TRAVAUX DU MUSÉUM NATIONAL D'HISTOIRE NATURELLE «GRIGORE ANTIPA»
THE JOURNAL OF "GRIGORE ANTIPA" NATIONAL MUSEUM OF NATURAL HISTORY

Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa" 66 (2): 355–365 (2023)
doi: 10.3897/travaux.66.e115008

RESEARCH ARTICLE

Nest box occupancy dynamics by hazel dormice (*Muscardinus avellanarius*) in central-western Romania

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Received 31 October 2023 | Accepted 10 November 2023 | Published 31 December 2023

Citation: Sevianu E, Bivoleanu R-A, Rădac IA (2023) Nest box occupancy dynamics by hazel dormice (*Muscardinus avellanarius*) in central-western Romania. Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa" 66(2): 355–365. https://doi.org/10.3897/travaux.66.e115008

Abstract

The hazel dormouse, *Muscardinus avellanarius* is a vulnerable and protected species that is challenging to study due to its specific way of life. Limited data on its distribution and population parameters are available for Romania. We collected data regarding species' biology and ecology in the hilly areas of central-western Romania, within deciduous forests dominated by oak or beech species. We regularly monitored 80 wooden nestboxes, which served as shelter and breeding sites for the species, to assess the seasonal and sex-related variations in nest box usage. The highest occupancy levels were observed during the autumn, with a smaller peak in the spring. Males occupied more nest boxes than females, although the difference was not statistically significant. They also travelled greater distances. Most nest boxes were occupied by a single individual at a time. Recapture rates did not differ significantly between males and females, and most individuals were recaptured only once. Hazel dormice showed a high level of site fidelity, often returning to the same nestbox or one nearby. Interestingly, 14% of the females bred twice a year, which is a lower percentage compared to findings from other studies. Nest box occupancy rates in this region were also lower than those reported in other areas. However, it is important to note that these variations may be attributed to differences in methodology. The occupancy rate declined with the increased presence of the larger species, the fat dormouse *Glis glis,* which outcompeted the hazel dormouse.

Keywords
arboreal rodent, artificial nesting site, breeding, life cycle, nest box sharing, recapture

Introduction

The hazel or common dormouse *Muscardinus avellanarius* (Linnaeus, 1758) is a small, nocturnal, and arboreal rodent. In Romania it is classified as a vulnerable species (Murariu 2005), and it is protected under the Annex IV of the Habitat Directive. As a result, monitoring, and reporting on the conservation status of this species is a legal obligation as stipulated in Articles 11 and 17 of Council Directive 92/43/EEC.

The current conservation status in Romania for the period between 2007 and 2018 is considered favourable, with a stable short-term population trend. However, this assessment is primarily based on expert opinion due to the very limited data available (Country Report*). Given that population trends can vary across the species' range, with declines in some areas and stability in others (Hutterer et al. 2021), it is crucial to gather field data from different regions and habitat types to detect trends in conservation status.

Wooden nest boxes, serving as a substitute for tree hollows, have been widely used in hazel dormouse research. They have been utilized in studies related to distribution, long-term population monitoring, habitat preference, life cycle, movement, reproduction, and as a conservation measure (e.g. Morris et al. 1990; Juškaitis 1997; Juškaitis 2000; Büchner et al. 2003; Duma 2007; Sevianu 2009). The installation of artificial nest boxes is also recommended as a necessary protection measure for the species in Romania (Murariu 2005).

In our study, we conducted regular checks of wooden nest box grids to investigate occupancy as a proxy for population abundance, and we hypothesized that the use of nest boxes would exhibit seasonal and sexual variations related to the species' life in central-western Romania.

Methods

Study area

The study was conducted in four separate sites in the central-western part of Romania, Hunedoara County (Fig. 1): two sites were situated in the Metaliferi Mountains (C, D), and the other two (A, B) in Orăștie Couloir, a depressionary area that separates two mountain ranges. All areas were covered in second-growth forests, with trees of essentially the same species, age, and height. Two sites were dominated by *Quercus* species, (A and B) situated at lower altitudes (260–340 m). At site A (45.8462°N; 23.2378°E), dominated by *Q. cerris,* there were also rare and scattered *Prunus avium* and *Carpinus betulus*. The understory was well-developed (*Crataegus monogyna, Euonymus europaeus, Ligustrum vulgare,* young *Acer tataricum* and *A. campestre*). Site

