Juškaitis *Avian Res* (2021) 12:21
https://doi.org/10.1186/s40657-021-00263-8

Avian Research

RESEARCH Open Access

Is nesting in closed nestboxes advantageous for the European Robin (*Erithacus rubecula*)?

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Abstract

Background: The European Robin (*Erithacus rubecula*) is eurytopic in its choice of nest site, which can be either half-open or closed, and situated either on the ground or at a height of several meters. On occasion, robins also nest in closed nestboxes, though generally only solitary such cases are documented, albeit that dozens of such events can be recorded during the course of some long-term studies. However, until now, nobody has summarised the peculiarities of robins nesting in closed nestboxes.

Methods: In the period 1978–2020, wooden tit and starling nestboxes were inspected regularly at five study sites in Lithuania, this totaling more than 18,000 nestbox-seasons. During these inspections, 90 cases of robins nesting in the nestboxes were recorded. Publications on this topic from the entire robin distribution range were reviewed.

Results: Robins prefer to nest in old large-sized fairly shallow nestboxes with wide entrance holes, for example starling nestboxes or tit nestboxes with enlarged entrance holes. Increased numbers of nestboxes being occupied by robins were recorded for 3–8 years in row. In Lithuania, nesting success in nestboxes is not higher than compared with nesting on the ground. Tree climbing mammals, Pine Martens (*Martes martes*), Hazel Dormice (*Muscardinus avellanarius*), Edible Dormice (*Glis glis*) and Forest Dormice (*Dryomys nitedula*), are the main predators of robin nests in nestboxes.

Conclusions: Some geographic variation was found in the occurrence of robins nesting in nestboxes with more such cases recorded in central and southern parts of the range. Possibly robins are more philopatric in these parts of the range, with the same females or their offspring nesting in nestboxes for several years in row. In areas inhabited by dormice, nesting in closed nestboxes is not advantageous for robins.

Keywords: *Erithacus rubecula*, European Robin, Nestbox dimensions, Nesting success, Predators

Background

The European Robin (*Erithacus rubecula*) may choose a wide variety of sites for building a nest. The nest site can be either half-open or closed. Although the majority of robin nests are situated on the ground beneath some form of shelter, the heights of nest sites can be up to 12 m above ground (Krištín 2010). However, prevailing nests sites are diverse in different parts of the species distribution range (reviews in Marti 1988; Pätzold 1995; Zimin 2009; Taylor 2015).

In the northern part of the range, robin nests are usually located on or near the ground. In Russian Karelia, on the northern edge of the range, ground nests accounted for 42.3% of all nests, with most of the rest located at heights of up to 0.5–1 m. Nests above 2 m accounted just 0.76% (Zimin 2009). Similarly, in the south of the Leningrad region, 72.7% of all nests recorded were on the ground (Prokof 'eva 2006), while the majority of robins in the Moscow region also nested on the ground (Blagosklonov 2017).

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In more southern parts of the distribution range, nest sites of robin tend to be situated higher. In the Ryazan region (Russia), 53.0% of all nests were situated in tree hollows and niches, and such places are considered to be the main nesting places of the robin in this region (Baranovskiy and Ivanov 2017). Similar, in north-eastern Ukraine, 56.5% of robin nests were located above ground (Knysh 2008, 2018).

In the Bialowieza Forest (Poland), where a surplus of natural tree hollows is present and competition for these hollows is almost absent, robins often nest in natural tree hollows (Tomiałojć and Wesołowski 2005; Wesołowski 2007; Czeszczewik and Walankiewicz 2016), but data on the proportions of robins nesting in tree hollows and on the ground are absent. By contrast, in the northern parts of the range (Moscow, Pskov, Leningrad regions), where hollow trees are scarce, robins nest in such places only in exceptional cases (Knysh 2008).

In Great Britain, robins often nest in human settlements, for example in gardens, and they frequently choose specially designed nestboxes with open-fronted entrances. Nests of robin are usually located about two meters off the ground (Marti 1988; Pätzold 1995; Taylor 2015). Thus, in the anthropogenic landscape of Great Britain, more robins nest above ground, but no difference was found between nest site selection in natural and anthropogenic landscapes of the Ryazan region (Baranovskiy and Ivanov 2017).

