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Assessing the occupation of nest boxes by dormice (Gliridae) in the Carpathian forests

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Abstract. Nest boxes for dormice (Gliridae) can significantly increase the habitat's carrying capacity for these species in areas under high anthropopressure and facilitate the long-term monitoring of populations. As part of the active protection of dormice in the Carpathian Landscape Parks in Małopolska, in August and September 2019, 575 boxes of two different sizes were checked for the presence of adults, young or nests. Additionally, habitat conditions within a 25 m radius were recorded (e.g. forest stand, estimated understory cover, the approximate number of natural shelters, fruiting plant species). The vast majority of all nest boxes – 79% – were used by dormice, but also birds and insects frequently occupied these shelters. Out of four species of dormice that occur in Poland, two were recorded in the study area: hazel dormice *Muscardinus avellanarius* and fat dormice *Glis glis*. They were found in all surveyed landscape parks and inhabited mainly fir stands. Hazel dormice preferred smaller nest boxes and were generally more common than fat dormice, which preferred large boxes. On the other hand, fat dormice were more common in areas rich in fruiting plant species. Our research thus confirmed the usefulness of artificial shelters for dormouse in active protection.

Keywords: dormouse, nest boxes, rodents, conservation, forest mammals, Gliridae

1. Introduction

Currently, all species of small mammals of the dormouse family (Gliridae) occurring in Poland – the fat dormouse *Glis glis*, hazel dormouse *Muscardinus avellanarius*, forest dormouse *Dryomys nitedula* and garden dormouse *Eliomys quercinus* – are legally protected (Regulation 2016). According to the International Union for Conservation of Nature classification, they are in the least concern category, except for the garden dormouse, which is considered a near threatened species. In Poland, the range of dormouse occurrence is dispersed; the hazel and fat dormice are the most common. The forest dormouse is found in the southern and eastern parts of the country, while the garden dormouse is found only in the Babia Góra massif (Atlas Ssaków Polski 2020). The current state and distribution of dormouse populations is the result of large-area deforestation in the past and forest management, changing the structure and continuity of forests (Jurczyszyn, Wołk 1998). Habitat loss and fragmentation have caused a decrease in the number of these mammals (Mortelliti et al. 2011, 2014). An important factor affecting dormouse survival and its local density is habitat quality, which mainly determines the amount of available food (Mortelliti et al. 2014). The small mammals of the Gliridae family need shelter to establish nests for resting, rearing young and protection from predators. Therefore the lack of natural hiding places in forests is a limiting factor (Juškaitis 2005). One of the possible measures for the active protection of this animal group, in addition to preserving habitats with old trees containing cavities, is to hang artificial nest boxes, which significantly increase the potential number of resting places and shelters. In addition, this type of measure allows for the long-term monitoring of the population, providing information on the changes occurring in it and assessing the effectiveness of their protection (Williams et al. 2013). A detailed analysis of the results of active protection measures for the dormouse will allow more effective methods to be developed and, in the long term, the proper status of the population to be maintained.

The presented research was aimed at verifying the degree of dormouse colonization of artificial nest boxes.

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2. Study area

The study area consisted of 4 of the 11 landscape parks (LPs) in the Małopolska Voivodeship Landscape Park Complex, located in south-eastern Poland, in the Pogórze Karpackie region of the Carpathian Mountains (Ciężkowicko-Rożnowski LP, Wiśnicko-Lipnicki LP and the Brzanki Range LP) and in the Beskids (Poprad LP). Their total area is 1013 km^2, of which 54.9% is forested (RDOŚ 2013).

3. Study methods

Fieldwork was conducted in August and September 2019. For the research, the "English" type of nest box was inspected (with the hole facing the tree trunk) in two sizes: small (12 cm×12 cm×15 cm) and large (16 cm×16 cm×35 cm), hung approximately 3 m above the ground. The boxes (nest boxes) were located along forest roads at average intervals of 40 m. The individual research plots were located at a minimum distance of 1 km from each other (Fig. 1). In total, 575 boxes were inspected, including 242 large and 333 small ones.