B (45.8675°N; 23.3165°E) was co-dominated by *Quercus cerris* and *Q. petraea,* with *Prunus avium* being quite frequent, rare *Carpinus betulus, Fraxinus excelsior*, *Malus sylvestris*, and planted *Robinia pseudoacacia* along the forest edge. The understory was very poor inside the forest, but well developed near the edge, with *Crataegus monogyna* and *Rubus cf. fruticosus*. The other two sites (C and D) were situated at slightly higher altitudes (370–420) and dominated by *Fagus sylvatica* and *Carpinus betulus*. At site C (45.9936°N; 23.1518°E) there were also rare *Acer campestre* and *A. pseudoplatanus,* with medium developed understory (*Corylus avellana).* Site D (46.0177°N; 23.0998°E) had a weak understory with *Cornus mas, Crataegus monogyna* and *Acer campestre* for the most part, but it was not homogenous and included a sector planted with *Populus tremula, Salix* sp. and *Robinia pseudoacacia,* a small open area with *Rubus cf. fruticosus,* and an old, abandoned orchard (*Malus domesticus, Prunus domestica).*

Methods

In our study we used 80 wooden dormouse nest boxes, with the design and installation position proposed for the study of the species (Morris et al. 1990). Each nest box had dimensions of 14×14×21 cm, an entrance of 3.5 cm, and was positioned 2–2.5 m above ground, facing the tree trunk. At each site, 20 nest boxes were spaced approximately 25 m apart, in a hollow square grid pattern, with one side relatively close to the forest

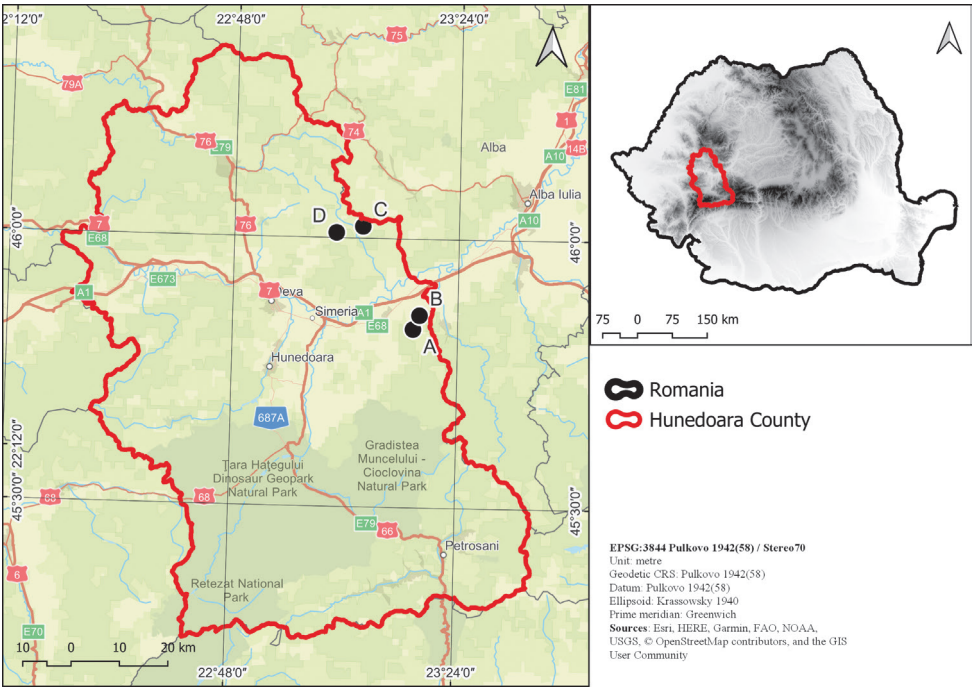

Figure 1. Location of the study sites.

edge (A – road, pasture; B – pasture; C – river, road; D – orchard, pasture). All 80 nest boxes were installed in April 2018, and their utilization by the hazel dormouse was monitored during 13 monthly surveys conducted from May to November 2018 and from April to November 2019.

A nest box was considered to be used by the species when at least one individual was found inside. During these surveys, adult and juvenile dormice found were sexed, weighed, and individually marked by ear tattoo. After being processed, these dormice were released in the same nest box.

Our research aimed to assess sexual and seasonal variation in the occupancy of the nest boxes. Data analysis was performed in Microsoft Excel and using spreadsheets available online (McDonald 2014). We used Bartlett's test to assess whether there were significant differences in the standard deviation between males and females in terms of individuals and captures. Sexual variation in nest box usage was analysed using the Welch t-test. We used the exact test of goodness-of-fit to assess the significance of the deviation from the expected ratio of male-to-female recapture rate and yearly nest boxes occupancy proportions.

