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Assessment of the habitat quality of the forest dormouse (*Dryomys nitedula*) in Daghestan, Russia: role of foods and vegetation structure

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Abstract. The suitability of two forest biotopes (oak and hornbeam-beech forests) for occupation by *D. nitedula* in Daghestan, Russia is considered. Biotopes have been characterized according to 11 parameters. All 11 vegetation parameters were significantly different between study areas. The indices of *D. nitedula* success in the studied biotopes demonstrated that numbers were higher in an oak forest than in a hornbeam-beech forest. Estimates of microhabitat distribution showed that *D. nitedula* individuals prefer to live in shrub associations and in areas with young trees in both biotopes. The body weight of adults and reproduction rate were similar in both biotopes. We concluded that in situation when the body weight and reproduction rates of individual *D. nitedula* were similar but the numbers of species in the both forest biotopes significantly differ, the structure of woody-shrub vegetation becomes a significant factor.

Key words: numbers, microhabitat distribution, reproduction characteristics, diet, oak forest, hornbeam-beech forest

Introduction

Arboreal rodents are one of the specialized and numerous groups of animals inhabiting the forest canopy, finding both refuge and food there (Malcolm & Ray 2000, Vasquez et al. 2002). The presence of natural hollows in trees or the possibility of convenient movement among the crowns of trees and shrubs can determine the occurrence or absence of a species in a biotope (Adler 2000, Di Bitetti 2001).

The forest dormouse (*Dryomys nitedula* Pallas, 1779) is a semi-arboreal species, the most widely distributed species of the family Gliridae (Airapetyants 1983, Rossolimo et al. 2001). Regrettably there are many areas where information about it is scarce. In Daghestan *D. nitedula* is widespread, but the main population occurs in the foothill zone (Airapetyants 1983, Magomedov et al. 2012). Daghestan, especially its mountain part, is characterized by a hilly landscape, even nearby sites located on different slopes can differ in microclimatic conditions, vegetation structure and productivity. Such a wide spectrum of habitat conditions should affect forest dormice in different areas of Daghestan.

In this paper the role of the forest canopy structure and its productivity are assessed as factors capable of determining the state of *D. nitedula* in different forest biotopes. Food is a fundamental factor determining the state of any species (Magomedov & Magomedov 2008) and at the same time, the structure of woody shrub vegetation could be no less important in one or another part of the forest (Likhachev 1972). The purpose of this study was to estimate the suitability of two typical forest biotopes for the forest dormouse in Daghestan.

Material and Methods

Study area – selection of experimental plots

Daghestan is the southernmost region of Russia, located in the northeastern Caucasus. The study was performed in the foothill zone of Daghestan during five years (2002-2004, 2009-2010). Two typical areas were selected: lower foothill (250-400 m a.s.l., 45° 54′ 34″ N, 47° 27′ 37″ E) – oak forest and upper foothill (750-800 m a.s.l., 41° 39′ 21″ N, 47° 59′ 59″ E) – hornbeam-beech forest (Fig. 1).

The foothill zone of Daghestan forms a multitude of ridges separated by valleys, basins, and canyons (Akaev et al. 1996). The climate here is moderately warm. Winters are characterized by comparatively mild temperatures with the average of three winter months around +1.5 °C, and a summer average of +17 °C (Akaev et al. 1996). The vegetation is composed