Robins nest willingly in half-open nestboxes, but very seldom in closed nestboxes (reviews in Pätzold 1995; Thiede and Juškaitis 1998; Knysh 2008). For this reason, ornithologists highlight such events, and even solitary cases are published in local journals. In a review by Thiede and Juškaitis (1998), 11 publications from Germany, Norway, Sweden and Lithuania are cited, in which from 1 to 8 cases are described in which robins nested in nestboxes. Knysh (2008) reviewed publications on this topic in the Russian language, and he cited 13 sources (including personal communications) describing robins in nestboxes from Russia, Ukraine and Lithuania. Subsequently, there have been further publications on this topic which are not included in the reviews indicated above (e.g. Luniak 1992; Ševčík and Pressen 1992; Prokof 'eva 2006; Lebedeva and Lomadze 2007; Veĺký and Zvářal 2008; Zimin 2009, 2019; Chaplygina et al. 2016; Baranovskiy and Ivanov 2017).

Long-term studies of birds nesting in nestboxes carried out in the Caucasus (Lebedeva and Lomadze 2007), Ukraine (Knysh 2008, 2018) and Czech Republic (Veĺký and Zvářal 2008) were marked by their higher numbers of cases of robins breeding in nestboxes. In the north-western Caucasus, robins occupied from 7.1 to 18% of all nestboxes, the number of boxes varying from 22 to 253 boxes per year in the 1975–1980 period. As well as half-open boxes, robins nested willingly in starling and tit nestboxes, and even in bat boxes (Lebedeva and Lomadze 2007). In the Sumy district of north-eastern Ukraine, 42 nesting cases in nestboxes were recorded during the 1969–2008 period (Knysh 2008, 2018). In eastern Moravia in the Czech Republic, there were 20 cases of robins nesting in tit nestboxes and 35 cases in wooden and plastic owl nestboxes during 1989–2008 (Veĺký and Zvářal 2008).

The robin is a common bird in Lithuanian forests. According to the expert evaluation, the Lithuanian population consists of 800,000–1,500,000 breeding pairs, with no fluctuations of abundance recorded. Typically, robin nesting sites are situated on the ground or at a certain height close to the ground, but they also nest in holes and niches within dead or living trees (Aleknonis 1992; Kurlavičius et al. 2006).

Preliminary data on the nesting of robins in nestboxes in Lithuania (39 cases) were published by Thiede and Juškaitis (1998). Since then, a further 51 cases were recorded during the 1998–2020 period. The data used in the earlier publication have been incorporated into the current study, with the objectives as follows: (1) to analyse long-term data on the nesting of robins in closed nestboxes in Lithuania, (2) to review all publications on this topic from the entire distribution range, and (3) to summarize all these data. Nesting of robins in half-open nestboxes is not analysed in the present paper because this type of nestbox was not used at the Lithuanian study sites.

Methods

Study sites

Data on the nesting of European Robins in closed nestboxes were collected at five study sites in Lithuania during the 1978–2020 period as part of long-term studies on the population dynamics of dormice (Gliridae) and secondary cavity-nesting birds. Some data were also collected during inspections of nestboxes at other localities of Lithuania (Table 1).

Site A (Šakiai district; 55°03′ N, 23°04′ E) was situated in middle-aged forest (about 60–70-year-old) consisting of diverse mixed tree stands. Stands dominated by birches (*Betula pendula* and *B. pubescens*) with Norway Spruce (*Picea abies*) and Black Alder (*Alnus glutinosa*), and Norway Spruce-dominated stands with deciduous trees were prevalent. A stand dominated by Pedunculate Oak (*Quercus robur*) was situated at the southern edge of the site. Stands dominated by Ash (*Fraxinus excelsior*) occupied a large area of the site during the 1978–1990 period, but spruce trees started to dominate these stands following the large-scale death of the Ash trees. Hazel

Table 1 Some characteristics of data collected on nesting of European Robins in closed nestboxes in Lithuania

Parameters	Study sites						Total
	Site A	Site B	Site C	Site D	Site E	Other sites	
Study period	1978–1990, 1997–2020	1984–1993	1990–2020	1999–2002	1999–2020	1995–2020	1978–2020
Total number of nestbox-seasons	9967	4356	2313	200	1450	*	18,286*
Numbers of tit nestbox-seasons	9910	4138	0	0	1450	*	15,498*
Numbers of starling nestbox-seasons	57	218	2313	200	0	*	2788*
Breeding cases of robins recorded	30	13	36	2	0	9	90
% of nestboxes occupied by robins	0.30	0.30	1.56	1.00	0	*	0.44*

* At other sites, data were collected by irregular inspection of nestboxes; these data are not comparable with data collected at study sites A–E, and they are not included in the total count

(*Corylus avellana*), Glossy Buckthorn (*Frangula alnus*), Bird Cherry (*Prunus padus*), Rowan (*Sorbus aucuparia*) and Dwarf Honeysuckle (*Lonicera xylosteum*) were the main species in the understorey.