Results

Hazel dormouse was identified at all four study sites, where it used nest boxes from April to October. On average, 12%±6.4 (SD) of nest boxes were occupied by the hazel dormouse (range 1.25%–26.25%) during the active season. Considering each site separately, per month, the highest occupancy rate (50%) was reached in September 2018, at site B. Pooled data over two years showed two distinct peaks in nest boxes occupancy, a smaller one during June (10.62%±2.12 SE) and a bigger one in September (21.25%±4.72 SE) (Fig. 2).

In total, we observed 113 different hazel dormouse individuals (adults and juveniles) in 151 captures. 49 individuals were males, 43 were females, and 21 were not sexed. Bartlett's test indicated that there were no significant differences between males and females' number of individuals or captures, as the p-value was greater than 0.05 (p=0.7). Considering all nest boxes checks (N=13), the average number of individual males (0.94±0.17; range 0–5) and females (0.82±0.17; range 0–7) did not differ significantly (t-value=0.46, df=103.72, p=0.64, Welch t-test), nor did the average number of captures (males 1.32±0.21, range 0–8; females 1.17±0.19, range 0–7, t-value=0.53, df=100.61, p=0.59, Welch t-test).

The nest boxes were occupied by the hazel dormouse in a slightly higher proportion in the first year (average 13.75%) compared to the second year (average 10.17%), with differences between sites (Tab. 1). Three other species of mammals also occupied the nestboxes during our study: fat dormouse *Glis glis,* yellow-necked mouse *Apodemus flavicollis,* and a bat species, the common pipistrelle *Pipistrellus pipistrellus,* with a combined occupancy rate of less than 3%. The proportion of nest boxes used by those species increased from first to second year (Tab.1). The increase

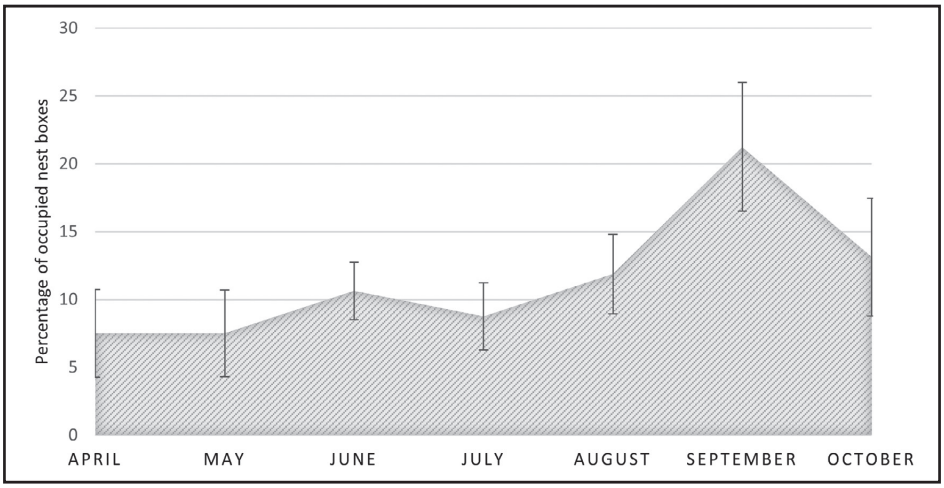

Figure 2. Percentage of occupied nest boxes by the hazel dormouse, pooled data (2018–2019) with standard error bars.

in nest boxes used by fat dormouse and yellow-necked mouse, and the decrease in occupancy by the hazel dormouse (Fig. 3), were significant only for site D ($p<0.05$, exact test of goodness-of-fit).

The number of hazel dormouse individuals found inside a nest box varied between 1 and 5 (females with litter were counted as one individual), and most nest boxes were occupied by one individual (81.3%), followed by two individuals (16.2%) and much lower percentages for three or more (0.8%).

During the study, 25 individuals were recaptured (16.5%) 1 to 5 times, 15 males and 10 females. The difference from the expected ratio of 1:1 was not significant ($p>0.05$ exact test of goodness-of-fit). Most individuals (76%, N=19) were recaptured only once, 8% (N=4) twice and three times, and 4% (N=2) four and five times.

Table 1. Yearly percentages of nest boxes (NB) occupied by different mammal species at each study site.