During the inspections, the species present in the box was recorded and, in cases where they escaped, the animals were identified by the evidence left behind and/or it was assigned to a higher taxon. In the absence of the animal in the box at the time of the inspection, where possible, nest remains were identified by their characteristic features (shape and material used). If more than one nest was left in the box, their number was determined by the apparent differences in construction, material used and degree of decomposition. If a nest was significantly decomposed, making it difficult to exactly ascribe it to species, it was assigned to a higher taxon. A nest box was defined as inhabited (hereinafter also used) when the presence of a given species or a nest left by that species was found in it at the time of inspection or when its nest was recognized. In addition, selected parameters were estimated of the habitat within a 25 m radius from the tree with the nest box: dominant tree species (stand); degree of undergrowth cover (in a four-stage scale, where 0 meant the complete lack of shrubs and undergrowth, 1 – single shrubs and trees covering up to 25% of the area, 2 – numerous shrubs and trees with cover from 26% to 75%, 3 – numerous shrubs and

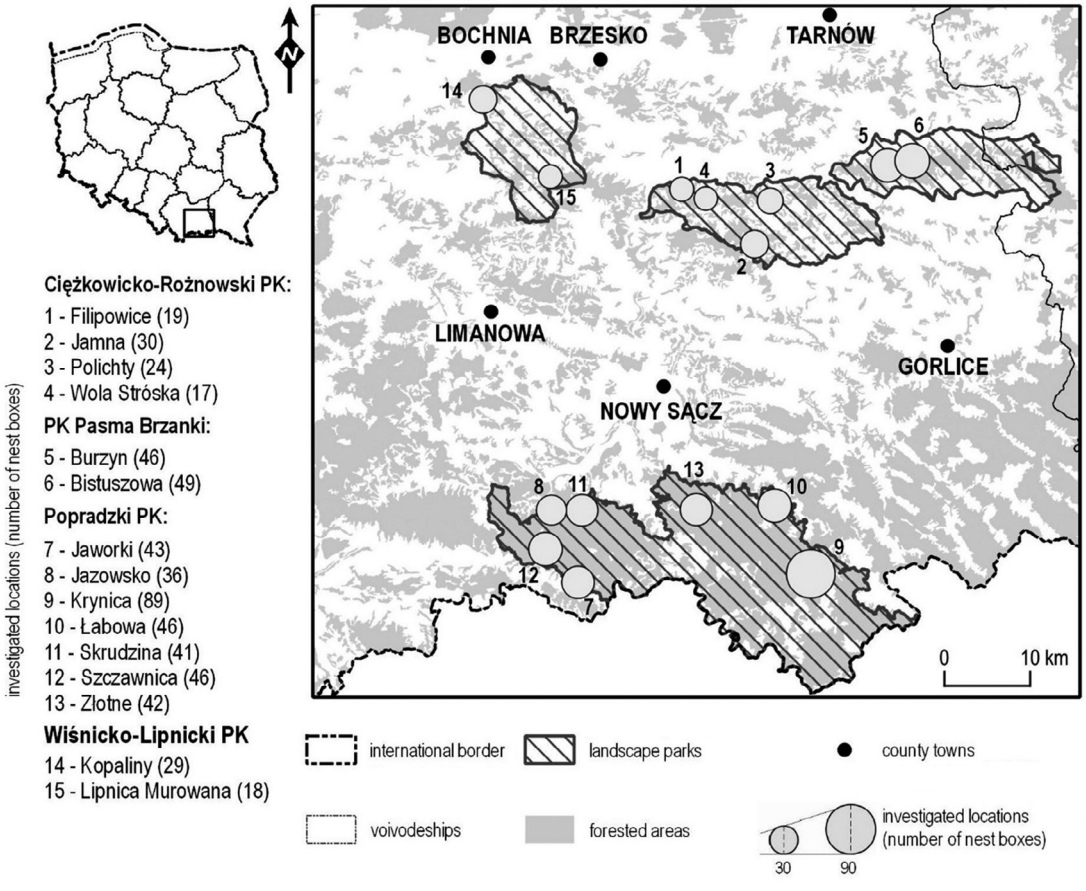

Figure 1. Locations of the surveyed Landscape Parks (PK) and study areas

trees covering ≥76% of the area); the presence of species potentially constituting a food base for dormice (among others, beech *Fagus sylvatica*, *Quercus* spp., common hazel *Corylus avellana*, blackberry*Rubus* spp. and blueberry*Vaccinium* spp.) as well as the presence of natural shelters –trees with cavities (0 – none, 1 – presence of trees with cavities).

The obtained data were analysed for the potential dependence of occupancy on the size of the boxes with chi-square tests at a significance level of α=0.05, using a sample of positive confirmations of the presence (finding an individual in the box at the time of inspection or recognition of a nest) of fat and hazel dormice and empty boxes (*N*=276). The analysis of nest boxoccupation by dormice, in relation to the number of nests in the box, was performed using the Kruskal–Wallis test, taking into account all the nest boxes used by these mammals, including the nests not identified to species (*N*=193, excluding currently occupiedboxes where it was impossible to check the number of nests in the box). The preference of dormouse occupancy depending on selected habitat parameters was calculated using the formula for Ivlev's index (1961):

