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THE DISTRIBUTION OF THE NORTHERN BAT *EPTESICUS NILSSONII* (KEYSERLING & BLASIUS, 1839) IN LATVIA ASSESSED BY PASSIVE ACOUSTIC SURVEY

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Abstract
The latest study about the distribution of bat species in Latvia was published in 1998. The rapid development of automatic ultrasound detectors has enabled researchers to conduct extensive bat acoustic monitoring. Thus, the knowledge on the distribution of many bat species in Latvia has increased in the last 20 years. The aim of this study was to examine the differences in the activity of the northern bat *Eptesicus nilssonii* (Keyserling & Blasius, 1839) across four geographical regions of Latvia using data provided by three-year bat acoustic monitoring program. We analyzed bat calls expressed as bat activity from 60 randomly selected LKS-92 25x25 km squares with a total of 360 observation stations. We found that *E. nilssonii* is less common in the southeastern part of Latvia and more common in the south-west and north-west parts of Latvia. Thus, though *E. nilssonii* is widespread, the distribution of across Latvia is uneven. However, further studies are needed to examine the possible drivers of differences in the distribution of this species.

Keywords: bats, distribution, passive acoustic monitoring, Latvia

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INTRODUCTION

The northern bat *Eptesicus nilssonii* (Keyserling & Blasius 1839) is a widespread Palearctic species reaching from Europe to eastern Russia and Mongolia, with a disconnected region in eastern-most Russia and Japan (Coroiu 2016, Tidenberg et al. 2019). It is mentioned as a common species over much of its range in Europe (Coroiu 2016). However, it is considered a rare species in neighbor countries such as Lithuania (Pauza et al. 2002) and in Belarus (Shpak et al. 2022, Pētersons & Vintulis 1999). While the northern bat has been observed across most of Poland, the distribution is uneven, with the breeding populations restricted to eastern regions and mountainous areas

(Sachanowicz et al. 2006). In Fennoscandia and Estonia, *E. nilssonii* is one of the most common bat species (Rydell 1993, Tidenberg et al. 2019).

It is also one of the most common bat species in Latvia (Pētersons & Vintulis 1998). According to passive bat acoustic monitoring, *E. nilssonii* is the most commonly recorded species (Kaupuža & Pētersons 2022).

Overall *E. nilssonii* is a generalist species, foraging in a wide variety of habitats (Tidenberg et al. 2019). Its general activity in Latvia is highest over water bodies, parklands and coniferous forests and significantly lowest in open agricultural habitats and broad-leaved forests (Kaupuža, unpublished data).

Pētersons and Vintulis (1998) suggested that *E. nilssonii* is less common in the southeastern part of Latvia, because no nurseries of *E. nilssonii* were found in this part of the country. Furthermore, the relative number of observation sites with bat detectors of this species was also lower than the rest of Latvia (Pētersons & Vintulis 1998). A recent analysis of the species composition and distribution among the hibernating bats in root cellars showed a lower occupancy of *E. nilssonii* in the western and south-eastern parts of Latvia (Vintulis & Pētersons 2014).

In this study, we tested the previously stated hypothesis on an uneven population density of the northern bat in Latvia using data from the countrywide acoustic monitoring of bats (Pētersons & Vintulis 2013).

MATERIALS AND METHODS

Study area

Latvia is located in the boreo–nemoral forest zone and characteristic of Latvia's climate is a half-year long vegetation period. We used data from an acoustic survey designed for monitoring purposes. The territory of Latvia was divided into four regions: SE (southeast), SW (southwest), NE (northeast) and NW (northwest) (Fig. 1) based on model used for bat monitoring program. Data were collected from 60 randomly selected LKS-92 (Latvian Geodetic Coordinate System 1992) 25x25 km squares with 360 observation stations installed in total. In each region, 15 squares were surveyed. In each square bat calls were recorded in six sites, each representing a different habitat group (broad-leaved forest stands, coniferous forest stands, urban-parklands, agricultural lands, small water bodies, and large water bodies) (Pētersons & Vintulis 2013). In total, bat recordings were made in 360 sites.