Site B (Molėtai district; 55°09′ N, 25°21′ E) was covered mainly by mature 100–120-year-old Pedunculate Oak-dominated stands with Norway Spruce, in some places with Aspen (*Populus tremula*), birch and Norway Maple (*Acer platanoides*). Two other types of forest stands occupied comparatively large areas: 40–50-year-old Aspen-dominated stands with Norway Spruce, oak and birch, and Norway Spruce-dominated stands with oak and other deciduous trees. There were also small plots of stands dominated by Grey Alder (*Alnus incana*). Hazel prevailed in the understorey.

Site C (Kaišiadorys district; 54°53′ N, 24°10′ E) was covered by mature 130–180-year-old mixed forest stands composed of Scots Pine (*Pinus sylvestris*), Pedunculate Oak and Norway Spruce with Small-leaved Lime (*Tilia cordata*), birch, Hornbeam (*Carpinus betulus*) and Aspen. Hazel, Rowan, Dwarf Honeysuckle and Glossy Buckthorn formed the understorey.

Site D (Vilnius district; 54°49′ N, 24°56′ E) was established in the valley of the rivulet Dūkšta which was overgrown with deciduous trees. Middle-aged (50–60-year-old) forest stands were dominated by Small-leaved Lime, elms (*Ulmus* spp.) and Grey Alder. In some places, 110–170-year-old Pedunculate Oak trees were present. Hazel, Bird Cherry and Rowan grew in the understorey.

Site E (Kaunas district; 54°58′ N, 23°30′ E) was situated in a forest with different mixed middle-aged (about 60-year-old) forest stands. The majority of the study site was covered by Scots Pine-dominated stands with Norway Spruce and birch, birch-dominated stands with Aspen, Norway Spruce and Scots Pine, and Norway Spruce-dominated stands with birch and Scots Pine. A Black Alder-dominated stand occupied an area of 0.9 ha. About 40-year-old Norway Spruce trees grew in the subcanopy of most of these stands. Rowan and Glossy Buckthorn were the main understorey species.

Study methods

Wooden tit and starling nestboxes were used in the present study, but their dimensions, number and spacing were different at the various study sites and also varied during the study period. The timing and frequency of nestbox inspections also varied, but during the main bird breeding season in May–June, they were inspected every two weeks, except site C (see below). Nestboxes were set at a height of 1.5–2.0 m at study site A during the 1984–1990 period and at study site B, but at a height of 3–4 m in all other cases.

At site A, the numbers of nestboxes inspected ranged from 24 to 357 in different years. Tit nestboxes with internal dimensions of $23 \times 12 \times 12$ cm and entrance hole diameters of 3.5 cm were used over most of the study period. However, obsolete nestboxes were replaced gradually by new wooden nestboxes with internal dimensions of $28 \times 11 \times 11$ cm and entrance hole diameters of 3.5 cm during the 2010–2014 period. In the periods 1984–1993 and 1999–2020, 262 and 272 nestboxes respectively were arranged in a 50 m grid system over the 60-ha area, with some additional nestboxes also set. Some starling nestboxes were placed and inspected in the initial study period.

At site B, the numbers of nestboxes inspected ranged from 276 to 474 during the 1984–1993 period. The majority of them (276 in 1984 and 371 in 1985–1993) were arranged in a 50 m grid system across areas of 65 ha and 85 ha respectively, with some additional nestboxes also present. Along with tit nestboxes with inner dimensions of $23 \times 10–12 \times 10–12$ cm and entrance hole diameters of 3.5 cm, there were also some starling nestboxes (5% of all boxes) with inner dimensions of

28 × 14–15 × 14–15 cm and entrance hole diameters of 4.0 cm at this study site.

At site C, 50 nestboxes were set at 30–50 m intervals along forest roads and rides, and were present from 1990. They were inspected twice a year (in late May—early June and in early September) in the period 1990–2014. In June 2011, 93 new nestboxes were set in a 50 m grid system over an area of 18 ha. About 60% of the old nestboxes (put up in the lines) fell within the area covered by the new nestbox grid. All boxes were wooden starling nestboxes with internal dimensions of 28 × 14 × 14 cm and entrance hole diameters of 4.5 cm.

At site D, 50 starling nestboxes (internal dimensions of 28 × 14 × 14 cm and entrance hole diameters of 4.5 cm) were set along the rivulet at distances of 30–50 m. They were inspected in the period 1999–2002.