Site	Year	% NB hazel dormouse	% NB fat dormouse	% NB yellow-necked mouse
A	2018	9.6	0	0
	2019	12.14	0	2.14
B	2018	20	0	0
	2019	13.5	1.4	1.4
C	2018	7.3	0	0
	2019	7.14	0	0
D	2018	20.8	2.5	0
	2019	7.85	12.14	1.4

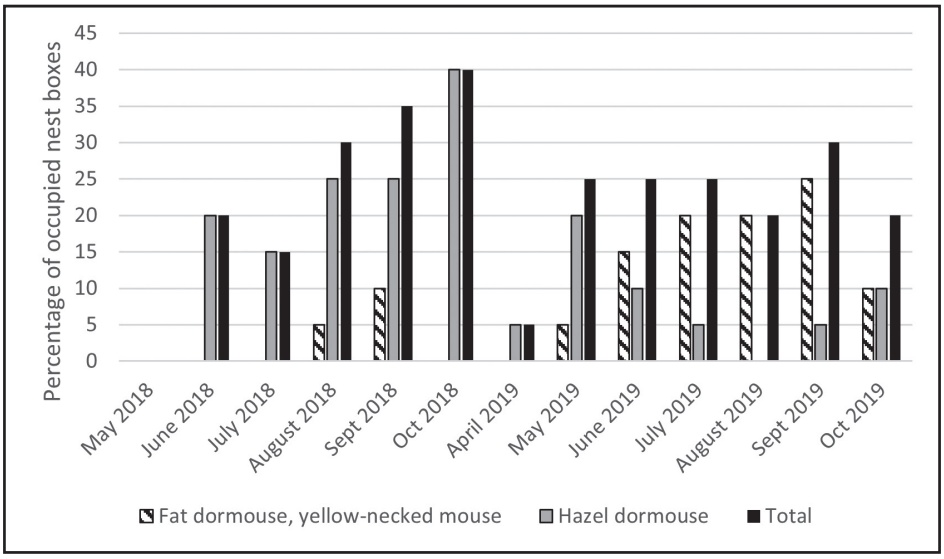

Figure 3. Site D. Dynamic of nest boxes occupancy by different mammal species: hazel dormouse, fat dormouse, yellow-necked mouse.

32% of the recaptures took place after one hibernation (N=8). More than half (54%, N=20) of recapture events took place in the same or adjacent nest box, 27% (N=10), 2 or 3 nest boxes away, 10% (N=4), 4–5 nest boxes away, 5% (N=2) 4 or 5 nest boxes away and only 2% (N=1) of recapture events took place 8 nestboxes away from the point of first capture. The maximum straight-line distance travelled between two recaptures was 50 m for females and 145 m for males.

Females with young were found inside nestboxes from May until September, and the litters consisted of 1–6 young (mean 3.6, N=15). 14% of the females had two litters per year.

Discussion

In central-western Romania, the hazel dormouse has been mostly reported in the Retezat Mountains (Csató 1867; Simionescu and Munteanu 1988; Cobzaru 2006; Duma 2007; Benedek 2014). It has also been reported near Simeria, where the hazel dormouse was last identified more than 60 years ago (Ene and Almăşan 1956). Our research confirmed the presence of the species in the depressionary area of the Orăştie Couloir and, to the best of our knowledge, was first noted in the Metaliferi mountains.

The species was identified through monthly nest box checks, from April to October, confirming the lengths of the active season of the species in Romania. However, some individuals may have been still active during the first days of November (Duma 2007; Sevianu 2009). Hazel dormice typically locate and occupy

nest boxes shortly after installation (Sevianu 2009; Juškaitis 2014), provided they are installed early in the season, before the start of the breeding period, although other authors have suggested that several months may be required (Bright et al. 1996). At our study sites, the interval between nest boxes installation and the first observation of the species varied between one and three months.

Nest box occupancy rate was lowest in early spring, peaked in late spring-early summer, decreased during the summer, and began to rise again in late summer-early autumn. Variations in nest box occupancy, even without knowledge of the population size or the proportion of the population using them, provide an important index for estimating population abundance and revealing aspects of the species' biology and ecology (Juškaitis 2000; Madikiza et al. 2010).

The species did not use the nest boxes to the same extent throughout the entire active season. Nest boxes were primarily utilized during spring-early summer (June), and in the autumn (September), showing two peaks in occupancy rate. Similar patterns, with the spring peak occurring either in May or in June, and the autumn peak in September or October, were observed in most studies across the species' range, including in Romania (Sevianu 2009) where the species hibernates during the winter (review in Juškaitis and Büchner 2013; Juškaitis 2014). The spring peak in our study fell at the lower end of the interval found in Lithuania (Juškaitis 1997), and the autumn peak, the result of the occupation of nest boxes by the independent juveniles born during spring and summer (Juškaitis 2014), had a lower value than in other areas (e.g. Juškaitis 1997; Juškaitis 2000). These outcomes might not necessarily reflect real differences in abundance between populations, but might result from methodological differences, as we did not count the nest boxes with signs of visitation but not occupied by the species during checks.