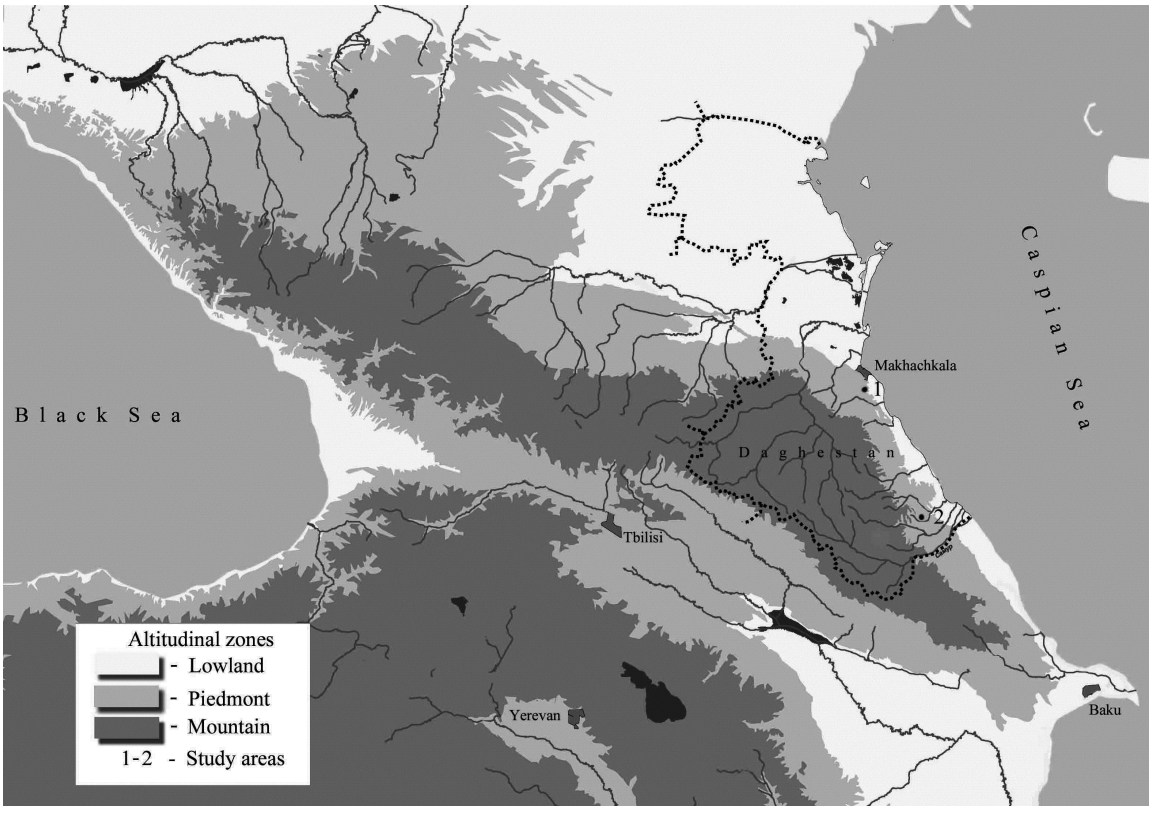

Fig. 1. Study area.

mainly of oak, beech, and beech-hornbeam types of forest (Lvov 1964).

Handling of animals

To estimate the relative abundance of *D. nitedula*, standard trap-lines of Gero traps were used (Kucheruk 2006). Each night from 50 to 100 traps were set at 3-5 m intervals. All abundance data were standardized "as catch per 100 trap-nights". During the entire period of the studies there were 4870 trap-nights employed and 173 animals were caught. In addition, numbers of *D. nitedula* nests per route line (10 km) were recorded. In order not to count accidentally the nests of birds, each nest was checked to determine its inhabitants. All the animals captured were weighed, had their body length measured and sex determined. To describe rates of reproduction, the following parameters were used: size (volume) of testes (using sliding calipers accurate to 0.01 cm), sex ratio and percentage of breeding females. Volume of testes were calculated using formula of ellipse $V = 4/3\ \pi*a*b*c$, where a, b, c are axes of testes. The percentage of females participating in reproduction was determined from the relationship between the number of reproducing, lactating females and the total number of females caught. Animals were divided into two age groups: juvenile (≤ 19.5 g) and adult (> 19.5 g), following Kryštufek (1985).