$$E = \frac{r - p}{r + p}$$

where

r–availability of a given type of habitat in the area under study,

p– share of the areas occupied by dormice.

This factor takes values from −1 (total avoidance) through 0 (use proportional to availability) to 1 (total positive selection).

The research was conducted on the basis of a permit from the Regional Director of Environmental Protection in Kraków (decision no. OP-I.6401.210.2019.GZ).

4. Results

Occupation of nest boxes

The presence of fat and hazel dormice was confirmed in all the LPs included in the study, whereas the presence of forest and garden dormice was not noted.

The vast majority of nest boxes (79%, *n*=452) contained evidence of their use by dormice. The fat dormice used 10% of the boxes (*n*=54; a litter was present in 18 of them), while hazel dormice were found in 16% (*n*=94; a litter was present in 2 of them). Due to the significant state of decomposition of plant material, 300 nests found in the boxes could not be attributed to a particular rodent species. In the remaining 67 boxes, nests of other animals, mainly birds, were found. Only 56 boxes (9.7%) were empty and did not have any evidence of use. Both nest box sizes were characterized by a similar degree of use – 93% of large and 87% of small ones were occupied by dormice, birds, insects or mice.

The fat dormouse occupied the large nest boxes significantly more often (X^2=56,649; *df*=1; p<0.00001), whereas the hazel dormouse occupied the small ones (X^2=43,369; *df*=1; p<0.00001). Additionally, occupation was influenced by the presence of old nests in the boxes. The nests of the fat and hazel dormice were found more frequently in nest boxes with a greater number of old bird nests (KW-H(1;193)=9.23; p<0.002; KW-H(1;193)=19.1227; p<0.00001).

Comparison of occupation among the parks

In all parks, most of the nest boxes were used by animals – dormice, mice, birds or insects (Table 1). Among dormouse species, the fat dormouse dominated nest box occupation only in Poprad LP, while the hazel dormouse dominated in the remaining parks.

