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NEST SITE PREFERENCE OF FOREST DORMOUSE *DRYOMYS NITEDULA* (PALLAS) IN THE NORTH-WESTERN CORNER OF THE DISTRIBUTION RANGE

ABSTRACT: Lithuania is situated in the very north-western corner of the large distribution range of the forest dormouse *Dryomys nitedula* and it might be considered that dormouse habitats should be both different and sub-optimal in this area in comparison to central parts of the range. The aims of the present study were to analyse which vegetation parameters determine nest site preference of *D. nitedula* and to compare these with nest site preferences of other dormouse species. The population of *D. nitedula* was studied from 2001 to 2011 using nestboxes set up in a grid system, with regular control of the nestboxes and ringing of dormice captured. During entire study period, 97 individuals were marked with rings and the total number of dormouse captures was 440. Vegetation parameters (the composition of the overstorey and understorey, the numbers and cover of different tree and shrub species, absence of vegetation *etc.*) were evaluated quantitatively in areas of 2500 m² around 58 nestboxes at this study site. During the period 2001–2002, the abundance of *D. nitedula* was relatively high, with the dormice using the entire area of the study site, showing a preference for nest sites with a more diverse overstorey and understorey. However, no significant correlations were found between indices of nestbox use and other vegetation parameters in this period. During the period 2003–2011, when the dormouse abundance was lower but stable, dormice used only part of the study site area, in this preferring nest sites with a better developed and

diverse understorey (especially with young rowan, lime and aspen trees), with more abundant mature oak, lime and black alder trees and a higher percentage of raspberry and bramble cover, as well as overgrown clearings. *D. nitedula* avoided nest sites with higher total number of mature trees (especially Scotch pine and Norway spruce), as well as areas with higher percentage of bilberry cover and open areas (rides, presence of stumps). In general, a well-developed and diverse understorey was the main habitat component which determined nest site preference of *D. nitedula* in the very north-western corner of its range. Thus, *D. nitedula* retains its main habitat requirement which is characteristic also for other parts of its large range. Vegetation parameters determining nest site preference of *D. nitedula* are rather similar to nest site preference of the common dormouse *Muscardinus avellanarius*. However, *D. nitedula* may live in less rich habitats probably because their diet includes more food of animal origin.

KEY WORDS: *Dryomys nitedula*, nest sites, vegetation parameters, nestbox use, understorey, distribution range, Lithuania

1. INTRODUCTION

Forest dormouse *Dryomys nitedula* (Pallas 1778) has very large distribution range, a large part of which is situated in Asia, reach-

ing China and Mongolia (Batsaikhan *et al.* 2008). In Europe, *D. nitedula* is a rather rare species, protected by international law under the EU Habitats and Species Directive (Annex IV) and the Bern Convention (Appendix III) in the parts of its range where these apply. The species is red listed in some European countries, *e.g.* in Germany (Bundesamt für Naturschutz 2009), Latvia (Andrušaitis 2000), Lithuania (Rašomavičius 2007), Poland (Głowaciński 2001), Romania (Botnariuc and Tatole 2005) and Switzerland (BUWAL 1994).

In its wide distribution range, *D. nitedula* lives in very different habitats (reviews in Ajrapet'anc 1983, Nowakowski and Boratynski 1997, Rossolimo *et al.* 2001). Lithuania is situated in the very north-western corner of the distribution range of this species (Kryštufek and Vohralik 1994, Mitchell-Jones *et al.* 1999). The northernmost population of *D. nitedula* is known from Latvia, occurring near the common borders of Latvia, Lithuania and Belarus (Pilats 1994). In Lithuania, only two populations of this species are known at present. It could be expected that habitats of *D. nitedula* in this north-western periphery of the range are both different and sub-optimal in comparison to central parts of the range.

In common with most other European dormouse species, *D. nitedula* is an arboreal rodent living in woodland and it is the case that forest management can have both positive and negative influences on dormouse habitats. For example, the system of forest management in Lithuania is favourable for the common dormouse *Muscardinus avellanarius* L., but not for the edible dormouse *Glis glis* L. (Juškaitis 2007), whilst the opposite situation is characteristic for Germany (Gatter and Schütt 2001, Juškaitis and Büchner 2010). In Europe, a lot of attention is paid to the conservation of *M. avellanarius* (*e.g.* Bright *et al.* 2006, Juškaitis and Büchner 2010), but not to the conservation of *D. nitedula*. A key part to the conservation management of rare and specialized species such as dormice is an accurate description of habitat requirements (Bright and Morris 1990).