Vegetation

For botanical description, 11 parameters were selected: density, height and diameter of trees (at the chest level), closeness of their crowns, production of seeds. For shrubs, the density, height and diameter (at the chest level), closeness of their crowns and protective cover were recorded, as well as the production of grasses (Voronov 1973). Six sites were selected and in each one geobotanical description was performed in four plots.

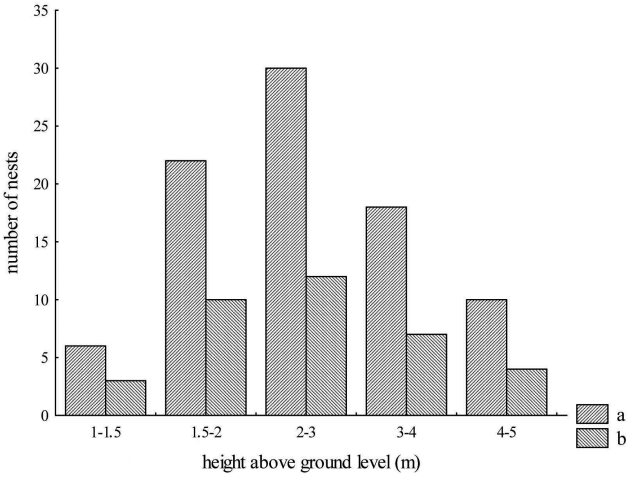

Fig. 2. Vertical distribution of *D. nitedula* nests in an oak forest (a, n = 90 per 10 km transect) and in a hornbeam-beech forest (b, n = 36 per 10 km transect).

Table 1. Vegetation characteristic of habitats of *D. nitedula*.

Indicators	Oak forest mean ± SE	Hornbeam-beech forest mean ± SE	*p*
Density of shrubs (ind./0.125 ha)	247 ± 25	106 ± 12	< 0.05
Density of trees (ind./0.125 ha)	707 ± 68	623 ± 64	< 0.05
Height of shrubs (m)	4.0 ± 0.24	7.8 ± 0.14	< 0.05
Height of shrubs (cm)	6.27 ± 0.27	7.21 ± 0.53	< 0.05
Canopy cover of shrubs (%)	58.12 ± 2.7	65.0 ± 4.23	< 0.05
Height of trees (m)	9.2 ± 0.48	13.82 ± 0.88	< 0.05
Diameter of trees (cm)	17.0 ± 1.01	24.0 ± 2.81	< 0.05
Canopy cover of trees (%)	62.0 ± 6.3	74.0 ± 3.9	< 0.05
Production of trees (kg/m^2)	2.02 ± 0.05	1.57 ± 0.05	< 0.05
Production of grass vegetation in a forest canopy (kg/ha)	0.44 ± 0.03	0.21 ± 0.01	< 0.05
Projective cover (%)	17 ± 0.71	11.3 ± 0.45	< 0.001

Table 2. Dynamics of numbers of *D. nitedula* (ind./100 trap-nights).

Years	Oak forest mean ± SE	Trap nights	Hornbeam-beech forest mean ± SE	Trap nights	*p*
2002	4.48 ± 1.55	500	3.33 ± 0.46	480	< 0.001
2003	6.67 ± 1.07	510	3.68 ± 0.49	450	< 0.0001
2004	7.46 ± 1.31	500	3.50 ± 0.52	480	< 0.0001
2009	6.0 ± 0.89	510	3.62 ± 0.43	470	< 0.0001
2010	6.3 ± 0.92	520	3.91 ± 0.66	450	< 0.001
mean ± SE	6.18 ± 0.87		3.61 ± 0.54		< 0.0001
		2540		2330	

Table 3. Microhabitat distribution of *D. nitedula* individuals (ind./100 trap-nights).

Microhabitat	Oak forest (n = 117)	Hornbeam-beech forest (n = 55)
Shrubby belt	12.36	7.94
Undergrowth	9.27	5.59
Forest edge	5.56	3.07
High forest	3.71	1.44
Open sites	0	0

Trees and shrubs were described at plots with an area of 50 × 50 m, and grass vegetation, 1 × 1 m. Production of seeds and root crops was determined by using plots of 1.0 m^2, and samples were dried to constant mass and weighed. STATISTICA 5.0 was used for r analysis of the empirical data obtained (Borovikov 2001).