Habitat characteristics in the area around the nest boxes

The boxes were mainly hung in three types of forests: dominated by fir, beech and beech–fir stands (Table 2). The boxes used by the fat and hazel dormice were located in the stands proportionally to their share (Ivlev's index *E* equal or close to zero). The boxes were placed in locations with different understory densities. Those characterized by a lack of understory were less frequently inhabited by dormice than would result from their availability (Table 2). The vast majority of boxes were located in forest areas lacking natural nest cavities (category 0), which was proportional to the availability of all boxes in the study area. Most of the boxes (93%) were located in an area where one (28%), two (44%) or three (21%) plant species

Table 1. Nest boxes occupation in Carpathian landscape parks in Lesser Poland

Landscape Park PK	Number of occupied nest boxes (share) [%]			
	fat dormouse	hazel dormouse	all dormice species	all animals
Ciężkowicko-Rożnowski PK	3 (3.3)	30 (33.3)	70 (77.8)	87 (96.7)
Pasma Brzanki PK	11 (11.6)	20 (21)	67 (70.5)	86 (90.5)
Popradzki PK	33 (10)	25 (7.3)	276 (80.5)	305 (88.9)
Wiśnicko-Lipnicki PK	7 (14.9)	19 (40)	39 (83)	41 (87.2)

Table 2. The value of the Ivlev index (*E*) for habitat variables around nest boxes

Habitat variables	Dormouse [%]			Ivlev index *E*	
	in community	fat	hazel	fat	hazel
forest type:					
beech forest	27.5	18.5	30.9	-0.2	0.1
fir forest	43.8	46.3	43.6	0.0	0.0
beech- fir forest	14.1	18.5	11.7	0.1	-0.1
understorey cover					
0	7.6	1.9	4.3	-0.6	-0.3
1	40.2	33.3	38.3	-0.1	0.0
2	37.3	48.1	36.2	0.1	0.0
3	14.5	16.7	21.3	0.1	0.2
cavities occurrence					
0	67.0	64.8	73.4	0.0	0.0
1	29.7	35.2	24.5	0.1	-0.1
fruiting plant species number					
0	2.2	0.0	3.2	-1.0	0.2
1	27.5	20.4	28.7	-0.1	0.0
2	43.8	44.4	34.0	0.0	-0.1
3	20.7	31.5	27.7	0.2	0.1
4	5.8	3.7	6.4	-0.2	0.0
forest floor species occurrence					
0	32.6	35.2	34.0	0.0	0.0
1	67.4	64.8	66.0	0.0	0.0
beech occurrence					
0	19.6	16.7	17.0	-0.1	-0.1
1	80.4	83.3	83.0	0.0	0.0
hazel occurrence					
0	70.7	70.4	68.1	0.0	0.0
1	29.3	29.6	31.9	0.0	0.0

were present as a potential food base for dormice. Both the fat and hazel dormice occupied mainly nest boxes located in plots with at least two fruiting species (80% and 68% of the boxes used by the species, respectively). The fat dormouse clearly avoided boxes in sites without fruiting species, while a preference was not observed for the hazel dormouse. Both the fat dormouse and hazel dormouse were more abundant in nest boxes located in areas with beeches (83%); however, this reflected the share of this species in the study area (it was found in 80% of the area with nest boxes). Additionally, over half of the boxes occupied by the fat dormouse (65%) and hazel dormouse (66%) were in plots characterized by the presence

of at least one fruiting understory species, mainly blackberry. Common hazel was present in 29% of the area surrounding the inspected boxes, which is reflected in the presence of this species in the vicinity of boxes occupied by the fat dormouse (30%) and the hazel dormouse (32%).

5. Discussion

The high percentage of nest boxes used by Gliridaemammals shown in this study confirms the validity and effectiveness of hanging artificial shelters for these woodland mammals. The frequent use of nest boxes by dormice probably indicates an insufficient number of natural shelters in the studied habitats.

Studies have shown that hazel dormice clearly prefer small nest boxes, probably due to the fact that they avoid competition with larger species (such as the fat dormouse) (Vogel, DuPlain 2012). Not infrequently,dormice and cavity nesting birds, which are a common food source in the diet of these small mammals, occupy the same boxes (Sarà et al. 2005; Adamík, Král 2008). Additionally, dormice can use material from bird nests to build their own nests (Ściński, Borowski 2006).