Nest site selection by animals is understood as the choice of certain features of the environment that differ from the gener-

ally available sites (Skórka *et al.* 2011). For some closed nest dwellers, such as ovenbird *Seiurus aurocapilla* L., the provision of suitable nest site requirements may be fulfilled by short-term forest management practices that favour single tree selection, as already after 20–25 years following forest felling nest-site characteristics did not differ from random-plot microhabitat parameters (Leblanc *et al.* 2011). Arizona grey squirrels *Sciurus arizonensis* Coues select their nesting site according to its ability to ensure access to food and its provision of protection. They require good canopy cover and many dead-wood elements, such as snags, logs, and large trees (Cudworth and Koprowski 2011). Bigger cavity-dwellers, such as western grey squirrel *Sciurus griseus* Ord, American red squirrel *Tamiasciurus hudsonicus* Erxleben, northern flying squirrel *Glaucomys sabrinus* Shaw and Siberian flying squirrel *Pteromys volans* L. require mature hollowed trees, thus introducing some constraints on forest management (Gregory *et al.* 2010, Kadoya *et al.* 2010, Aitken and Martin 2012).

Amongst dormouse species, nest site preferences have been previously studied in *M. avellanarius* (Panchetti *et al.* 2007, Juškaitis and Šiožinytė 2008), *G. glis* (Schlund *et al.* 1993, 1997, Juškaitis and Šiožinytė 2008) and garden dormouse *Eliomys quercinus* L. (Bertolino and Cordero di Montezemolo 2007), but not in *D. nitedula*. Habitats of *D. nitedula* are described in many publications (see reviews in Ajrapet'anc 1983, Rossolimo *et al.* 2001), but previous studies have been descriptive only, simply cataloguing the features of sites where dormice occurred. The present study appears to be the first quantitative analysis of nest site preference of *D. nitedula*. The aims of the study were to analyse which vegetation parameters determine nest site preference of *D. nitedula* in the north-western corner of the distribution range and to compare them with nest site preferences in other dormouse species.

2. STUDY AREA

The study site (area = 13.8 ha) was situated in Kaunas district (54°58'N, 23°30'E), central Lithuania, in the southern part of the large Kazlų Rūda forest massive (area 58,700 ha).

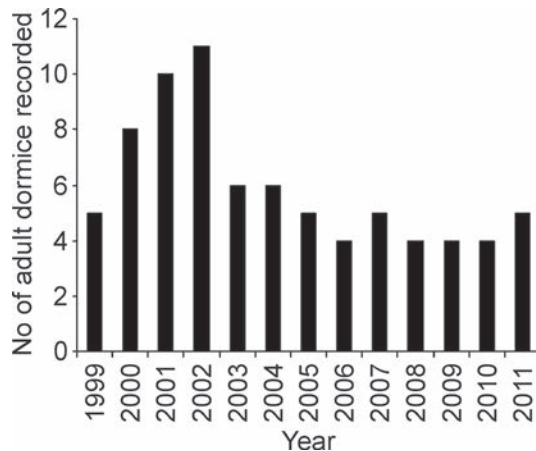


Fig. 1. Dynamics of numbers of adult *D. nitedula* recorded in nestboxes in the area of the study site in Lithuania in the period 1999–2011. Note: only 20 nestboxes arranged in a line were controlled in 1999–2000, whereas 63 nestboxes spaced in a grid system were controlled in the period 2001–2011.

This part of the forest was not homogeneous, with many different comparatively small forest stands. According to the forest inventory data from 2004, the composition of each of the main forest stands in which studies were carried out was:

1) 50% birch *Betula pendula* Roth. and *B. pubescens* Ehrh. (55 years old), 20% aspen *Populus tremula* L. (55), 20% Norway spruce *Picea abies* (L.) Karst. (65), and 10% Scotch pine *Pinus sylvestris* L. (55); 40 year-old spruce trees grew in the sub-canopy. Plot area = 3.4 ha.

2) 40–60% pine (55–75), 20–40% spruce (55–75), 20–40% birch (55); 40 year-old spruce trees grew in the sub-canopy. Plot area = 5.6 ha.

3) 40% spruce (55), 20% spruce (75), 30% birch (55), 10% aspen (55); 40 year-old spruce trees grew in the sub-canopy. Plot area = 3.3 ha.

4) 90% pine (60), 10% birch (60). Young spruce and oak *Quercus robur* L. trees formed the understorey, with sparse glossy buckthorn *Frangula alnus* Mill. and rowan *Sorbus aucuparia* L. Plot area = 0.9 ha.