The average percentage of nest boxes used by the species during our study varied between years. Still, long-term studies are required to detect trends in abundance, which generally show little variation from year to year (Juškaitis 2000). The decrease in nest boxes use by the hazel dormouse in the second year was mostly driven by the sharp decrease at site D, where a significant increase in nest boxes occupied by fat dormouse was registered. At the other three sites, the percentage of nest boxes occupied by other mammal species was low. Hazel dormouse was outcompeted and had lower occupancy rates when other mammal species, especially fat dormouse and yellow-necked mouse, occupied nest boxes in high percentages (Juškaitis 2000; Sevianu and Filipaș 2008; Sevianu 2009). At our study site, such competition could explain the decrease in nest boxes occupancy by the hazel dormouse in the second year. The usage of nest boxes by fat dormouse and yellow-necked mouse might have been even higher than the occupancy detected during this study, as we considered a nest box occupied only when animals were present at the time of check. When there was low competition for nestboxes, high rates of occupancy were reached both in beech and Turkish oak forests. Our results concurred with other studies that detected no preference for either tree species (review in Juškaitis 2014). Those forests had weak understorey, and although a well-developed understorey was generally regarded as

essential for safety and food supply, the species seemed to be able to inhabit various types of habitats (Juškaitis 2014). More detailed studies are needed to detect the factors that influence hazel dormouse abundance.

Our results showed that, although the nest boxes were used slightly more by male hazel dormice than by females, the difference was not statistically significant. Sex ratio studies among different populations of the species showed that males outnumbered females to some extent (Juškaitis 2014), and this could be reflected in the usage of nest boxes.

Hazel dormice used nest boxes for shelter and breeding. In approximately 81% of the cases, a single individual was found inside the nest box, which is similar to the results from Lithuania (Juškaitis 1997), but differs from other studies where nest box sharing was more common (Morris et al. 1990). Most individuals were recaptured only once (76%), and males and females were equally prone to recapture. Hazel dormice used multiple nest boxes and natural nests (Morris et al. 1990), which can explain the fact that less than 20% of the marked individuals were ever recaptured. Slightly more than half of the recaptures, during subsequent checks or later, occurred in the same or adjacent nest box, indicating a high site fidelity. Nevertheless, only 21% of the recaptures took place in the same nestbox, meaning that it was unlikely to recapture an individual in the same nest box, a result similar to observations from Great Britain (Trout et al. 2017). Males travelled further than females, a result consistent with other studies (Juškaitis 2014), yet the maximum distance registered was limited by the arrangement of the nest boxes.

At our study site, 14% of the females gave birth to two litters per year, a percentage similar to results in Moldova (Lozan 1970 in Juškaitis 2014), but less than in southwestern Romanian lowlands, which showed 30% of females having two litters in the same season (Duma 2007). Due to relatively low number of recaptured females and the fact that some females might give birth in natural nests (Juškaitis 2014), the percentage may be underestimated. The first litter was born in May–June, and the second in July–September, consistent with other findings in Romania (Duma 2007) and Lithuania (Juškaitis 2014). We found one case of a female with confirmed two litters in 2018 and a new litter in May 2019. Multiple litters per year in hazel dormouse separate the life cycle of the species from the much larger fat dormouse, which reproduces only once per year (Kryštufek 2010), with almost all births occurring late in the season, during a four-week period (21st of July–22nd of August) in Romania (Sevianu 2009). A second litter was found only exceptionally, as a replacement brood (Holcová-Gazárková and Adamík 2016). The mean litter size was similar to other studies, and can vary over the years, but was usually close to 4 (Duma 2007, review in Juškaitis and Büchner 2013).

Conclusions

Our study indicates that the hazel dormouse may take up to three months to discover and occupy wooden nest boxes installed as an alternative for tree hollows. The species predominantly utilized nest boxes during the end of spring-early summer and during the autumn, and it can be outcompeted by the fat dormouse and the yellow-necked mouse. Males were more mobile than females and travelled longer distances. Most nest boxes were occupied by a single individual. Both males and females were equally likely to be recaptured and showed a high degree of site fidelity, even in subsequent years, but not necessarily for the same nest box. Our findings suggest that at least 14% of the females gave birth to two litters per year, and some breed annually. The hazel dormouse seems to inhabit a great variety of habitat types, and not to be strictly dependent on the presence of a well-developed understorey.

Acknowledgements

We are grateful to I. Coroiu and two anonymous reviewers for their constructive comments and suggestions that helped to improve the manuscript.

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*** Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. https://www.eea.europa.eu/policy-documents/council-directive-92-43-eec