At site E, in the period 1999–2020, the number of tit nestboxes varied from 21 to 84, these having internal dimensions of 23 × 12 × 12 cm and entrance hole diameters of 3.5 cm. Seventy nestboxes were set in a 50 m grid system in an area of 13.5 ha during 2003–2014, and 63 nestboxes in an area of 12 ha in 2001–2002 and 2015–2020.

The total number of nestboxes inspected was counted in terms of nestbox-seasons, i.e. a single box controlled across 10 years was counted as 10 nestbox-seasons. Nestboxes were in surplus at all study sites, about one third of them being unoccupied by birds, mammals or social insects in spring. Adult robins nesting in nestboxes were not captured or marked. Nesting success was defined as the proportion of clutches laid that resulted in at least one offspring fledged (Armstrong et al. 2002; Wesołowski and Tomiałojć 2005). The data are expressed as mean ± standard deviation (mean ± SD).

Predators of robin nests in nestboxes were identified according to characteristic signs of their activity. Pine Martens (*Martes martes*) can insert their paws through a nestbox entrance hole and drag out bird nests or they can manage to open the lids of nestboxes. Different dormouse species were identified according to the size and shape of their feaces, and the nature of the destruction of the bird nests when the dormice themselves were absent (Ulevičius and Juškaitis 2005; see Additional file 1: Table S1).

Results

In total, 90 cases of European Robins nesting in nestboxes were recorded in Lithuania from a total of more than 18,000 nestbox-seasons in the 1978–2020 period (Table 1). Of these, 53 cases (58.9%) were recorded in starling nestboxes and the rest in tit nestboxes (Fig. 1). Robins evidently preferred to nest in starling nestboxes (1.90%) compared to tit nestboxes (0.24%) ($\chi^2 = 133.3$, $p < 0.00001$). The highest proportion of nestboxes occupied by robins (1.56%) was recorded at study site C where starling nestboxes were present, whilst at site A where tit nestboxes prevailed this proportion was only 0.30% (Table 1). When robins bred in tit nestboxes, the entrance holes of these boxes had been enlarged by Great Spotted Woodpeckers (*Dendrocopos major*) in 12 out of 34 cases (35.3%). At site A, robins nested twice in a starling nestbox when a tit nestbox was present alongside.

In seven cases, robins nested for the second time in the same nestbox during the same breeding season. In eight cases, robins nested in the same nestbox in two or three different years. Robins occupied nestboxes set at height intervals of both 1.5–2 m and 3–4 m. Typically, some open areas of several tens of square meters not overgrown with trees and shrubs were present in front of the nestboxes occupied by robins (Fig. 1c).

Robins clearly preferred to nest in old nestboxes with darkened walls. They never occupied new boxes, and only in exceptional cases bred in one- or two-year-old boxes (three and four cases respectively). The highest numbers of nestboxes occupied by robins were recorded a few years after the establishment of nestboxes at the study sites, e.g. in the fifth year at site C (Fig. 2c). It is noteworthy that increased numbers of nestboxes occupied by robins were recorded for several years in a row, e.g. at site A in 1988–1990, at site B in 1991–1993 and at site C in 1994–2001 and 2005–2008 (Fig. 2).

The robin nests inside the tit nestboxes were relatively high, even up to 12–13 cm in empty nestboxes, being often stacked on top of old nests of dormice or birds. In some cases ($n = 10$), the upper edge of the nest cup reached the lower edge of the entrance hole or it was only 1–2 cm below it, and the head of the robin sitting on the nest could be seen through the entrance hole of the nestbox.

The average clutch size of robins nesting in nestboxes was 6.56 ± 0.84 eggs ($n = 50$). The average number of fledglings in successful litters was 5.93 ± 0.98 ($n = 30$). The total nesting success of robins in nestboxes ($n = 78$) was only 52.6%. The main predators of robin nests in nestboxes were Pine Martens, Hazel Dormice (*Muscardinus avellanarius*) and Edible Dormice (*Glis glis*). Although the difference of nesting success among study sites was non-significant ($\chi^2 = 5.83$, df = 3, $p = 0.12$), the lowest nesting success was recorded at site C where two dormouse species occurred (Table 2).