5) 90% black alder *Alnus glutinosa* (L.) Gaertn. (70), 10% spruce (70). Young spruce trees with sparse glossy buckthorn grew in the understorey. Plot area = 0.6 ha.

Standard forest management, including clear felling, was prominent in most of the forest, including the study site.

3. MATERIAL AND METHODS

In the study site, a pilot study of *D. nitedula* population was carried out in the period 1997–2000 controlling 11–20 wooden tit-nestboxes which were put up in a line along the edge of the forest compartment and forest road. In April 2001, 63 wooden tit-nestboxes were put up in a grid pattern, each a distance of 50 m from the next (see Fig. 2). The old nestboxes arranged in a line were removed in early August 2001. The internal dimensions of nestboxes used were 12 × 12 × 23 cm and the entrance hole diameter was 35 mm. Most nestboxes were put up in spruce trees at a height of 3–4 m.

All dormice caught in the nestboxes in the period from 1999 were marked with aluminium rings (inner diameter 3.0 mm, height 3.0 mm). The rings were placed on the right hind leg above the ankle. During the entire study period, 97 individuals were marked with rings and the total number of times that dormice were handled was 440. All the animals caught were aged, sexed and weighed using PESOLA 100 g balances with an accuracy to 1 g. Dormice were considered adults if they had survived at least one hibernation. Nestboxes were controlled regularly during entire dormouse activity period: from late April until early September. During May–August, nestboxes were controlled once per month in 1999–2000 and 2004–2009, and twice per month in 2001–2003 and 2010–2011.

The present study was designed to verify the association between the nestboxes used by *D. nitedula* and specific habitat characteristics. Vegetation parameters (including the absence of vegetation) were evaluated in areas of 50 × 50 m (2500 m²) around 58 nestboxes in August 2011. Around each nestbox, all canopy, sub-canopy and young trees (higher than 1 m and with diameter at breast height <7.5 cm) and shrubs in the understorey were counted and their species identified. The percentage of cover of potential food plants in the field layer was estimated visually in six quadrates (10 × 10 m) chosen randomly in the surroundings of each nestbox.

Taking into consideration the habitat variables used in previous analogous studies (Bright and Morris 1990, Schlund *et al.* 1993, 1997, Capizzi *et al.* 2002,

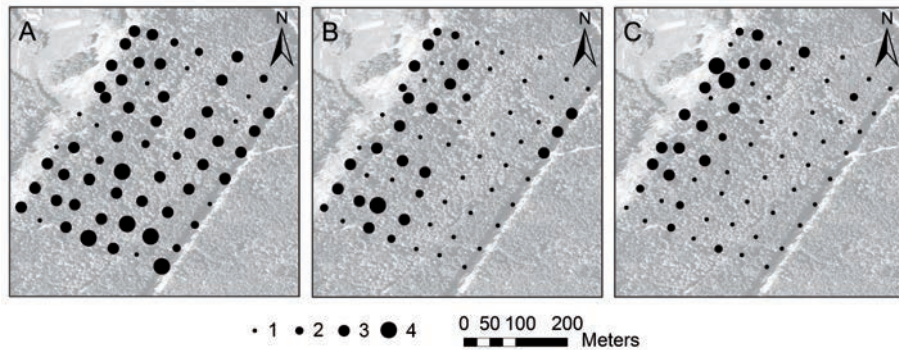


Fig. 2. Spacing of nestboxes used by *D. nitedula* at study site in Lithuania: A) in 2002, B) in 2006 and C) in 2011. 1 – nestbox not used, 2 – short-term use of nestbox, 3 – long-term use of nestbox, 4 – nestbox used for breeding.

2003, Milazzo *et al.* 2003, Juškaitis and Šiožinytė 2008), 61 variables around each nestbox were derived from direct field measurements and different combinations of these. They are presented in the following groups:

