were $Log_{10}x + 0.1$ transformed.

in July than in the other two months but this was mostly driven by longer calls at the Czech sites (Fig. 5). Call length did not change significantly over the night (b = 0.91, 95% CI [-0.07, 1.90], t = 1.81, p = 0.070). The model's total explanatory power is weak (conditional $R^2$ = 0.04, marginal $R^2$ = 0.03).

## Discussion

We found that edible dormice were calling at about the same rate in both core and peripheral populations. The patterns of the intensity of calls varied considerably across nights and sites. There were nights when calling activity was higher at Lithuanian sites and vice versa. For most nights, activity was highest in August. In mid-September, there was an apparent decline in activity in both countries. However, the drop was stronger at Czech sites leading to an overall higher call activity in September in Lithuania. This is an unexpected pattern, as in autumn edible dormice have a shorter activity season at the northern periphery of the range in comparison to southern populations (Juškaitis et al. 2015a, Gazárková & Adamík 2016).

The only striking difference between the populations in the two countries was in the length of calls. Edible dormouse calls in Lithuania were much shorter than at the Czech sites. The most profound difference was in September. As we do not fully understand the communication role of the calls, we can only speculate about possible explanations. It might be that adult dormice in Lithuania from 18–23 September could have already gone into hibernation, and only juveniles, which are active longer in the season, might provide short squeaks. According to Rossolimo et al. (2001), juvenile dormice start calling at two months of age. In 2020, at the Airėnai site, nest boxes were inspected on 22 September, and there were 29 juveniles found but not a single adult. At the Dūkštos site, nest boxes were checked between 12 and 19 September 2020, with 10 adults and 20 juveniles found. At one of the Czech sites, Krmelec, we found 26 juveniles and 24 adults in nest boxes on 15 September. The next nest box inspection was on 25 September, and we found 19 juveniles and two adults. It would be interesting to gather detailed data on vocalizations by young-of-the-year and compare them with adult dormice.

We could also see a negative effect of rain or wind on call frequency. Clearly, adverse weather leads to a noisy background in the recordings, making it more difficult to detect calling dormice. It would be crucial to know whether the animals reduce their vocalising in adverse weather or if the observed decline in activity is purely a methodological artefact of missed detections.

From a methodological perspective, it is interesting that, even in peripheral populations, the edible dormice call at a high rate. This is a promising result for biodiversity surveys and acoustic monitoring. We still need to understand completely the function of the calls. Given that during the peak of the active season the dormice were calling at about the same rate in both countries, it seems unlikely that call frequencies are density-dependent. Thus, dormouse calls can be a reliable detection method, e.g., for mapping surveys. As the call activity peaked in August, we suggest that for survey purposes this month is the best period to put effort into surveying the species.

For most sites, the peak of calls occurred four to six hours after sunset. There were very few cases of calling prior to sunset. Call frequencies rapidly increased within an hour after sunset at most sites. Thus, we suggest initiating fieldwork an hour after sunset. In addition, for surveys, it is necessary to focus on calm nights as clearly wind and rain affect the detectability of the calls or the call frequencies themselves. This is in line with suggestions in previous studies (Jurczyszyn 1994, Bieber 1996, Jurczyszyn et al. 2018).

Our study was done in years with available tree seeds, which are the main food of the edible dormouse (Juškaitis et al. 2015b). For survey purposes, it would be best to avoid fieldwork in non-masting years when dormouse activity is low (Bieber 1998, Morris & Morris 2010, Jurczyszyn 2011). According to Jurczyszyn et al. (2018) and Jurczyszyn (2023), in non-masting years, even if the animals are active in the tree canopies, they call rarely or not at all.

To summarise the results of our study, we show that edible dormouse calls can be successfully used for species detection in both core and peripheral populations. However, some results found in the present study – different lengths of dormouse calls and an evident drop in calling activity in mid-September, remain unexplained. Further studies should focus on unravelling factors driving these differences.

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