Discussion

Our summary of long-term data collected in Lithuania and a review of publications from the entire distribution range enabled us to establish some patterns of European Robins nesting in closed nestboxes. Although

Fig. 1 European Robin nesting in a wooden closed tit nestbox at study site A in Lithuania: **a** robin sitting on the nest inside of the nestbox; **b** robin nest with eggs; **c** tit nestbox occupied by robin set in a Hazel at a height of 4 m

robins are small birds, they prefer to nest in nestboxes with large entrance holes due to their comparatively long legs (Thiede and Juškaitis 1998): starling nestboxes with entrance hole diameters of 4.5 cm are preferred or tit nestboxes with entrance holes enlarged by woodpeckers (Knysh 2008, 2018; Veĺký and Zvářal 2008; present study). When nestboxes with large entrance holes are scarce (e.g. at study site A in Lithuania), robins may also nest in tit nestboxes with entrance hole diameters of 3.5 cm. In some studies, nestboxes with entrance hole diameters of 2.8–3.1 cm were used, though this circumstance might prevent robins from nesting in these nestboxes (Thiede and Juškaitis 1998).

Robins also prefer to nest in nestboxes with larger inner dimensions. In Ukraine, they preferred old nestboxes with dimensions of the bottom area from 132 to 273 cm^2 and only once nested in a small tit nestbox with a bottom area of 102 cm^2 (Knysh 2008). In the Moscow region, robins nested in nestboxes with bottom area not less than 200 cm^2 and wide entrance holes (6–7 cm) which were located 10–12 cm from the bottom (Blagosklonov 2017). In Lithuania, robins evidently preferred to nest in starling nestboxes. Robins nested even in large owl nestboxes with entrance hole diameters of 13–15 cm, making the nest in the corner of these nestboxes (Veĺký and Zvářal 2008; Krištín 2010).

Robins prefer to nest in relatively shallow nestboxes. They fill the cavities of deep nestboxes with dry leaves or occupy nestboxes with old nests of dormice or birds (Knysh 2008; present study). For this reason, nests built inside nestboxes are higher than ground nests (Knysh 2008). Robins nesting in old holes made by woodpeckers also bring a lot of nest material as these holes are too deep for them. An essential condition for the nest site is an open view to the nearest surroundings for the female during incubation and the warming of nestlings (Zimin 2009). This is the reason why the nests in cavities and nestboxes are usually located so close to the entrance.

Robins prefer to nest in old nestboxes with darkened walls and even partly broken nestboxes. The numbers of nestboxes occupied by robins increase a few years after the establishment of nestboxes in the forest (Knysh 2008, 2018; Blagosklonov 2017; present study). Only solitary exceptional cases were recorded in Lithuania when Robins bred in one- or two-year-old nestboxes. In summary, robins prefer to nest in old large-sized and relatively