1. numbers of mature trees in canopy or sub-canopy – spruce, birch, oak, aspen, pine, black alder, lime *Tilia cordata* Mill., apple *Malus sylvestris* (L.) Mill. and elm *Ulmus glabra* Huds.;
2. numbers of young trees – spruce, birch, oak, aspen, pine, black alder, maples *Acer platanoides* L. and *A. negundo* L., pear *Pyrus* sp., lime, common buckthorn *Rhamnus cathartica* L., apple, elm;
3. number of specimens of different shrub species – glossy buckthorn, rowan, bird cherries *Padus avium* Mill. and *P. serotina* (Ehrh.) Borkh., dwarf serviceberry *Amelanchier spicata* (Lam.) Koch;
4. number of tree stumps with diameter > 10 cm; number of logs lying on the ground; number of dead trees; number of trunks (dead trees without branches, higher than 1 m);
5. cover (in %) of separate species of fruiting plants forming the field layer – bilberries *Vaccinium myrtillus* L., wild strawberries *Fragaria vesca* L., stone brambles *Rubus saxatilis* L.; total cover (in %) of raspberries *Rubus idaeus* L. and brambles *Rubus caesius* L. and *R. nessensis* Hall;
6. area of forest roads, rides and other open areas; area of overgrown clearings;
7. densities per hectare of canopy trees, sub-canopy trees, young trees and shrubs;
8. number of trees which have a crown or a trunk connected to the crown of the nestbox tree;
9. different combinations of mentioned variables or derived variables (*e.g.*, total number of mature trees; total number of spruce trees in canopy and sub-canopy *etc.*);
10. presence of forest habitat edge;
11. Shannon-Wiener biodiversity index of overstorey and understorey.

The index of nestbox use by dormice was considered to be an indicator of habitat suitability for dormice in the areas surrounding nestboxes. Indices were calculated using data from nestbox controls in 2001–2011. Use of nestboxes by dormice in separate years was scored in points:

0 point – dormice did not use nestbox at all;

1 point – short-term use of nestbox (dormouse found in empty nestbox, small amount of excrement or food remains);

2 points – long-term use of nestbox during one activity season (dormouse nest, large amount of excrement or food remains, one or several dormice found in nest);

3 points – female with litter of juveniles using nestbox.

For each nestbox, the numbers of points from different years were totalled up for two periods (2001–2002 and 2003–2011), and the sum was divided by the number of years during which the particular nestbox was monitored. Pearson correlations be-

tween vegetation parameters and indices of nestbox use by *D. nitedula* were calculated. Additionally, vegetation parameters around nestboxes used and not used by *D. nitedula* were compared using Student's t-test. Nestboxes used by *D. nitedula* were deemed those in which any signs of dormouse activity (dormice, their nests, excrement, food remains) had been found during the activity season. A Shannon-Wiener biodiversity index based on the \log_2 was calculated for the understorey and overstorey separately, comparing vegetation around nestboxes. Comparisons were done for used versus not used nestboxes in the periods 2001–2002 and 2003–2011, and for nestboxes used for breeding (in which females with litters of juveniles were recorded) versus nestboxes not used for breeding.

Rényi diversity numbers were used for testing differences in diversity of understorey and overstorey around nestboxes used and not used by *D. nitedula*. Different traditional diversity indices measure different aspects of the partition of abundance between species and they have particular drawbacks. The numbers of species are not comparable statistically; the Shannon-Wiener biodiversity index is sensitive to presence of rare species, while Simpson's index emphasizes dominant species. It is possible that one community could be evaluated as more diverse using one index which put emphasis on rare species, while a second community could be found more diverse us-

ing another index which emphasizes common/dominant species (Tóthmérész 1998). The major advantage in applying the Rényi diversity numbers is that they display not just a single index but a family of indices, many of which are currently applied and widely used in ecology and have varying sensitivities to the presence of rare and abundant species (Carranza *et al.* 2007).

A family of diversity indices may be portrayed graphically by plotting diversity values against the scale parameter α to get Rényi's diversity curves for communities compared. The understorey and overstorey diversities around the nestboxes were compared in different species' dominance levels, using scale parameters of α between 0 and 4. Scale parameter $\alpha = 0$ gives Rényi diversity equal to the logarithm of the number of species, $\alpha = 1$ yields Rényi diversity equal to Shannon's H , $\alpha = 2$ is related to Simpson's index of dominance, while $\alpha = 3$ and 4 represent a growing emphasis on the dominant species (Tóthmérész 1998, Carranza *et al.* 2007). Rényi's diversity curves for understorey and overstorey around nestboxes used and not used by *D. nitedula* were created using the freeware DOSBox ver. 0.74, running DivOrd program ver. 1.90 (Tóthmérész 1993). If the diversity curves produced by this method do not intersect, the diversity of either understorey or overstorey in areas around used and not used nestboxes differs significantly. According to

Table 1. Pearson correlations between vegetation parameters and indices of nestbox use by *D. nitedula* in the periods 2001–2002 and 2003–2011 (* = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$).