Differences in nest box use in individual parks by the fat dormouse and hazel dormouse may result from the different habitat preferences of these species (Juškaitis, Šiožinytė 2008) or from the different status of dormouse populations in these areas. The results suggest that in Ciężkowicko-Rożnowski LP and Wiśnicko-Lipnicki LP, the boxes were located in much more convenient sites for the hazel dormice as they inhabited a significant share of the available boxes. On the other hand, only a small number of fat dormicewere observed despite the presence of the large nest boxes they prefer.

The dormouse inhabited mainly three types of forests, fir, beech and beech–fir, which are the most common ones in the Carpathians, and this is where most of the nest boxes were located. It may seem surprising to see a frequent occurrence of dormice in fir stands. In the case of the hazel dormouse, there are data in the literature confirming the presence of this species in coniferous forests. The frequent use of nest boxeshung in such stands by the hazel dormouse was described by Juškaitis (2007) among others. Even fat dormice, which are usually strongly associated with beech stands, may sometimes prefer habitats with an increased proportion of coniferous trees, whose shoots provide a certain source of food, especially in years when beech crops are less abundant (Cornils et al. 2017; Jurczyszyn 2018). The presence of coniferous species such as fir, due to their construction, may facilitate the movement of dormice. It is also possible that their frequent occurrence in fir-dominated forests is due to the timing of the observations (a year of a poor beech crop). The presence of a dense understoryin the forest areas where most of the boxes were inhabited by dormice confirms its importance in the selection of habitats by these animals. Shrubs and young trees form corridors for their safe movement (Karantanis et al. 2017), and a complex spatial arrangement of the vegetation may be more important in this mammal's habitat selection than species diversity (Panchetti et al. 2007). Hazel dormice in particular are known as a species closely linked to habitats with a dense and species-differentiated understory, which they willingly choose as nesting sites (Juškaitis et al. 2013). Thus, the observations made seem quite surprising as one would expect that in such habitats, the percentage of nest boxes occupied by the hazel dormouse will not be high due to the availability of numerous natural nesting sites (Wolton 2009).

Tree cavities can serve as natural shelters and nesting sites for dormice (Sevianu, Philippas 2008), but when they are in short supply, these mammals successfully occupy artificial shelters. The nutritional abundance of a habitat is important in the selection of nesting sites by dormice (Bright, Morris 1990). The vast majority of the boxes used were located in the vicinity of beech, which is an important source of food for these animals. Common hazel is also one of the plant species providing high-energy food for the dormouse (Juškaitis 2007, Jurczyszyn 2018). However, the mere presence of fruiting vegetation, such as beech, hazel and those in the understory, is not a good indicator of the attractiveness of habitats for dormouse species as these plants are characterized by a varied abundance of their fruiting over the years and only good crop years (in the case of beech) may influence the more numerous occupancy of nest boxes (Trout et al. 2015). Dormice prefer forests with a large number of fruiting species, which provide a varied diet throughout their active season, especially in years when beech does not have a good crop (Cornils et al. 2017).

Summary

This study, conducted in Carpathian LPs, was a preliminary attempt to assess the use of nest boxes by the dormouse in relation to selected habitat parameters. The obtained results confirm the high demand for nest boxes by dormice (fat dormouse and hazel dormouse). Nest boxes for dormice perform well in areas where the number of natural shelters is insufficient, and hanging them proves to be a useful tool in the active protection of these endangered mammals.

Conflict of interest

The authors declare that they have no potential conflicts of interest.

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Authors' contribution

I.F. – author of the concept and research project, fundraising, development of the research assumptions and methods, data collection, analysis of results, manuscript preparation; E.P. – data collection, statistical analysis, analysis of results, manuscript preparation; K.N. – data collection, statistical analysis; J.W. – data collection, preparation of figures and tables; A.M. – data collection, literature preparation; K.Ś. – author of the concept and research project, development of the research assumptions and methods.