



Go to the city: urban invasions of four pipistrelle bat species in eastern Slovakia

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ABSTRACT

Until now, late summer or autumn invasions into inhabited building have been regarded as phenomenon typical for the common pipistrelle, *pipistrellus pipistrellus*, exclusively. During the investigation of this phenomenon in the city of Košice (eastern Slovakia), we discovered that it was not always entirely specific for this species. During the period 2016–2018, we recorded 3 events out of 35 invasions, where small groups of common pipistrelles that invaded into inhabited buildings were also accompanied by individuals of two con-generic bat species, *pipistrellus pygmaeus* and *pipistrellus kuhlii*. Cryptic species *p. pipistrellus* and *p. pygmaeus* were determined by genetic test. In addition, in 2019, we recorded the first winter occurrence of another pipistrelle species, *pipistrellus nathusii*, in this urban environment. We conclude that areas of frequent invasive behaviour of *p. pipistrellus* may be sometimes associated with concomitant occurrence of other related species that share common thermal or foraging niche and such behaviour could be evidence of their urbanisation tendencies.

KEYWORDS

ecological trap; multi-species aggregations; synurbanisation; urban habitats; Vespertilionidae

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INTRODUCTION

Among five *Pipistrellus* species occurring in Europe (cf. Dietz et al. 2009), four of them (common pipistrelle [*Pipistrellus pipistrellus*], soprano pipistrelle [*Pipistrellus pygmaeus*], Kuhl's pipistrelle [*Pipistrellus kuhlii*], and Nathusius's pipistrelle [*Pipistrellus nathusii*]) belong to the most widespread and abundant bats with distributional ranges covering or reaching central Europe. Common occurrence of first two species is well known in the area, whereas Nathusius's pipistrelle occurs here mainly as a result of seasonal migration (Hanák & Gaisler 1976; Hutterer et al. 2005), but, recently, an increase of records was found in large agglomerations during wintering period (Sachanowicz et al. 2019). On the other hand, the emergence of Kuhl's pipistrelle is the result of recent northward expansion there (e.g. Sachanowicz et al. 2006; Ancillotto et al. 2015; 2016).

Most parts of central Europe represent region of sympatric distribution of these four species, and in several regions, some of them also have year-round syntopic occurrence

(e.g. Jahelková et al. 2000; Mayer & von Helversen 2001; Russ & Montgomery 2002; Lučan 2004; Nicholls & Racey 2006a, 2006b). In general, ecological requirements of these small-sized aerial hawking species are similar; however, besides different migration patterns (e.g. Hutterer et al. 2005), there other substantial differences in roosting or foraging ecology were also found. The common and Kuhl's pipistrelles exhibit higher level of synanthropy as frequent records come from various human settlements, whereas soprano and Nathusius's pipistrelles are avoiding highly urbanised areas. Regarding roosting sites, Nathusius's pipistrelle is typically tree-dwelling, whereas Kuhl's pipistrelle is the so-called petrophilous species (in general reviewed by Dietz et al. 2009). Foraging areas of these species cover various habitats, from semi-open landscape in *P. kuhlii* through forests and similar vegetation in *P. nathusii* and *P. pipistrellus* up to surroundings of water surfaces often found in *P. pygmaeus* (e.g. Barlow & Jones 1999; Bartonička & Řehák 2004; Sattler et al. 2007). Nevertheless, foraging habitats of all

these species could be identical if they live at the same site (e.g. Russ & Montgomery 2002; Lučan et al. 2007; Davidson-Watts & Jones 2006; Davidson-Watts et al. 2006; Lintott et al. 2016).

There is solid evidence from several studies that all four abovementioned pipistrelle species may regularly or occasionally roost in shelters located in urban sites (e.g. Gaisler et al. 1998; Cefuch et al. 2006; Hanák et al. 2009; Ancillotto et al. 2015). However, behaviour known as autumn invasions that typically happen into inhabited buildings in cities and towns mostly in northern part of western and central Europe was reported exclusively for *P. pipistrellus*, thus being probably species specific (Smit-Viergutz & Simon 2000; Kaňuch et al. 2010). During the study of autumn invasions of the common pipistrelle in the city of Košice (eastern Slovakia), one of the most invaded urban areas within the species range, we found some invasion groups formed by more pipistrelle species. In this short communication, we discuss circumstances of recorded multi-species autumn invasions and also report the first winter record of *Nathusius's* pipistrelle in urban environment.

1. MATERIAL AND METHODS

During late summer and autumn seasons in 2016–2018, we analysed 35 invasion events of *P. pipistrellus* that have occurred within the territory of the city of Košice (eastern Slovakia; Košická kotlina Basin; N48°43'12", E21°15'29", 208 m a.s.l.). In the case of suspicion, based on the preliminary morphological determination that cryptic species *P. pygmaeus* may occur amongst bats that got stuck inside buildings, bats were genetically identified. DNA was obtained from wing membrane (3-mm biopsy punch) by Chelex 100 extraction method (Walsh et al. 1991). Species identification was confirmed by a rapid polymerase chain reaction (PCR)-based test, which is non-destructive, low-cost and quick molecular method based on amplification of species-specific fragments of their mitochondrial DNA. Multiplex PCR using the primers PIP-F, PIP-R, Ppip-F2 and Ppyg-F and agarose gel electrophoresis were performed according to protocol described by Kaňuch et al. (2007). Genetic test was not applied on specimens of *P. kuhlii* and *P. nathusii* because their morphology differs unambiguously from other pipistrelle species (cf. Dietz et al. 2009). Primary source of information about the occurrence of bats in buildings came from citizens and that was also the case of random record of *P. nathusii* in winter season 2019.