Results

Characteristics of forest biotopes

Table 1 provides data characterizing the state of the vegetation in habitats of *D. nitedula*. Oak forest as a whole consisted of *Quercus sessiliflora* and *Quercus pubescens* (up to 80 %) with an admixture of *Pinus sosnovsky* and *Acer campestre.* In the understory well developed shrubby vegetation was recorded: *Crataegus pseudogeterophilla*, *Mespilus germanica*, *Cornus mas*, *Prunus spinosa*, *Paliurus spina-christi*, *Rosa canina*, etc. The hornbeam-beech forest consisted of *Carpinus betulus*, *Fagus orientalis*, *Quercus sessiliflora*, *Quercus pubescens*, and *Tilia caucasica.* The shrubby vegetation was sparse, consisting of *Crataegus pseudogeterophilla*, *Rosa canina*, *Rubus sanctum*, and *Corylus avellana* (Table 1).

The sites differed significantly from each other. The densities of trees and shrubs were higher in oak forest than in hornbeam-beech forest, whereas linear sizes of trees and shrubs were higher in the latter (Table 1). Production of trees and grass vegetation was higher in oak forest.

Populations and habitat

Table 2 shows the dynamics of *D. nitedula* numbers in both forest biotopes. For a given study period, average numbers of these dormice in oak forest was 1.7 times higher than in hornbeam-beech forest ($t = 5.7$, $p < 0.0002$).

To assess microhabitat distribution of *D. nitedula* individuals the forest canopy was divided into five microhabitats: open sites, forest edge, high-standing

forest, undergrowth, and shrubby vegetation. Table 3 shows that maximum numbers of *D. nitedula* were found in shrub associations and in parts of a forest dominated by young trees in both forest area types. Minimal numbers of the species were found in high forest microhabitats (Table 3).

Additionally we estimated vertical distribution of *D. nitedula* nests and found optimal height of nests in both forest biotopes was 2-3 m above the ground surface (Fig. 2).

Table 4. *D. nitedula* reproduction characteristics. %♀ – reproductively active females.

	Oak forest			Hornbeam-beech forest			*p*
	♂♂	♀♀	%♀	♂♂	♀♀	%♀	
2002	12	11	54.5	5	4	50	
2003	14	10	70	6	5	60	
2004	14	13	69.2	6	6	50	
2009	11	10	60	5	6	66.6	
2010	13	10	60	7	5	60	
Average			62.7			57.3	> 0.05
♂♂/♀♀	1.18:1			1.11:1			

Reproduction rates and sex ratio

Sexual activity of D. nitedula males was measured by the size of testes. The first signs of sexual activity among males were recorded soon after the animals came out of hibernation in both forest biotopes. The maximum size of testes was seen in April in both forest biotopes: 0.834 ± 0.99 cm^3 (n = 49) in oak forest and 0.872 ± 0.11 cm^3 (n = 18) in hornbeam-beech forest. Subsequently sexual activity of males began to decline and, by August, the size of testes was 0.195 ± 0.06 cm^3 in oak forest and 0.185 ± 0.09 cm^3 in hornbeam-beech forest. Thus, sexual behavior of *D. nitedula* males was not significantly different in the two biotopes (t = 0.02, $p = 0.98$). Sex ratios showed domination of males in both forest biotopes: 1.18:1 (n = 118) in oak forest and 1.11:1 (n = 55) in hornbeam-beech forest (Table 4).

Age groups of *D. nitedula* did not differ significantly between biotopes ($p > 0.05$). The spring population of *D. nitedula* consisted only of adult individuals in both biotopes. By the end of summer (August juveniles formed 48 % and 43 % of the population in oak and hornbeam-beech forests respectively.