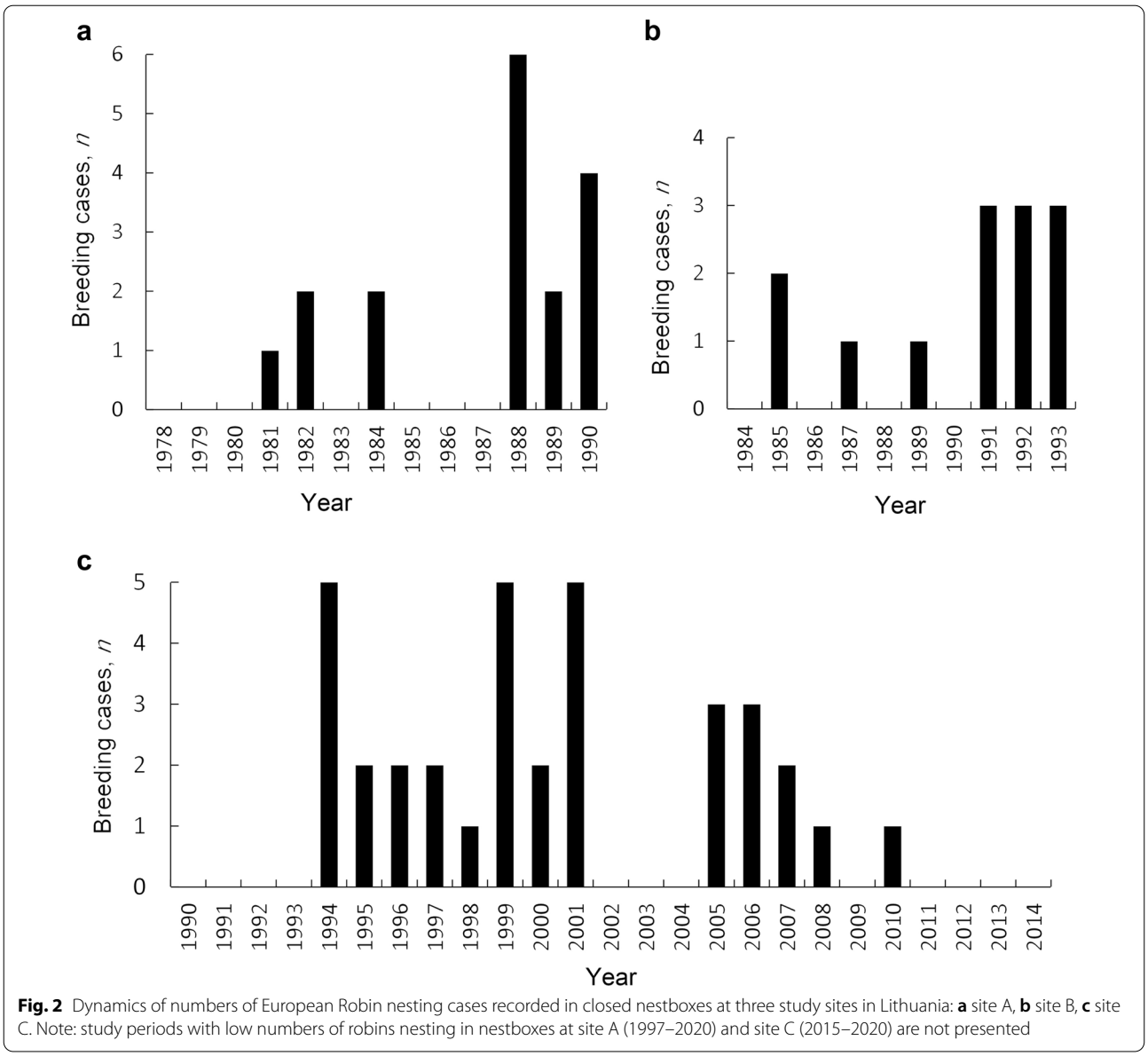

Fig. 2 Dynamics of numbers of European Robin nesting cases recorded in closed nestboxes at three study sites in Lithuania: **a** site A, **b** site B, **c** site C. Note: study periods with low numbers of robins nesting in nestboxes at site A (1997–2020) and site C (2015–2020) are not presented

Table 2 Predators of nests of European Robins and nesting success in closed nestboxes in Lithuania (only cases with known nesting outcomes are included)

Predators	Study site				Total ($n=78$)
	Site A ($n=25$)	Site B ($n=13$)	Site C ($n=30$)	Other sites ($n=10$)	
Pine Marten	5	2	4	1	12
Hazel Dormouse	3	–	7	–	10
Edible Dormouse	–	–	5	–	5
Great Spotted Woodpecker	–	1	–	–	1
Other reasons	3	1	3	2	9
Total unsuccessful	11	4	19	3	37
Nesting success (%)	56.0	69.2	36.7	70.0	52.6

shallow nestboxes with wide entrance holes, but they also can nest in tit nestboxes.

Robins nest in nestboxes set at very different heights. In Ukraine, the average height was 1.8 m (Knysh 2008). Nestboxes were set at similar height at study site A in 1984–1990 and at site B in Lithuania. At study site C and in the Moscow region, nestboxes were set at a height of 3–4 m (Blagosklonov 2017; present study). Owl nestboxes in which robins nested were erected at the height of 5–6 m (Veĺký and Zvářal 2008). In Slovakia, robins nested in owl nestboxes set even at heights of 8 and 12 m (Krištín 2010).

Robins can nest in the same nestbox for the second time during one breeding season making a new nest on the top of the old nest (Knysh 2008, 2018; Lebedeva and Lomadze 2007; present study). Some nestboxes are more preferred by robins than others, and these can be used several times in subsequent years (Thiede and Juškaitis 1998; Knysh 2008; Lebedeva and Lomadze 2007).

An interesting peculiarity of robins nesting in nestboxes was identified when several long-term studies were carried out in different parts of the species distribution range. Although nestboxes were present in some forests for many years in a row, increasing numbers of nestboxes occupied by robins were observed only in a single year or over the course of several years in a row, but both before and later robins did not breed in these nestboxes. For example, four cases were recorded in the Moscow region only in 1964 (Blagosklonov 2017), and three cases in Sweden only in 1989 (Enemar 2002). In Lithuania, periods with increased nesting cases of robin were recorded at three study sites (see Fig. 2). In Ukraine, studies of birds nesting in nestboxes were carried out from 1969, but the first case of a robin nesting was recorded only in 1993, and regular nesting only during 2002–2008 (Knysh 2008, 2018).