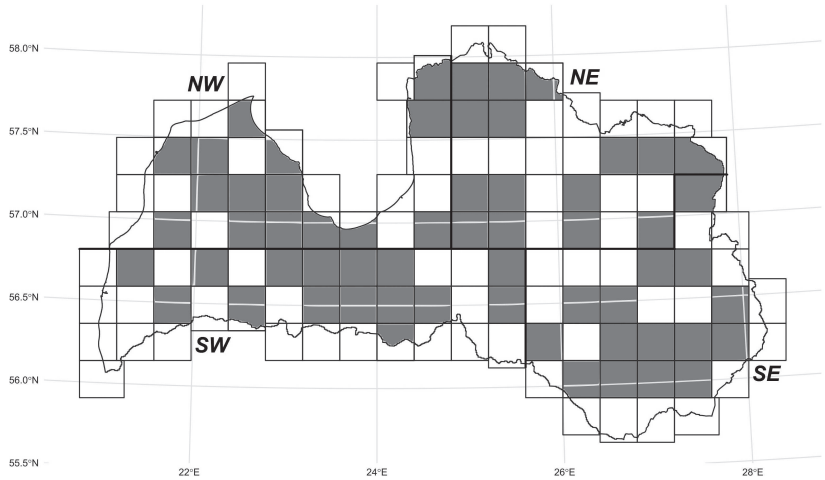

Figure 1. The map of Latvia divided in four regions under LKS-92 25x25 km square network. Bat activity was studied in randomly selected squares (visited squares marked grey). In total, 60 squares were surveyed with six survey sites chosen in each square (n=360).

Data collection

Bat calls were recorded using automatic bat detectors *Pettersson Elektronik* AB D500X. The detector settings were: trigger level 40, gain 30, recording length 3 sec, interval 15 sec. All data were collected between 2020 and 2022, with each square monitored for one night. All recordings were done between 20th of June and the 31st of July when most juveniles should be able to fly. The detectors were set to record bat calls from sunset until sunrise and only deployed on nights with favorable weather conditions (without rain and strong wind). The sound files were stored on CF cards in WAV format, and recordings analyzed using *BatSound* (v. 4.2.0. or v. 4.4.0.).

The identification of *E. nilssonii* is generally straightforward (Russ 2012, Barataud 2015, Skiba 2003), however the calls of the northern bat must be distinguished from those of the parti-coloured bat *Vespertilio murinus* (Linnaeus, 1758), the Serotine bat *Eptesicus serotinus* (Schreber 1774) and possibly the Leisler's bat *Nyctalus leisleri* (Kuhl, 1817). While the Serotine and Leisler's bats are very rare in Latvia, the parti-colored bat is more common (Pētersons & Vintulis 1998). Thus, we used the EF (end frequency) of FM-QCF (frequency modulated followed by quasi-constant frequency) calls within 27–30 kHz as a diagnostic feature of *E. nilssonii*. Bat activity (b_{act}) was calculated for each site as the number of passes (n) per hour across the whole night, where t_{min} is duration of the night in minutes:

$$b_{act} = \frac{n}{t_{min}} \cdot 60$$

A pass was defined as a series of at least two echolocation pulses.

Data analysis

The *Jamovi* (v. 2.3.21) was used for the analysis of the data (Jamovi 2022, R Core Team 2021). The data conformity to a normal distribution was checked with *Q – Q* plots together with p values of the *Shapiro-Wilk* test. The data outliers were tested with the *Box plot* method and *IQR (variable)* calculations. Since the data did not follow a normal distribution, non-parametric tests were chosen. To assess the differences in the activity of *E. nilssonii* in the four regions of Latvia, we used *Kruskal-Wallis H* test. To distinguish comparable variables between groups, we used post hoc analysis followed by Dwass – Steel – Critchlow – Fligner test for multiple comparisons. We considered results with p-values ≤ 0.05 as statistically signicant.

RESULTS

During three years of acoustic bat monitoring, in total we recorded 10549 passes of *E. nilssonii* (5852 passes in 2020, 1543 passes in 2021 and 3154 passes in 2022). We found that the distribution of *E. nilssonii* in four parts of Latvia was not equal ($\chi^2(3)=34.6$, $p<0.001$, $\varepsilon^2=0.097$). Observed median values of b_{act} were the following: at SE 0.16 (IQR=0.00–0.76), at SW 1.44 (IQR=0.31–4.89), at NE 0.58 (IQR=0.00–2.31), at NW 1.10 (IQR=0.28–4.11). Post hoc analysis showed that there were statistically significant differences in the activity of *E. nilssonii* between the SE and SW ($p<0.001$) parts of Latvia; between the SE and NW ($p<0.001$), and the SW and NE ($p=0.02$) (Fig. 2A). These results indicated that *E. nilssonii* is more frequent in the SW and NW parts than in the SE and more common in the SW than in the NE part of Latvia (Fig. 2B).