Diet

We found a wide spectrum of items in the diet of forest dormice including animal material, along with fruit and seeds of almost all species of trees and shrubs occurring at the study sites. The main types of food of *D. nitedul*a were animals and seeds; 29.6, 24.05 %, respectively, in oak forest and 30.88, 27.06 %, respectively, in hornbeam-beech forest.

Species composition of the diet was revealed by analyzing food remains. The diet of individuals of the species from oak forest consisted of 18 species of foods, and in individuals from hornbeam-beech forest of 19 species. The degree of similarity between diets of dormice from both forest biotopes was 86 %. In both biotopes the animals attained similar body weight during the active phase of the year: 35.63 ± 0.79 g (n = 73) in oak forest and 34.33 ± 1.14 g (n = 46) ($p > 0.05$) in hornbeam-beech forest.

Table 5. Spearman rank correlations between *D. nitedula* state and forest habitats structure attributes in both habitats. Significant values are in bold ($p < 0.05$).

	Oak forest		Hornbeam forest	
	Body weight	Numbers	Body weight	Numbers
Production of grass vegetation (kg/ha)	0.45	–0.47	0.36	–0.48
Projective cover (%)	**0.54**	0.40	**0.44**	0.51
Production of seeds (kg/m^2)	**0.66**	0.35	**0.71**	0.48
Density of trees (ind./0.125 ha)	0.28	**0.61**	0.34	**0.57**
Height of trees (m)	–0.24	**–0.67**	–0.49	**–0.74**
Diameter of trees (cm)	–0.25	**–0.59**	–0.31	**–0.66**
Canopy cover of trees (%)	–0.21	**0.69**	–0.17	**0.70**
Density of shrubs (ind./0.125 ha)	0.38	**0.67**	0.33	**0.61**
Height of shrubs (m)	–0.18	**–0.77**	–0.24	**–0.70**
Diameter of shrubs (cm)	0.36	0.42	0.41	0.31
Canopy cover of shrubs (%)	–0.54	0.15	–0.46	0.1

Thus, food cannot be a key factor limiting numbers and distribution of the species in the study areas.

We used numbers and body weight of adult individuals to indicate relative "success" in the two habitats. Table 5 shows values of Spearman Rank correlations comparing the state of the dormouse population and vegetation parameters. Body weight significantly correlates with production of seeds and protective cover provided by grassy vegetation in both biotopes. The second indicator of the species success (numbers) demonstrated significant dependence on six parameters of the vegetation in both biotopes. Numbers of *D. nitedula* positively correlate with an increase in the density of trees, shrubs, and closeness of crowns and negatively correlates with the height of trees, shrubs, and the diameter of trees in both biotopes. Thus, *D. nitedula* does well in areas with abundant vegetable foods, although the numbers of dormice are higher in oak forest.

Discussion

According to several authors the key condition for the existence of *D. nitedula* is well developed shrubby vegetation (Likhachev 1972, Airapetyants 1983). Studies performed in Moldova and the Ukraine have shown that the density of *D. nitedula* in biotopes with a well developed shrubby vegetation was 20-25 individuals per hectare, in young oak groves up to 8/ha and in high forests with sparse undergrowth 1-3 individuals per hectare (Airapetyants 1983, Kryštufek & Vohralík 1994, Nowakowski & Boratyński 1997, Pilāts et al. 2012). Similar results were found in our studies, with *D. nitedula* numbers higher in the biotope oak forest with greatest density of shrubby vegetation. We suppose that the structure of the oak forest is more suitable for *D. nitedula* offering more convenient movement, and nest locations than the structure of the hornbeam-beech forest. Despite the great vegetation productivity of the oak forest, *D. nitedula* individuals reached similar body weights in hornbeam-beech forest. One may conclude that when body weights and the intensity of reproduction are similar, but numbers of forest dormice significantly differ, the structure of woody-shrub vegetation becomes more important as a factor determining the state of *D. nitedula* populations in Daghestan.

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