| Vegetation parameter | Coefficients of Pearson correlation | |
|---|-------------------------------------|-----------|
| | 2001–2002 | 2003–2011 |
| Number of young rowan trees | 0.01 | 0.62 *** |
| Number of young lime trees | 0.07 | 0.54 *** |
| Number of young aspen trees | 0.03 | 0.38 ** |
| Number of young black alder trees | -0.12 | 0.22 * |
| Density of shrub layer, ind./ha | 0.07 | 0.47 *** |
| Number of mature lime trees | 0.11 | 0.48 *** |
| Number of mature black alder trees | -0.17 | 0.41 *** |
| Cover of raspberries and brambles, % | -0.07 | 0.44 *** |
| Area of overgrowing clearings, m ² | -0.25 | 0.48 *** |
| Number of all mature trees | 0.02 | -0.40 ** |
| Number of mature Scotch pine trees | -0.01 | -0.41 ** |
| Number of Norway spruce trees in sub-canopy | 0.03 | -0.38 ** |
| Number of young Norway spruce trees | 0.14 | -0.28 * |
| Cover of bilberries, % | -0.09 | -0.29 * |
| Area of rides, m ² | 0.10 | -0.22 ** |

the theory of diversity ordering, one community can be regarded as more diverse than another only if all its Rényi diversity numbers are higher (Tóthmérész 1998).

4. RESULTS

D. nitedula found new nestboxes erected in the area of the study site very quickly and used them willingly. In early June 2001, six females with litters were found in new grid nestboxes erected only two months previously. Over the period of the whole activity season, dormice used 73% of all nestboxes in 2001 and 83% in 2002 (see Fig. 2a). Regular control of nestboxes and individual marking of dormice enabled all adult dormice living in the area of the study site to be recorded. Numbers of adult dormice recorded increased at the beginning of the study, reaching a maximum in 2002. From 2003, dormouse abundance then decreased by half, thereafter remaining at a similar level for the subsequent nine years (Fig. 1).

During the period 2001–2011, dormice had the possibility to use 63 nestboxes spaced evenly in the area of 13.8 ha. In 2001–2002, when dormouse abundance was relatively high, they used nestboxes spaced across the entire area of the study site (Fig. 2a). In the period 2003–2011, when dormouse abundance had decreased to a lower, but stable level, they used nestboxes situated mainly in the western part of the grid, with only a few nestboxes used in the eastern part of the study area (Fig. 2b, c).

No significant correlations were found between vegetation parameters and indices of nestbox use by *D. nitedula* during 2001–2002 (Table 1). However, many statistically significant correlations were established between vegetation parameters and indices of nestbox use for the period 2003–2011 (Table 1). Additionally, vegetation parameters around nestboxes used and not used by *D. nitedula* during 2003–2011 were compared (Table 2).

Results of both analysis (Tables 1 and 2) show that *D. nitedula* preferred nest sites situated in areas with:

- 1) better developed understorey (especially with young rowan, lime and aspen trees);
- 2) higher numbers of mature oak, lime and black alder trees;
- 3) a higher percentage of raspberry and bramble cover;
- 4) overgrown clearings.

D. nitedula avoided nest sites situated in areas with:

- 1) higher total numbers of mature trees (especially Scotch pine and Norway spruce);
- 2) a higher percentage of bilberry cover;
- 3) open areas (rides, presence of stumps).

Analysis of understorey diversity around nestboxes proved that *D. nitedula* preferred sites with diverse understorey, which was true for both the periods 2001–2002 (Fig. 3a) and 2003–2011 (Fig. 3b). Also, the diversity of understorey was significantly higher around nestboxes where *D. nitedula* bred in 2003–2011 (Fig. 3c). In general, the understorey diversity was low around nestboxes in

Table 2. Comparison of vegetation parameters around nestboxes used and not used by *D. nitedula* in the period 2003–2011 (Student's t-test; df = 56; * = $P < 0.05$; ** = $P < 0.01$).

| Vegetation parameter | Average value of vegetation parameter | | t-value |
|---|---------------------------------------|---------------------------|----------|
| | around nestboxes used | around nestboxes not used | |
| Number of young rowan trees | 13.3 | 3.1 | 3.12 ** |
| Number of young lime trees | 13.8 | 0.5 | 2.41 * |
| Number of shrubs | 34.8 | 16.6 | 2.38 * |
| Number of mature oak trees | 1.5 | 0.4 | 2.34 * |
| Number of mature lime trees | 3.3 | 0.0 | 2.10 * |
| Cover of raspberries and brambles, % | 13.2 | 2.3 | 2.10 * |
| Area of overgrowing clearings, m ² | 231.9 | 44.8 | 2.01 * |
| Number of mature Scotch pine trees | 9.1 | 23.9 | -3.16 ** |
| Number of all mature trees | 88.8 | 109.3 | -2.61 * |
| Number of stumps | 0.3 | 1.0 | -2.12 * |
| Cover of bilberries, % | 1.4 | 5.8 | -2.48 * |