Blagosklonov (2017) related such one-time increase of robins nesting in nestboxes with cold and rainy weather during the breeding period. Enemar (2002) related analogous one-time increase of robins with an increased abundance of Bank Voles (*Myodes glareolus*). The last assumption could be supported by several publications. Various rodents are indicated among the main predators of nests of robins situated on the ground (Aleknonis 1992; Pätzold 1995; Zimin 2009). In the Bialowieza Forest, high rodent (Bank Vole and Yellow-necked Mouse (*Apodemus flavicollis*) numbers coincided with low Wood Warbler (*Phylloscopus sibilatrix*) numbers when the arriving birds avoided settling in rodent outbreak areas (Wesołowski et al. 2009).

Zimin (2009) found a seasonal trend for the height of robin nests above the ground, which was due to both changing soil moisture and the activity of terrestrial predators. In early spring, the birds built their nests higher than in mid-breeding season due to moisture. At the end of the season, they increased the height of the nest position due to the activity of the Common Vipers (*Vipera berus*) and other terrestrial predators.

Bad weather conditions or increased rodent abundance could explain one-time increases of robin nesting in nestboxes. However, in several long-term studies indicated above, increases of numbers of such nesting cases were observed 3–8 years in row. Thiede and Juškaitis (1998) made an assumption that the same individuals or their offspring could nest in nestboxes for several years in row.

Site fidelity varies broadly in robins across their range from very low to rather high. It was found in several studies that philopatry and nest site fidelity is not typical for robins (e.g. Jędraszko-Dąbrowska 1979; Gavrilov et al. 2010; Vostretsova et al. 2011; Zimin and Noskov 2020). A total of 5751 robins were trapped and banded in the Moscow region, but only 2 birds (0.03%) were retrapped the following years, and the philopatry of marked juveniles was equal to 0 (Gavrilov et al. 2010; Vostretsova et al. 2011).

Meanwhile in Great Britain, site fidelity was recorded in both wintering and migrating marked females which stayed or returned to their "summer familiar areas" (Harper 1985; Marti 1988 and references therein). According to Taylor (2015), there is a tendency for females aged two years and older to go back to the territory where they bred previously. Solitary cases of return of marked robins to their previous breeding or birth places were also recorded in Germany (Drost and Schütt 1932). In the Caucasus, seven out of 109 marked adult females were recaptured. One marked female nested twice in the same nestbox in the same year, and another marked female nested in the same nestbox two years in row (Lebedeva and Lomadze 2007). It is possible that robins are more philopatric in central and southern parts of their range compared to the northern parts of the range. Unfortunately, any data on nest site fidelity of marked robins are absent in Lithuania.

The average clutch size of robins nesting in closed nestboxes tend to be a little larger than in other nest sites, although data are scant. In Lithuania, it was 6.56 and 6.20 respectively (Aleknonis 1992; present study) while 6.65 and 6.44 respectively in Ukraine (Knysh 2018). More clutches with 8 eggs were recorded in nestboxes, but the eggs were a little smaller (Knysh 2018).

Polish ornithologists collated data on the nesting successes of ground-nesting, canopy-nesting and non-excavator hole-nesting birds in Bialowieza Forest. This comparison showed that the nesting success of hole-nesters (51–74%) and their brood productivity were the highest among all three groups (Wesołowski and Tomiałojć

2005). Pätzold (1995) stated that the nesting success of robins nesting above ground is higher compared to those nesting on the ground. In Switzerland, nesting success in above ground nests (49%) was almost twice as high as in ground nests (27%; Marti 1988).

However, data on robins nesting in nestboxes from Lithuania and Ukraine do not support these statements. In Lithuania, the nesting success in nestboxes (52.6%, present study) and in other nest sites (54%, Aleknonis 1992) was very similar. Meanwhile in Ukraine, the total breeding success expressed as the percentage of fledglings from the number of eggs laid was significantly lower in nestboxes than in ground nests (59.5 and 70.9% respectively; Knysh 2018). The average number of fledglings per pair was also lower in nestboxes (3.46 and 4.28 respectively; Knysh 2018). Nesting failure determined by predators was almost three-fold higher in nestboxes in comparison with nesting on the ground (29.1 and 11.7% respectively; Knysh 2008).