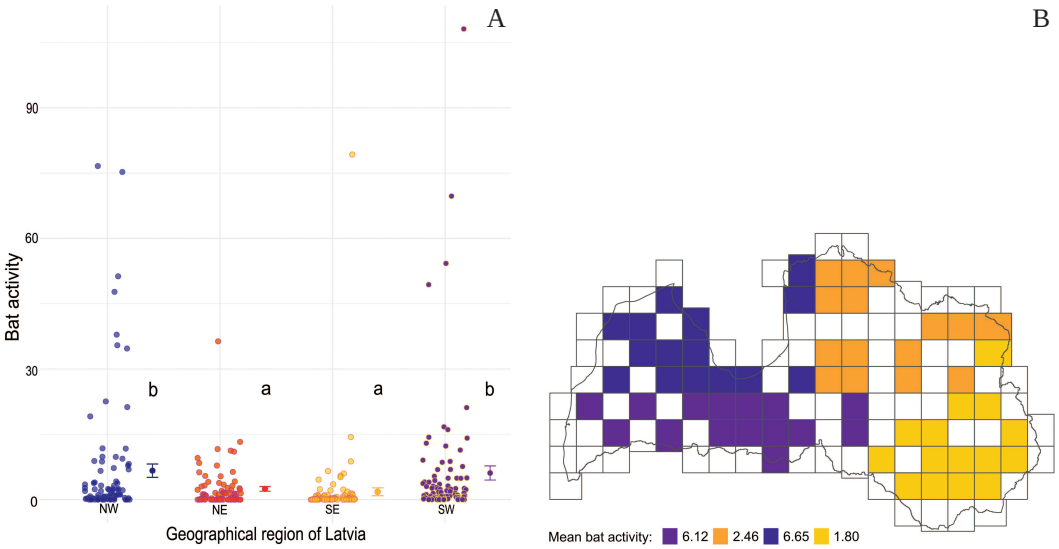

Figure 2. Dot plot showing the activity of *E. nilssonii* in each observation site. The outer dot in each region represents the mean and the whiskers the standard error of the mean. Different letters indicate statistically significant differences (p<0.05) (A). Data visualization depicting the gradient of the activity of *E. nilssonii* in four parts of Latvia. The darker color represents the higher activity (B).

DISCUSSION

In this study, we found that the activity of *E. nilssonii* across Latvia is uneven, with the highest activity in the south-west (SW) and north-west (NW) parts of Latvia, and lowest in the south-eastern (SE) part of Latvia. The conclusion, that *E. nilssonii* is less common in the southeastern (SE) part of Latvia also matches with the earlier hypothesis expressed by Pētersons and Vintulis (1998).

In the earlier studies (Pētersons 2004, Pētersons & Vintulis 1999), the authors proposed that the lower activity of *E. nilssonii* in the south-eastern part of the country could be due to the higher abundance of the Nathusius' bat *Pipistrellus nathusii* (Keyserling & Blasius 1839), resulting in a competition between both species. However, we found that the activity of *P. nathussi* is even across the four regions of Latvia (Kaupuža, unpublished data). Thus, it is unlikely that inter-specific competition between *E. nilssonii* and *P. nathusii* drives the differences in *E. nilssonii* activity.

The SE region is dominated by a mosaic type landscape that mainly consists of small patches of agricultural land and forests. Compared to the other regions, in SE there are no large boreal forest massifs. Considering that *E. nilssonii* is a boreal forest species (Suominen et al. 2022, Lapini et al. 2015), we suggest that lack of boreal forest massifs in SE, results in a lower activity of *E. nilssonii* in this region. Possibly, for the same reason *E. nilssonii* is considered as a rare species in Lithuania. Anyway, a further analysis of the distribution pattern of this species and the possible influencing factors are beyond the scope of this paper and needs to be addressed in the future.

The acoustic monitoring program is ongoing and more data, spanning most territory of Latvia will be available and may provide a deeper insight into the distribution patterns of *E. nilssonii* in Latvia.

CONCLUSIONS

In this study we analyzed a three-year bat acoustic monitoring data and assessed, whether the activity of *E. nilssonii* differs between four regions of Latvia. The study confirms expected differences in activity and occurrence of the northern bat *E. nilssonii* in four parts of Latvia, which could inspire future research to reveal key aspects concerning ecology of this species.

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