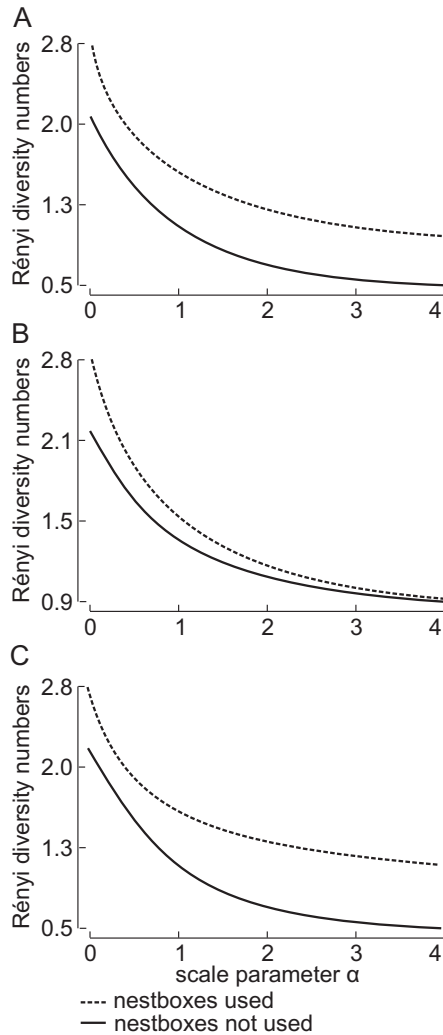


Fig. 3. Comparison of understorey diversity around nestboxes of *D. nitedula* at study site in Lithuania: A) nestboxes used and not used by *D. nitedula* during the period 2001–2002; B) nestboxes used and not used by *D. nitedula* during the period 2003–2011; C) nestboxes used and not used by *D. nitedula* for breeding during the period 2003–2011. Rényi's diversity curves include a family of different diversity indices and reveal the diversity in a continuum of possible diversity measures. Non-intersecting curves show statistically significant differences in understorey diversities compared, irrespective of the influence of rare or common plant species.

17 cases (Shannon's $H < 1.0$), medium in 30 cases ($H = 1.01$ – 2.00), and high in 11 cases ($H > 2.0$).

In general, overstorey diversity around the nestboxes was low: in 10 cases Shannon's $H < 1.0$, in 48 cases $H = 1.01$ – 2.00 , there were

no cases where $H > 2.0$. In the 2001–2002 period, *D. nitedula* preferred sites with a more diverse overstorey (Fig. 4a). In 2003–2011, the diversity of overstorey was not different around nestboxes used and not used by *D. nitedula* (curves intersect in Fig. 4b). However, a more diverse overstorey was found around nestboxes where *D. nitedula* bred (Fig. 4c).

5. DISCUSSION AND CONCLUSIONS

In different parts of its range, *D. nitedula* mainly use two types of nests: situated in closed cavities (e.g. tree hollows) or built among thick (preferably thorny) twigs (Ajrapet'anc 1983, Rossolimo *et al.* 2001). In the Lithuanian dormouse study site, both these nest site possibilities are very limited, the forest stands not being old and lacking natural tree holes. Thorny plants which could keep harbour dormouse nests are totally absent. The erection of nestboxes, which represent artificial substitutes of tree hollows and are safe closed nest sites for dormice (e.g. Morris *et al.* 1990, Juškaitis 2008) evidently had a positive influence on the abundance of *D. nitedula* during 1999–2002. Although only 20 nestboxes, which were located in a line in the south-eastern corner of the study site, were present in 2000, eight adult dormice were recorded in them. In May 2001, nine adult dormice were recorded in these nestboxes. Already in June, all of these marked individuals were recorded in new nestboxes spaced in a grid system. Marked individuals of *D. nitedula*, especially males, moved rather long distances between nestboxes. It seems that the individuals using 'line-nestboxes' situated in the south-eastern corner of the study site knew entire area of the study site well. They detected and started to use new 'grid-nestboxes' very soon. For unknown reasons, the numbers of dormice recorded in the area of the study site decreased by half from 2003 as compared to the maximum number recorded in 2002, with the population thereafter remaining comparatively stable during the rest of the study period until 2011.