According to Mainwaring et al. (2014), birds vary the height at which they build their nests in response to predators: they build their nests higher from the ground in response to mammalian predators and lower in response to avian predators. Small mustelids such as American Mink (*Mustela vison*), Stoat (*M. erminea*) and Weasel (*M. nivalis*), corvids such as Hooded Crow (*Corvus cornix*) and Eurasian Jay (*Garullus glandarius*), Red Squirrels (*Sciurus vulgaris*), Common Vipers and small rodents are the main predators of ground nests of robins (Marti 1988; Aleknonis 1992; Pätzold 1995; Zimin 2009). The nesting success of robins in nestboxes is comparatively low due to the appearance of new mammalian predators climbing the trees. Pine Martens, Hazel Dormice, Edible Dormice and Forest Dormice (*Dryomys nitedula*) as well as woodpeckers rob the nests of robins (Juškaitis 1995, 2006; Knysh 2008; Chaplygina et al. 2016). Robins built their nests on the top of old nests of dormice which can return to their previous nest sites and destroy the nests of robins.

The occurrence of different dormouse species which willingly occupy nestboxes reduces the nesting success of birds (e.g. Gatter and Schütt 1999; Koppmann-Rumpf et al. 2003; Juškaitis 2006; Adamík and Král 2008). Birds, their eggs and nestlings may form a significant portion of the diet of different dormouse species in spring and early summer (Gil-Delgado et al. 2009; Juškaitis and Baltrūnaitė 2013a, 2013b; Juškaitis et al. 2015). Meanwhile, ten out of 12 breeding attempts of robins in nestboxes were successful in Switzerland, and only one nest was robbed by a woodpecker and another was loaded by a Pied Flycatcher (*Ficedula hypoleuca*) (Marti 1988). Veĺký and Zvářal (2008) indicate that the nesting of robins in cavities creates ideal antipredator conditions for the successful rearing of young. In both these studies, the presence of dormice at the study sites is not indicated. It seems that the nesting success of robins in nestboxes can be much higher if dormice are absent in the surrounding forest.

Brood parasitism by the Common Cuckoo (*Cuculus canorus*) is an important reason for nesting failure of the European Robin. The latter is one of the most common hosts for cuckoos, the chicks of which remove the robin eggs or chicks from the nest (Marti 1988; Aleknonis 1992; Pätzold 1995; Zimin 2009). Even robins nesting in nestboxes are parasitised by cuckoos. In the Caucasus, a 6–7-day-old cuckoo chick was found in a nest of a robin inside a nestbox, and an egg of a cuckoo was found on the edge of a robin nest in another half-open nestbox (Lebedeva and Lomadze 2007).

Conclusions

One of the most interesting findings of the present study was the increased numbers of nestboxes occupied by robins for several years in row recorded in Lithuania and in other parts of the distribution range where long-term studies were carried out. Solitary cases of robins nesting in closed nestboxes may occur because these birds are eurytopic in choice of nest site. Numbers of robins nesting in nestboxes may increase in some years when nesting conditions on the ground surface become poorer, e.g. in constantly humid ground conditions or when the abundance of small rodents is increased. However, the question regarding which factors determine an increase in numbers of robins nesting in nestboxes for several years in a row remains unanswered. The most likely explanation is that the same individuals or their offspring nest in nestboxes for several years in row. It is possible that higher site fidelity is characteristic for robins living in more southern parts of the range (see Lebedeva and Lomadze 2007). Long-term capture-mark-recapture studies of robins nesting in nestboxes might answer this question.

Another rather unexpected finding was that the nesting success of robins nesting in closed nestboxes was not higher than in other nest sites, including ground nests. This means that previous findings that bird nesting success is higher in higher-situated and closed nest sites might not be universal. The lower nesting success is related with the occurrence of several dormouse species recorded at study sites in Lithuania and Ukraine. The lowest nesting success of robins in nestboxes was estimated in a forest where two dormouse species (Hazel and Edible Dormice) occurred. In forests where dormice are absent, the nesting success of robin in nestboxes should be higher, and nesting in closed nestboxes should be advantageous for this species.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40657-021-00263-8.

Additional file 1: **Table S1**. Signs of dormice (Gliridae) activity inside of bird nestboxes in Lithuania (changed after Ulevičius and Juškaitis 2005).

Acknowledgements
Tomasz Wesołowski, Peter Adamík and an anonymous reviewer made valuable comments on an earlier version of the manuscript. Jos Stratford revised the English of the manuscript. Vita Augutė, Olius Atkočaitis and Julius Kaselis provided some unpublished data on robins nesting in nestboxes in Lithuania.

Authors' contributions
Not Applicable.

Funding
This research received no external funding.

Availability of data and materials
The dataset used in the present study is available from the author on reasonable request.

Declarations

Ethics approval and consent to participate
Not Applicable.

Consent for publication
Not applicable.

Competing interests
The author declares that he has no competing interests.

Received: 6 December 2020 Accepted: 13 May 2021
Published online: 20 May 2021

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