2. RESULTS

Along with frequent single-species invasions of the common pipistrelle that significantly predominated ($G = 19.6$, $df = 2$, $p < 0.001$), three multi-species groups of pipistrelle bats (8.6%, $n = 35$) were recorded in the city of Košice. All of them represented invasions of few (5–21) individuals inside the buildings located in central urban zone of the city. For comparison, invasions that comprised solely *P. pipistrellus* ranged from 2 to 350 (mean 57) individuals. Multi-species invasions comprised 37 bats in total (8 individuals of *P. pipistrellus*, 16 of *P. pygmaeus* and 13 of *P. kuhlii*; Table 1). Two aggregations were composed of three species: *P. pipistrellus*, *P. pygmaeus* and *P. kuhlii*, and one aggregation was composed of two species, *P. pipistrellus* and *P. kuhlii*. Common pipistrelle did not dominate in any of multi-species invasions. Bats unexpectedly had flown into the buildings usually through open windows and later were found in various shelters as piano, behind paintings on wall or hanging on curtains. This information is supplemented by the record of solitary male of *P. nathusii* found in wash bowl in an apartment in the city centre (Baštová St. No. 4) on 10 January 2019.

3. DISCUSSION

Behaviour of bats in documented multi-species invasion events had character similar to that found during *P. pipistrellus* invasions into buildings reported through its range in Europe (e.g. Sachteleben 1991; Smit-Viergutz & Simon 2000; Nusová et al. 2019). Apart from very recent records of rapidly expanding *P. kuhlii* that is obviously associated with manmade structures in the region (Cefuch & Ševčík 2006; Sachanowicz et al. 2006; Danko 2007; Maxinová et al. 2016; Michálek et al. 2017), urban environment is characteristic mainly for *P. pipistrellus* that is also significantly more frequent species than *P. pygmaeus* in large urban agglomeration of central Europe (Jahelková et al. 2008; Hanák et al. 2009). However, observation of transient common roosting of the common and soprano pipistrelles in multi-storey prefab house in central Slovakia during spring migration period (Cefuch et al. 2006) also suggests possibility for autumn co-occurrence. Considering distributional trends in other regions and in similar bats (e.g. *Hypsugo savii*), urban invasions of either *P. pygmaeus* or *P. kuhlii* could be combined result of two possible factors; urbanisation tendency and climate change (Jones & Rebelo 2013; Russo & Ancillotto 2015; Ancillotto et al. 2016; Uhrin et al. 2016; Voigt et al. 2016). Although roosting and foraging of both species in urban habitats has been well documented, until now, their participation in urban invasions was not reported yet. However, it is not surprising

Table 1. Species composition and structure of multi-species invasion events of pipistrelle bats in the city of Košice during 2016–2018 autumn invasions (males/females)

| Date | Address | Lat (°N) | Lon (°E) | <i>Pipistrellus pipistrellus</i> | <i>Pipistrellus pygmaeus</i> | <i>Pipistrellus kuhlii</i> |
|-------------|-----------------|----------|----------|----------------------------------|------------------------------|----------------------------|
| 21 Sep 2016 | Šrobárova St. 1 | 48.719 | 21.251 | 0/1 | 0/3 | 4/3 |
| 28 Aug 2017 | Panelová St. 9 | 48.707 | 21.260 | 1/1 | 0/0 | 0/3 |
| 28 Aug 2017 | Tolstého St. 22 | 48.734 | 21.252 | 2/3 | 8/5 | 3/0 |

that such unusual observations were recorded in the city of Košice as a site of very frequent autumn invasions of *P. pipistrellus* during the past two decades. Plausible mechanism behind concomitant occurrence of different *Pipistrellus* species in autumn invasions may suppose eavesdropping of con-generic species during seasonal migration or searching for swarming sites (Dorado-Correa et al. 2013). It was found that eavesdropping behaviour, experimentally tested for groups of *P. pipistrellus*, *P. pygmaeus* and *P. nathusii*, might favour the formation of multi-species foraging aggregations (Voigt-Heucke et al. 2016). Thus, it is likely that formation of multi-species autumn invasions could have similar *modus operandi*. Some support for this hypothesis also offers display calls of males at their mating territories or distress calls of trapped individuals, which may have an attracting effect not only for con-specifics, especially if there is not clear niche partitioning between different species (e.g. Sachteleben 1991; Dietz et al. 2009; Bartoničková et al. 2016).

The record of *P. nathusii* in Košice was not associated with autumn invasions but the circumstances were similar to such events as in related pipistrelle bats. Regarding to regional species distribution, it is worth mentioning that this record is the only second record of *P. nathusii* from this city after almost 160 years. In September 1860, it was found at periphery in Bankov; this time it was situated certainly out of urbanised part of the city (Jeittles 1862). Moreover, according to our

best knowledge, the record is only the third documented winter record of the species from Slovakia, first two being reported from similar urban circumstances in Bratislava (Danko et al. 2012; Sachanowicz et al. 2019). Recent winter records of this species are very scarce but increasing in central Europe (Řehák & Foral 1992; Benda & Hotový 2004; Jahelková et al. 2014; Sachanowicz et al. 2019), and when considering generally strong social affinity of bats to hibernacula (Lewis 1995), such records of wintering *Nathusius's* pipistrelle could indicate some process of synurbanisation. Another explanation suggests recent north-eastern shift of winter range in this species because of climate change (Lundy et al. 2010), where cities play a role of habitat-suitable islands or step stones during their expansion (Sachanowicz et al. 2019). Thus we conclude that areas of frequent invasive behaviour of *P. pipistrellus* may be sometimes associated with concomitant occurrence of other related species that share common thermal or foraging niche and such behaviour could be evidence of their urbanisation tendencies.

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