The positive influence of nestboxes on dormouse abundance has also been recorded in other dormouse species – *M. avellanarius* (Morris *et al.* 1990, Juškaitis 2005, 2008), as well as in bigger hollow-dwelling species

– American red squirrel *Tamiasciurus hudsonicus* and northern flying squirrel *Glaucomys sabrinus* (Aitken and Martin 2012). In the case of *M. avellanarius*, an increased dormouse density resulting from a high nestbox density (25 boxes per ha) remained for the entire six-year period that the boxes were present. In this case, the density only decreased again with the restitution of the former low nestbox density (4 boxes per ha; Juškaitis and Büchner 2010). In the case of *D. nitedula*, even though no changes were made to the density or arrangement of nestboxes, the observed increase in dormouse density reversed naturally after a few years.

When the abundance of *D. nitedula* was comparatively high, dormice being territorial were forced to use entire area of the study site, despite habitats possibly being suboptimal for them in part of this area. When dormouse abundance decreased, *D. nitedula* had the possibility to choose nestboxes located in the best dormouse habitats present in the study area. This latter circumstance allowed the establishment of nest site preference in *D. nitedula*.

Analysis of correlations between indices of nestbox use and vegetation parameters shows that a well-developed understorey is one of the main nest site requirements of *D. nitedula*. Dormice preferred nest sites with a higher density of shrub layer and with higher numbers of young rowan, lime and aspen trees. They avoided nest sites with a higher total number of mature trees because these trees block development of understorey. Dormice preferred nest sites with areas of overgrown clearings, in which young trees and shrubs, including potential food plants such as raspberries and glossy buckthorns grew.

Among mature trees, a positive correlation was found with some tree species, namely oak, lime and black alder trees. Both mature oak and lime trees have well developed horizontal branches which are important for dormouse movement in canopy. Acorns of oak are also potential food source for dormice (Ajrapet'anc 1983). It seems that mature black alder trees do not have a direct positive impact on dormice, but their number around nestboxes was positively correlated with the total number of understorey specimens and numbers of several understorey species. This

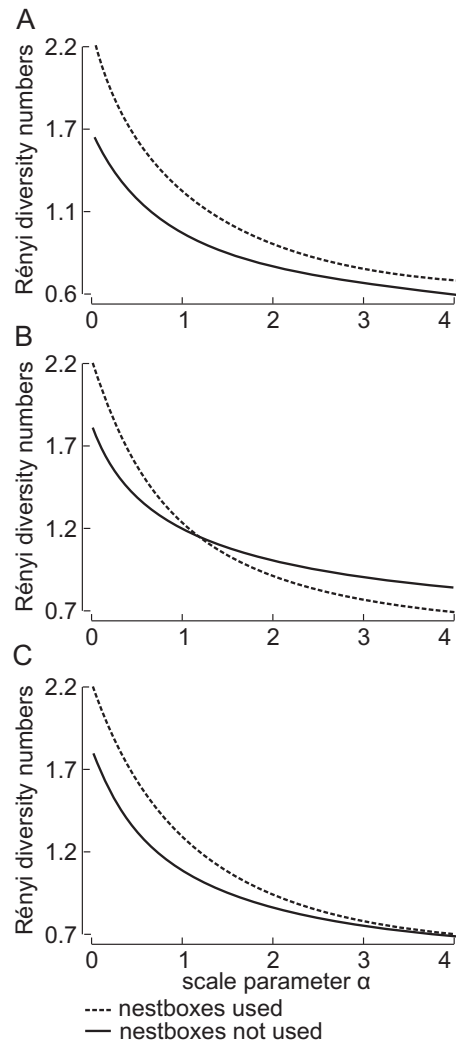


Fig. 4. Comparison of overstorey diversity around nestboxes of *D. nitedula* at study site in Lithuania: A) nestboxes used and not used by *D. nitedula* during the period 2001–2002; B) nestboxes used and not used by *D. nitedula* during the period 2003–2011; C) nestboxes used and not used by *D. nitedula* for breeding during the period 2003–2011. Non-intersecting curves show statistically significant differences in overstorey diversities compared.

means that the understorey, which is important for *D. nitedula*, was better developed in places where black alder trees grew.

D. nitedula avoided forest stands with mature Scotch pine trees. These trees are tall, their trunks are branchless and dormice are not able to move in the canopy layer of such forest stands. A significant negative correlation with the number of Norway spruce trees in the sub-canopy was unexpected, because

such trees with long horizontal branches provide good movement routes for dormice. However the negative correlation between this parameter and the number of understorey specimens could explain this discrepancy. *D. nitedula* being arboreal animals avoided nest sites with open areas which were not covered by woody plants, e.g. rides or places where tree stumps were present.

An inverse relationship between *D. nitedula* and some potential food plants present in the areas surrounding their nest sites was established. *D. nitedula* preferred nest sites with a higher percentage of raspberry and bramble cover, but avoided increased percentages of bilberry cover. Typically bilberries grow in forest stands dominated by mature Scotch pine trees, which are unsuitable habitats for *D. nitedula*.

According to Ajrapet'anc (1983), the presence of a shrub layer and dense young trees in the understorey is the main habitat requirement of *D. nitedula*. Many other researchers (e.g. Goloduško and Padutov 1961, Angermann 1963, Lihačev 1972, Rossolimo *et al.* 2001) also stressed this habitat preference of *D. nitedula*. In the very north-western corner of its range, *D. nitedula* retains this main habitat requirement – the preference of nest sites situated in areas with a well-developed and diverse understorey. However, the species composition of the understorey in habitats of *D. nitedula* is different in Lithuania as compared to other parts of its range, especially in Asia, showing the high plasticity of *D. nitedula* in this respect.

Vegetation parameters determining nest site preference of *D. nitedula* are rather similar to those for nest site preference of *M. avellanarius*. Both species prefer nest sites with a well-developed understorey and the presence of overgrown clearings, and both avoid forest stands with high numbers of coniferous trees in the canopy and sub-canopy (Panchetti *et al.* 2007, Juškaitis and Šiožinytė 2008). It is assumed that *M. avellanarius* probably prefers nest sites with high understorey density due to the presence of routeways through branches and visual protection from predators, particularly from owls (Panchetti *et al.* 2007). The same reasons may be important also for nest site preference by *D. nitedula*. Also *E. quercinus* prefers

sites with denser shrub cover, which provides protection from aerial predators (Bertolino and Cordero di Montezemolo 2007). In contrast to these three dormouse species, *G. glis* prefers nest sites with well-connected tree canopies (including coniferous trees), and the density of the understorey is not important for this species (Schlund *et al.* 1993, 1997, Juškaitis and Šiožinytė 2008).

Nest site selection in *D. nitedula* was related to the environmental diversity: they preferred nest sites with a higher understorey diversity in the surroundings of the nestboxes used both for living and breeding. In similar studies of nest site selection by *M. avellanarius* using nestboxes, no significant correlation with understorey species diversity was found either in Italy or Lithuania (Panchetti *et al.* 2007, Juškaitis and Šiožinytė 2008). However, the number of shrub species was one of the main factors for selection of sites for the building of natural nests in unenclosed situations (not in nestboxes) in Sweden (Berg and Berg 1998). Plant species diversity was an important habitat requirement for *M. avellanarius* in large scale habitat selection in England (Bright and Morris 1990). In *G. glis*, a significant correlation between tree diversity and nestbox occupation was found in deciduous forest (both in small scale and large scale), but no correlation was found in coniferous-mixed forest in Germany (Schlund *et al.* 1993, 1997). These examples show that the importance of woody plant diversity to dormice may vary depending on dormouse species, habitat and some other factors.

According to Bright and Morris (1990), the amount of plant diversity needed for dormice will depend on the combination of species at any one site. For example, *M. avellanarius* require a certain diversity of woody plant species to provide a continuum of food sources through the seasons, but some individual species may appear disproportionately important for feeding. Telemetry observations of *M. avellanarius* clearly showed that their nest sites do not correspond to foraging areas (Panchetti *et al.* 2007). The same could also be true for *D. nitedula* which can travel rather long distances, up to several hundred meters (Goloduško and Padutov 1961, Angermann 1963, Ściński and Borowski 2006, R. Juškaitis, unpublished). This

last circumstance means that the presence of woody plants which can supply potential food (fruit or insects living on these plants) in the surroundings of dormouse nest sites is desirable, but not an obligate element: these plants may grow at some distance from the nest site.

Two dormouse species – *D. nitedula* and *M. avellanarius* – rather often live sympatrically (review in Juškaitis 2008), and they were both also recorded in the area of the study site. However during entire study period, *M. avellanarius* was recorded in nestboxes situated within the area only three times. *M. avellanarius* is widespread and common in different forest stands across Lithuania (Juškaitis 2007). The relative rarity of this species in the area of the study site may be determined by habitat quality: even the most suitable forest stands for *D. nitedula* with comparatively well-developed understorey were unsuitable for *M. avellanarius* to live permanently. It should be noted that hazel *Corylus avellana* L. was absent totally in the area of the study site and other plants providing suitable vegetable food for *M. avellanarius* were scarce. The diet of *D. nitedula* includes much more food of animal origin (e.g. Nowakowski and Godlewska 2006) and these dormice may live permanently in habitats which are not rich enough for *M. avellanarius*.

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